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1984 Stock Status of Division 4RST Redfish

by

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ABSTRACT

Nominal catches of Div. 4RST redfish have declined from a high of 130,000 t in 1973 to 15,000 t in 1980, followed by an increase to about 25,000 t in 1982-83 and 35,857 t in 1984. The commercial catch rates were adjusted for a shift to the use of Engel high lift trawls and standardized to Maritimes and Quebec tonnage class 4 otter trawlers fishing in Div. 4R. The catch rate standardized by the multiplicative model was highest in 1967 1.65 t/hr, then declined to 0.59 t/hr in 1975. Since then, catch rates increased to 1.27 t/hr in 1982 and 1.29 t /hr in 1983, then declined slightly to 1.20 t/hr in 1984. The percentage of the total catch taken from Div. 4T was higher in 1984 (29.3%) compared to 1983 (11.1%).

The age determinations from 1984 commercial redfish samples were noted to be inconsistant with previous years. The corrected weights and catch at age for 1983 were added to the appropriate matrices. Cohort analysis and projections were conducted utilizing the 1972-1983 catch-at-age and weight-at-age matrices. The estimated 1984 catch in weight (35,857 t) and a 1985 catch set equal to the announced TAC of 50,600 t were used for final projections of catches and mortality rates to 1991. These data were compared to projections at $F_{0.1}$ for all years and to the announced TAC's from 1985 to 1988 and $F_{0.1}$ thereafter. If 50,600 t is taken in 1985, projections at $F_{0.1}$ = 0.15 result in catches of 57,000 t in 1986 and 52,000 t in 1987. The announced TAC for 1986 is 55,000 t.

RÉSUMÉ

Le total des prises de sébaste dans les divisions 4R, 4S et 4T a diminué pendant une bonne période, passant de 130 000 T en 1973 à 15 000 T en 1980, puis a connu une hausse, pour atteindre environ 25 000 T en 1982-1983 et 35 857 T en 1984. Les taux de prises commerciales ont été rajustés, pour tenir compte de l'utilisation des chaluts à grande ouverture de marque Engel, et standardisés au tonnage des bateaux de pêche au chalut à panneaux de classe 4 des Maritimes et du Québec qui pêchent dans la division 4R. Le taux de prises standardisé par le modèle multiplicatif est passé de 1,65 T/h en 1967 à 0,59 T/h en 1975. Depuis lors, le taux de prises a augmenté pour atteindre 1,27 T/h en 1982 et 1,29 T/h en 1983. Il y a ensuite légèrement baissé pour atteindre 1,20 T/h en 1984. Le pourcentage du total des prises pêchées dans la Division 4T était plus élevé en 1984 (29,3 %) qu'en 1983 (11,1 %).

On a noté que le relevé de l'âge des échantillons commerciaux de sébaste de 1984 ne correspondait pas à celui des années précédentes. On a donc ajouté aux matrices pertinentes la période de la prise et les poids corrigés pour 1983. Des projections et des analyses de cohorte ont été effectuées au moyen des matrices de prises selon l'âge et de poids selon l'âge pour la période allant de 1972 à 1983. Les prises, en poids, prévues pour 1984 (35 857 T) et les prises pour 1985 fixées au TPA annoncé de 50 600 T ont été utilisées pour faire les projections finales des prises et des taux de mortalité jusqu'en 1991. On a comparé ces données aux projections à un taux d'exploitation $F_{0.1}$ pour toutes les années, puis avec les TPA annoncés, de 1985 à 1988, et avec le taux d'exploitation $F_{0.1}$ par la suite. Si l'on prend le chiffre de 50 600 T en 1985, les projection à $F_{0.1}$ = 0.15 pour 1986 et 1987 donnent des prises de 57 000 T et de 52 000 T respectivement. Le TPA annoncé pour 1986 est de 55 000 T.

INTRODUCTION

This fishery commenced in 1952 in the Gulf of St. Lawrence. Landings from 1952 - 1982 were summarized by Maguire, et. al. (1983). Landings by division since 1979 are presented (Table 1). An estimated 35,857 metric tonnes (t) were landed in 1984. This comprises an increase of 11,352 t since 1983 out of a total TAC of 50,600 t. The changes in the total landings are indicated in Figure 1. As in previous years, the fishery in 1984 was concentrated in the mouth of the Esquiman Channel at depths from 200-400 meters.

Nominal Catches

Provisional catch statistics from Gulf, Quebec, Scotia-Fundy and Newfoundland regions were summarized by NAFO divisions, region and year (Table 1). Division 4S had the largest share of the redfish catch (12,849 t), followed by 4R (12,531 t) and then 4T (10,477 t). The fishery is mainly Canadian; only 47 t was taken by France in 4R. More redfish were taken by Maritimes (CAN-M) vessels in 4R and 4T, while catches were higher for Quebec (CAN-Q) vessels in 4S.

The Maritimes NAFO statistics were compiled separately for the first time by Gulf Region for Gulf-based and by Scotia-Fundy Region for non-Gulf based vessels in 1984. Gulf-based vessels landed 7,900 t in Gulf Region (CAN-M) ports and 13,850 t in Quebec ports (CAN-Q). Total landings for non-Gulf based vessels were about 2,250 t (CAN-N) and 11,850 t for Scotia-Fundy Region (CAN-M) vessels.

Nominal catches by division, region and month are summarized in Table 2. The largest catches were taken during June, July and August for divisions 4RST combined. In Division 4R, the highest catches occurred in July. Division 4S had the highest catches in November, while catches peaked in August in 4T. High catches in 4T in October may reflect both the seasonal distribution pattern (Atkinson 1984) and attempts by the fishermen to take their quotas. Catches in Div. 4T comprised 29.3% of total landings in 1984 compared to 11.1% in 1983 (Rubec, et. al. 1984). This indicates a shift in the distribution of the fishery into 4T occurred in 1984.

The redfish fishery is primarily an otter trawl fishery in the Gulf of St. Lawrence. Out of the total landings, 33,595 t were taken by bottom trawlers and 1,327 t by shrimp trawlers using bottom trawls. In 1984, 97.4% of the redfish landed were caught in bottom trawls. Tonnage class (TC) 4 vessels using primarily bottom trawls took 80% of the total catch in 1984 (Table 3). A breakdown of catches according to division, gear and tonnage class is given in Table 4.

Sampling

Port samplers and observers from Gulf, Quebec, Newfoundland and Scotia-Fundy regions measured the length of 103,356 redfish during 1984 (Table 5). A large proportion (68,582) were measured by Quebec Region

Observers. Table 6 summarizes the numbers of male and female redfish measured by month, division and gear type. Bottom trawlers (OTB) and midwater trawlers (OTM) using 90 mm or greater mesh are separated from shrimp trawlers (ST) using less than 60 mm mesh. Length frequency samples were adequate for most months where large landings occurred. November and December landings in Division 4T were not sampled.

Shift to High Lift Trawls

The redfish fishery in the Gulf during the 1960's was by TC-3 and TC-4 otter trawlers (Table 3). First side trawlers and later stern trawlers came into use. These vessels used Yankee 41 bottom trawls or their equivalent. Starting in 1971, midwater trawls came into widespread use (Tables 7 and 8). Midwater trawls predominated from 1972 to 1976. Since then, the use of midwater trawls declined and were replaced by the use of bottom trawls. From 98-100% of the landings were taken by bottom trawls from 1982 to 1984 (Table 8.)

The type of bottom trawls used by TC-4 and 5 vessels is of importance for the standardization of commercial catch rates, using the multiplicative model (Gavaris 1980). The catchability for TC-4 and TC-5 vessels is assumed to be constant. An examination of logbook records indicates that a shift to the use of high lift (Engel 145 and 116 models) bottom trawls has occurred.

All TC-5 boats which fish for redfish in the Gulf are from non-Gulf based ports. TC-5 vessels based in Nova Scotia adopted the Engel 145 high lift bottom trawl starting in 1974 (D. Bolivar, pers. comm. 1984). The catchability of TC-5 vessels would be expected to have increased after 1974. However, from 1974 to 1976, Nova Scotia vessels used primarily midwater trawls (Table 7). The landings by TC-5 vessels are broken down into OTB and OTM categories. From 1973 to 1976 (Table 8) midwater catches exceeded bottom trawl catches. Non-Gulf based vessels were excluded from fishing for redfish from 1976 to 1981. A marked decrease in the use of midwater trawls commencing in 1977 (Table 7). Consequently, the use of Engel high lift bottom trawls by TC-5 boats was limited from 1974 to 1980.

The number of boats using Engel high lift trawls increased from 1980 to 1984 (Table 9). Two TC-4 vessels based in PEI tested high lift trawls in 1980 and 1981, and the 3 remaining boats converted in 1982. Three NS based TC-4 boats switched to the Engel in 1981. Six Quebec based TC-4 vessels switched in 1982. One NB based TC-4 vessel adopted a rock hopper high lift trawl in 1982. One NS based (TC-5) boat adopted the Engel in 1984. All CAN-M plus all CAN-Q OTB-4 and all CAN-M OTB-5 vessels which direct for Gulf redfish presently have high lift trawls.

The number of TC-4 and 5 boats by month which used Engel high lift trawls (Tables 10, 11 and 12) are given. These data have been used in calculations of correction factors by month to account for the change in catchability. Table 13 summarizes the total number of OTB-4 CAN-M+Q boats plus the number and percent with high lift trawls from 1980-1984. Corrections were made to catch-effort data for OTB-4 CAN-M+Q alone, OTB-4 plus OTB-5 CAN-M+Q combined, and OTB-4 and OTB-5 CAN-M+Q plus OTB-4 CAN-N combined.

Commercial Catch Rate Standardization

Examination of logbook records identified 5 boats; 2 from PEI, 1 from Quebec, 1 from Nova Scotia and 1 from New Brunswick for which data were available during the month previous and the month following the switch from Yankee 41 to high lift trawls (4 Engel, 1 rock hopper trawl). The CPUE for each boat before and after the conversion was calculated. The increase in CPUE ranged from 11.2% to 44.9%. The increase in the mean CPUE before and after the conversion was estimated to be 28%. This is believed to represent a realistic average value for OTB-4 CAN-M+Q vessels. No data were available from which to calculate a conversion factor for OTB-5 CAN-M+Q vessels, which converted in 1974. Similarly no conversion factor could be calculated for OTB-4 CAN-N vessels which changed to high lift trawls at the beginning of the fishing season in May 1984.

Maritimes and Quebec TC-4 vessels represent the major component in the 4RST redfish fishery. These boats landed 80% of the redfish during 1984 (Table 3). It was decided to correct the CPUE for these boats by increasing the effort by 1.28 to compensate for the increased catchability. From 1980 to 1984, the monthly ratio of the number of boats with Engel trawls was multiplied by the corrected CPUE to obtain monthly adjusted catch rates.

The commercial catch rates have been used as an abundance index due to the brevity of research vessels time series (Maguire, et. al. 1983). The corrected commercial catch rates from 1980 to 1982 for the directed redfish fishery (50% or more redfish catches) for vessels TC-4 and larger were standardized to Maritimes and Quebec otter trawlers fishing in Division 4R during January using the multiplicative model (Gavaris 1980). Corrected provisional catch and effort data for 1983 and 1984 were added to already existing data since 1959.

Regressions were conducted using the following weighting factors: unweighted, catch, effort, and the fourth root of catch x effort; and EGLS weights derived from effort. The data set used (up to 1979) with the combinations by gear and months were identical to that used by Maguire, et. al. (1983). All regressions showed essentially the same pattern (Figure 2).

The multiplicative model was first run with the uncorrected catch matrix up to 1984. The catch rate for the multiple regressions weighted by effort is 1.64 t/hr in 1967, 1.56 t/hr in 1982, 1.52 t/hr in 1983 and 1.44 t/hr in 1984 (Table 17).

