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Assessment of 4RST Redfish (*Sebastes* spp.)

by

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ABSTRACT

Reported landings for the NAFO Divisions 4RST redfish fishery in 1986 were estimated at 33,107 t. Although they constitute a 5,000 t increase from last year, they still represent only 60% of the TAC. Catch rates for bottom trawls (excluding Engels high-lift), Engels high-lift trawls and midwater trawls were analyzed separately using a multiplicative model. The catch rate series shows 2 distinct peaks, one in 1967-1968 (1.33 t/h) and the other in 1981-1982 (1.29 t/h) and have declined since then; the decline appears to have stopped in 1986. Length frequency distributions based on commercial sampling and research survey data show the presence of 2 strong year-classes: one from the early 1970's (fish about 30 cm) and one from the early 1980's (fish about 20 cm). These smaller fish should be recruiting to the fishery in the next few years. The current biomass (beginning of 1987) was estimated from a non-linear version of the Schaefer general production model to be 473,000t. Because of uncertainties with regard to the changes in availability of fish to the gear, and therefore the effort levels implied, the recommended catch for 1988 were set at the $2/3f_{mey}$ equilibrium yield of 56,000 t.

RESUME

Les débarquements totaux de sébaste des Divisions 4RST de l'OPANO ont été évalués à 33,107 t pour 1986. Malgré une augmentation de 5,000 t par rapport aux valeurs de débarquement de l'an dernier, seulement 60% des TPA n'auront été pêchés. Les taux de prises des chaluts Engel, des chaluts de fond (autres que les chaluts de type Engel) et des chaluts pélagiques ont été analysés séparément à l'aide d'un modèle multiplicatif. La série de taux de prises normalisés qui en résulte montre la présence de 2 maxima, un premier en 1967-1968 (1.33 t/h) et l'autre en 1981-1982 (1.29 t/h), suivis d'une diminution; la baisse de taux de prises enregistrée depuis 1982 semble s'être arrêtée en 1986. Les distributions de fréquence de longueur obtenues de l'échantillonnage des prises commerciales et des relevés de recherche indiquent la présence de 2 fortes classes d'âge: celle du début des années 70 (poissons d'environ 30 cm) et celle du début des années 80 (poissons d'environ 20 cm). Ces dernières seront commercialement exploitables dans quelques années. Les résultats d'une version de non-équilibre du modèle de production de Schaefer indiquent une biomasse actuelle (début de 1987) de 473,000 t. Le modèle est cependant imprécis quant à l'estimation du point d'inflexion de la courbe d'équilibre passé le REM. Etant donné cette incertitude le TPA pour 1988 a été établi, sur la base de rendement au point $2/3f_{rme}$, à 56,000 t.

1. INTRODUCTION

1.1.The fishery

Catches of Divisions 4RST redfish have varied widely in the last 28 years. The landings increased steadily during the 1960's to reach a peak of 130,000 t in 1973, then declined sharply up to 1980 and have, in the recent years, stabilized around 30,000 t (Fig. 1).

The peak landing in 1973 resulted from the availability to the fishery of the strong 1956 and 1958 years-classes. The appearance of the next successful year-classes of the early 1970's is reflected by the increase in the landings since 1980 (Gavaris and Atkinson, 1982).

From 1959 to 1976, the Canadian fleet shared the exploitation of the Gulf redfish fishery with the U.S.A., Portugal and the United Kingdom. However, with the extension of jurisdiction to 200 miles in 1977, the stock was then exploited only by Canada except for a 1% allocation to the Saint-Pierre and Miquelon and the Metropolitan France fleets (Tables 1 and 2). Historically, most of the fishing has been done by the mobile fleet of vessels equipped with bottom or midwater trawls (Rubec et al., 1986).

1.2. Nominal catches

There was a small increase in the reported landings in 1986 from 27,827 t to 33,107 t (Table 1). This however represents only 60% of the TAC. From the fleet allocation scheme and reported catches (Table 2), the mobile fleet of larger vessels and mainly the non-Gulf based vessels (NGBV) are the most successful at catching their allocations. The reported catches shown in Table 2 differ slightly from those of Table 1 as they are based on the last weekly quota report of the year, while the values in the Table 1 are extracted from the ICNAF/NAFO Statistical Bulletins.

The nominal catches for 1986, broken down by division, provinces, gear, tonnage classes and months are given in Tables 3a to 3d. Landings made in Newfoundland, Quebec and the Maritimes were obtained from the respective Statistics Branches of the Department of Fisheries and Oceans. The largest share of the catch is reported from Division 4S. When all divisions are considered (Table 3d) we can see that fishing occurs mainly from May to December, with maximum catches reported in July. The Maritime vessels caught 61% of the total nominal catch, and when the gear and tonnage classes are considered, the tonnage 4 bottom trawlers accounted for 64% of the catch.

2. COMMERCIAL SAMPLING DATA.

Commercial length frequencies and otoliths from port and sea sampling were obtained from the four Atlantic regions of DFO. The number of fish sampled is given in Table 4. Sea samples obtained by the observer programs were combined within each trip by weighting the length frequencies by the catch weight per tow. The trips length frequencies were then combined to create monthly length frequencies (program OBSERVERPREP.WS, written by J. Wright, DFO, Gulf Region). Port sampling length frequencies were combined into monthly length frequencies (CATCHPREP.WS). These frequencies were merged with those from the sea samples to create one set of monthly length frequencies.

CATCH.WS software (Anon. MS, 1986) was used to combine the weighted monthly length frequencies within NAFO divisions and main gear types (OTB, OTM and ST). The sequence of frequency distribution combinations is given in Table 5. These combinations were made for each sex separately to obtain annual length frequencies (Fig. 2). Males were most prevalent at 30 and 31 cm, while females were most prevalent at 33 cm. Examination of length frequencies of fish caught by different gears showed a modal length difference between midwater and shrimp trawls (Fig. 3). The downward shift of exactly 4 cm recorded for both modes in the shrimp trawls length frequency could not be explained at the present time, but the situation will be investigated further.

The same procedure was used to construct separate age-length keys for males and females. The age-length data for unsexed fish (less than 16 cm) were arbitrarily added in equal proportion (assuming a 1:1 sex ratio) to data for sexed fish. The numbers at age, their variance (Gavaris and Gavaris 1983) and the mean length and weight at age were obtained by combining each key with its respective length frequency (Table 6). The proportion at age (sexed and unsexed fish combined) in the commercial catch are presented in Figure 4. The 1970 year-class dominated the landings in 1987 whereas the partially recruited 1979 and 1980 year-classes were stronger than the neighbouring year-classes.

3. COMMERCIAL CATCH RATES.

3.1 Input data.

Catch and effort data from ICNAF/NAFO Statistical Bulletins for the period 1959-1984 were combined with provisional data for 1985 and 1986, with the exception of the Québec based vessels, for which the data were obtained from the Ministère de l'agriculture, des pêcheries et de l'alimentatation du Québec (1975-1983).

3.2. Corrections for Engels trawls.

Starting in 1974, there was a general shift in the Divisions 4RST redfish commercial fishery from conventional bottom trawls to the use of Engels high-lift trawls. Previously (Rubec et al. 1985,1986), the proportion of effort accounted for by vessels using high-lift trawls was adjusted upward by a 28% correction factor in order to compensate for the increased catchability of that type of trawl. The adjusted effort represented the effort required to realize the observed catch, had all the vessels been using the regular trawls.

In the present document, the catch rates series for the 2 types of bottom trawls (regular and Engels high-lift) were analyzed separately. Their catch-effort data were coded in separate categories using information from the ships logbooks and the ICNAF/NAFO Statistical Bulletins.

Tonnage class 5 bottom trawlers (CAN-M and CAN-N) were reported to have switched to the use of the Engels high-lift trawl in 1974 (Rubec et al., 1985). Consequently, their respective catch and effort data were coded as such from 1974 to the present.

In 1980, one tonnage class 4 vessel (CAN-M) was identified as using an Engels trawl. Its catch-effort was subtracted from the TC-4 catch-effort in the ICNAF/NAFO Statistical Bulletin.

In 1981, 2 out of 5 vessels from P.E.I. and 5 TC-4 vessels from Nova Scotia were determined to have used high-lift trawls. The P.E.I. vessels were separated and their catch-effort were determined from logbook records for Engels and non-Engels categories. The Nova Scotia vessels were coded as using high-lifts using the NAFO OTB1 (CAN-M) data in the Statistical Bulletin. Quebec (CAN-M) TC-4 vessels were coded from the Bulletin as using midwater trawls.

In 1982, N.B., P.E.I. and Québec TC-4 bottom trawlers had switched to the Engels high-lift trawl by the month of July. Logbook records for the above vessels were examined for January to July and the non-Engels catch-effort was coded. Some of the gear data from Québec in the set-by-set logs were midwater, some had the characteristics of the " Yankee 41" bottom trawl. Québec boats using high-lift trawls from May to July were coded from the logs. From July 1982 to the present, all CAN-M TC-4 vessels were using high-lift trawls and their catch-effort data were taken from the ICNAF/NAFO Statistical Bulletins and from provisional data provided by the four DFO Atlantic regions Statistical Branches (for 1985 and 1986).

Only TC-4 vessels from Newfoundland region were still not using high-lift trawls after 1982. Some of those CAN-N vessels started to use Engels high-lift trawls in 1984 (Rubec et al., 1985,1986). Logbooks were used to determined the catch-effort by division and month for the high lift catches for 1984, 1985 and 1986. These data were subtracted from the reported data (ICNAF/NAFO Statistical Bulletin 1984 and provisional DFO Statistical Branches for 1985 and 1986) and the differences were coded in the non-Engels category for CAN-N TC-4 vessels.

3.3 Standardization of commercial catch rates.

Commercial catch rates were standardized using the multiplicative model (Gavaris, 1980) with the program STANDARD.AWS (Anon. MS, 1986). Values of catch and effort of less than 10 t or 10 h were deleted from the analysis because of possible rounding errors in the data.

Some differences in the catch rate series between the assessment presented last year (Rubec et al., 1986) and the present assessment are a result of the changes described above: 1) the non-Gulf TC-4 vessels are now known to have switched to the Engels high-lift trawl in 1981 rather than 1982 and 2) the distribution of the fishing effort in 1981 and 1982 between Divisions determined from the logbooks differs from that reported in the ICNAF/NAFO Statistical Bulletins, with more effort in Division 4S and less in Divisions 4T. Some differences in the analytical procedure were also carried out: 1) some combined month categories were separated and 2) the number of category types was increased from 4 to 6. The category gear+province+tonnage class was broken down into its three components. Preliminary runs indicated that the province category was not significant, and was thus deleted from the model ($n= 2$, $F=1.394$ $p>0.5$).

From 1959 to 1971, catch rates are based entirely on regular bottom trawls; between 1972 and 1980, midwater trawls were the dominant gear; and since 1981, Engels high-lift trawls have become the most important gear in the fishery (Table 7). Because there is little overlap between the series, the catch rates (unweighted CPUE) for the three gears were examined independently (Fig. 5). The trends in catch rates for the three gears were similar after 1974. In 1974, the catch rates for Engels high-lift trawls were high, and for 1972 to 1974, catch rates for midwater trawls were also very high. It was concluded that these catch rates were probably anomalous and thus not representative of the stock abundance in those years. Therefore these data were deleted from the analysis.

The data were weighted by a factor derived from the residuals (function EGLS) ranked on 5 levels of effort. The results of the analysis are presented in Tables 8 to 10. The catch rate series shows two distinct peaks in 1967-1968 and 1981-1982, followed by a rapid decline (Fig. 6). Catch rates in 1986 were approximately 30% lower than the peak levels seen in the early 80's.

4. RESEARCH SURVEY DATA.

Since 1978, stratified random groundfish surveys have been conducted in January on the GADUS ATLANTICA in the Divisions 4RST and Subdivision 3Pn. The stratification scheme is presented in Figure 7. Complete coverage of the entire area has never been accomplished because of ice cover. The average number and weight of redfish caught per set for all strata are shown in Tables 11 and 12.

Changes in the distribution of the redfish catches from 1983 to 1986 are best illustrated in Figure 8. These interannual variations may be

related to the state in the migration of the fish at the time of the survey. There is a tendency for the fish to be found in greater concentration in the southern portion of Division 4R and in Subdivision 3Pn in 1986 (Fig. 8). A similar pattern seems to occur in 1987 as the largest concentration of fish was found in the region close to Port-aux-Basques (strata 810-811, Table 11 and 12).

Biomass estimates from the winter research surveys show large fluctuations (Fig. 9), the major features being the two low estimates in 1980 and 1987, and the steady increase from 1980 to 1986. It is however interesting to note that the low values recorded in 1980 and 1987 correspond to increased estimates for the 3P Division redfish in the same years (unpublished data, B. Atkinson). It was therefore considered that the exceptionally low estimate of 1987 was not indicative of a decline in the stock abundance.

Examination of length frequencies from the winter surveys between 1978 and 1987 (Fig. 10 and 11) consistently indicated two pulses of recruitment, one representing the early 1970's year-classes and the second, the year-classes of the early 1980's. The latter should be recruiting to the fishery in the coming years.

The minimum exploitable biomass from the 1986 summer research survey was estimated at 352,563 t (Table 13). The estimates for 1984 and 1985 were respectively 473,209 t and 486,822 t (Rubec et al., 1986). Problems in the transfer of the database from these surveys and therefore different approaches to calculate biomass estimates hindered possible comparison of the results.

5. PRODUCTION MODEL.

Due to low fishing mortalities, no convergence can be achieved in fishing mortality matrix when using SPA. A general production model is therefore the appropriate analytical technique that should be used to obtain the assessment parameters. The Divisions 4RST redfish stock is not in a steady state; the catch rates series indicates that it was very strong in the mid 1960's, heavily exploited and severely reduced in the mid 1970's and is now rebuilding. Therefore, a non-equilibrium version of the Schaefer model (Rivard and Bledsoe, 1978) was used. From this model, the maximum equilibrium yield (MEY) of the 4RST redfish stock was estimated at 63,535 t $\pm$ 7,887 t (S.E.). Standard statistics on the estimated parameters, i.e. virgin stock biomass (B_∞), maximum equilibrium yield and catchability coefficient (q), are presented in Table 14. The transient (non-equilibrium) yield levels predicted by the model are given in Table 15. The model has a coefficient of determination (R^2) of 0.952.

