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Assessment of Divisions 4RST Redfish (Sebastes spp.)

by

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ABSTRACT

Reported landings for the NAFO Divisions 4RST redfish fishery in 1987 were estimated at 34,137 t, which represent 70% of the TAC. Most of the fishing activity (46%) has occurred in Division 4S. The midwater trawl component of the fleet increased their share of the total catch from 3% recorded in 1986 to 29% in 1987. The catch-at-age analysis indicate the presence of 3 modes: the partly recruited 8 year old fish, at a mean length of 23.9 cm, the 17 year old fish, at a mean length of 32.3 cm, and the 25 year old fish, at a mean length of 35.6 cm. The length frequency data from the 1987 summer research survey show similar modes, and further suggest the presence of a new pulse of recruitment, indicated by a mode at 8-9 cm. It is too soon to judge the strength of that pulse. Catch rates for side and stern trawlers were analyzed separately using a multiplicative model. The catch rate series shows 2 peaks of equal importance (1.28 t/h), one in 1967-1968 and the other in 1981-1982, and have declined since then; the 1987 catch rate represents a 14% decrease over last year value. Results from the non-equilibrium version of the Schaefer general production model indicate that the stock size is fairly stable. Because of uncertainties with regard to the changes in availability of fish to the gear, as reflected by the decrease in catch rates, and therefore the effort levels implied to reach the maximum equilibrium yield (MEY), it is recommended that the catch for 1989 stays at the $2/3f_{mey}$ equilibrium yield level of 56,000 t.

RESUME

Les débarquements totaux de sébaste des Divisions 4RST de l'OPANO ont été évalués à 34,137 t pour 1987, représentant 70% des TPA. L'activité de pêche a été plus intensive dans la Division 4S, avec 46% des débarquements. La part des prises totales effectuée par les chalutiers munis de chaluts pélagiques est passée de 3% en 1986 à 29% en 1987. Les données de capture à l'âge indiquent la présence de 3 modes: le premier est constitué des poissons de 8 ans qui, à une taille moyenne de 23.9 cm, sont partiellement recrutés à la pêche; le deuxième est formé par les poissons de 17 ans qui atteignent 32.3 cm; le troisième est formé des poissons de 25 ans, à une longueur moyenne de 35.6 cm. Ces longueurs modales sont aussi mises en évidence dans les données de fréquence de longueur du relevé de recherche de l'été 1987. Ces données suggèrent de plus la possibilité d'un nouveau pic de recrutement, par la présence d'un mode à 8-9 cm. Il est cependant trop tôt pour juger de la force de cette nouvelle classe d'âge. Les taux de prises des chalutiers à pêche arrière et latérale 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 de même importance (1.28 t/h), un premier en 1967-1968 et l'autre en 1981-1982, suivis d'une diminution; le taux de prises observé en 1987 constitue une diminution de 14% sur la valeur enregistrée en 1986. Les résultats d'une version de non-équilibre du modèle de production de Schaefer indiquent une certaine stabilité de la biomasse exploitable. Cependant, le modèle est imprécis quant à l'estimation du niveau d'effort associé au rendement maximum à l'équilibre (RME). Etant donné cette incertitude, couplée au fait que les taux de prises sont anormalement bas depuis les quelques dernières années, le TPA pour 1989 a été établi, sur la base du rendement au point $2/3f_{mey}$, à 56,000 t.

1. INTRODUCTION

1.1. The fishery

The recorded landings for the Divisions 4RST redfish increased steadily during the 1960's to reach a peak of 130,000 t in 1973, then declined sharply to 13,000 t in 1978, to slowly increase again and have, for the last few years, fluctuated around 30,000 t (Fig. 1).

The peak landing in 1973 resulted from 3 main factors: 1) the availability to the fishery of the fully-recruited 1956 and 1958 year-classes which were particularly strong 2) the presence in the Gulf of large trawlers from Newfoundland and Nova-Scotia, subsequently to quota limitations for redfish in the fishing zones outside the Gulf and 3) the introduction of the use of midwater trawls (Maguire et al., 1983). The drop in the catches recorded in the following years incited the implementation of a quota system for the Gulf redfish in 1976 (Table 1). It is to be noted that, except for 1976 and 1981, the landings have been below the TAC level. However, in recent years some components of the fishing fleet have caught their allocation (Table 2) and have applied for transfers.