Initial runs, correcting for TC-4 vessels CAN-M+Q, indicated that the combinations reported previously (Rubec, et. al. 1984) were still appropriate for gear and months. The fourth root regression and weighting by effort gave the highest correlations and the smoothest relationships for residual plots. Effort consistently gave a higher R^2 value compared to the fourth root of catch x effort. Thus the regression weighted by effort was chosen and the resulting Analysis of Variance (ANOVA) is shown in Table 14. The variance about the various factors in the model are shown in Table 15. The catch rates are shown in Table 16 and Figure 2. Catch rates increased from 1962 to 1967 (1.65 t/hr) and then declined until 1977 (0.59 t/hr). The catch rates have increased since then to reach 1.27 t/hr in 1982 and 1.29 t/hr in 1983 and then declined to 1.20 t/hr in 1984.

If we assume the increase in catchability for TC-5 vessels is similar to TC-4 vessels, it is possible to correct the CPUE of both tonnage classes. The standardization was run with both OTB-4 and OTB-5 effort data for CAN-M+Q corrected by 1.28 and adjusted by the number of boats with high lift trawls from 1974 to 1984. The results are very similar to the results obtained with only the TC-4 data corrected (Table 17). An additional standardization run with OTB-4 CAN-N data adjusted for 1984 by the correction factor (1.28) gave similar results. Correcting the model for CAN-M+Q TC-5 vessels and Can-N TC-4 vessels does not change the results because they comprise a small proportion of the total landings.

Catch at Age

Length frequencies by month from the commercial fishery were combined for each sex separately using computer software described by Gavaris and Gavaris (1983). This program allows weighting of each monthly length frequency by the appropriate catch weights (shown in Table 5) to obtain composite length frequencies for a chosen time period. Length frequencies were combined within each NAFO Division and within main gear types, by displaying the data and combining months with similar distributions (Figure 3). The combinations were made for each sex to obtain two annual length frequencies. The length frequencies are presented in Figure 4. Males were most prevalent at a modal length of 30 cm, females at 32 cm.

A comparison of the length frequencies for 1984 (Figure 4) with those for 1983 (Figure 5) indicates that more large redfish (34-40 cm) were taken in 1984. This appears to be due to the greater percentage of redfish caught in Div. 4T during 1984. There are more larger, older redfish in Div. 4T in comparison to Divs. 4R and 4S.

The previous assessment noted discrepancies in the 1983 age determinations (Rubec, et. al. 1984). The otoliths were re-aged during the past year and the catch at age calculations were redone to be consistent with previous ageing of redfish done by Newfoundland biologists. Age length keys for 1983 for male and female redfish respectively are presented in Tables 18 and 19. The catch-at-age matrix from 1972-1983 is presented (Table 20). The catch at age for the sexes combined is depicted (Figure 6). The catch at age for 1982 was modified to correct for final catch statistics, reported by NAFO. The catch-at-age matrix from 1972 to 1981 was taken from Gavaris and Atkinson (1982).

CAFSAC noted that calculations of catch at age for 1984 were not consistent with the progress of dominant year-classes noted in previous years. Consequently, the subcommittee recommended that the 1984 otoliths should have age determinations redone. The catch at age for 1972 to 1983 (Table 20) should be used for cohort analysis and as the basis for projections.

Weights at Age

The 1972 to 1982 weights at age were taken from Maguire, et. al. (1983). Weights at age for 1983 (Table 21) were calculated from average length at age and the following weight-length relationships (McKone, et. al. 1980).

$$Male_{wt} = 0.01659\ FL^{2.9548}$$

$$Female_{wt} = 0.013272\ FL^{3.0210}$$

Where FL signifies fork length in centimeters and weights are in grams.

Partial Recruitment

Various methods for calculating a partial recruitment vector were attempted (O'Boyle 1981; Rivard 1984). Since the dominant age groups for Div. 4RST redfish for 1984 were 13 and 14 years old, CAFSAC decided that the most appropriate partial recruitment (PR) vector would be that used previously (Maguire, et. al. 1983). The vector used was the following:

AGE	5	6	7	8	9	10	11	12	13	14-29
PR	.003	.003	.060	.170	.300	.450	.600	.750	.900	1.0

Sequential Population Analysis

VPA runs were conducted with various terminal fishing mortalities (F_t). The partial recruitment fully recruited at age 14 gave the best regression relationships with 5+ exploited biomass vs CPUE. The analysis indicated a very low terminal fishing mortality. CAFSAC noted that VPA fails to converge at low terminal fishing mortalities and that population estimates were too high. CAFSAC considered a range of F_t values which gave results from VPA comparable to research survey population estimates (Table 22). The subcommittee adopted $F_t = 0.05$ for use in final cohort analysis.

Cohort analysis was conducted using the 1972-1983 catch at age (Table 20). The natural mortality was assumed to be M = 0.10. The estimates of population numbers are given in Table 23. Mean population biomass are given (Table 24) and fishing mortalities are presented (Table 25).

Yield Per Recruit

The 1983 weights at age (Table 21) and partial recruitment were used to calculate Thompson and Bell yield-per-recruit with M = 0.10. Maximum yield-per-recruit is 0.159 kg (Table 26) at a fishing mortality of $F_{max} = 0.72$. The yield at $F_{0.1} = 0.16$ is 0.137 kg or 86% of the maximum yield per recruit. The yield per unit effort at $F_{0.1}$ is 3.79 times higher than the YPUE at F_{max}. This calculated $F_{0.1}$ value cannot be considered to be significantly different from the $F_{0.1} = 0.15$ used in the previous assessment.

Catch Projections

Biomass projections from 1984 to 1991 (Table 27) were made using the 1983 population estimates from cohort at F_t = 0.05, the 1983 average weights at age and the PR vector. Recruitment at age 5 from 1985-1991 was calculated as 287 million, the geometric mean recruitment at age 5 for 1972-1979. $F_{0.1}$ was set equal to 0.15 as a historic average value (Gavaris and Atkinson 1982). Three options are presented, setting 1984 to the estimated landings and 1) all years from 1985-1991 at $F_{0.1}$; 2) 50,600 t in 1985 and remaining years at $F_{0.1}$; 3) announced TAC's to 1988 and $F_{0.1}$ thereafter.

Projections at age for the years 1986 and 1987 for options, 1, 2 and 3 respectively are summarized (Tables 28, 29 and 30). Option 1 indicates an $F_{0.1}$ biomass of 50,711 t in 1986 and 45,768 t in 1987. Option 2 indicates that if 50,600 t is taken in 1985, 57,406 t will be exploitable at $F_{0.1}$ in 1986 and 51,930 t in 1987. The announced TAC of 55,000 t in 1986 and 55,000 t in 1987 represents option 3.

General Production Model

An equilibrium production model was run using adjusted catch rate data (TC-4 CAM-M+Q). The catch rate and effort series from the standardization were lagged for 6, 8 and 10 years. The best relationships were found by lagging the data for 8 years. These data are similar to results of projections at $F_{0.1}$ for 1986. Yield at 2/3 F_{msy} is 55,620 t.

F_{msy}	= 75,604 h
MSY	= 62,572 t
2/3 F_{msy}	= 50,403 h
Yield at 2/3 F_{msy}	= 55,620 t

Conclusions

A potential upward bias in catch rates (Maguire, et. al. 1983) was corrected by adjusting effort data used in the multiplicative model. Catch rates were found to be about 28% higher from 1981-1984 due to the switch to the use of Engel high lift trawls.

Projections were conducted from the 1983 corrected catch at age and weights at age. Poor recruitment in the latter part of the 1970's are reflected in the decline in projected catches until 1990. The announced TAC of 55,000 t for 1986 would be below the 57,000 t TAC for 1986 calculated at $F_{0.1}$. For 1987 and 1988 the announced TAC's would exceed $F_{0.1}$ projected catches.

Research surveys indicate strong year classes from the early 1980's. These fish should contribute to the fishery by 1988 leading to increased landings in the early 1990's.

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REFERENCES

Atkinson, D.B. 1984. Distribution of beaked redfish in the Gulf of St. Lawrence. J. Northw. Atl. Fish. Sci. 5(2): 189-197.

Gavaris, C.A. and D.B. Atkinson, 1982. Assessment of redfish in Divisions 4RST. CAFSAC Res. Doc 82/30: 1-24.

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial catch data. Can J. Fish. Aquat. Sci. 37(12): 2272-2275.

Gavaris, S. and C.A. Gavaris, 1983. Estimation of catch at age and its variance for groundfish stocks in the Newfoundland region. Can. Spec. Publ. Fish. Aquat. Sci. 66: 178-182.

Maguire, J.J., J.-P Lussiaà-Berdou, and P. Rubec, 1983. The 1982 stock status and 1983-84 yield projections for 4RST redfish. CAFSAC Res. Doc 83/50: 1-39.

McKone, W.D., D.B. Atkinson and W. Legge, 1980. Gulf of St. Lawrence redfish assessment. CAFSAC Res. Doc. 80/60: 1-43.

O'Boyle, R.N. 1981. The generation of input paratmeters for sequential population analysis. CAFSAC Res. Doc. 81/78: 1-37 (revised).

Rivard, D. 1984. Estimating partial recruitment from catches and a research survey index: A Monte-Carlo simulation. CAFSAC Res. Doc. 84/70: 1-12.

Rubec, P.J., J. Wright, and A. Boudreau, 1984. The 1983 stock status and 1984-85 yield projections for Div. 4RST redfish. CAFSAC Res. Doc. 84/80: 1-28.

Table 1: Nominal catches of redfish by division, country, region and year in the Gulf of St. Lawrence in metric tons.

	4R					4S					4T					4RST	
YEAR	CAN-N	CAN-M	CAN-Q	FRAN	TOTAL	CAN-N	CAN-M	CAN-Q	FRAN	TOTAL	CAN-N	CAN-M	CAN-Q	FRAN	TOTAL	QUOTA	TOTAL
1979	717	1722	1197	127	3763	32	2408	5189	0	7629	74	1773	1795	0	3642	16000	15034
1980	709	2476	1567	57	4809	184	2444	5497	0	8125	0	668	1230	0	1898	16000	14832
1981	1207	3802	2660	16	7685	411	3618	6144	0	10173	270	1100	1321	0	2691	20000	20549
1982	1880	4028	3492	10	9410	358	6792	6647	0	13797	117	498	2607	0	3222	28000 31000[a]	26429
1983	2015	5049	3361	38	10463	36	6963	4496	0	11495	41	656	1850	0	2547	31000 33000[a]	24505
1984	2174	7901	2409	47	12531	81	5371	7402	0	12849	1	6426	4045	0	10477	50600	35857

[a]Quota changed during year after consultation with fishing industry.

Table 2: 4RST redfish nominal catches by division, region and month in 1984.

MONTH	4R				4S				4T				4RST TOTAL
	CAN-N	CAN-M	CAN-Q	TOTAL	CAN-N	CAN-M	CAN-Q	TOTAL	CAN-N	CAN-M	CAN-Q	TOTAL	
J	0	530	0	530	0	747	0	747	0	0	0	0	1277
F	52	338	0	390	0	0	0	0	0	0	0	0	390
M	5	10	0	15	0	0	0	0	0	0	0	0	15
A	5	35	0	40	2	3	5	10	1	0	0	1	51
M	174	903	144	1221	70	635	1173	1878	0	158	150	308	3407
J	791	1326	244	2361	9	820	409	1238	0	273	1273	1546	5145
J	625	1564	276	2465	0	852	574	1426	0	256	1144	1400	5291
A	196	1073	147	1416	0	238	787	1025	0	1944	1073	3017	5458
S	125	1326	407	1858	0	424	1441	1865	0	768	174	942	4665
O	0	203	158	361	0	494	1597	2091	0	1288	112	1400	3852
N	201	567	272	1040	0	1153	1226	2379	0	929	17	946	4365
D	0	26	761	787	0	0	190	190	0	815	102	917	1894
TOTAL	2174	7901	2409	12484	81	5366	7402	12849	1	6431	4045	10477	35810

Table 3: 4RST Redfish. Percent landings according to Tonnage Class.