Although the parameters of the non-equilibrium model were reasonably well estimated, the information content of the data series is limited beyond the maximum (i.e. for large effort values) of the parabolic Schaefer production curve. This observation suggests that the confidence intervals around the underlying equilibrium curve may be large in this

range of effort values despite the small variance of the three parameters in the model. The difference in the values of the parameters from this year's assessment compared with those derived previously (Rivard and Gavaris, 1986) (Table 16) is a consequence of that lack of precision. The proportion of increase in this year estimated $2/3f_{mey}$ (62 vs 37 x 10^3 hrs), and consequently the fishing mortality at $2/3f_{mey}$, is much higher than the one obtained for the estimated MEY (63,000 t vs 56,000 t). This reflects the fact that catches close to the MEY level can be realized by a large range of effort, resulting in an impossibility of a precise estimation of the location of the downward (right) limb of the equilibrium curve and therefore reducing the confidence in the estimation of effort at MEY for this stock. Inversely, the catch at MEY is more easily defined, as it constitutes a maximum value which at equilibrium vary little for a wide range of effort.

A validation of the Schaefer model was carried out by inspecting the trajectory of the transient yield around the equilibrium curve (Fig. 12). The large 1956 and 1958 year-classes pushed the stock above the equilibrium level for the 1965-1974 period. Because of the gradual depletion of these year-classes through fishing, the stock returned below equilibrium in the late seventies and has remained there since. While the early 1970's year-classes appear strong, they have not yet brought the stock to or above the equilibrium level.

The biomass estimated by the model is now at approximately the level seen in the mid sixties (Table 15). Trends in biomass (standardized to the mean) and catch rates are consistent (Fig. 13), although in recent years, the catch rates are much lower than predicted by the model. The yearly catchabilities, derived from the ratio between annual catch rates and biomass estimates, are plotted in Figure 14. Although the 1986 value is still below average, it has increased compared to 1985.

The decrease in catch rates recorded over the last years appears more pronounced than what could be expected for redfish. Given the fact that redfish is a long-lived species, we could expect that strong incoming year-classes would result in increased catch rates that should be sustained over a number of years. The recruitment to the fishery of the strong 1970's year-classes has however not brought about the expected results. Consequently, factors other than stock abundance might help explain the low catch rates obtained in the 80's. The exact nature and influence of those factors (possibly environmental) are however very difficult to quantify.

6. MANAGEMENT IMPLICATIONS.

The results of the non-equilibrium analysis are:

		f_{mey}	$2/3f_{mey}$
Equilibrium	Effort (hrs)	93,574	62,382
Equilibrium	CPUE (t/hr)	0.679	0.905
Equilibrium	Catch (t)	63,535	56,476

The non-equilibrium Schaefer model implies a biomass level of 473,000 t at the beginning of 1987 and a fishing mortality rate of 0.088. At $2/3f_{mey}$, the non-equilibrium yield was estimated at 64,225 t in 1988. This catch would correspond to a fishing mortality rate of 0.15 for 1988. This yield is above the equilibrium $2/3f_{mey}$ of 56,476 t, but very close to the MEY level (63,535 t).

The effort exerted on this stock has been below $2/3f_{mey}$ in recent years, and the catch rates have been above those at f_{mey} since 1979 and above $2/3f_{mey}$ from 1980 to 1984.

This assessment estimates stock size approximately equal to the stock size estimated last year. However, the $2/3f_{mey}$ is higher than suggested in 1986, and the increase in projected catch is due to this increase. It must be noted that the projected yields are above equilibrium yields at $2/3f_{mey}$ and that exploitation at this level of effort would result in a rapid decline toward equilibrium catches (56,000 t). In view of the uncertainties in the $2/3f_{mey}$ level, a TAC at the equilibrium level of 56,000 t was suggested.

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Table 1. Nominal catches (t) of redfish by division, country, region and year in the Gulf of St. Lawrence.

	4R							4S							4T							4RST	
YEAR	CAN-N	CAN-M	CAN-Q	FRAN	USA	OTHERS	TOTAL	CAN-N	CAN-M	CAN-Q	FRAN	USA	OTHERS	TOTAL	CAN-N	CAN-M	CAN-Q	FRAN	USA	OTHERS	TOTAL	TAC	TOTAL
1959	1333	4066			4345		9744	442	4369			809		5620	4	1551			59		1614		16978
1960	1439	3095		6	970	2	5512	153	4206			319		4678	250	1768			9	1	2028		12218
1961	421	3444			62		3927	16	4328			138		4482	80	1883		19			1982		10391
1962	120	1427			62		1609	4	3440					3444	269	1258			5		1532		6585
1963	1361	2385			3162		6908	1171	6990			1513		9674	565	2443			204		3212		19794
1964	1370	3243		88	5266		9967	1309	8696			6838		16843	359	2357			174		2890		29700
1965	4843	3301		5	11966		20115	2138	16328			5051		23517	540	4573			82		5195		48827
1966	13480	9177			10400		33057	825	21052			2256		24133	262	7653			110		8025		65215
1967	8896	10393		388	11173	5	30855	733	25571			4408	1	30713	368	8100					8468		70036
1968	16374	15110		729	11430		43643	759	34209		253	5007		40228	916	6092		84			7092		90963
1969	15958	12473		838	7414		36683	4084	32418		142	4708		41352	192	10627		21			10840		88875
1970	18524	13395		178	5322		37419	9430	29131		86	2270		40917	836	8416					9252		87588
1971	12529	13295		33	2097		27954	3502	37456		17	2565		43540	593	7275			44		7912		79406
1972	13753	11267		2	784	278	26084	4102	42359			327		46788	815	6640		2			7457		80329
1973	25752	39703		772	1130	717	68074	6425	40189		437	497	46	47594	855	13542		81		18	14496		130164
1974	9909	20110		148	329	400	30896	3165	21435		31	703	350	25684	876	5868		165			6909		63489
1975	11256	18770		520		292	30838	7108	21223		49		119	28499	633	5295		71		65	6064		65401
1976	8485	10986		192		300	19963	973	15370		31		20	16394	266	1326		34			1626	30000	37983
1977	672	4702		246			5620	14	7891		1			7906	3	2311					2314	18000	15840
1978	809	2170		105			3084	18	6334					6352		4155					4155	18000	13591
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	26429
																						31000a	
1983	2015	5049	3361	38			10463	36	6963	4496	0			11495	41	656	1850	0			2547	31000	24505
																						33000a	
1984	2332	7386	2408	7			12133	81	5198	7421	0			12700	1	5938	4049	0			9988	50600	34821
1985*	2613	7629	1357	12			11611	743	6331	5101	0			12175	2	1216	2823	0			4041	50600	27827
1986*	1983	8466	260	0			10709	1337	10269	6437	0			18043	5	1594	2756	0			4355	55600	33107

a : TAC changed during year after consultation with fishing industry.
* : Provisional data

Table 2. Recent allocation scheme and reported catches (t) for Divisions 4RST redfish.

YEAR	FLEET		FINAL ALLOCATION	REPORTED CATCH	%
1980	Mobile >100'	GBV	7900	8173	103
		NGBV	1000	975	98
	Mobile <100'		5000	5069	101
	Mobile <100'	BCSF	1500	1232	82
	FRANCE		600	57	10
	TOTAL		16000	15506	97
1981	Mobile >100'	GBV	8400	8909	106
		NGBV	2000	1891	95
	Mobile <100'		7500	9217	122
	Mobile <100'	BCSF	1500	875	58
	FRANCE		600	16	3
	TOTAL		20000	20908	104
1982	Mobile >100'	GBV	12300	12218	99
		NGBV	3600	3659	101
	Mobile <100'		12300	8613	70
	Mobile <100'	BCSF	1500	1083	72
	Fixed <65'		700	89	13
	FRANCE		600	10	2
	TOTAL		31000	25672	83
1983	Mobile >100'	GBV	12300	10913	89
		NGBV	5600	5267	94
	Mobile <100'		12300	7437	60
	Mobile <100'	BCSF	1500	716	48
	Fixed <65'		700	193	28
	FRANCE		600	38	6
	TOTAL		33000	24564	74
1984	Mobile >100'	GBV+NGBV	37500	24767	66
	Mobile <100'		10700	7436	69
	Mobile <100'	BCSF	1500	1343	90
	Fixed <65'		300	126	42
	FRANCE		600	7	1
	TOTAL		50600	33679	67
1985	Mobile >100'	GBV	26250	12319	47
		NGBV	11250	10978	98
	Mobile <100'		10700	4318	40
	Mobile <100'	BCSF	1500	959	64
	Fixed <65'		300	66	22
	FRANCE		600	2	0
	TOTAL		50600	28642	57
1986	Mobile >100'	GBV	27500	13136 *	48
		NGBV	15000	15639 *	104
	Mobile <100'		10700	4229 *	40
	Mobile <100'	BCSF	1500	828 *	55
	Fixed <65'		300	101 *	34
	FRANCE		600	0 *	0
	TOTAL		55600	33933 *	61

NOTE: GBV = Gulf Based Vessels
NGBV = Non Gulf Based Vessels
BCSF = By Catch Shrimp Fishery
* = provisional data (weekly quota report Dec.31,1986)

Table 3a. Preliminary catch statistics (t) for redfish in Division 4R in 1986.

CANADA-NEWFOUNDLAND

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	1	0	3	1	0	0	0	0	1	0	0	0	0	5
	2	0	1	0	0	2	0	1	1	0	0	0	0	5
	3	0	3	1	8	14	7	48	4	0	0	0	0	85
	4	77	5	0	8	105	280	156	274	43	45	173	54	1220
	5	3	9	0	0	0	77	32	104	13	126	165	34	563
ST	1	0	0	0	0	0	0	1	0	2	5	0	0	8
	2	0	0	0	0	2	0	1	3	6	11	2	0	25
	3	0	0	0	2	0	2	8	9	9	13	9	0	52
GNS	1	0	0	0	0	3	4	3	1	2	3	1	1	18
LLS	1	0	0	0	0	0	0	0	2	0	0	0	0	2
TOTAL		80	21	2	18	126	370	250	399	75	203	350	89	1983

CANADA-MARITIMES

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	3	0	0	0	0	39	0	0	0	0	0	0	0	39
	4	30	0	0	0	314	893	924	515	642	942	85	248	4593
	5	1193	0	0	0	85	41	125	5	22	46	784	682	2983
OTM	5	431	0	0	0	0	0	30	0	60	0	286	0	807
ST	3	0	0	0	0	17	20	7	0	0	0	0	0	44
Total		1654	0	0	0	455	954	1086	520	724	988	1155	930	8466

CANADA-QUEBEC

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	3	0	0	0	0	0	0	0	7	0	0	0	0	7
	4	0	0	0	6	3	18	13	86	49	56	22	0	253
Total		0	0	0	6	3	18	13	93	49	56	22	0	260

Div. total	1734	21	2	24	584	1342	1349	1012	848	1247	1527	1019	10709

Table 3b. Preliminary catch statistics (t) for redfish in Division 4S in 1986.

CANADA-NEWFOUNDLAND

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	4	0	0	0	0	0	238	120	283	57	132	7	104	941
	5	0	0	0	0	0	110	192	0	3	51	15	25	396
Total		0	0	0	0	0	348	312	283	60	183	22	129	1337

CANADA-MARITIMES

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	1	0	0	0	0	0	0	0	19	3	106	10	0	138
	3	0	0	0	0	0	4	6	0	1	0	0	0	11
	4	0	0	0	0	76	330	1191	821	432	751	445	31	4077
	5	59	0	0	0	3	885	419	671	932	1032	389	348	4738
OTM	5	151	0	0	0	0	0	194	9	227	163	235	0	979
ST	1	0	0	0	0	0	0	0	0	1	0	0	0	1
	3	0	0	0	1	9	33	61	69	70	53	0	0	296
	4	0	0	0	0	2	7	5	8	6	1	0	0	29
Total		210	0	0	1	90	1259	1876	1597	1672	2106	1079	379	10269

CANADA-QUEBEC

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	1	0	0	0	0	0	6	3	4	6	3	0	0	22
	2	0	0	0	0	0	0	17	0	1	0	0	0	18
	3	0	0	0	0	0	3	42	90	9	3	0	0	147
	4	0	0	0	8	486	946	1219	1022	742	1254	158	0	5835
ST	1	0	0	0	0	0	0	0	1	0	1	0	0	2
	2	0	0	0	1	6	6	7	5	4	2	0	0	31
	3	0	0	5	9	59	56	83	42	48	34	0	0	336
GNS	1	0	0	0	0	0	4	8	3	1	1	0	0	17
	2	0	0	0	0	1	1	4	3	1	0	0	0	10
	3	0	0	0	0	0	0	0	0	16	0	0	0	16
LLS	1	0	0	0	0	0	0	1	0	1	0	0	0	2
Others	1	0	0	0	0	0	0	1	0	0	0	0	0	1
Total		0	0	5	18	552	1022	1385	1170	829	1298	158	0	6437

Div. total	210	0	5	19	642	2629	3573	3050	2561	3587	1259	508	18043

Table 3c. Preliminary catch statistics (t) for redfish in Division 4T in 1986.

CANADA-NEWFOUNDLAND

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	4	0	0	0	0	0	3	2	0	0	0	0	0	5
Total		0	0	0	0	0	3	2	0	0	0	0	0	5

CANADA-MARITIMES

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	2	0	0	0	0	0	0	0	1	6	0	0	0	7
	3	0	0	0	0	0	11	2	4	25	10	0	0	52
	4	0	0	0	0	0	256	423	446	187	63	40	107	1522
ST	3	0	0	0	0	0	0	1	0	0	3	0	0	4
SDN	3	0	0	0	0	0	6	3	0	0	0	0	0	9
Total		0	0	0	0	0	273	429	451	218	76	40	107	1594

CANADA-QUEBEC

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	1	0	0	0	0	0	0	2	7	7	9	3	0	28
	3	0	0	0	0	1	13	34	10	4	1	0	0	63
	4	0	0	0	14	248	713	878	526	179	26	14	0	2598
ST	2	0	0	0	0	0	1	1	2	1	2	0	0	7
	3	0	0	0	3	0	0	1	2	3	4	0	0	13
GNS	1	0	0	0	0	2	5	8	9	4	4	0	0	32
	2	0	0	0	0	0	7	0	0	1	1	0	0	9
LLS	1	0	0	0	0	0	0	1	1	3	1	0	0	6
Total		0	0	0	17	251	739	925	557	202	48	17	0	2756
Div. total		0	0	0	17	251	1015	1356	1008	420	124	57	107	4355

Table 3d. Preliminary catch statistics (t) for redfish in Divisions 4RST in 1986.