Following the extension of fishing jurisdiction to 200 miles in 1977, the Gulf redfish stock is exploited only by Canada except for a 1% allocation to the Saint-Pierre and Miquelon and the Metropolitan France fleets. Historically, most of the fishing is prosecuted by the mobile fleet of vessels equipped with bottom and midwater trawls.

1.2. Nominal catches

The reported landings of 34,137 t in 1987 constitute a small increase relatively to last year figure (Table 1), but is still representing only 70% of the TAC (Table 2). 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. This increase is due mainly to larger catch reported in 1987 for three components of the fleet, namely the large Gulf based vessels, the vessels smaller than 100 feet other than the shrimp trawlers, and the fixed gears (Table 2).

The nominal catches for 1987, 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. Similarly to last year (Laberge et al., 1987), most of the fishing activity has occurred in NAFO Division 4S, with 46% of the total landings. There was however an increase in the catches reported for both Divisions 4R and 4T with respectively 35% and 19% of the total catch compared to 32% and 14% recorded last year. Fishing activities are prosecuted all through the year but are more intensive in the June to December period (Table 3d). One of the major change observed in 1987 is the increased importance of the midwater trawl (OTM) component of the fleet, which accounted for 29% of the total catch, compared to 3% recorded last year.

2. COMMERCIAL SAMPLING DATA.

Sampling of the Divisions 4RST redfish fishery, composed of both sea and port samples, was adequate for the 3rd and 4th quarters, when most of the landings occurred, but not as good for the first half of the year (Table 4). The data obtained from the observer programs of the different regions were brought to a level equivalent to the port sampling (1 sample per trip) by 1) combining within one trip the weighted length frequencies (by the catch weight per tow) and 2) applying the proportion at length from the resulting global length frequency to the total number of fish measured for that trip to obtained a "sample level" length frequency. The sample weight was then estimated using the length-weight relationship given in Maguire et al. (1983) and associated to the trip weight. These modified data were merged to the port sampling data in order to obtain monthly length frequency distributions.

Length frequencies for each quarter (Fig. 2) were associated to equivalent age-length keys to obtain quarterly age frequencies. Those were subsequently combined to derive the catch at age for the commercial landings (Table 5). The results indicate the presence of 3 modes: the partly recruited 8 year old fish, at a mean length of 23.9 cm, the 17 year old fish, at a mean length of 32.3 cm, and, to a lesser extent, the 25 year old fish, at a mean length of 35.6 cm. The discrepancy between these modes and the ones depicted in the length frequencies is a consequence of the large range of length for a given age (ex: the length of an 8 year old fish may vary between 17 and 26 cm) which is characteristic to redfish. As the age composition of the catch is based on proportions (prop. at age for each length x prop. of each length in the catch), a large spread in the age-length key will produce differences such as the ones observed in the present study. Because of a recently discovered problem with the software used to analyse catch-at-age data for the last few years (CATCH.WS software, Anon. MS, 1986) comparison of age compositions between years could not be done.

The mean length at age for the 5 to 10 year old fish seems somewhat high. A possible aging problem was rejected as the age determinations effectuated by the Quebec readers for those small fish were corroborated at the Fisheries Centre in Newfoundland. The situation will be investigated further. However, it is worth pointing out that the mean length of those 8 year old fish corresponds to the mode in the length frequency (mean number per tow) recorded from the 1987 summer research survey (see next section).

A comparison of length frequencies from the 1987 fishery (Fig. 3) indicated that midwater trawlers caught smaller fish than otter trawlers in contrast to what was observed in the previous years. This will be monitored in 1988. Comparisons between the shrimp and midwater trawls length frequencies from 1986 fishery (Laberge et al., 1987) had shown that the former gear fished smaller sized individuals. This was not observed in 1987 and the differences seen in 1986 could not be explained.