TC	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0	0	0	0	0	0	0	0	0	1	0	3	9	0	0	0	0	0
2	10	7	3	4	4	2	1	1	2	2	4	4	2	2	2	2	1	1
3	54	52	31	28	28	18	10	11	13	17	39	27	22	10	26	15	10	4
4	36	41	62	57	59	49	41	53	41	22	50	53	63	82	67	76	75	80
5	0	0	4	11	10	31	47	33	44	57	6	13	3	5	5	7	13	15
6	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Table 4: 4RST redfish nominal catches by gear, tonnage class, division and region in 1984.

GEAR	TON CLASS	4R				4S				4T				TOTAL
		CAN-N	CAN-M	CAN-Q	TOTAL	CAN-N	CAN-M	CAN-Q	TOTAL	CAN-N	CAN-M	CAN-Q	TOTAL	
OTB	0	0	0	0	0	0	0	0	0	0	0	0	0	
	1	0	0	0	0	0	0	0	0	0	0	5	5	5
	2	0	13	0	13	0	0	135	135	0	0	23	23	171
	3	0	89	0	89	0	20	48	68	0	75	33	108	265
	4	1639	4729	2408	8776	79	3051	6379	9509	0	6047	3868	9915	28200
	5	535	2705	0	3240	2	1922	0	1924	1	54	0	55	5219
ST	2	0	17	0	17	0	0	48	48	0	0	6	6	71
	3	0	74	1	75	0	309	789	1098	0	0	24	24	1197
	4	0	0	0	0	0	59	0	59	0	0	0	0	59
SDN	2	0	1	0	1	0	0	0	0	0	4	6	10	11
	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0
GNS	NS	0	37	0	37	0	0	2	2	0	1	76	77	115
LLS	2	0	0	0	0	0	0	1	1	0	0	4	4	5
OTM	4	0	0	0	0	0	5	0	5	0	250	0	250	255
	5	0	236	0	236	0	0	0	0	0	0	0	0	236
TOTAL	—	2174	7901	2409	12484	81	5366	7402	12849	1	6431	4045	10477	35810

Table 5 Summary of redfish (1984) length frequency sampling effort.

Division	Males	Females	Unsexed[a]	Total
	Scotia-Fundy Observers - 86 samples			
4S	1,152	1,334	81	2,567
4R	5,933	6,424	182	12,539
	Quebec Observers - 291 samples			
4R	7,978	8,885	237	17,100
4S	13,635	19,163	833	33,631
4T	8,798	8,031	1,022	17,851
	Gulf Port Samplers - 63 samples			
4R	2,805	2,912	10	5,727
4S	3,278	2,556	2	5,836
4T	714	816	24	1,554
	Quebec Commercial Samplers - 13 samples			
4S	1,318	1,397	1,091	3,806
4T	138	112	-	250
	Quebec Provincial Program Samples - 6 samples			
4S	195	341	-	536
4T	215	579	-	794
	Newfoundland Port Samplers - 2 samples			
4R	275	293	-	568
4S	241	356	-	597
Totals	46,675	53,199	3,482	103,356

[a]Unsexed samples not included in catch at age calculations.

Table 6: Commercial sampling of 4RST redfish and nominal catches for 1984. Fish measured males - females/followed by nominal catches (t).

	4R			4S			4T		
MONTH	OTB	ST	OTM	OTB	ST	OTM	OTB	ST	OTM
J	290-258/491			0 - 0 / 747		113/96/0			
F	664-363/289		140-105/30						
M	0 - 0 / 12								
A	0 - 0 / 6			0 - 0 / 2	0 - 0 / 5		0 - 0 / 1		
M	569-584/1200			1586-1259/1939	0 - 0 / 34		278-155/308		
J	2488-2166/2291	0 - 0 / 38		1078-692/1067	0 - 0 / 171		1228-738/1300	0 - 0 / 1	0 - 0 / 245
J	2517-2606/2450	0 - 0 / 9		2387-2217/1245	326-436/183		5047-5324/1386	0 - 0 / 10	
A	1567-1424/1392	66-219 / 14		1312-1483/702	1069-1232/326		1953-2466/2649	0 - 0 / 3	
S	3072-3397/1744	0 - 0 / 3	0 - 0 / 5	2027-2414/1593	681-1046/267	199-135/0	626-886/930	69-119/ 7	0 - 0 / 5
O	884-964/342	0 - 0 / 11	0 - 0 / 201	5193-9791/1576	1189-531/174	212-271/341	462-499/1644	0 - 0 / 1	
N	2128-3180/828	0 - 0 / 11		3921-4817/2015	0 - 0 / 50		0 - / 945	0 - 0 / 1	
D	1805-2471/784	0 - 0 / 3		643-853/190			0 - 0 / 915	0 - 0 / 2	

Table 7: Redfish Landings TC-5 for Maritimes - Quebec (CAN-M+Q)

YEAR	DIRECTED REDFISH CATCH OTB-5	DIRECTED REDFISH CATCH OTM-5	DIRECTED TOTAL OTB + OTM	TOTAL UNDIRECTED	TOTAL LANDINGS ALL GEAR TYPES
1974	585	14,505	15,090	20,781	63,489
1975	1,701	14,048	15,749	28,622	65,401
1976	1,369	11,495	12,864	21,651	37,983
1977	156	105	261	990	15,840
1978	421	353	774	1,827	13,591
1979	4	0	4	460	15,034
1980	136	0	136	752	14,832
1981	692	0	692	939	20,549
1982	1,207	0	1,207	1,823	26,429
1983	2,761	0	2,761	2,828	24,505
1984	3,844	891	4,735	4,917	35,857

Table 8: 4RST Redfish - Percent landings according to gear.

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
OTB	100	100	100	100	92	50	23	36	36	39	67	66	54	48	63	100	99	98
OTM	0	0	0	0	8	50	77	65	65	62	33	31	36	52	36	0	0	1
SDN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GNS	0	0	0	0	0	0	0	0	0	0	1	2	9	0	0	0	0	0
MIS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Table 9 Tonnage Class 4 and 5 Vessels by Port Directing for 4RST Redfish in the Gulf of St. Lawrence

PROVINCE	YEAR	NO. OF BOATS	NO. OF BOATS WITH HIGH LIFT TRAWLS	PERCENT USING HIGH LIFT TRAWLS	GEAR AND TONNAGE CLASS
PEI	1980	5	1	20	OTB4
	1981	5	2	40	OTB4
	1982	5	5	100	OTB4
	1983	5	5	100	OTB4
	1984	5	5	100	OTB4
NB	1980	1	0	0	OTB4
	1981	1	0	0	OTB4
	1982	1	1	100	OTB4
	1983	1	1	100	OTB4
	1984	2	2	100	OTB4
PQ	1980	4	0	0	OTM4
	1981	4	0	0	OTM4
	1982	4	4	100	OTB4
	1983	6	6	100	OTB4
	1984	6	6	100	OTB4
NS	1980	2	0	0	OTB4
	1981	2	2	100	OTB4
	1982	2	2	100	OTB4
	1983	4	4	100	OTB4
	1984	7	7	100	OTB4
NS	1980	4	4	100	OTB5
	1981	4	4	100	OTB5
	1982	7	7	100	OTB5
	1983	5	5	100	OTB5
	1984	7	7	100	OTB5
	1984	1	1*	100	OTM5
	1984	2	0	0	OTM5
NFLD.	1980	5	0	0	OTB4
	1981	5	0	0	OTB4
	1982	5	0	0	OTB4
	1983	5	0	0	OTB4
	1984	5	3	60	OTB4

* Used both bottom and midwater trawls.

Table 10 CAN (M + Q) OTB Tonnage Class 4 Vessels Directing for 4RST Redfish

MONTH	1980		1981		1982		1983		1984	
	# BOATS FISHING	# BOATS USING HI-LIFT TRAWL	# BOATS FISHING	# BOATS USING HI-LIFT TRAWL	# BOATS FISHING	# BOATS USING HI-LIFT TRAWL	# BOATS FISHING	# BOATS USING HI-LIFT TRAWL	# BOATS FISHING	# BOATS USING HI-LIFT TRAWL
J	-	-	-	-	-	-	2	2	1	1
F	-	-	-	-	-	-	-	-	-	-
M	-	-	-	-	-	-	-	-	-	-
A	-	-	-	-	2	1	-	-	-	-
M	6	0	5	1	5	4	4	4	17	17
J	6	0	7	2	10	9	13	13	16	16
J	6	0	6	2	10	10	11	11	17	17
A	6	0	6	2	8	8	10	10	18	18
S	6	0	6	2	9	9	10	10	15	15
O	6	1	6	2	9	9	9	9	14	14
N	6	0	1	0	8	8	7	7	13	13
D	-	-	-	-	1	1	6	6	7	7

Table 11 CAN (M + Q) OTB Tonnage Class 5 Vessels Directing for 4RST Redfish all of which had Engel High Lift Trawls

MONTH	1980 # BOATS FISHING	1981 # BOATS FISHING	1982 # BOATS FISHING	1983 # BOATS FISHING	1984 # BOATS FISHING
J	0	3	0	0	3
F	0	0	0	0	0
M	0	1	0	0	0
A	0	2	0	0	0
M	0	1	0	0	1
J	0	1	1	1	1
J	0	0	1	2	2
A	1	3	0	0	4
S	2	0	0	4	4
O	1	1	0	0	3
N	0	0	0	0	1
D	0	0	0	0	0

Table 12 CAN-N OTB Tonnage Class 4 Vessels Directing for 4RST Redfish

MONTH	1984	
	NUMBER OF BOATS FISHING	NUMBER OF BOATS WITH HI-LIFT TRAWLS
J	0	0
F	0	0
M	0	0
A	0	0
M	5	3
J	5	3
J	4	3
A	4	3
S	0	0
O	0	0
N	0	0
D	0	0

Table 13 Summary of CAN M + Q Tonnage Class 4 Vessels With High Lift Trawls Fishing for 4RST Redfish from 1981 to 1984

YEAR	PEI	NB	NS	QUEBEC
	# of Boats # Highlift (%)	# of Boats # Highlift (%)	# of Boats # Highlift (%)	# of Boats # Highlift (%)
1981	5 2(40%)	1 0(0%)	2 2(100%)	4 0(0%)
1982	5 5(100%)	1 1(100%)	2 2(100%)	4 4(100%)
1983	5 5(100%)	1 1(100%)	4 4(100%)	6 6(100%)
1984	5 5(100%)	2 2(100%)	6 6(100%)	6 6(100%)

Table 14 Analysis of variance for Division 4RST redfish adjusted for TC-4 vessels CAN-M+Q.

Multiple R 0.771
Multiple R squared.....0.595

ANALYSIS OF VARIANCE

	Source of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F-Value
	Intercept	1	74.81	74.81	
	Regression	40	254.30	6.36	60.418
Gear	Type 1	5	13.95	27.90	265.138
Months	Type 2	8	10.89	1.36	12.934
Divisions	Type 3	2	5.20	2.61	24.756
Years	Type 4	25	113.30	4.53	43.071
	Residuals	1644	173.00	0.11	
	Total	1685	502.20		

Table 15 Variability for multipicative model weighted by effort. Coding by gear, months, division and year are indicated.