CANADA-NEWFOUNDLAND

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	1	0	3	1	0	0	0	0	1	0	0	0	0	5
	2	0	1	0	0	2	0	1	1	0	0	0	0	5
	3	0	3	1	8	14	7	48	4	0	0	0	0	85
	4	77	5	0	8	105	521	278	557	100	177	180	158	2166
	5	3	9	0	0	0	187	224	104	16	177	180	59	959
ST	1	0	0	0	0	0	0	1	0	2	5	0	0	8
	2	0	0	0	0	2	0	1	3	6	11	2	0	25
	3	0	0	0	2	0	2	8	9	9	13	9	0	52
GNS	1	0	0	0	0	3	4	3	1	2	3	1	1	18
	2	0	0	0	0	0	0	0	2	0	0	0	0	2
Total		80	21	2	18	126	721	564	682	135	386	372	218	3325

CANADA-MARITIMES

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	1	0	0	0	0	0	0	0	19	3	106	10	0	138
	2	0	0	0	0	0	0	0	1	6	0	0	0	7
	3	0	0	0	0	39	15	8	4	26	10	0	0	102
	4	30	0	0	0	390	1479	2538	1782	1261	1756	570	386	10192
	5	1252	0	0	0	88	926	544	676	954	1078	1173	1030	7721
OTM	5	582	0	0	0	0	0	224	9	287	163	521	0	1786
ST	1	0	0	0	0	0	0	0	0	1	0	0	0	1
	3	0	0	0	1	26	53	69	69	70	56	0	0	344
	4	0	0	0	0	2	7	5	8	6	1	0	0	29
SDN	3	0	0	0	0	0	6	3	0	0	0	0	0	9
Total		1864	0	0	1	545	2486	3391	2568	2614	3170	2274	1416	20329

CANADA-QUEBEC

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB	1	0	0	0	0	0	6	5	11	13	12	3	0	50
	2	0	0	0	0	0	0	17	0	1	0	0	0	18
	3	0	0	0	0	1	16	76	107	13	4	0	0	217
	4	0	0	0	28	737	1677	2110	1634	970	1336	194	0	8686
ST	1	0	0	0	0	0	0	0	1	0	1	0	0	2
	2	0	0	0	1	6	7	8	7	5	4	0	0	38
	3	0	0	5	12	59	56	84	44	51	38	0	0	349
GNS	1	0	0	0	0	2	9	16	12	5	5	0	0	49
	2	0	0	0	0	1	8	4	3	2	1	0	0	19
	3	0	0	0	0	0	0	0	0	16	0	0	0	16
LLS	1	0	0	0	0	0	0	2	1	4	1	0	0	8
Others	1	0	0	0	0	0	0	1	0	0	0	0	0	1
Total		0	0	5	41	806	1779	2323	1820	1080	1402	197	0	9453

GRAND TOTAL	1944	21	7	60	1477	4986	6278	5070	3829	4958	2843	1634	33107

Table 4. Commercial sampling of Divisions 4RST redfish for 1986: the number of fish measured (male-female/unsexed) provided by the regions (A) and how they were distributed through months and main gears (B).

A)

Division	Scotia-Fundy		Newfoundland		Quebec		Gulf
	Sea samples	Port samples	Sea samples	Port samples	Sea samples	Port samples	Port samples
4R	3028-3708/0	422-788/0	1102-722/0	640-831/0	636-605/0	209-241/27	1238-1288/1
4S	5158-6083/1333	388-429/0		317-544/0	4753-4763/391	5619-7171/2450	1443-2062/0
4T					799-484/110	2170-1965/555	

B)

MONTH	OTB			OTM		ST		
	4R	4S	4T	4R	4S	4R	4S	4T
JAN	493-574/0							
MAR							59-147/146	0-0/110
APR		145-105/11					317-398/220	
MAY	1511-1026/3	382-590/24	212-256/32				201-165/0	
JUN	524-404/0	2980-1765/276	1068-511/187				352-360/24	
JUL		1543-1616/364	972-927/40		1341-1038/219		86-172/0	
AUG	669-690/1	1008-1342/286	454-477/75			60-50/0	164-332/0	
SEP	74-127/26	1369-2093/583	176-205/76		283-384/1173	69-92/0	309-616/0	
OCT	112-121/0	2685-3460/707			2118-2649/235		114-157/0	
NOV	587-794/0	1042-1447/329	69-91/35	2618-2956/0	86-114/0			
DEC	267-602/0			303-591/0	795-1015/0			

Table 5. Length frequency combinations for Divisions 4RST redfish for catch at age calculations for 1986. The number of fish sampled is given in parentheses.

LFJAN4ROTB(1303)		
LFMAY4ROTB(562)	- LFSPR4ROTB(1910)	
LFJUN4ROTB(1316)	- LFSUM4ROTB(2615)	- LFALL4ROTB
LFAUG4ROTB(997)		
LFSEP4ROTB(769)	- LFFAL4ROTB(1766)	
LFOCT4ROTB(1215)		
LFNOV4ROTB(1229)	- LFWIN4ROTB(3462)	
LFDEC4ROTB(1018)		
LFAPR4SOTB(8)		
LFMAY4SOTB(565)	- LFSPR4SOTB(632)	
LFJUN4SOTB(2522)		
LFJUL4SOTB(3209)	- LFSUM4SOTB(5731)	- LFALL4SOTB
LFAUG4SOTB(2910)		
LFSEP4SOTB(2186)	- LFFAL4SOTB(5096)	
LFOCT4SOTB(3332)		
LFNOV4SOTB(1024)	- LFWIN4SOTB(4864)	
LFMAY4TOTB(249)	- LFSPR4TOTB(263)	
LFJUN4TOTB(996)		
LFJUL4TOTB(1341)	- LFSUM4TOTB(2337)	- LFALL4TOTB
LFAUG4TOTB(994)	- LFFAL4TOTB(1402)	
LFSEP4TOTB(408)		
LFNOV4TOTB(54)	- LFWIN4TOTB(270)	
LFJUL4SOTM(194)	- LFSUM4SOTM(806)	
LFSEP4SOTM(227)	- LFFAL4SOTM(296)	
LFOCT4SOTM(163)		- LFALL4SOTM
LFNOV4SOTM(235)		
LFDEC4SOTM(0)		
LFNOV4ROTM(286)		
LFDEC4ROTM(0)	- LFWIN4SOTM(684)	

Table 5. (cont'd)

LFMAR4SST(5) LFAPR4SST(11) LFMAR4TST(0)	-	LFSPR4SST(21)		
LFMAY4SST(76) LFJUN4SST(102)	-	LFSUM4SST(220)		
			-	LFALL4SST
LFAUG4RST(12) LFJUL4SST(156) LFAUG4SST(125)	-	LFFAL4SST(317)		
LFSEP4RST(17) LFSEP4SST(129) LFOCT4SST(91)	-	LFWIN4SST(286)		

LFMAY4RGNS(3) LFJUN4RGNS(4)	-	LFALL4RGNS

LFALL4ROTB(9753) LFALL4RGNS(102)	-	LFALL4R(10709)		
LFALL4SOTM(1786) LFALL4SST(844)			-	LFFIN4R-S-T(33107)
LFALL4SOTB(16323)	-	LFALL4S(18043)		
		LFALL4TOTB(4355)		

Table 6. Divisions 4RST redfish catch at age (thousands) and average weight (kg) and length (cm) in the commercial fishery in 1986. a

	Average		Catch		
Age	Weight	Length	Mean	Std. Er.	C. V.
3	0.037	13.691	19	10.429	0.549
4	0.049	14.913	217	40.822	0.188
5	0.075	17.211	1679	170.462	0.102
6	0.098	18.804	3584	240.259	0.067
7	0.133	20.842	4028	251.423	0.062
8	0.129	23.039	2770	243.631	0.089
9	0.223	24.820	3099	322.755	0.104
10	0.250	25.841	5389	449.981	0.083
11	0.279	26.790	4960	469.891	0.095
12	0.331	28.313	3332	426.232	0.114
13	0.360	29.214	4954	528.200	0.107
14	0.387	29.885	2658	432.742	0.163
15	0.425	30.868	5944	679.205	0.116
16	0.464	31.754	7695	775.435	0.101
17	0.426	32.013	3498	589.255	0.168
18	0.519	32.906	2819	539.848	0.192
19	0.553	33.636	3139	509.989	0.162
20	0.571	33.913	2295	454.458	0.190
21	0.581	34.171	1960	397.961	0.203
22	0.599	34.521	1485	330.067	0.222
23	0.611	34.783	1934	359.760	0.186
24	0.669	35.800	2106	309.240	0.147
25	0.681	36.015	2248	320.364	0.143
26	0.758	37.236	1730	250.210	0.145
27	0.781	37.672	1352	194.349	0.144
28	0.832	38.429	1545	197.033	0.128
29	0.913	39.584	807	128.226	0.159
30	0.965	40.347	545	86.177	0.158
31	1.061	41.520	313	61.709	0.197
*32	1.043	41.300	229	61.059	0.266
33	1.147	42.576	118	30.799	0.261
*34	1.243	43.785	42	11.694	0.280
*35	1.403	45.568	15	5.637	0.372
36	1.535	47.242	14	6.483	0.457
37	1.347	45.926	6	4.532	0.705
*38	1.654	47.974	7	2.754	0.412

TOTAL WEIGHT: 33107 t TOTAL CATCH: 78834

Note:

*: Ages for which an age-length key with only one age determination for some length was available. The variance could therefore not be evaluated for this length. Consequently, this variance component is not included in the variance for the flagged ages.

a: Sexed and unsexed fish combined

Table 7. Proportion (%) of catch per gear category used in the standardization of catch rates.

Years	OTB*	ENG*	OTM*
1959	39.19	0.00	0.00
1960	38.91	0.00	0.00
1961	39.35	0.00	0.00
1962	20.82	0.00	0.00
1963	36.11	0.00	0.00
1964	16.23	0.00	0.00
1965	24.21	0.00	0.00
1966	33.17	0.00	0.00
1967	26.09	0.00	0.00
1968	39.49	0.00	0.00
1969	49.42	0.00	0.00
1970	55.53	0.00	0.00
1971	53.11	0.00	0.00
1972	27.96	0.00	46.17
1973	14.40	0.00	68.87
1974	20.25	2.18	56.78
1975	15.15	5.17	61.55
1976	8.39	5.81	56.39
1977	20.17	0.86	28.50
1978	24.67	6.61	27.45
1979	25.58	0.00	35.15
1980	27.58	1.63	51.09
1981	16.77	33.13	35.80
1982	7.62	85.01	0.00
1983	5.51	80.40	0.00
1984	2.27	66.69	2.39
1985	8.91	79.29	2.98
1986	4.57	76.34	5.92

* ENG : Engels high lift trawls
OTB : Bottom trawls other than Engels
OTM : Midwater trawls

Table 8. Analysis of variance of regression of CPUE against dummy variables. The OTM and ENG catch and effort data for 1972 to 1974 were deleted.

REGRESSION OF MULTIPLICATIVE MODEL

Multiple R.....0.680
Multiple R squared.....0.462

ANALYSIS OF VARIANCE

Source of variation	DF	Sums of squares	Mean squares	F
Intercept	1	1.247E0001	1.247E0001	
Regression	43	3.127E0001	7.272E-001	31.276
Gears	2	2.115E0000	1.058E0000	45.488
Ton. class	1	2.864E0000	2.864E0000	123.161
Months	11	2.792E0000	2.538E-001	10.915
Divisions	2	1.232E0000	6.160E-001	26.495
Years	27	1.516E0001	5.613E-001	24.142
Residuals	1564	3.636E0001	2.325E-002	
TOTAL	1608	8.011E0001		

Table 9. Regression coefficients from regression of ln(CPUE) against dummy variables. The OTM and ENG catch and effort data from 1972 to 1974 were deleted.

Category	Code	Variable	Coefficient	Std. Error	No. Obs.
OTB (2)	10	Intercept	-0.605	0.083	1608
Can-M (3)	4				
Jul. (4)	7				
4R (5)	41				
1959 (6)	59				
OTM (2)	13	1	0.396	0.042	199
ENG	99	2	0.131	0.047	385
Can-N (3)	5	3	0.333	0.030	361
Jan (4)	1	4	0.392	0.066	68
Feb	2	5	0.504	0.080	38
Mar	3	6	0.071	0.145	14
Apr	4	7	0.216	0.082	40
May	5	8	-0.111	0.050	100
Jun	6	9	-0.008	0.039	210
Aug	8	10	0.035	0.038	221
Sep	9	11	0.008	0.038	214
Oct	10	12	-0.046	0.039	210
Nov	11	13	0.143	0.041	178
Dec	12	14	0.027	0.049	114
4S (5)	42	15	0.038	0.022	603
4T	43	16	-0.198	0.032	263
Years(6)	60	17	-0.030	0.112	24
	61	18	-0.135	0.123	18
	62	19	-0.365	0.133	17
	63	20	0.316	0.107	29
	64	21	0.432	0.116	24
	65	22	0.468	0.109	25
	66	23	0.531	0.098	48
	67	24	0.716	0.099	51
	68	25	0.713	0.093	63
	69	26	0.346	0.089	80
	70	27	0.141	0.087	102
	71	28	0.125	0.088	88
	72	29	0.078	0.091	83
	73	30	-0.067	0.092	72
	74	31	-0.156	0.094	52
	75	32	-0.071	0.088	154
	76	33	-0.052	0.102	58
	77	34	-0.144	0.103	43
	78	35	0.031	0.105	43
	79	36	0.184	0.106	32
	80	37	0.534	0.106	40
	81	38	0.683	0.100	68
	82	39	0.638	0.101	76
	83	40	0.475	0.106	44
	84	41	0.519	0.103	60
	85	42	0.250	0.096	111
	86	43	0.304	0.099	82

Table 10. Predicted catch rates from regression of ln(CPUE) against dummy variables. The OTM and ENG catch and effort data from 1972 to 1974 were deleted.

Predicted catch rates

Standards used:
Gear : Engel trawl (99)
Province: Can-M (4)
Month : July (7)
Division: 4S

Year	Catch		Catch rate		
	Weight	Prop.	Mean	S.E.	Effort
1959	16978	0.392	0.651	0.062	26081
1960	12218	0.389	0.632	0.061	19330
1961	10391	0.394	0.568	0.062	18303
1962	6585	0.208	0.451	0.054	14605
1963	19794	0.361	0.893	0.081	22158
1964	29700	0.162	1.002	0.102	29648
1065	48827	0.242	0.026	0.096	46974
1966	65215	0.332	1.108	0.088	58833
1967	70036	0.261	1.333	0.109	52525
1968	90963	0.395	1.330	0.098	68385
1969	88875	0.494	0.922	0.064	96396
1970	87588	0.555	0.751	0.050	116564
1971	79406	0.531	0.740	0.050	107363
1972	80329	0.280	0.705	0.051	113973
1973	130164	0.144	0.610	0.044	213384
1974	63489	0.202	0.558	0.042	113769
1975	65401	0.819	0.608	0.036	107605
1976	37983	0.706	0.619	0.049	61396
1977	15840	0.495	0.565	0.045	28059
1978	13591	0.587	0.672	0.055	20214
1979	15034	0.607	0.783	0.067	19197
1980	14832	0.803	1.112	0.094	13340
1981	20549	0.857	1.292	0.087	15902
1982	26429	0.926	1.235	0.071	21397
1983	24505	0.859	1.049	0.071	23368
1984	35759	0.714	1.097	0.067	32590
1985	27827	0.912	0.838	0.043	33188
1986	33107	0.868	0.885	0.050	37426

Average C.V. for the mean: 0.078

Table 11. Average number of redfish caught per set from winter research vessel surveys on the Gadus Atlantica in Divisions 4R, 4S and 4T.