3. COMMERCIAL CATCH RATES.

Catch and effort data from ICNAF/NAFO Statistical Bulletins for the period 1959-1985 were combined with provisional data for 1986 and 1987, 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). Following a recommandation by CAFSAC in 1987, the side and stern bottom trawlers were separated using the information from the ICNAF/NAFO statistical bulletins. As no distinction between side and stern trawlers was made by NAFO for the years prior to 1966, and given the fact that tonnage 4 and 5 stern trawlers are of a more recent construction (mostly after 1968), all the catch and effort data for the period 1959-1965 were assigned to side trawlers. The resulting dataset was analysed using a multiplicative model (Gavaris, 1980) to derive a standardized catch rate series, deleting the 1972-1974 midwater trawl and the 1974 Engels high lift trawl data as was done last year (Laberge et al., 1987). The data were weighted by a factor derived from the residuals (function EGLS) ranked on 5 levels of effort.

The regression analysis (Table 6) explained only 43% of the variation in the data, but all category types were highly significant, and the plot of the residuals (Fig. 4) does not show the presence of any obvious outliers. The similarity in the regression coefficients for the side and stern trawlers (Table 7) would tend to indicate that there no significant difference in their catch rates.

The resulting catch rate series shows two distinct peaks in 1967-1968 and 1981-1982, followed by a rapid decline up to 1985 (Fig. 5). After a small increase in 1986, the catch rate is down again in 1987 by a factor of 14%. It corresponds to the level recorded in 1979 (Table 8).

4. RESEARCH SURVEY DATA.

Two series of stratified random groundfish surveys are available to monitor the Gulf redfish stock. Since 1978, a winter survey is conducted in January on the GADUS ATLANTICA in the Divisions 4RST and Subdivision 3Pn and oriented mainly towards cod. Complete coverage of the entire area has never been accomplished because of ice cover. A summer (July-August) survey series has been initiated in 1984 on the M/V Lady Hammond to cover the same region but is this time oriented towards redfish. For the summer survey of 1987, the stratification of the Gulf has been extended to cover the Saint Lawrence estuary up to Les Escoumins on the Quebec north shore. The new stratification scheme used in both surveys is presented in Figure 6. The strata 835 and 836 with depth range between 30 and 50 fathoms are not sampled during the summer survey.

The database from the summer surveys (1984-1986) has been edited to assure compatibility with the STRAP analysis program for stratified research surveys. In the course of that editing, all the information concerning the tows, i.e. positions, depth, distance towed, success of the tow, were verified and some corrections were made, mainly in 1985. The congruence between length frequency information, weight of the catch and ratio subsampled was verified by applying the length-weight relationship given in Maguire et al. (1983) to the length frequency to obtain the theoretical weight of the sample. If the difference between the theoretical and recorded sample weight was greater than 30%, the theoretical sample weight was taken as the true value and the ratio changed accordingly. These corrections applied to approximatly 15% of the sets.

The distributions of the catches from the summer research surveys (Fig. 7) do not seem to indicate any major difference in the distribution of redfish through the years. However, the sampling design of 1985 (fixed allocation of set per stratum vs proportionnal allocation) makes the comparison with the other years difficult to interpret. Redfish tend to consistently be found in greater abundance in the area southeast of Anticosti (strata 809, 810 and 404) (Table 9), in a depth range of 276-366 m (151-200 fms). The between year variations in the minimum exploitable biomass are presented in Figure 8a. The estimated values for the 1984 and 1985 are lower than the ones presented in Rubec et al. (1986) (426,095 t and 368,606 t vs 473,209 t. and 486,882 t). The modifications to the database and the fact that our present 1984 estimate was not adjusted to account for strata not sampled can account for the difference. Given the limitation of the series (few data points and large confidence intervals), the biomass of redfish in the Gulf seems to be relatively constant. It is to be noted that the research survey estimated biomass value for 1987 (450,509 t) is close to the estimated level of biomass at the beginning of 1987 (473,390 t) as projected from the non-equilibrium Schaefer model in last year assessment (Laberge et al., 1987).

Examination of the length frequencies (Fig. 9) indicates relatively strong recruitment of the 1979-1980 year-classes and their progression from a modal length of 13 cm in 1984 to a modal length of 23 cm in 1987. The data from the 1987 summer research survey suggest the presence of a new pulse of recruitment, with the presence of a mode at 8-9 cm. It is, however, too soon to judge the strength of this new pulse.

An estimated biomass of 4,271 t was obtained for the new region covered by the survey in 1987 (extension of Division 4T to the Saint Lawrence estuary). The coverage of that new zone was minimal, mainly due to bad weather in the last part of the survey and the presence of fixed gear in the area. This estimate should therefore be taken with caution. The size composition of the catch is dominated by small fish (Fig. 10).