REGRESSION COEFFICIENTS

Catagory	Variable	Coefficient Log Scale	Standard Error	No. Obs.	
Gear					Type 1
	Intercept	-0.349	0.082	1685	
CAN-M+Q OTB4	-	0.000	-	-	
CAN-M+Q OTB5	1	0.416	0.041	170	
CAN-N OTB4	2	0.189	0.022	361	
CAN-N OTB5	3	0.283	0.058	121	
CAN-M+Q OTM4	4	0.715	0.030	190	
CAN-M+QN OTM5	5	1.104	0.032	188	
Month					Type 2
January	-	0.000	-	-	
Feb.-March	6	-0.033	0.075	76	
April	7	-0.100	0.087	53	
May	8	-0.286	0.063	118	
June-July	9	-0.337	0.054	405	
Aug.-Sept.	10	-0.308	0.054	421	
Oct.	11	-0.406	0.057	206	
Nov.	12	-0.435	0.057	184	
Dec.	13	-0.388	0.060	135	
Division					Type 3
4R	-	0.000	-	-	
4S	14	-0.005	0.018	635	
4T	15	-0.212	0.031	270	
Year					Type 4
1959	-	0.000	-	-	
1960	16	0.036	0.097	26	
1961	17	0.008	0.098	19	
1962	18	-0.281	0.128	20	
1963	19	0.370	0.092	33	
1964	20	0.416	0.108	24	
1965	21	0.517	0.086	30	
1966	22	0.650	0.078	49	
1967	23	0.798	0.083	51	
1968	24	0.745	0.072	66	
1969	25	0.384	0.068	81	
1970	26	0.198	0.067	103	
1971	27	0.156	0.067	94	
1972	28	0.230	0.069	136	
1973	29	0.123	0.067	163	
1974	30	-0.207	0.068	149	
1975	31	-0.226	0.069	164	

Continued...

Table 15 continued

REGRESSION COEFFICIENTS

Category	Variable	Coefficient Log Scale	Standard Error	No. Observations
Year				
1976	32	-0.030	0.084	67
1977	33	-0.233	0.086	61
1978	34	-0.016	0.090	48
1979	35	0.046	0.098	23
1980	36	0.445	0.097	28
1981	37	0.499	0.096	35
1982	38	0.538	0.076	77
1983	39	0.554	0.076	51
1984	40	0.477	0.072	64

Table 16 4RST redfish catch rate standardized to Maritimes and Quebec OTB-4 Otter trawlers, adjusted for the shift to Engle High lift trawls.

Year	Total Catch(t)	Catch Rate Mean(t/h)	Catch Rate Standard Error	Effort(h)
1959	16978	0.741	0.061	22910
1960	12218	0.768	0.067	15905
1961	10391	0.746	0.068	13927
1962	6585	0.557	0.069	11825
1963	19784	1.073	0.094	18446
1964	29700	1.121	0.117	26504
1965	48827	1.243	0.101	39275
1966	65215	1.421	0.103	45887
1967	70036	1.647	0.128	42531
1968	90963	1.563	0.104	58190
1969	88875	1.090	0.066	81539
1970	87588	0.905	0.053	96771
1971	79406	0.868	0.051	91515
1972	80329	0.934	0.059	86009
1973	130164	0.840	0.052	155032
1974	63489	0.603	0.037	105256
1975	65401	0.592	0.037	110450
1976	37983	0.720	0.047	52731
1977	15840	0.587	0.047	26983
1978	13591	0.729	0.062	18645
1979	15034	0.775	0.072	19386
1980	14832	1.156	0.107	12835
1981	20549	1.219	0.112	16857
1982	26429	1.270	0.088	20804
1983	24505	1.290	0.089	18992
1984	35857	1.196	0.077	29980

Average C.V. for the Mean: 0.077.

Table 17 Comparison of catch rates (t/h) calculated from multiplicative model for adjusted and unadjusted data. All runs weighted by effort.

Year	Unadjusted	Adjusted CAN-(M+Q) TC-4	Adjusted CAN-(M+Q) TC-4,TC-5	Adjusted CAN-(M+Q) TC-4,TC-5 CAN-N TC-4
1959	0.737	0.741	0.730	0.730
1960	0.765	0.768	0.758	0.758
1961	0.743	0.746	0.735	0.735
1962	0.553	0.557	0.547	0.547
1963	1.064	1.073	1.055	1.055
1964	1.113	1.121	1.103	1.103
1965	1.236	1.243	1.222	1.223
1966	1.415	1.421	1.399	1.400
1967	1.640	1.647	1.622	1.623
1968	1.555	1.563	1.539	1.540
1969	1.085	1.090	1.077	1.077
1970	0.893	0.905	0.898	0.898
1971	0.855	0.868	0.860	0.860
1972	0.955	0.934	0.947	0.947
1973	0.832	0.840	0.819	0.819
1974	0.591	0.603	0.587	0.587
1975	0.572	0.592	0.574	0.574
1976	0.719	0.720	0.702	0.702
1977	0.584	0.587	0.564	0.564
1978	0.726	0.729	0.707	0.707
1979	0.770	0.775	0.740	0.740
1980	1.147	1.156	1.118	1.118
1981	1.228	1.219	1.180	1.180
1982	1.555	1.270	1.243	1.244
1983	1.521	1.290	1.235	1.235
1984	1.444	1.196	1.161	1.158

Table 18 Commercial age length key for male redfish caught in Division 4RST in 1983.

Fork Length	Numbers at Age																											Total
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
10		1																										1
11	1																											1
12		1																										1
13		2																										2
14		1																										1
15		1																										1
16			1																									1
17			1																									1
18			1																									1
19				1																								1
20					2			1																				3
21					2	5	2	1																				10
22						3	2																					5
23					1	11	2	3																				17
24						6	7	7	3																			23
25						4	14	9	3					1														31
26						2	7	15	13	4																		41
27							6	8	17	9	5		1															46
28								6	13	13	5		2		1		1											41
29								2	16	12	5	4	1	1		1												42
30							1	2	3	6	5	9	5	4		2		1		2	1							41
31										3	5	5	8	4	1	2	2	1	3	1		1						36
32										3	1	7	4	3	4	1	1	1		1	2	7	1	1		2		39
33											2	1	5	4		1	1	1	1	3	4	7		3	1			34
34													5	1			1	4		2	2	9	2	4			1	31
35													1		1		2	1	1	1	2	3	1	6	3		1	23
36															1				1	3	2	5	1	3	1	2		19
37															1			2				4		7	4	1	4	24
38																				1	1	1	1	4	1	2	1	12
39																						1	1	1	1	2	3	9
40																						1		2		1	2	6
41																								1	1	1	2	5
42																							1				2	3
43																											1	1
44																										1		1
Sum	1	6	3	1	5	31	41	54	68	50	28	26	33	18	9	7	8	11	6	14	14	39	8	32	12	12	17	554

Table 19 Commercial age length key for female redfish caught in Division 4RST in 1983.

Fork Length	Numbers at Age																											
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total
12	1																											1
13	1																											1
14	1	1																										2
15		1																										1
16		1	1																									2
17			1																									1
18			1																									1
19				1																								1
20				1																								1
21					1	2	1																					4
22					1	3	1	1																				6
23					1	4	3	3																				11
24					1	6	5	2	1																			15
25						3	18	3	1																			25
26						2	8	6	4																			20
27							1	11	7	4	1																	24
28							2	5	10	3	3	2	1															26
29							1	6	9	7	4	3	1															31
30								3	4	10	9	5	6	1														38
31									2	8	10	8	9	2	1													40
32									2	2	6	11	8	8	2	1			1									41
33										1	5	10	8	7	4	2	2			1	1							41
34											2	7	6	4	5	2	1	1	2	1		3	1					35
35												3	2	2	2	1	2	3	3	3	3	5		4				33
36													1	2			3	2	1	4	5	10		6	1	1	1	37
37																	6	2	1	3	1	3	1	10		3	4	34
38														1					1	3	1	4	1	9	3	3	6	32
39																					1	4	2	11	4	2	5	29
40																				1	1	6	4	6	3	2	4	27
41																			1	1		3	3	1	2	1	3	15
42																						1	1	1	3	1	4	11
43																								1	3	1	4	9
44																											3	3
45																										1	6	7
46																											1	1
Sum	3	3	3	2	4	20	40	40	40	35	40	49	42	27	14	6	14	8	10	17	13	39	13	49	19	15	41	606

Table 20 4RST redfish catch at age for 1972-1983.

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
5	142	273	170	355	7359	3801	3368	2266	125	1	1	33
6	1272	639	698	620	1482	2119	2656	2379	285	4	1	89
7	784	3112	292	290	1073	824	511	2233	2728	308	73	1
8	944	2380	444	401	372	669	280	2899	7800	2586	782	71
9	1887	803	510	448	188	620	800	2373	7923	10810	3714	612
10	4297	3434	210	286	44	416	708	2753	5723	11974	4492	1499
11	2938	8043	403	161	146	409	491	1902	2141	7276	9824	3452
12	6366	2497	463	329	125	236	372	1838	1516	5222	9607	6626
13	2588	12850	2240	974	383	171	131	931	953	3449	8634	7192
14	14034	7060	5381	1654	716	177	131	510	532	2085	6833	6093
15	7971	76633	6364	2956	1836	79	153	326	531	1219	5198	6205
16	66593	8222	28739	4572	3913	123	86	346	265	940	2298	5753
17	5102	88382	7953	25149	4025	509	247	887	306	328	1761	3076
18	7659	5583	37269	5771	15842	379	1003	1131	300	401	681	1265
19	4299	9916	2989	41020	3380	2959	1399	2392	500	973	924	914
20	3697	7166	3387	4156	16519	1273	3621	1943	1601	858	1015	922
21	2471	4548	1371	3453	1533	5259	1294	3376	921	1133	808	735
22	2598	4333	1233	3489	2131	2519	3468	1542	2446	1192	1017	747
23	2366	4934	471	2634	1431	2314	4425	3048	1348	2120	1370	1160
24	1168	1306	1168	1632	1317	1814	1027	1013	2219	1235	2060	948
25	5940	2277	825	1356	543	1160	725	869	822	1555	1021	2320
26	1	7963	1815	1186	430	1027	222	905	505	826	1362	450
27	1	1	5844	2080	408	229	222	506	298	458	686	1960
28	1	1	1	7259	659	515	315	522	234	262	550	580
29	1	1	1	1	2370	196	103	102	78	136	250	563

Table 21 4RST redfish weights at age for 1972-1983.

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
5	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.049
6	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.103	0.095	0.085	0.075
7	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.135	0.165	0.118	0.115
8	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.219	0.197	0.159
9	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.263	0.245	0.194
10	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.293	0.287	0.258
11	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.282	0.32	0.317	0.312
12	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.322	0.346	0.345	0.339
13	0.362	0.362	0.362	0.362	0.362	0.362	0.362	0.362	0.362	0.388	0.377	0.373
14	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.406	0.387	0.408
15	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.443	0.454	0.420	0.441
16	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.465	0.483	0.450
17	0.521	0.521	0.521	0.521	0.521	0.521	0.521	0.521	0.521	0.502	0.478	0.472
18	0.559	0.559	0.559	0.559	0.559	0.559	0.559	0.559	0.559	0.535	0.529	0.504
19	0.596	0.596	0.596	0.596	0.596	0.596	0.596	0.596	0.596	0.522	0.479	0.453
20	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.631	0.569	0.492	0.556
21	0.665	0.665	0.665	0.665	0.665	0.665	0.665	0.665	0.665	0.552	0.518	0.552
22	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.698	0.621	0.527	0.541
23	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.613	0.567	0.576
24	0.759	0.759	0.759	0.759	0.759	0.759	0.759	0.759	0.759	0.626	0.602	0.552
25	0.788	0.788	0.788	0.788	0.788	0.788	0.788	0.788	0.788	0.682	0.652	0.621
26	0.815	0.815	0.815	0.815	0.815	0.815	0.815	0.815	0.815	0.757	0.666	0.732
27	0.841	0.841	0.841	0.841	0.841	0.841	0.841	0.841	0.841	0.782	0.753	0.718
28	0.866	0.866	0.866	0.866	0.866	0.866	0.866	0.866	0.866	0.869	0.771	0.808
29	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.889	0.879	0.835	0.763

Table 22 4RST Redfish estimated population numbers ($x10^3$) and population biomass (t) from research cruises.