TRIP No.	Gadus 4	Gadus 16	Gadus 31	Gadus 46	Gadus 73	Gadus 89	Gadus 104	Gadus 119	Gadus 134
Year	1978	1979	1980	1981	1983	1984	1985	1986	1987
Strata									
Div. 4R									
801	187.33	277.33	10.50	4.00	546.33	1036.00	162.33	341.67	10.00
802	181.67	986.00	586.00	1749.00	284.43	727.40	546.67	547.29	313.00
809	475.27	957.67	916.00	269.00	294.00	168.20	1190.87	377.57	148.20
810	1690.67	8729.66	552.75	659.31	2697.60	1327.75	1637.67	872.71	784.50
811	1323.40	6808.00	3048.75	1118.00	239.71	248.71	30353.43	7800.38	223.00
812	863.20	1181.80	42.00	20.71	197.90	199.78	349.93	624.00	18.00
813	692.67	35.00	9.00	0.00	270.09	275.90	200.40	320.00	1.75
820	52.25	38.25	134.75	20.67	12.29	15.40	32.60	15.00	3.20
821	26.50	29.50	38.25	0.00	55.14	12.80	24.20	9.00	23.78
822	0.25	25.00	10.00	8.00	6.80	1.62	24.50	14.63	0.50
823	21.50	4.33	1.67	5.60	5.50	104.50	29.00	-	-
824	-	10.50	0.00	0.50	5.00	8.67	23.33	6.00	-
Div. 4S									
803	87.00	-	195.57	292.25	18.27	18.24	75.40	458.79	31.31
804	7.33	-	50.50	20.00	14.20	17.80	15.00	-	33.00
805	-	-	21.00	19.13	17.00	-	-	-	-
806	16.00	-	21.67	7.00	6.00	-	-	-	-
807	336.33	48.00	18.00	21.50	58.00	25.00	39.50	111.40	37.86
808	151.00	449.80	138.00	33.67	357.12	691.17	96.50	350.70	54.86
814	572.50	7.67	6.67	4.50	125.67	24.33	414.60	0.00	8.50
815	76.00	84.50	48.33	138.92	391.86	885.00	222.80	68.50	53.33
816	45.80	121.33	34.00	7.71	319.70	105.50	245.25	-	-
817	-	-	9.50	1.00	1.00	-	-	-	-
818	211.50	-	8.00	1.67	9.00	-	-	-	-
819	135.00	567.00	67.67	29.00	23.00	86.00	264.71	191.60	101.00
825	-	-	3.00	0.50	12.00	-	-	-	-
826	-	-	0.00	0.00	0.00	-	-	-	-
827	19.50	-	1.00	14.40	25.50	2.20	0.80	0.00	-
828	15.00	-	17.50	0.33	1.25	-	-	-	-
829	49.33	15.00	0.67	2.33	5.00	4.00	-	-	7.00
830	57.50	-	0.33	4.33	7.50	9.25	22.40	0.50	0.33
831	0.50	-	0.00	10.50	-	-	-	-	-
832	-	-	4.50	0.00	0.00	-	-	-	-
833	0.00	-	0.00	0.00	1.50	0.00	7.33	-	-
834	-	-	1.50	0.50	-	-	-	-	-
Div. 4T									
401	185.00	-	6.50	-	86.00	1.67	-	9.00	-
402	-	121.45	6.50	-	300.50	11.33	-	-	-
404	42.00	-	11.00	-	12.50	6.33	-	90.33	-
405	-	23.50	5.00	-	3.50	13.33	-	-	20.25
406	-	-	-	3.50	-	-	-	-	-
407	50.00	-	34.00	-	23.00	22.33	-	153.17	-
408	-	37.00	15.50	-	36.00	19.29	-	-	22.00

- : Strata not sampled

Table 12. Average weight (kg) of redfish caught per set from winter research vessel surveys on the Gadus Atlantica in Divisions 4R, 4S and 4T.

TRIP No.	Gadus 4	Gadus 16	Gadus 31	Gadus 46	Gadus 73	Gadus 89	Gadus 104	Gadus 119	Gadus 134
Year	1978	1979	1980	1981	1983	1984	1985	1986	1987
Strata									
Div. 4R									
801	34.17	42.53	0.75	0.55	95.47	79.75	88.50	33.50	3.25
802	87.70	672.37	332.67	1271.58	184.09	496.44	354.50	336.57	147.00
809	197.10	403.60	165.92	73.25	156.43	69.40	402.16	86.43	24.40
810	985.97	2442.76	261.56	254.42	1129.40	683.75	804.67	461.00	163.00
811	458.95	1040.12	288.56	173.00	63.21	60.50	1042.96	1127.69	36.35
812	106.32	173.70	6.75	2.36	34.09	115.50	81.93	107.25	2.19
813	58.36	3.41	1.39	1.22	73.83	14.45	28.80	39.44	0.15
820	24.38	12.60	39.75	0.00	5.43	10.00	11.90	1.48	0.60
821	2.49	7.80	3.19	1.25	25.23	5.90	2.30	1.83	7.42
822	0.15	3.80	0.97	0.54	3.33	0.53	4.91	4.80	0.06
823	2.04	0.45	0.50	-	3.80	25.00	4.33	-	-
824	-	0.45	0.00	0.05	1.90	2.18	4.00	0.75	-
Div. 4S									
803	53.67	-	107.56	129.00	11.72	12.53	56.53	307.21	10.09
804	3.78	-	11.50	6.67	8.00	9.30	7.17	-	7.20
805	-	-	3.62	9.25	4.50	-	-	-	-
806	3.02	-	4.27	2.13	2.40	-	-	-	-
807	122.78	13.16	2.07	4.13	9.70	6.52	12.33	14.80	9.22
808	77.27	118.83	25.67	10.00	193.75	42.90	29.17	48.85	14.64
814	195.04	1.51	0.63	1.75	42.93	5.00	116.04	0.00	1.10
815	5.22	19.86	5.83	19.86	161.20	424.44	68.30	7.50	9.36
816	3.67	17.56	3.53	0.44	74.31	8.25	12.38	-	-
817	-	-	1.65	0.03	0.07	-	-	-	-
818	13.83	-	2.00	0.87	2.73	-	-	-	-
819	10.32	81.94	5.70	3.75	10.33	7.40	67.21	21.96	14.58
825	-	-	0.25	0.11	3.60	-	-	-	-
826	-	-	0.00	0.00	0.00	-	-	-	-
827	0.85	-	0.05	0.40	3.80	0.30	0.04	0.00	-
828	0.79	-	2.00	0.00	0.13	-	-	-	-
829	2.5	1.59	0.07	0.40	2.13	0.38	-	-	1.50
830	2.83	-	0.02	0.58	3.63	1.30	3.30	0.02	0.17
831	0.27	-	0.00	0.20	-	-	-	-	-
832	-	-	0.25	0.00	0.00	-	-	-	-
833	0.00	-	0.00	0.00	0.50	0.00	1.50	-	-
834	-	-	0.05	0.05	-	-	-	-	-
Div. 4T									
401	19.96	-	1.13	-	33.50	1.00	-	3.00	-
402	-	11.84	0.57	-	107.00	2.17	-	-	-
404	18.37	-	2.50	-	7.00	4.83	-	19.83	-
405	-	8.63	0.55	-	3.10	8.67	-	-	4.25
406	-	-	-	2.00	-	-	-	-	-
407	13.83	-	12.50	-	16.25	14.17	-	81.50	-
408	-	20.65	3.80	-	18.25	7.43	-	-	6.93

- : Strata not sampled

Table 13. Average weight (kg) and number of redfish per set, and 1986 minimum fishable biomass from summer research surveys on the Lady Hammond in Divisions 4R, 4S and 4T.

Trip no.	Hammond 121	Hammond 140	Hammond 150		Minimum fishable
Year	1984	1985	1986		biomass (t) 1986
Strata					
Div. 4R					
801	138.6	125.5	335	(421)	
802	51.4	138.9	71	(124)	
809	647.6	269.9	343	(1022)	
810	525.1	628.1	770	(2831)	
811	414.8	202.0	435	(2704)	
812	230.8	273.6	306	(1073)	
813	11.7	385.0	53	(369)	
820	1.2	8.5	2	(9)	
821	1.3	1.6	5	(43)	
822	3.8	15.0	2	(7)	
823	3.6	21.5	1	(8)	
824	140.0	54.8	1	(6)	94272
Div. 4S					
803	127.3	229.2	137	(226)	
804	384.7	394.2	103	(177)	
805	7.9	63.7	175	(317)	
806	172.1	229.3	77	(180)	
807	391.6	1589.1	133	(400)	
808	244.4	275.3	186	(709)	
814	98.8	385.0	259	(468)	
815	141.0	309.0	366	(1626)	
816	69.3	182.7	209	(681)	
817	187.1	114.1	76	(271)	
818	291.3	300.8	330	(1827)	
819	520.5	406.0	546	(2675)	
825	0.0	218.0	17	(27)	
826	-	0	-	-	
827	-	49.3	301	(827)	
828	-	0.6	2	(7)	
829	-	36.9	2	(27)	
830	209.7	88.6	12	(59)	
831	-	32.9	6	(15)	
832	-	17.0	5	(35)	213665
Div. 4T					
401	487.9	79.1	285	(836)	
402	365.6	406.2	229	(592)	
403	-	136.0	146	(278)	
404	826.7	402.9	151	(333)	
405	328.0	251.0	124	(235)	
406	637.1	222.4	219	(429)	
407	486.4	234.0	82	(139)	
408	209.1	201.7	96	(149)	44626

- : Strata not sampled

() : Average number

TOTAL 352563

Table 14. Approximate statistics from the linear theory on the parameters of the non-equilibrium version of the Schaefer model estimated from 1959-1986 commercial data.

Parameter	Estimated value	Standard Error	t-value
B_∞	577664 t	151316 t	3.82
MEY	63535 t	7887 t	8.06
q	2.3508E-6	5.0667E-7	4.64

Correlation matrix of the estimated parameters:

	B	MEY	q
B_∞	1.00		
MEY	-0.88	1.00	
q	-0.95	0.76	1.00

Table 15. Results from the non-equilibrium Schaefer model for the period 1959 to 1986.

Year	Biomass	Observed Yield (t)	Predicted Yield (t)	Residuals
1959	278212	16978	18615	-1637
1960	322880	12218	15845	-3627
1961	367924	10391	16801	-6410
1962	406993	65855	14662	-8077
1963	441595	19794	23626	-3832
1964	461100	29700	32506	-2806
1965	468296	48827	51221	-2394
1966	457290	65215	62104	3111
1967	439080	70036	53934	16102
1968	431979	90963	68111	22852
1969	413419	88875	89806	-931
1970	378048	87588	98442	-10854
1971	339031	79406	83290	-3884
1972	317802	80329	82960	-2631
1973	297881	130164	131918	-1754
1974	228513	63489	61692	1797
1975	227632	65401	58579	6822
1976	229962	37983	35539	2444
1977	256403	15840	18597	-2757
1978	301151	13591	155580	-1989
1979	347957	15034	16790	-1756
1980	389606	14832	12929	1903
1981	428886	20549	16662	3887
1982	457335	26429	23510	2919
1983	473349	24505	26357	-1852
1984	482957	35759	37009	-1250
1985	480840	27827	37520	-9693
1986	478807	33107	41972	-8685

Table 16. Estimates from the non-equilibrium Schaefer model.

	1986 Estimates	1987 Estimates
Maximum equilibrium yield (MEY) ..	56,522 t	63,535 t
Catchability coefficient (q)	2.6697×10^{-6}	2.35079×10^{-6}
2/3 $effort_{mey}$ (2/3 f_{mey})	36,846 hr	62,382 hr
Virgin stock biomass (B_{∞})	766,100 t	577,664 t
Fishing mortality (F) at 2/3 f_{mey}	0.098	0.147
F	0.074	0.088

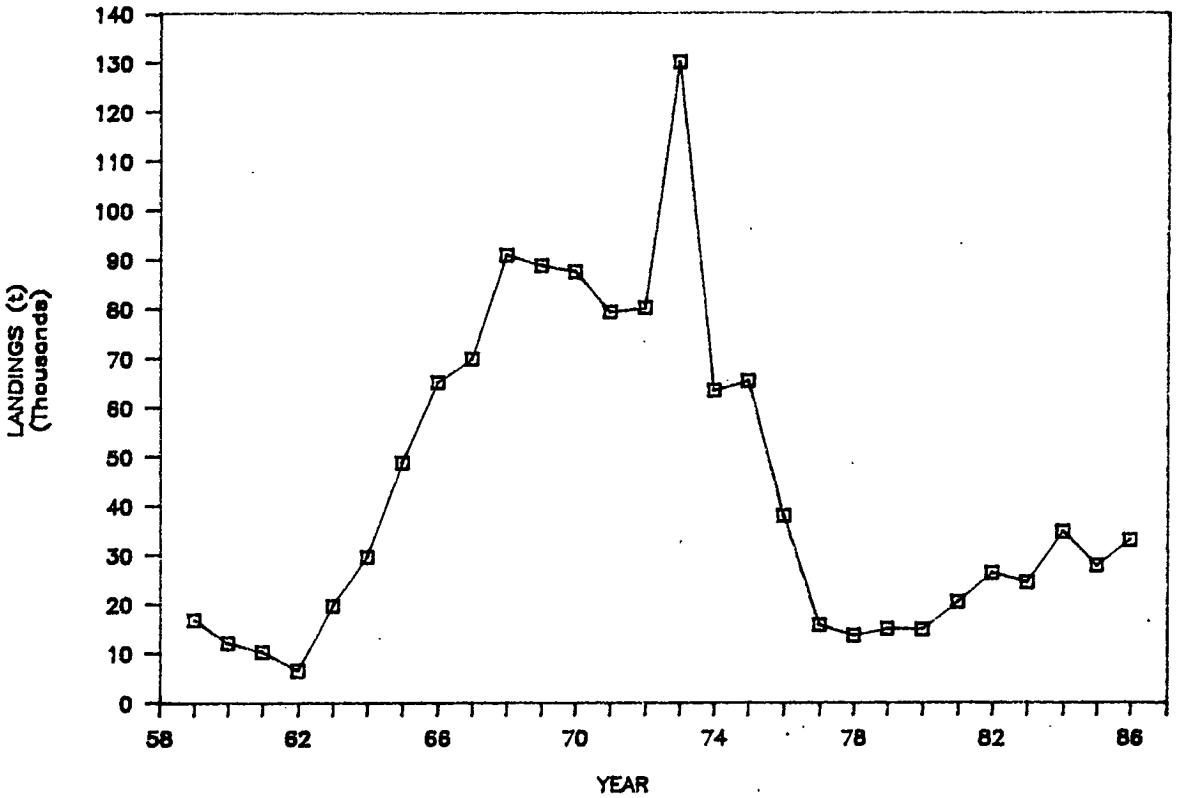


Figure 1. Historical landings for Divisions 4RST redfish commercial fishery.

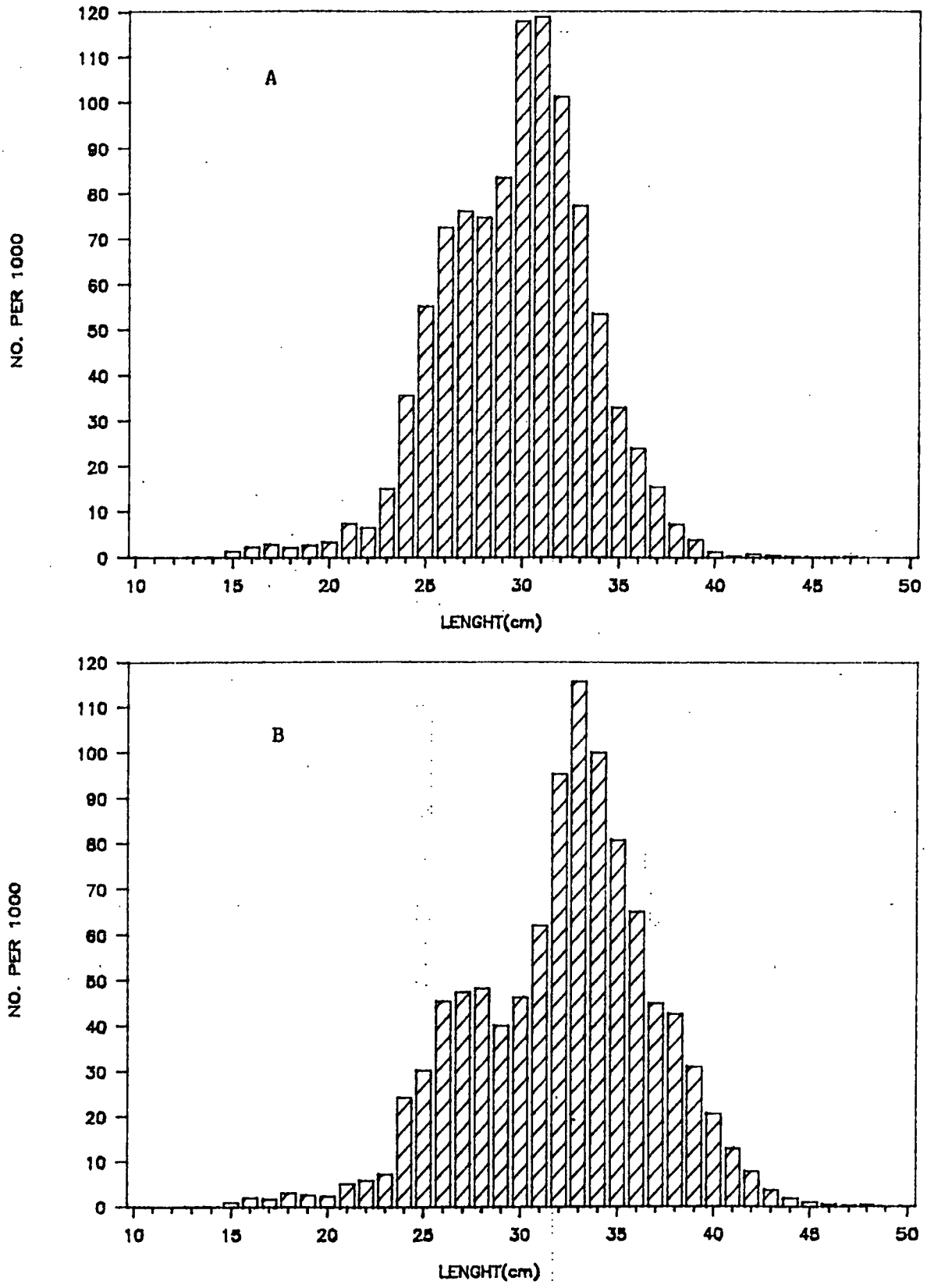


Figure 2. Annual length frequencies for male(A) and female(B) redfish from commercial fishery data from Divisions 4RST in 1986.

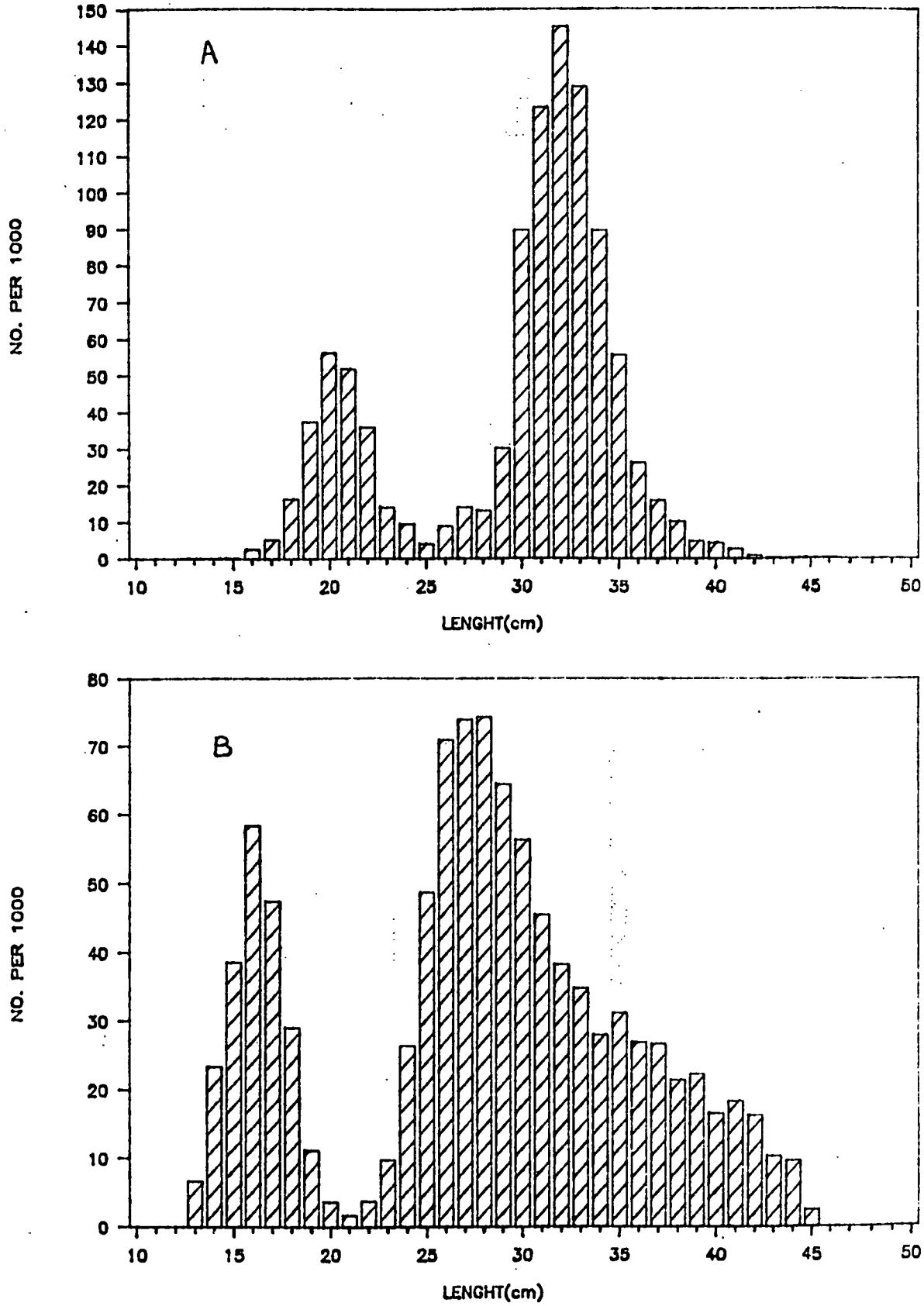


Figure 3. Length frequencies for midwater trawls (A) and shrimp trawls (B) for Divisions 4RST redfish for 1986, sexed and unsexed fish combined.

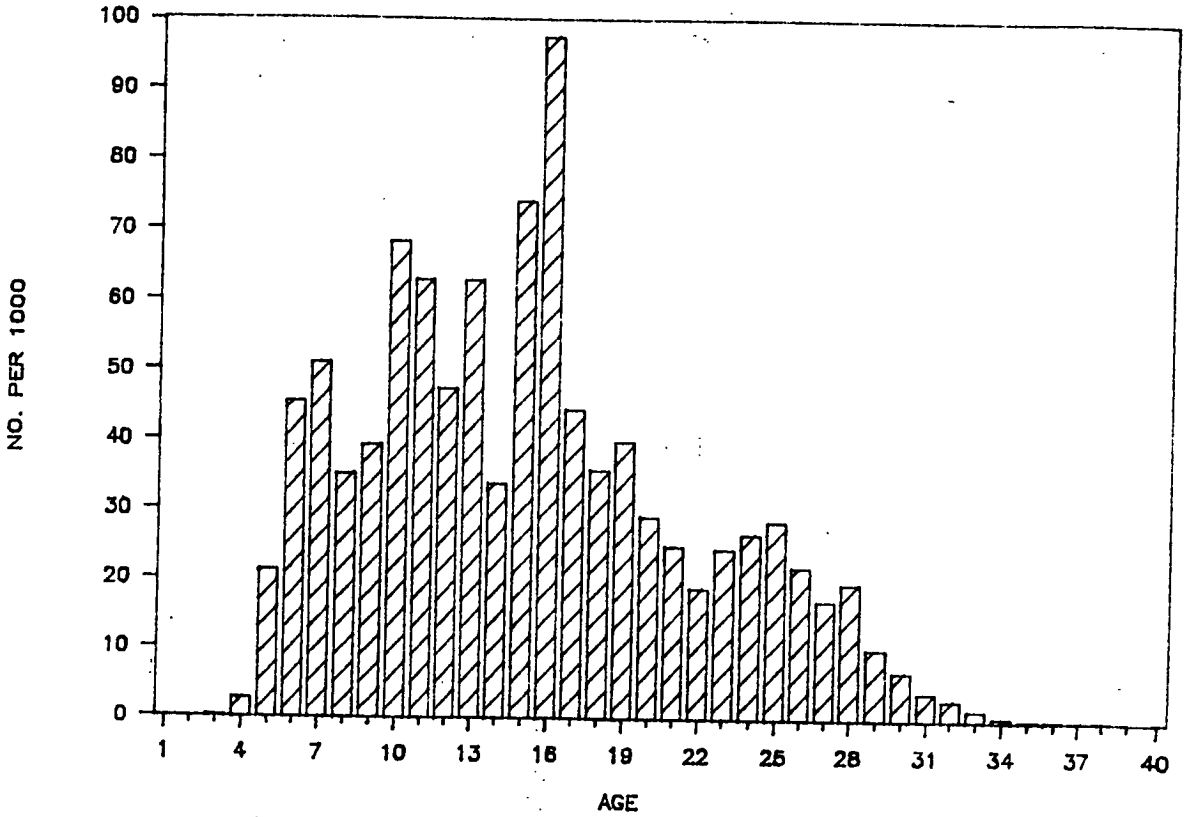


Figure 4. Proportion at age (sexed and unsexed fish combined) of Divisions 4RST redfish in the commercial fishery in 1986.

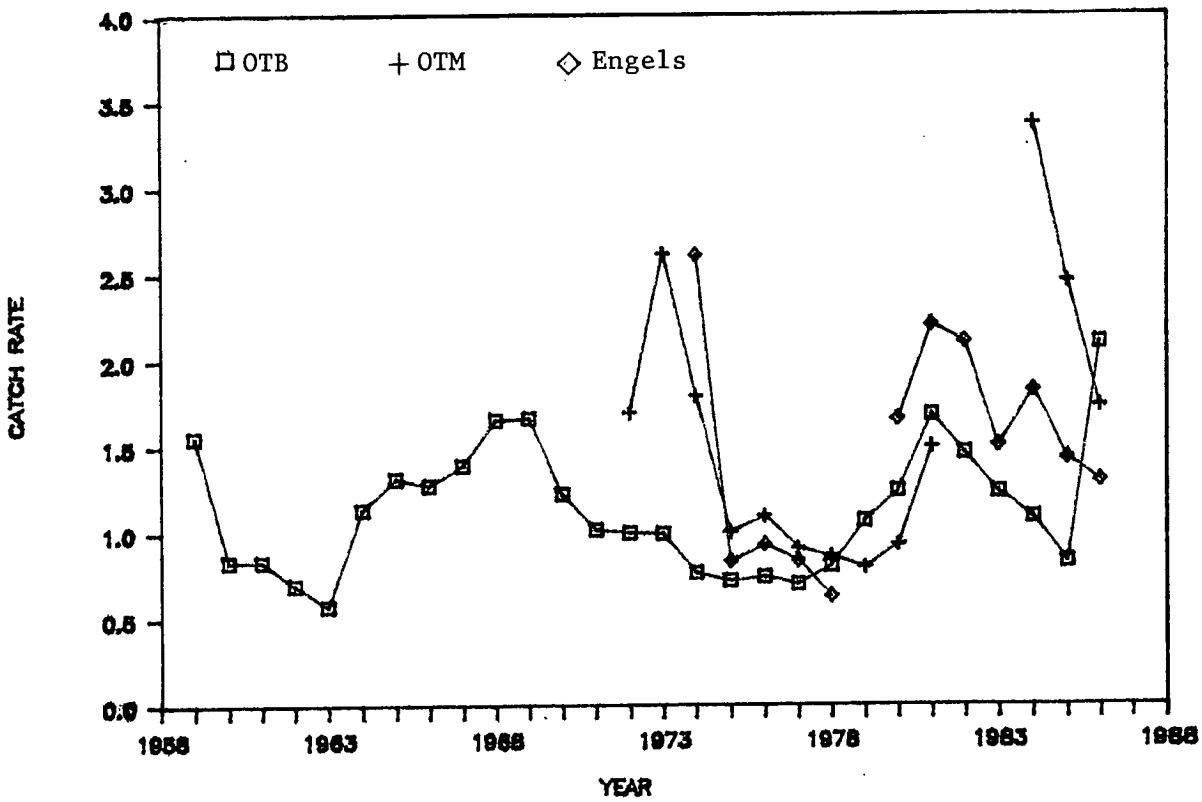


Figure 5. Comparison of catch rates of the major gears used in the Divisions 4RST redfish commercial fishery.