Vessel	Year	Numbers ages 5-9	Numbers ages 10-29	Total Numbers ages 5-29	Total biomass
A. T. CAMERON	1977	250,150	203,216	453,366	142,474
	1978	402,115	211,106	613,221	164,471
	1979	532,916	345,959	878,875	298,178
	1980	650,243	498,718	1,148,961	323,604
GADUS ATLANTICA	1978	197,063	111,696	308,759	87,974
	1979	464,563	152,860	617,423	144,243
	1980	175,983	47,552	223,535	53,259
	1981	43,505	124,496	168,001	75,397
	1983			242,496[a]	
	1984			277,895[a]	
	1985			322,008[a]	
BEOTHIC VENTURE	1976	3,299,943	367,863	3,667,806	610,111
	1978	4,904,271	446,307	5,350,578	629,011
	1979	1,417,022	290,127	1,707,149	413,567
	1980	861,003	409,455	1,270,458	384,134
VICKI & BROTHERS	1981	318,129	573,229	891,359	353,095
	1982	1,040,027	514,701	1,554,728	
E. P. QUEBECOIS	1976	1,101,620	261,126	1,362,746	
	1977	1,129,328	927,662	2,056,990	
	1978	656,349	281,720	938,069	
	1979	1,343,782	862,357	2,206,139	

[a]Provisional, includes some age 1-4 redfish.

Table 23. Population numbers estimated from cohort analysis for Division 4RST redfish at F_t equals 0.05.

POPULATION NUMBERS $(\times 10^3)$

	I	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
5	I	402156	400059	366848	433568	447814	269328	136007	68652	12128	431	689120	231200
6	I	219608	363751	361729	331776	391971	398198	240083	119861	59963	10855	389	623540
7	I	97172	197499	328527	326642	299614	353261	358289	214709	106193	53986	9818	351
8	I	66417	87179	175744	296986	295282	270081	318860	323707	192153	93492	48555	8814
9	I	72940	59198	76619	158598	268343	266828	243743	288250	290145	166447	82135	43191
10	I	72815	64203	52801	68843	143079	242628	240847	219787	258562	254993	140325	70786
11	I	71203	61799	54827	47571	62019	129421	219143	217254	196253	228513	219337	122708
12	I	131366	61632	48267	49226	42891	55979	116716	197822	194770	175540	199846	189119
13	I	109835	112810	53392	43233	44229	38690	50427	105255	177248	174793	153868	171689
14	I	387635	96921	89851	46180	38193	39656	34846	45504	94353	159569	154878	131013
15	I	87965	337398	80982	76182	40212	33877	35714	31405	40688	84868	142401	133640
16	I	466796	72012	232394	67222	66121	34639	30578	32169	28106	36311	75633	123905
17	I	82523	359029	57338	182942	56476	56106	31226	27586	28779	25180	31962	66249
18	I	80346	69817	240791	44316	141610	47273	50283	28019	24117	25749	22471	27245
19	I	44261	65415	57862	182426	34609	113065	42414	44544	24277	21537	22917	19685
20	I	27959	35959	49757	49513	126046	28101	99490	37047	38029	21491	18562	19858
21	I	18382	21782	25721	41800	40848	98338	24216	86578	31673	32888	18630	15830
22	I	16940	14282	15383	21969	34538	35502	83977	20680	75128	27783	28680	16089
23	I	10188	12857	8801	12746	16560	29224	29728	72687	17246	65652	24005	24983
24	I	12718	6967	6940	7516	9028	13622	24242	22690	62870	14322	57388	20418
25	I	65265	10397	5062	5168	5248	6916	10601	20958	19567	54777	11785	49967
26	I	9	53499	7241	3796	3387	4232	5154	8902	18137	16923	48085	9692
27	I	10	7	40833	4826	2306	2655	2852	4453	7194	15931	14527	42213
28	I	7	8	6	31388	2388	1699	2185	2370	3548	6226	13979	12492
29	I	9	5	6	4	21496	1534	1047	1677	1648	2987	5384	12126
5+	I	2544524	2564486	2437725	2534438	2634307	2570854	2432667	2242566	2002775	1771244	2234679	2186803
6+	I	2142369	2164426	2070877	2100870	2186493	2301525	2296659	2173914	1990647	1770813	1545560	1955603
7+	I	1922761	1800676	1709148	1769094	1794522	1903327	2056577	2054053	1930684	1759958	1545171	1332063
8+	I	1825589	1603176	1380621	1442452	1494909	1550067	1698288	1839344	1824492	1705972	1535353	1331712

Table 24. Mean population biomass for Division 4RST redfish estimated from cohort analysis at F_t equals 0.05.

MEAN POPULATION BIOMASS (KG)

	I	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
5	I	34437	34252	31412	37118	38027	22898	11499	5779	1033	37	59021	10780
6	I	21461	35622	35420	32488	38345	38923	23397	11628	5863	878	31	44500
7	I	12432	25165	42186	41944	38420	45328	45995	27435	13461	8452	1098	38
8	I	10603	13822	28227	47729	47458	43380	51257	51819	30250	19204	9027	1328
9	I	14038	11467	14896	30895	52330	51991	47469	55993	55799	40243	18698	7915
10	I	16319	14432	12184	15885	33081	56057	55610	50495	59104	69358	37689	17189
11	I	18697	15441	14657	12744	16623	34675	58741	58038	52368	68435	64622	35901
12	I	39237	18487	14717	15032	13123	17116	35706	60326	59442	56905	63967	59899
13	I	37374	36524	17991	14719	15168	13298	17348	36093	60908	63878	53585	59614
14	I	145860	35751	33380	17380	14505	15173	13338	17350	36079	61234	55727	49637
15	I	35317	124767	32733	31467	16549	14264	15022	13168	17037	36394	55834	54728
16	I	197889	31039	99621	29736	29391	15859	14005	14673	12829	15852	34214	51777
17	I	39592	154208	26335	84087	26956	27687	15418	13449	14190	11948	14120	29037
18	I	40597	35582	117535	21948	70882	25043	26472	14592	12747	13004	11134	12751
19	I	23820	34109	31933	90892	18620	63255	23643	24556	13622	10447	10227	8281
20	I	15612	19280	28814	28421	70432	16475	58610	21637	22335	11395	8443	10253
21	I	10803	12234	15824	25306	25345	60494	14897	53677	19741	16966	8976	8114
22	I	10334	7902	9788	13358	22201	22706	54581	13200	49058	16052	14118	8083
23	I	6187	7005	5943	7870	10982	19459	19017	49392	11489	37655	12566	13363
24	I	8742	4587	4562	4792	6015	9145	17123	16007	44577	8146	32262	11035
25	I	46640	6875	3466	3321	3721	4722	7665	15377	14352	35026	6979	28814
26	I	7	38208	4851	2436	2450	2850	3908	6535	13863	11881	30027	6588
27	I	8	6	30195	2914	1671	2029	2190	3350	5633	11678	10153	28146
28	I	5	6	4	22630	1671	1166	1663	1721	2823	5036	10046	10533
29	I	7	4	5	3	17130	1210	540	1374	1360	2440	4175	8591
5+	I	786018	716715	656681	635116	631095	625203	635414	637661	629963	638541	626741	576895
6+	I	751581	682463	625270	597999	593068	602305	623916	631882	628929	632504	567721	566115
7+	I	730120	646842	589849	565510	554723	563382	600518	620254	623066	631627	567689	521615
8+	I	717689	621677	547663	523566	516303	518053	554523	592819	609606	623175	566591	521577

Table 25. Fishing mortalities estimated from cohort analysis for Division 4RST redfish at F_t equals 0.05.

FISHING MORTALITY 12/ 5/85

	I	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
5	I	0.000	0.001	0.000	0.001	0.017	0.015	0.026	0.035	0.011	0.002	0.000	0.000
6	I	0.006	0.002	0.002	0.002	0.004	0.006	0.012	0.021	0.005	0.000	0.003	0.000
7	I	0.009	0.017	0.001	0.001	0.004	0.002	0.002	0.011	0.027	0.006	0.008	0.003
8	I	0.015	0.029	0.003	0.001	0.001	0.003	0.001	0.009	0.044	0.030	0.017	0.009
9	I	0.028	0.014	0.007	0.003	0.001	0.002	0.003	0.009	0.029	0.071	0.049	0.015
10	I	0.064	0.058	0.004	0.004	0.000	0.002	0.003	0.013	0.024	0.051	0.034	0.023
11	I	0.044	0.147	0.008	0.004	0.002	0.003	0.002	0.009	0.012	0.034	0.048	0.030
12	I	0.052	0.044	0.010	0.007	0.003	0.004	0.003	0.010	0.008	0.032	0.052	0.038
13	I	0.025	0.128	0.045	0.024	0.009	0.005	0.003	0.009	0.005	0.021	0.061	0.045
14	I	0.039	0.080	0.065	0.038	0.020	0.005	0.004	0.012	0.006	0.014	0.047	0.050
15	I	0.100	0.273	0.086	0.042	0.049	0.002	0.005	0.011	0.014	0.015	0.039	0.050
16	I	0.162	0.128	0.139	0.074	0.064	0.004	0.003	0.011	0.010	0.028	0.032	0.050
17	I	0.067	0.299	0.158	0.156	0.078	0.010	0.008	0.034	0.011	0.014	0.060	0.050
18	I	0.106	0.088	0.178	0.147	0.125	0.008	0.021	0.043	0.013	0.017	0.032	0.050
19	I	0.108	0.174	0.056	0.270	0.108	0.028	0.035	0.058	0.022	0.049	0.043	0.050
20	I	0.150	0.235	0.074	0.092	0.148	0.049	0.039	0.057	0.045	0.043	0.059	0.050
21	I	0.152	0.248	0.058	0.091	0.040	0.058	0.058	0.042	0.031	0.037	0.047	0.050
22	I	0.176	0.384	0.088	0.183	0.067	0.078	0.044	0.082	0.035	0.046	0.038	0.050
23	I	0.280	0.517	0.058	0.245	0.095	0.087	0.170	0.045	0.086	0.035	0.062	0.050
24	I	0.102	0.219	0.195	0.259	0.166	0.151	0.046	0.048	0.038	0.095	0.038	0.050
25	I	0.099	0.262	0.188	0.323	0.115	0.194	0.075	0.045	0.045	0.030	0.095	0.050
26	I	0.121	0.170	0.306	0.398	0.143	0.295	0.046	0.113	0.030	0.053	0.030	0.050
27	I	0.111	0.153	0.163	0.604	0.206	0.095	0.085	0.127	0.045	0.031	0.051	0.050
28	I	0.176	0.139	0.202	0.279	0.343	0.384	0.164	0.263	0.072	0.045	0.042	0.050
29	I	0.120	0.239	0.179	0.283	0.123	0.144	0.109	0.066	0.051	0.049	0.050	0.050
14+	I	0.107	0.236	0.129	0.163	0.100	0.041	0.040	0.043	0.027	0.027	0.243	0.050

Table 26 YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	0.1000	0.286	0.115	0.402	1.368
$F_{0.1}$	0.1624	0.364	0.137	0.367	1.000
	0.2000	0.395	0.144	0.363	0.853
	0.3000	0.452	0.153	0.338	0.605
	0.4000	0.489	0.157	0.321	0.465
	0.5000	0.515	0.158	0.307	0.376
	0.6000	0.535	0.159	0.297	0.315
	0.7000	0.551	0.159	0.289	0.270
F_{max}	0.7150	0.554	0.159	0.288	0.264
	0.8000	0.565	0.159	0.282	0.236
	0.9000	0.577	0.159	0.276	0.210
	1.0000	0.587	0.159	0.270	0.188
	1.1000	0.595	0.158	0.266	0.171
	1.2000	0.603	0.158	0.261	0.158
	1.3000	0.610	0.157	0.258	0.144
	1.4000	0.617	0.157	0.254	0.133
	1.5000	0.623	0.156	0.251	0.124

Table 27 Biomass projections in metric tonnes for 4RST redfish from 1972-1983 catch-at-age matrix. The partial recruitment is that used in the 1983 assessment and recruitment at age 5 was set at 287 million.