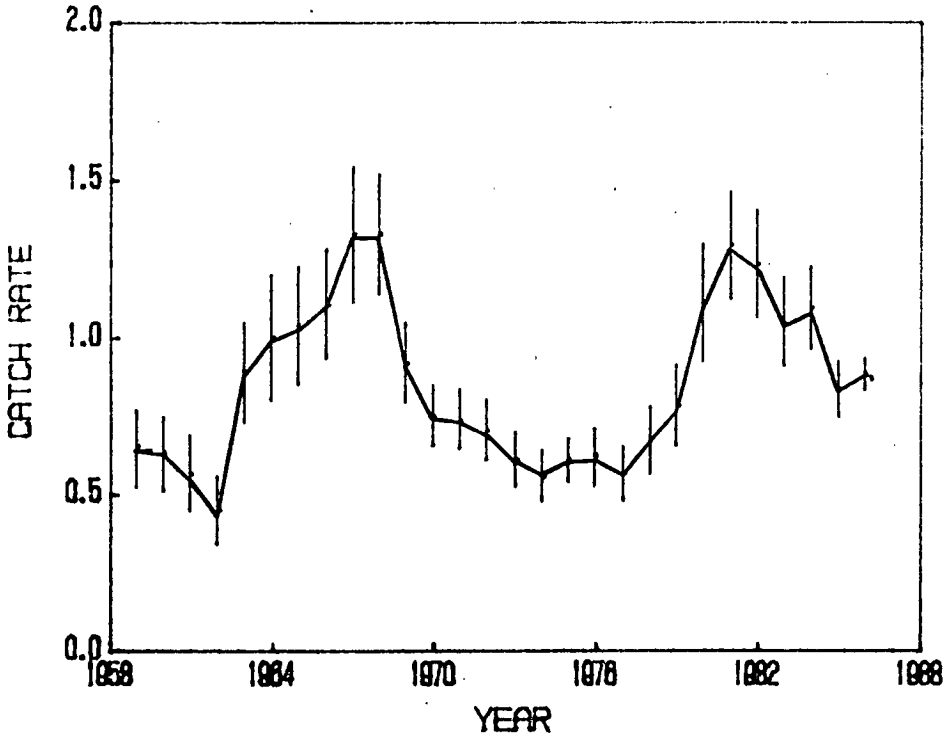


Figure 6. Standardized catch rates for Divisions 4RST redfish commercial fishery.

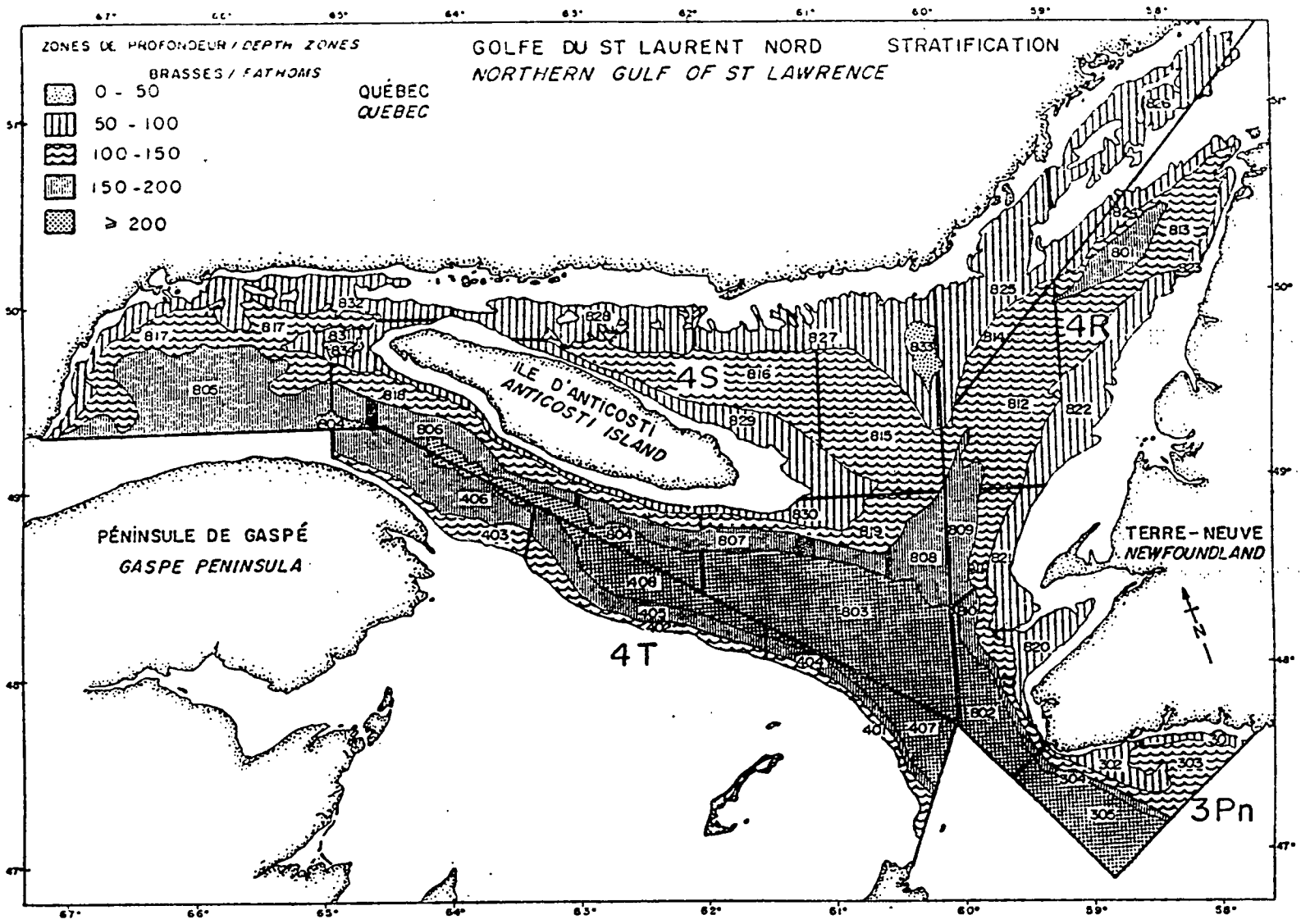
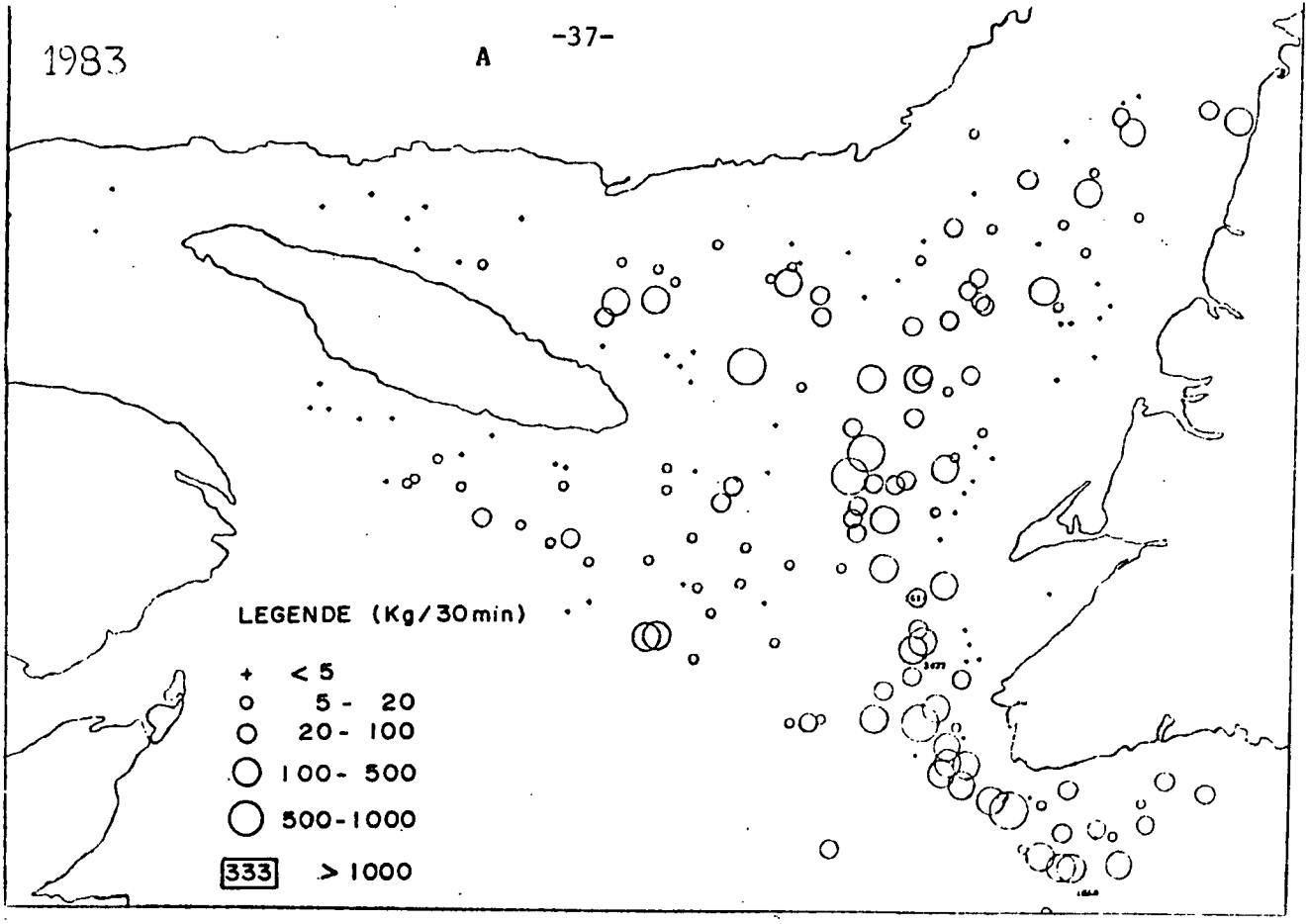


Figure 7. Stratification scheme used for the January groundish surveys in Divisions 4RST and Subdivision 3Pn.



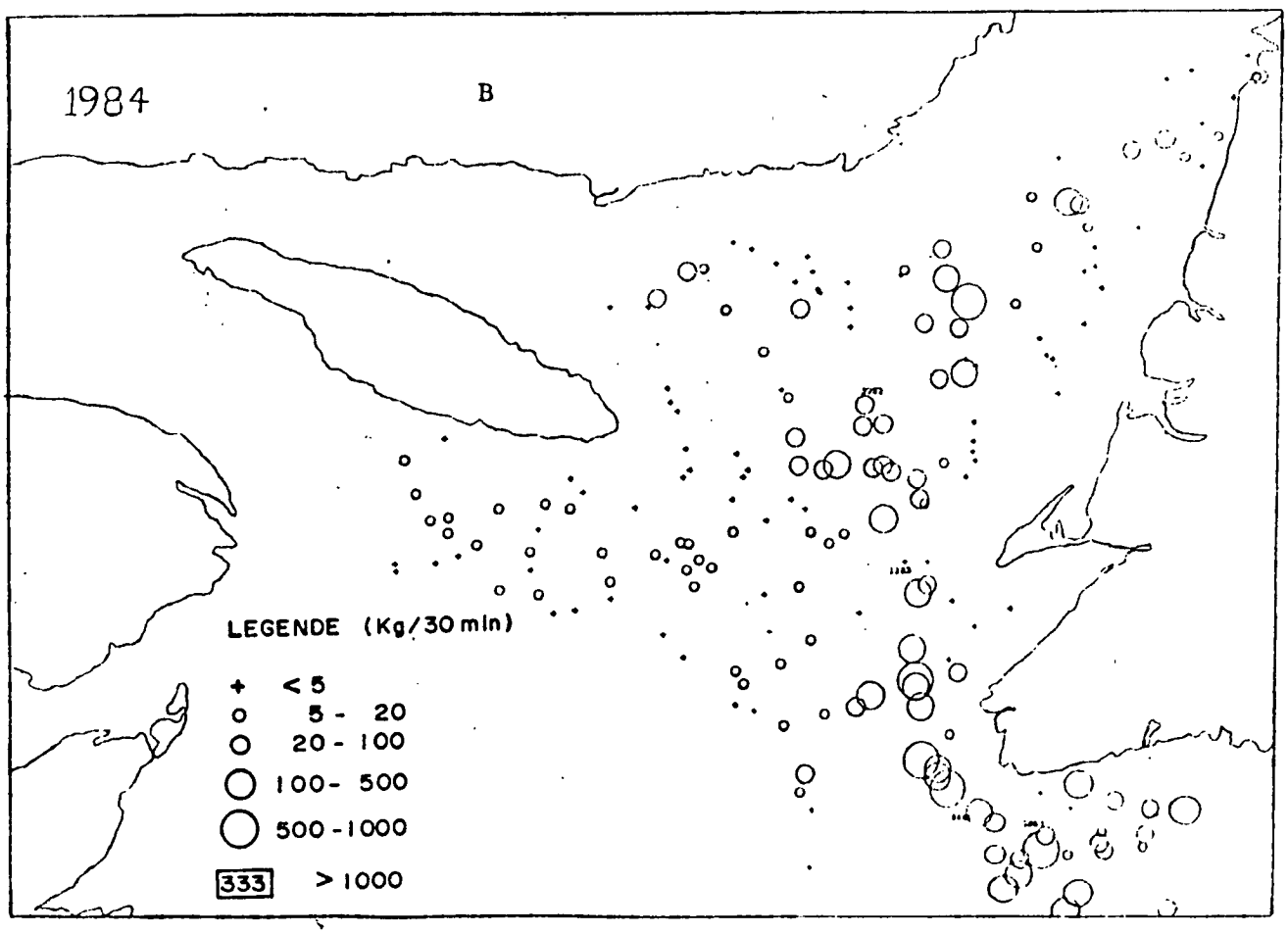
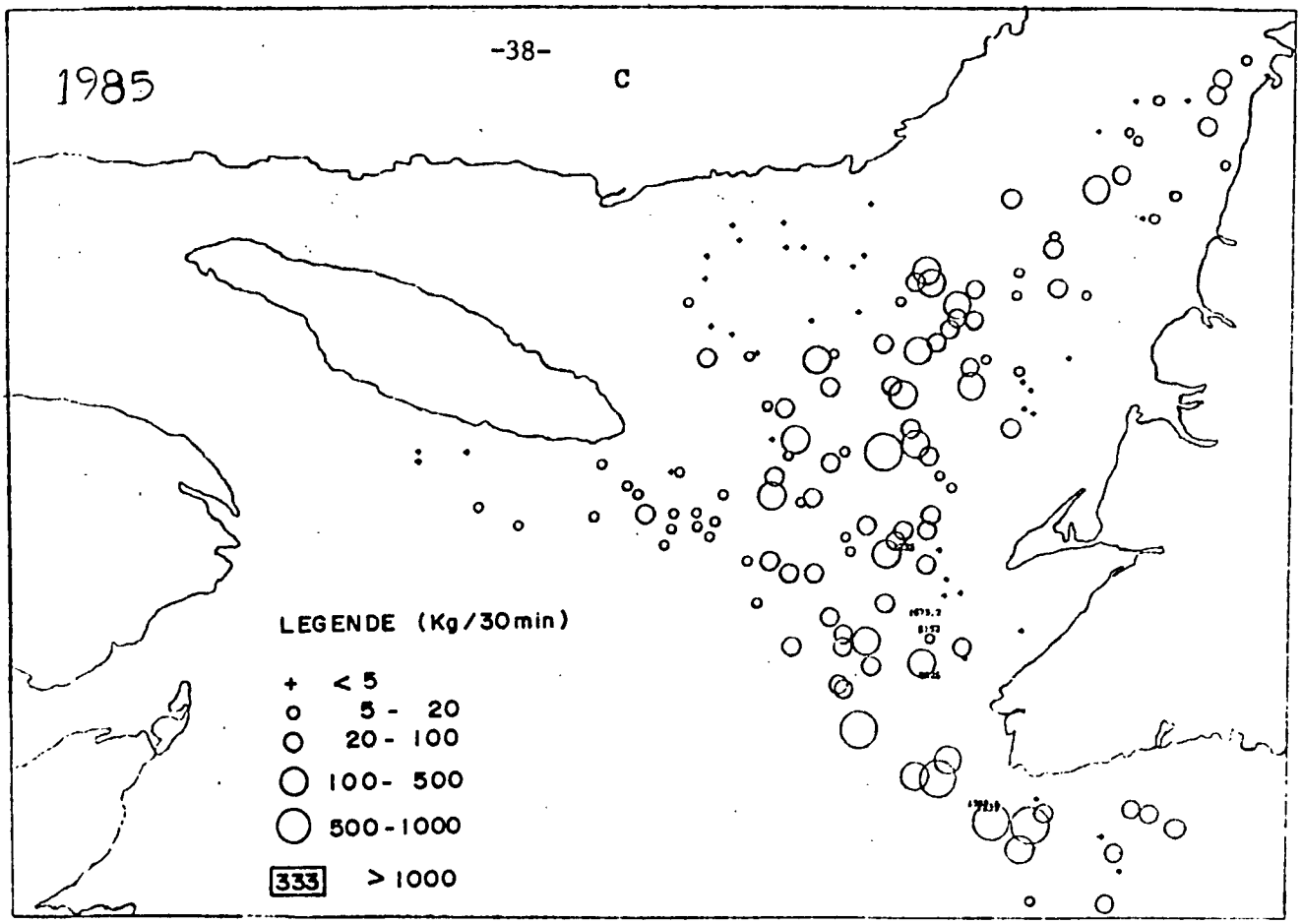