	1984	1985	1986	1987	1988	1989	1990	1991
1.	Projection with estimated 1984 landings and all subsequent years at $F_{0.1}$.							
	35,857	59,864	50,711	45,768	41,671	39,713	39,107	39,123
2.	Projection with estimated 1984 landings, 1985 set at 50,600 t and $F_{0.1}$ thereafter.							
	35,857	50,600	57,406	51,930	46,421	44,086	42,812	42,254
3.	Projection with estimated 1984 landings and with approved TAC's from 1985-1988 and $F_{0.1}$ thereafter.							
	35,857	50,600	55,000	55,000	60,000	36,991	36,731	37,050

Table 28 Division 4RST redfish projections from 1972-83 catch at age matrix at $F_{0.1}$ for 1986 and 1987. G. M. recruitment is 287 million, partial recruitment as used in 1983 assessment.

Age	Population Numbers in thousands 1986	1987	Mean Population Biomass Metric Tonnes 1986	1987	Catch Biomass Metric Tonnes 1986	1987	Fishing Mortality 1986	1987
5	287,000	287,000	13,380	13,380	6	6	0.000	0.000
6	259,572	259,572	18,522	18,522	8	8	0.000	0.000
7	234,814	234,764	25,584	25,579	230	230	0.009	0.009
8	169,677	210,565	25,354	31,464	647	802	0.026	0.026
9	448,088	149,664	80,921	27,028	3,641	1,216	0.045	0.045
10	244	387,606	58	92,075	4	6,215	0.068	0.068
11	5,909	207	1,679	59	151	5	0.090	0.090
12	27,794	4,887	8,488	1,492	955	168	0.113	0.113
13	43,682	22,473	14,520	7,470	1,960	1,009	0.135	0.135
14	72,613	34,533	26,213	12,466	3,932	1,870	0.150	0.150
15	108,124	56,551	42,189	22,066	6,328	3,310	0.150	0.150
16	96,653	84,207	38,483	33,528	5,772	5,029	0.150	0.150
17	73,386	75,273	30,648	31,436	4,597	4,715	0.150	0.150
18	74,858	57,153	33,382	25,487	5,007	3,823	0.150	0.150
19	69,405	58,299	27,818	23,367	4,173	3,505	0.150	0.150
20	37,109	54,053	18,256	26,591	2,738	3,989	0.150	0.150
21	15,261	28,901	7,454	14,115	1,118	2,117	0.150	0.150
22	11,027	11,885	5,278	5,689	792	853	0.150	0.150
23	11,123	8,588	5,669	4,377	850	656	0.150	0.150
24	8,867	8,663	4,566	4,461	685	669	0.150	0.150
25	9,012	6,906	4,952	3,794	743	569	0.150	0.150
26	13,994	7,018	9,064	4,546	1,360	682	0.150	0.150
27	11,437	10,899	7,266	6,924	1,090	1,039	0.150	0.150
28	27,989	8,907	22,486	7,156	3,373	1,073	0.150	0.150
29	5,429	21,798	3,665	14,716	550	2,207	0.150	0.150
5+	2,123,066	2,090,372	475,895	457,788	50,711	45,768		
10+	723,916	948,807	312,134	341,815	46,179	43,503		

Table 29 Divisions 4RST redfish projections from 1972-83 catch-at-age matrix with estimated 1984 landings, 1985 TAC (50,600 t) and $F_{0.1}$ thereafter.

Age	Population Numbers in thousands 1986	1987	Mean Population Biomass Metric Tonnes 1986	1987	Catch Biomass Metric Tonnes 1986	1987	Fishing Mortality 1986	1987
5	287,000	287,000	24,575	24,575	11	11	0.000	0.000
6	259,599	259,572	25,440	25,437	11	11	0.000	0.000
7	234,842	234,790	30,037	30,030	270	270	0.009	0.009
8	170,044	210,590	27,007	33,447	689	853	0.086	0.026
9	450,947	149,988	86,054	28,622	3,872	1,288	0.045	0.045
10	247	390,079	55	87,276	4	5,891	0.068	0.068
11	6,013	209	1,544	54	139	5	0.090	0.090
12	28,457	4,973	8,255	1,443	929	162	0.113	0.113
13	44,996	23,009	14,516	7,423	1,960	1,002	0.135	0.135
14	75,252	35,572	26,833	12,684	4,025	1,903	0.150	0.150
15	112,535	58,606	44,110	22,972	6,616	3,446	0.150	0.150
16	100,643	87,642	42,922	37,377	6,438	5,607	0.150	0.150
17	76,416	78,381	35,226	36,132	5,284	5,420	0.150	0.150
18	77,949	59,513	38,553	29,435	5,783	4,415	0.150	0.150
19	72,270	60,706	38,111	32,013	5,717	4,802	0.150	0.150
20	38,641	56,284	21,574	31,424	3,236	4,714	0.150	0.150
21	15,891	30,094	9,350	17,707	1,403	2,656	0.150	0.150
22	11,482	12,376	7,091	7,643	1,064	1,146	0.150	0.150
23	11,582	8,942	7,481	5,776	1,122	866	0.150	0.150
24	9,233	9.020	6,201	6,058	930	909	0.150	0.150
25	9,384	7,191	6,543	5,014	981	752	0.150	0.150
26	14,572	7,308	10,508	5,270	1,576	791	0.150	0.150
27	11,909	11,349	8,862	8,445	1,329	1,267	0.150	0.150
28	29,144	9,275	22,331	7,107	3,350	1,066	0.150	0.150
29	5,653	22,698	4,447	17,854	667	2,678	0.150	0.150
5+	2,154,703	2,115,167	547,626	521,216	57,406	51,931		
10+	752,269	973,227	354,513	379,107	52,553	49,498		

Table 30 Division 4RST redfish projections from 1972-83 catch at age matrix with approved TAC's for 1986 and 1987. G. M. recruitment set at 287 million, partial recruitment as used in 1983 assessment.

Age	Population Numbers in thousands 1986	1987	Mean Population Biomass Metric Tonnes 1986	1987	Catch Biomass Metric Tonnes 1986	1987	Fishing Mortality 1986	1987
5	287,000	287,000	13,380	13,380	6	7	0.000	0.001
6	259,591	259,564	18,523	18,521	9	10	0.000	0.001
7	234,831	234,775	25,578	25,557	245	277	0.010	0.011
8	169,928	210,456	25,371	31,368	689	962	0.027	0.031
9	449,968	149,636	81,143	26,903	3,891	1,457	0.048	0.054
10	246	388,087	58	91,578	4	7,438	0.072	0.081
11	5,975	207	1,693	58	162	6	0.096	0.108
12	28,208	4,912	8,584	1,484	1,029	201	0.120	0.135
13	44,496	22,640	14,728	7,428	2,119	1,207	0.144	0.162
14	74,240	34,868	26,675	12,405	4,263	2,239	0.160	0.180
15	110,819	57,253	43,038	22,017	6,879	3,974	0.160	0.180
16	99,063	85,463	39,258	33,535	6,274	6,053	0.160	0.180
17	75,216	76,396	31,265	31,443	4,997	5,675	0.160	0.180
18	76,724	58,005	34,054	25,493	5,443	4,601	0.160	0.180
19	71,135	59,169	28,378	23,373	4,536	4,218	0.160	0.180
20	38,034	54,859	18,623	26,597	2,976	4,800	0.160	0.180
21	15,642	29,332	7,604	14,119	1,215	2,548	0.160	0.180
22	11,302	12,063	5,384	5,691	861	1,027	0.160	0.180
23	11,400	8,716	5,783	4,378	924	790	0.160	0.180
24	9,088	8,792	4,658	4,462	744	805	0.160	0.180
25	9,237	7,009	5,051	3,795	807	685	0.160	0.180
26	14,343	7,123	9,246	4,547	1,478	821	0.160	0.180
27	11,722	11,061	7,412	6,925	1,185	1,250	0.160	0.180
28	28,687	9,040	22,939	7,157	3,666	1,292	0.160	0.180
29	5,564	22,123	3,739	14,719	598	2,657	0.160	0.180
5+	2,142,460	2,098,549	482,165	456,931	55,000	55,000		
10+	741,142	957,118	318,170	341,202	50,160	52,287		

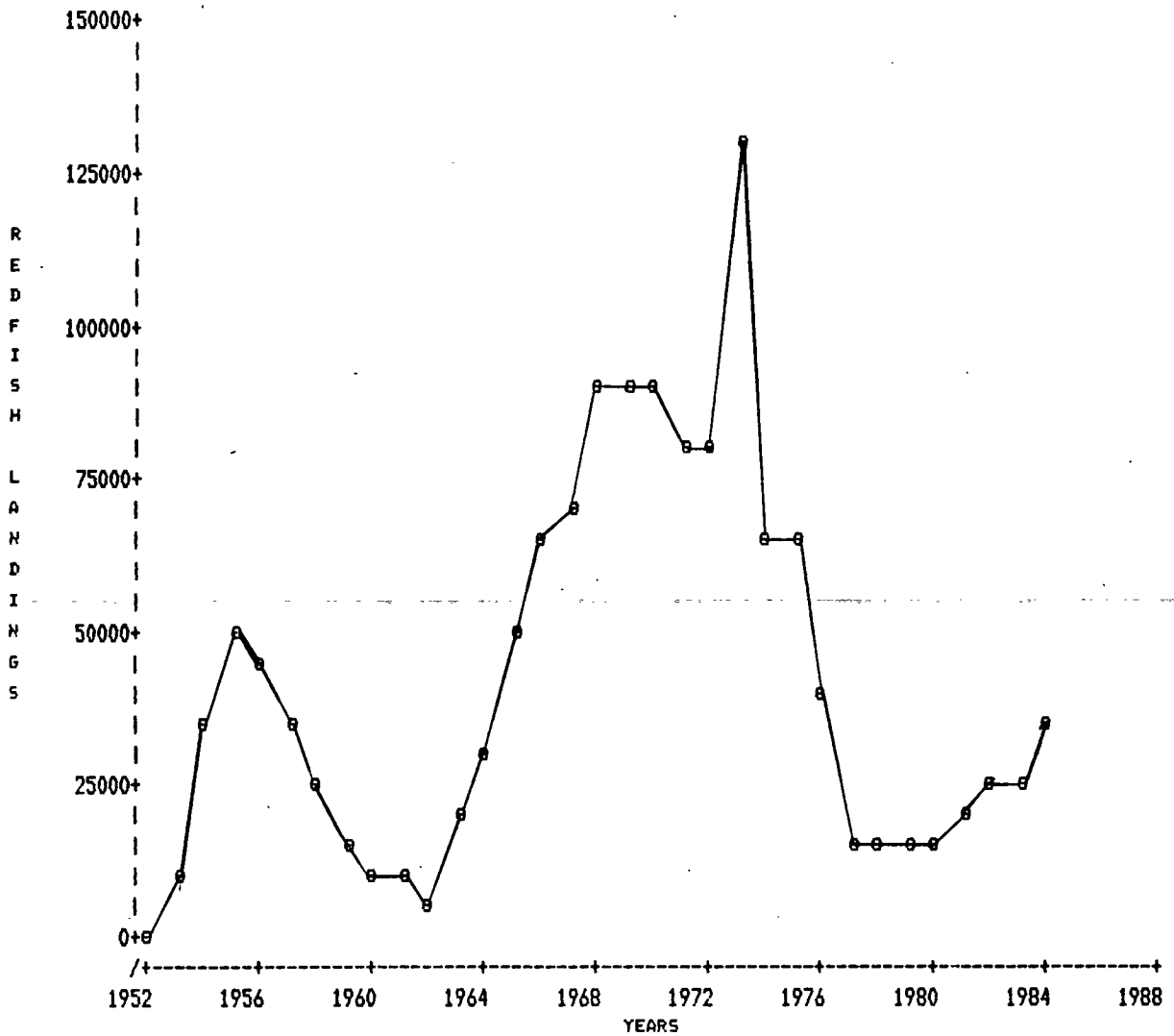


Figure 1. 4RST redfish total nominal catches (t) for 1952-1984.

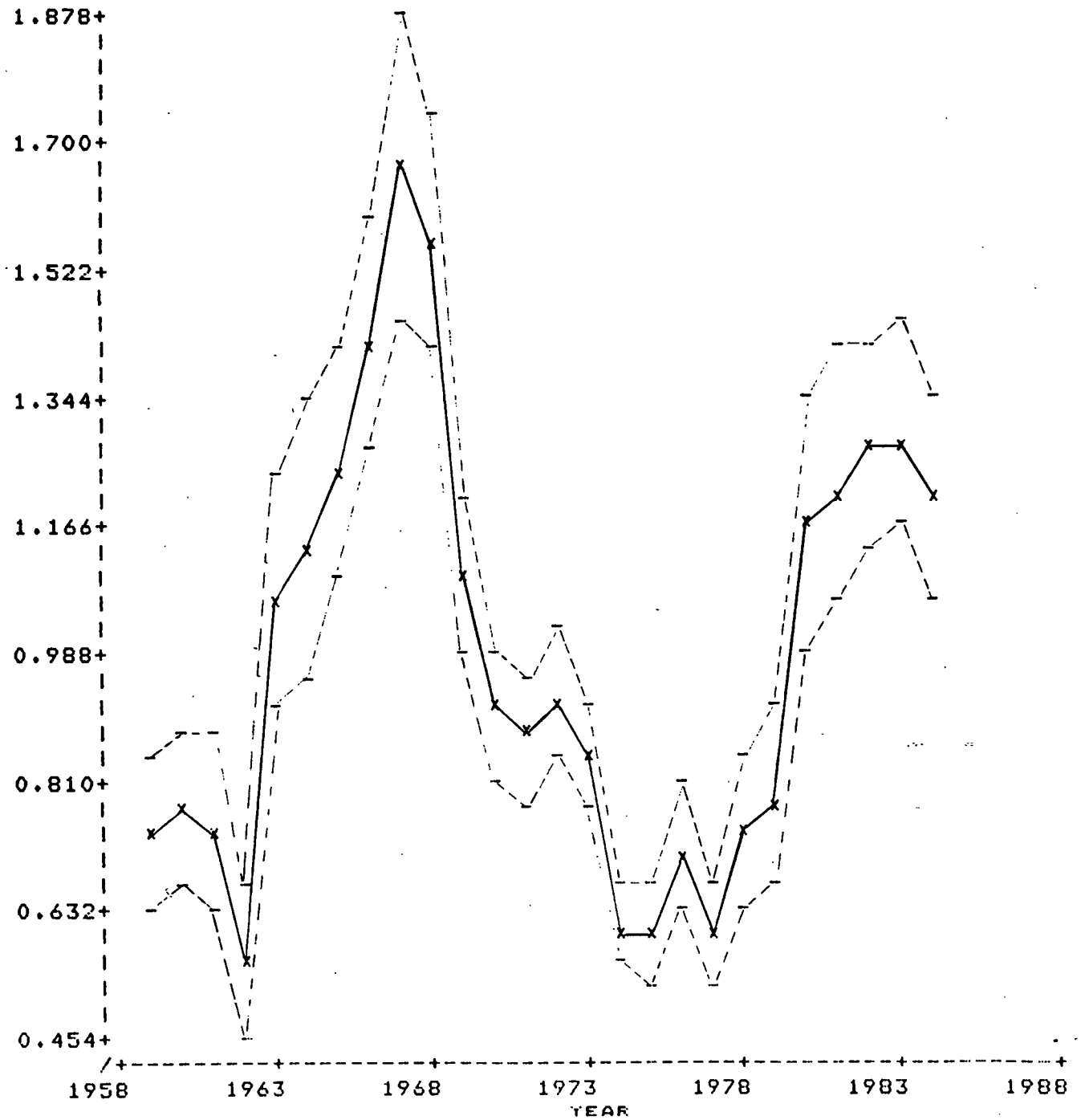
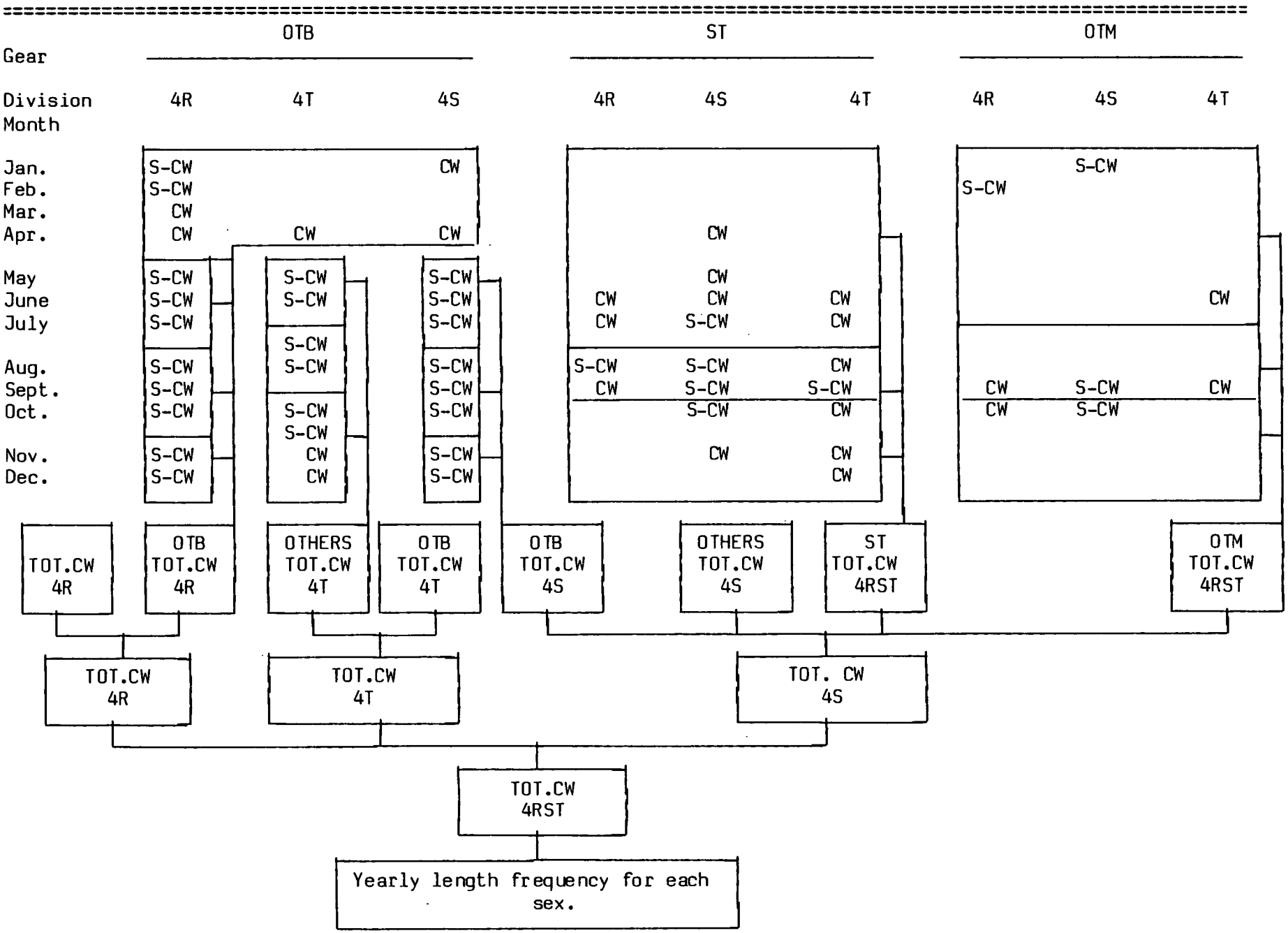
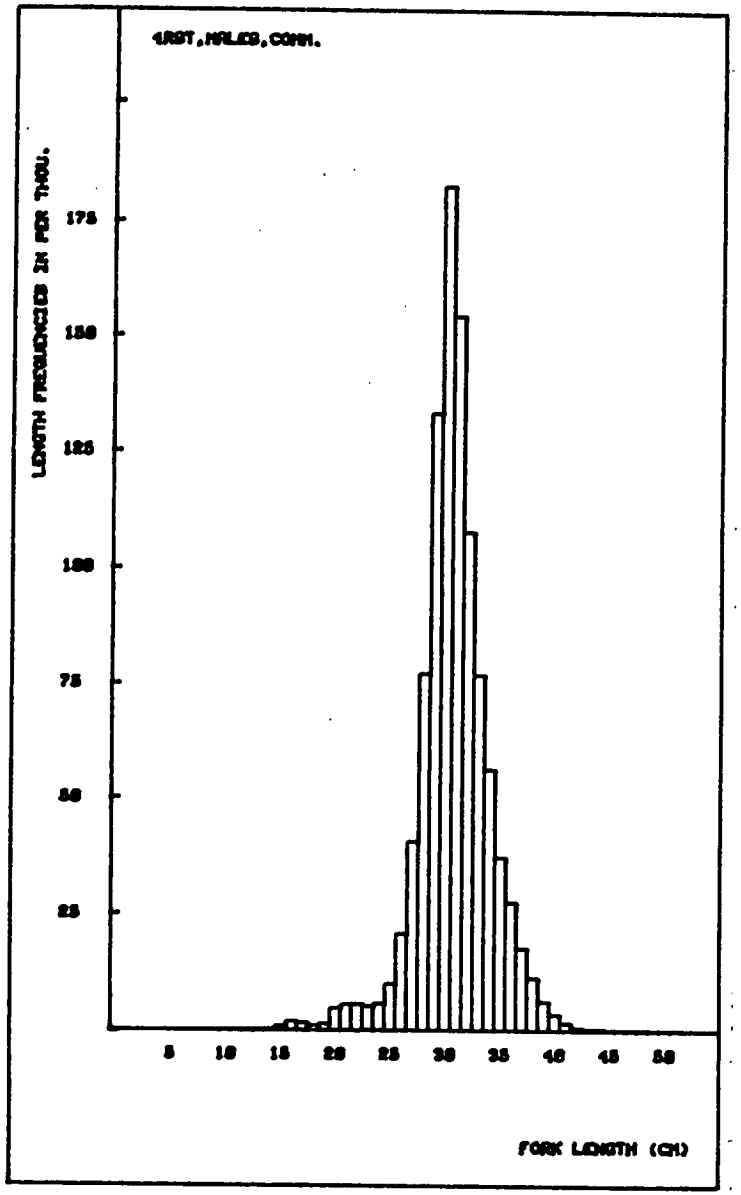