Figure 8. Distribution and catch rate (kg/30 min. tow) of redfish from winter research surveys in Divisions 4RST and Subdivision 3Pn in (A) 1983, (B) 1984, (C) 1985 and (D) 1986.



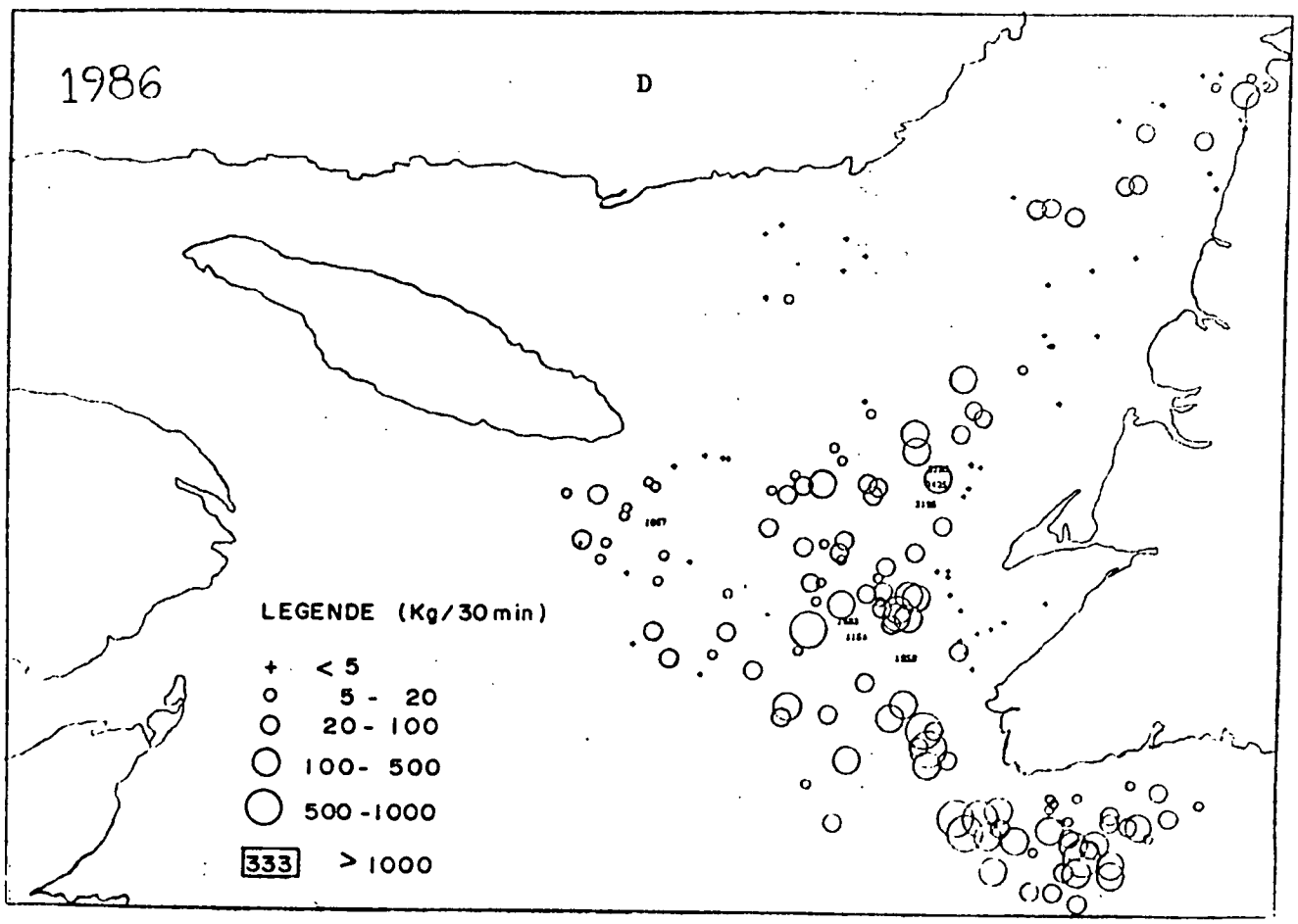


Figure 8. (cont'd)

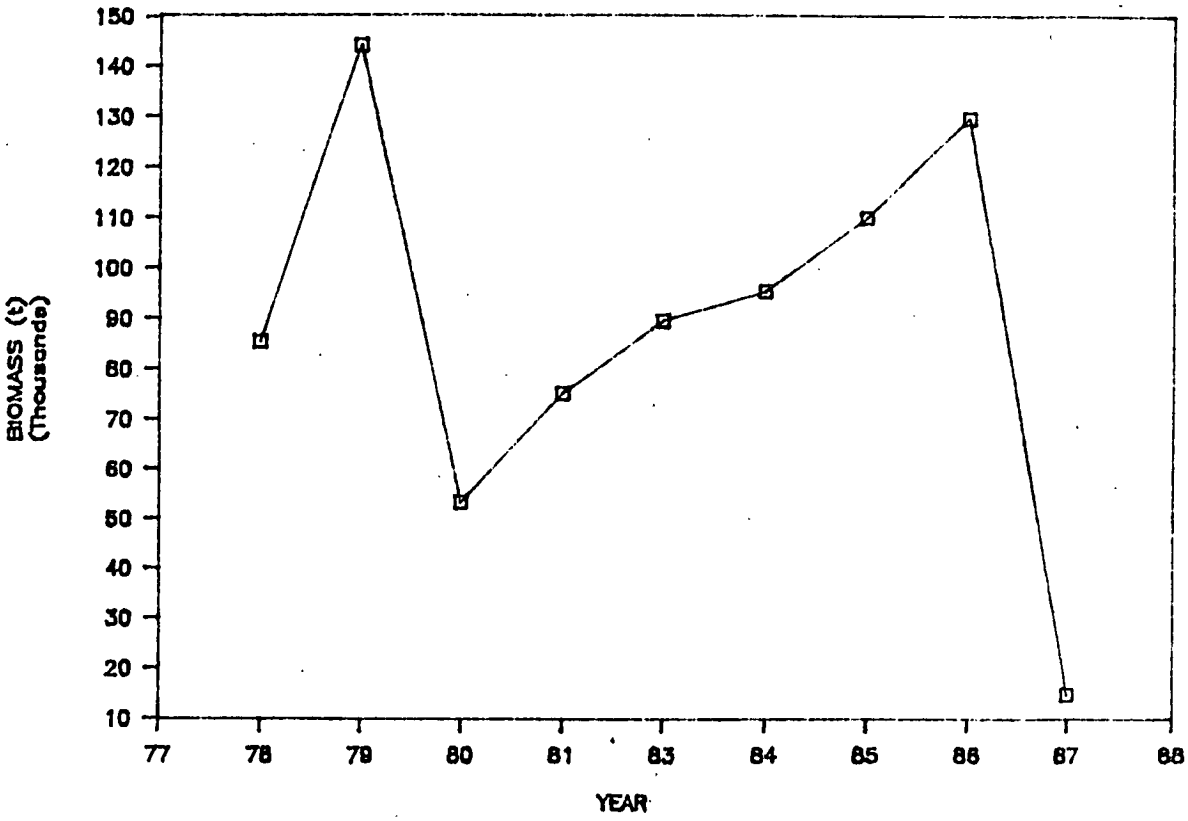


Figure 9. Minimum exploitable biomass of redfish in Divisions 4RST as estimated by random stratified surveys on the Gadus Atlantica.

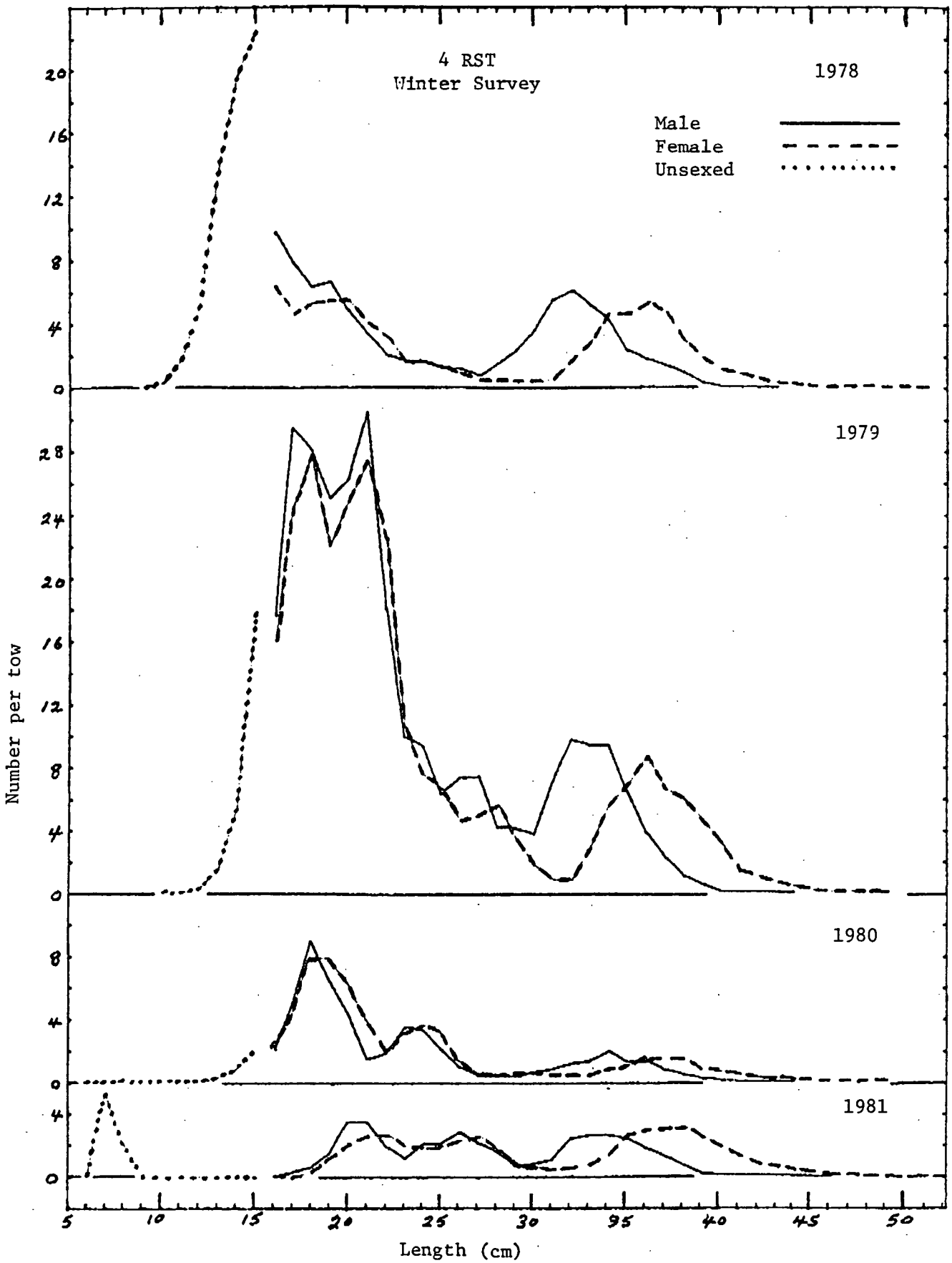


Figure 10. Length frequency distributions for Divisions 4RST redfish from winter research surveys, 1978-1981 (provided by B. Atkinson).

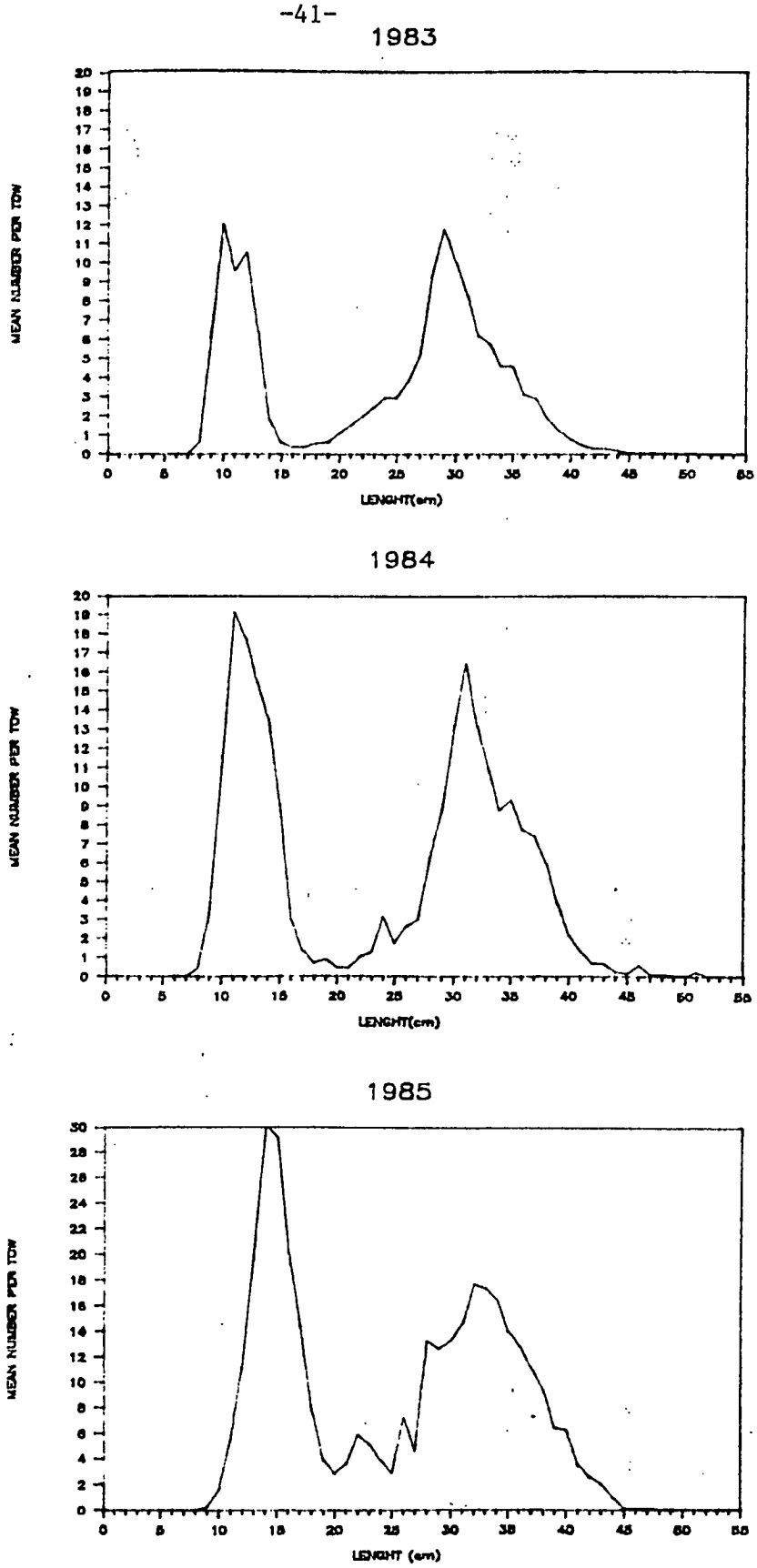
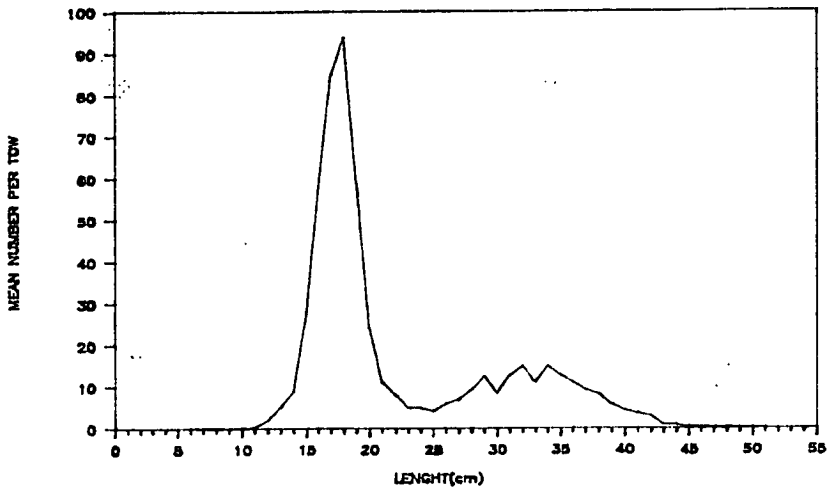


Figure 11. Length frequency distributions for Divisions 4RST redfish from winter research surveys, 1983-1987.

1986



1987

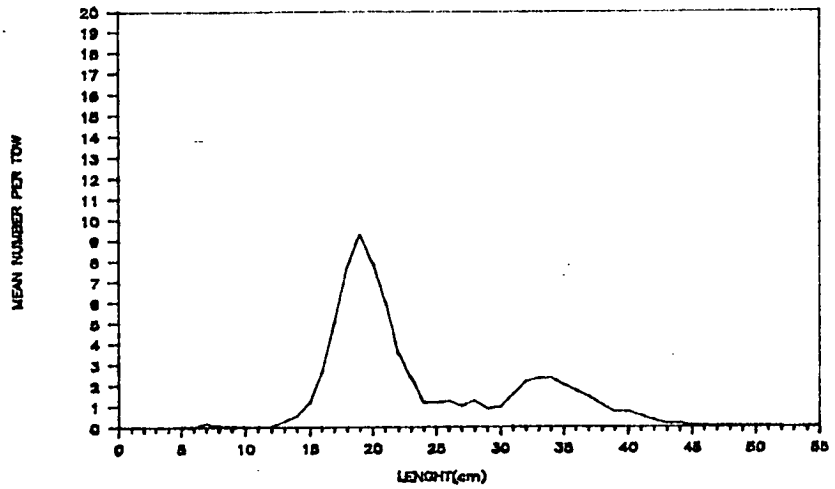


Figure 11.(Cont'd)

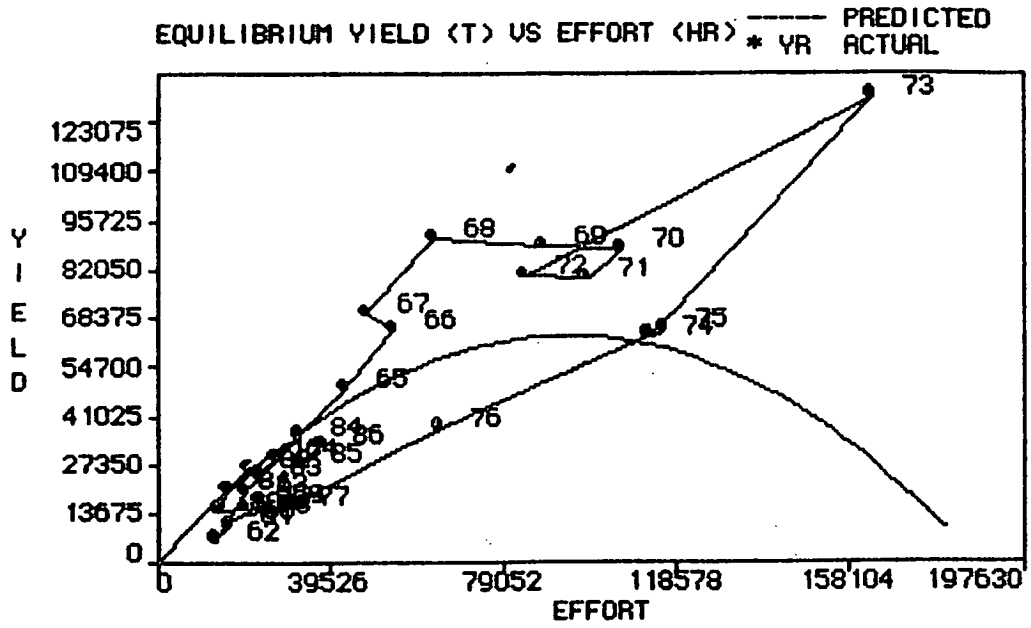


Figure 12. Transient trajectory and equilibrium Schaefer curve for Divisions 4RST redfish.

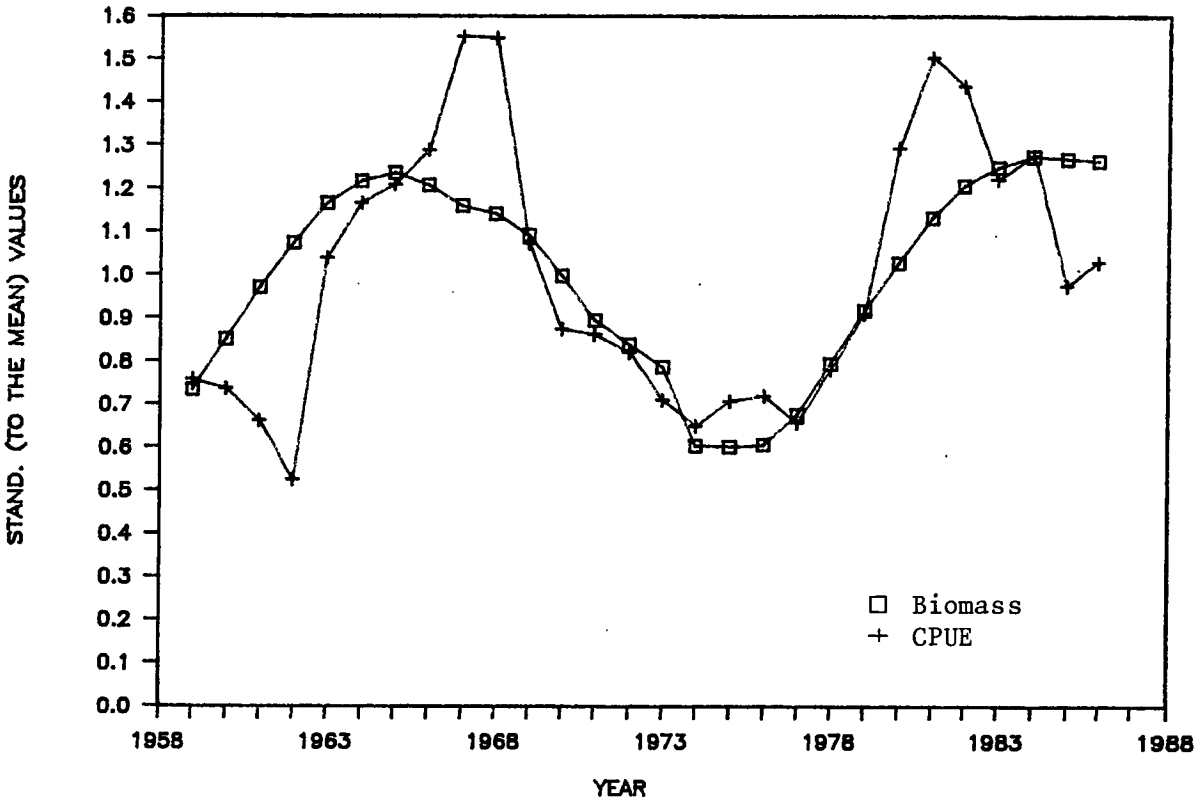


Figure 13. Comparison of standardized catch rates and biomass as estimated from the non-equilibrium version of the Schaefer model for Divisions 4RST redfish.

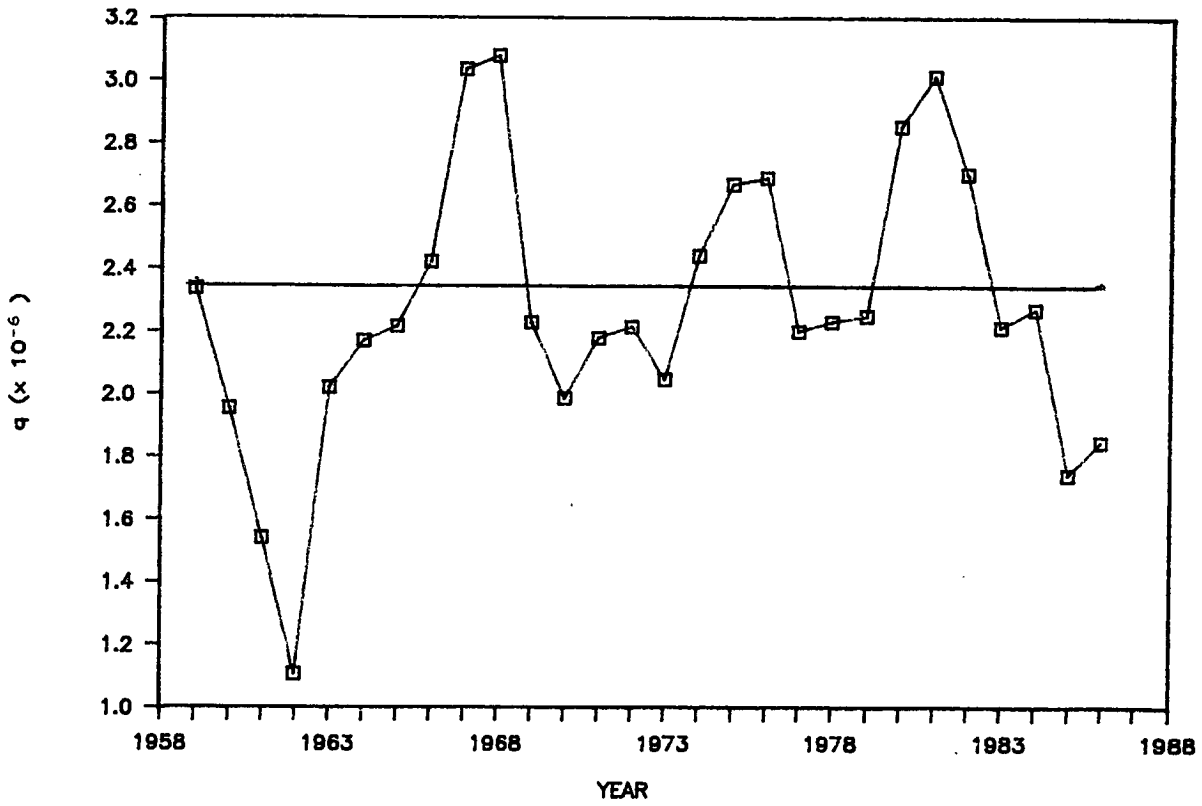


Figure 14. Yearly catchability coefficients for Divisions 4RST redfish. The straight line represents the catchability coefficient resulting from the Schaefer production model estimate under non-equilibrium conditions.