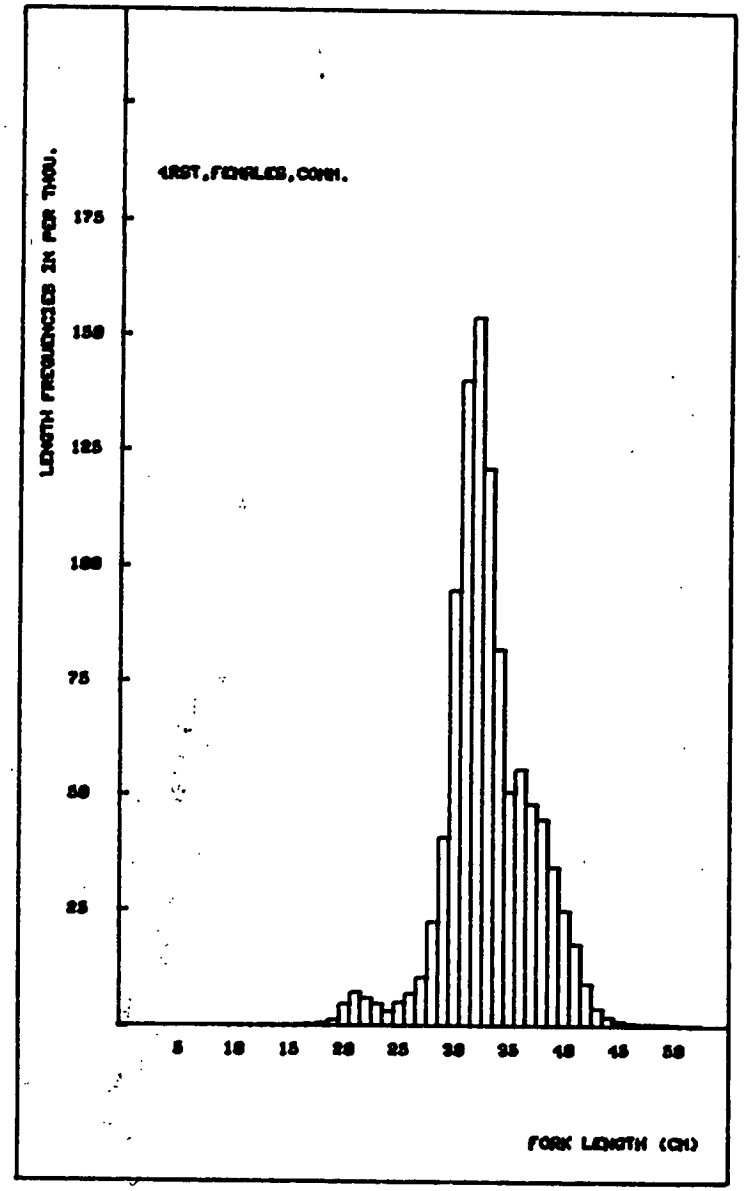
Figure 2. 4RST redfish standardized CPUE for 1959-1984 with approximate 90% confidence interval

Figure 3 4RST redfish sample combinations used to calculate the 1984 composite length frequencies for each sex. Length frequency samples "S" were combined and weighted by monthly catch weights "CW", gear types are bottom trawls (OTB), shrimp trawls (ST), midwater trawls (OTM).



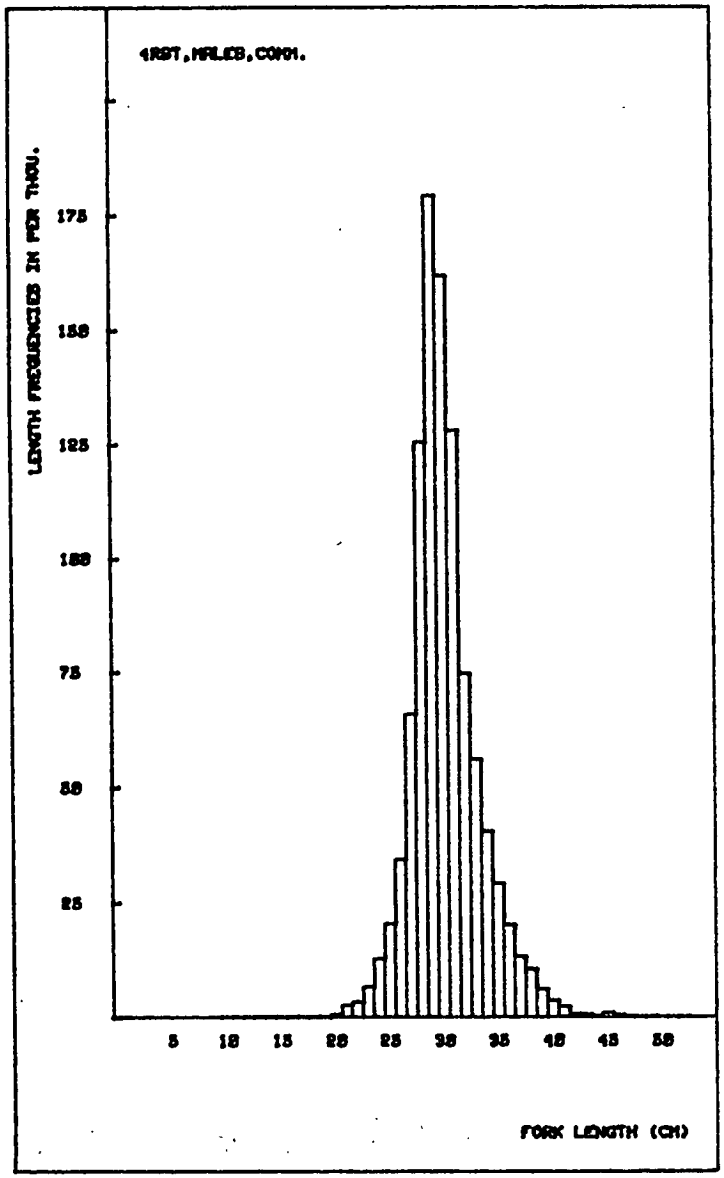


Comm'84
Males - length

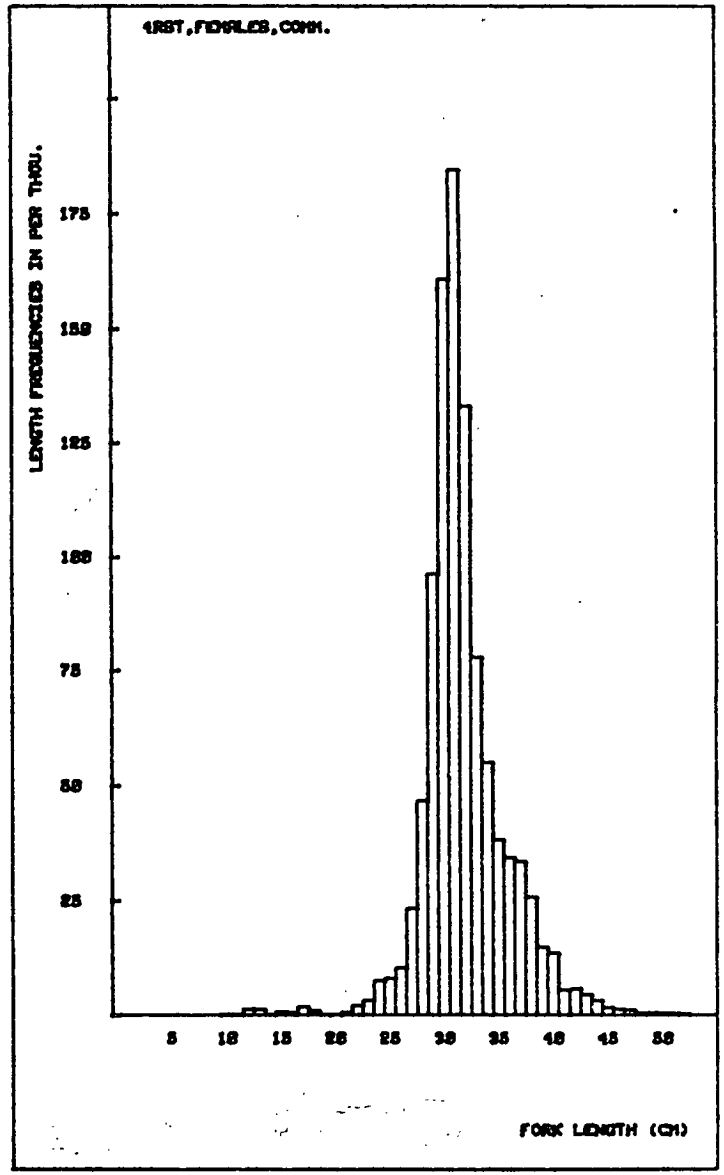


Comm'84
Females - length

Fig. 4. 4RST redfish yearly length frequencies from commercial sampling.



Commercial '83
Males - length



Commercial '83
Females - length

Figure 5. 4RST redfish yearly length frequencies from commercial sampling.

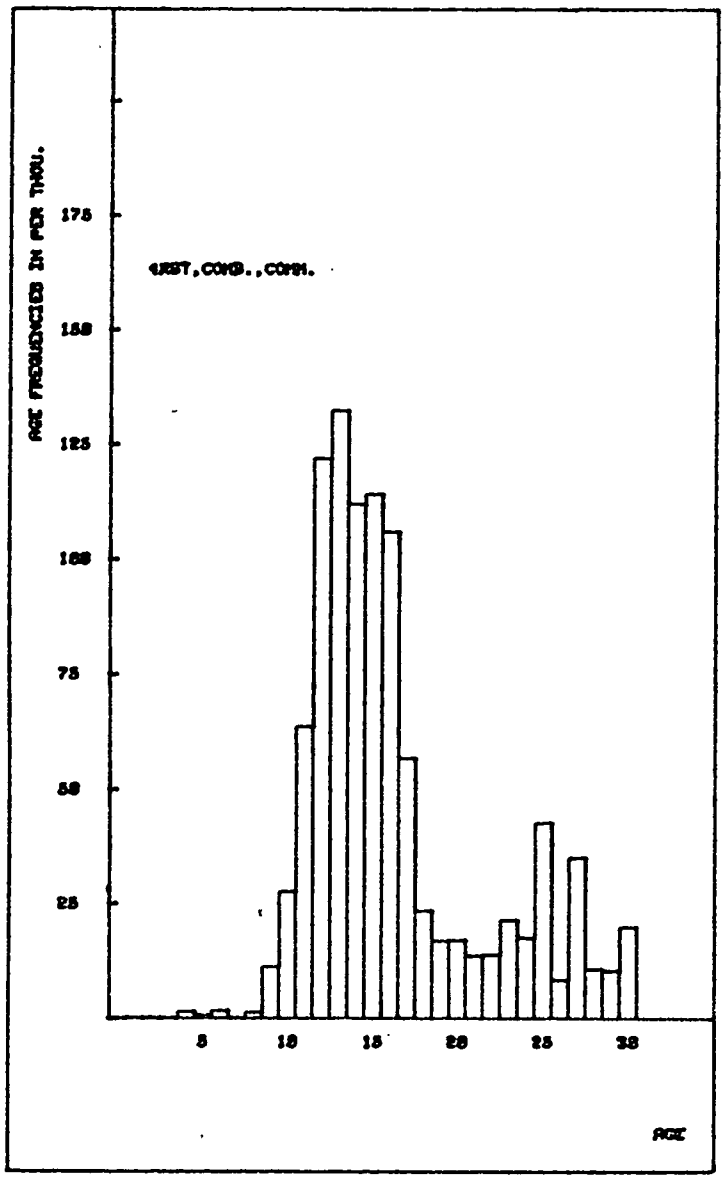


Figure 6. Corrected catch at age for Div. 4RST redfish for 1983, sexes combined.