A similar series of data is presented for the winter research surveys. (Table 10, Fig. 11 and 12). The interannual variations in distribution and abundance are probably related to the state in the migration of the fish at the time of the surveys. The tendency for the fish to concentrate in the southern portion of Division 4R and in Subdivision 3Pn is most evident for the last 2 years. As part of the stock may be unavailable to the survey, the trend in biomass observed from the winter research survey series (Fig. 8b) is not thought to be indicative of a decrease in stock size.

5. PRODUCTION MODEL.

The large number of ages present in the population and the low level of fishing mortality in recent years renders sequential population analysis inappropriate for this stock. Since there are significant year effects in the multiplicative analysis of commercial catch and effort data, a general production model is considered as a suitable analytical technique to obtain the assessment parameters. The Divisions 4RST redfish stock is not in a steady state. The catch rate series indicate that the stock 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.

The parameters estimated by the model in the present assessment are very similar to last year values (Table 11). There is a small increase in maximum equilibrium yield (MEY), a decrease in catchability coefficient (q) and the virgin stock biomass (B) stays at the same level. The standard statistics for those parameters are presented in Table 12 while the transient (non-equilibrium) yield levels predicted by the model are given in Table 13 and Figure 13. The model has a coefficient of determination (R^2) of 0.949 (i.e. 95% of the variation in the transient yield is explained by the model).

Although the parameters of the non-equilibrium model are 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 (Fig. 14). 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. Further, a precise estimation of the location of the downward limb of the equilibrium curve is not possible, reducing the confidence in the estimation of effort at MEY for the stock.

The trajectory of the transient yields around the equilibrium curve indicates that 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 appeared strong, they have not brought the stock to or above the equilibrium level.

Results of this assessment (Table 13) indicates that the stock size has been fairly stable in recent years. This is consistent with the summer research survey data (Fig. 8a). However, there is an overall decline in commercial catch rates since 1983. Changes in fish behaviour or distribution due to possible environmental factors may bring about changes in the availability of the fish to fishing gears, unrelated to any changes in abundance. This is exemplified by the trends in yearly catchabilities (Fig. 15), the values for the last 3 years being below average. This means that catch rates are lower than could be expected (by the presence of strong year-classes) and that while more effort would be needed to take a given catch, this would not increase fishing mortality.

6. MANAGEMENT IMPLICATIONS.

Results of the non-equilibrium Schaefer model indicate a biomass level of 470,702 t at the beginning of 1988 and a fishing mortality rate of 0.100. At $2/3f_{mey}$, the projected transient (non-equilibrium) yield for 1989 was estimated at 64,404 t, which is similar to the one estimated for 1988 (64,225 t) in last year assessment. This catch would correspond to a fishing mortality rate of 0.15. This yield is above the equilibrium $2/3f_{mey}$ of 56,925 t, but very close to the MEY level (64,040 t). While we cannot define precisely how the current fishing mortality relates to the reference f-level (i.e. $2/3\ f_{mey}$), it is clear that the equilibrium catch estimated in the "60,000-70,000 hrs" range is well estimated. It must be noted that the projected yields for both years 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).

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.

Results from this assessment shows that the stock size has been fairly stable in the last few years. The estimated transient yields for the near future should remain above equilibrium yield at $2/3f_{mey}$ if catches stay at the present level. It was noted, however, that the catchability coefficients have been below average for the last 3 years and that the catch rates continue to decline probably as a result of that phenomena. On the other hand, there is good indication, both from the summer research surveys and catch at age composition of the commercial landings, that a strong year-class is close of being fully recruited.

Considering all these observations, it is therefore recommended that the TAC remains at the equilibrium yield at $2/3f_{mey}$ (56,000 t) until the early 1980's year-classes are fully recruited and catch rates increase again.

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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				7629	74	1773	1795				3642	16000	15034
1980	709	2476	1567	57			4809	184	2444	5497				8125		668	1230				1898	16000	14832
1981	1207	3802	2660	16			7685	411	3618	6144				10173	270	1100	1321				2691	20000	20549
1982	1880	4028	3492	10			9410	358	6792	6647				13797	117	498	2607				3222	28000	26429
																						31000a	
1983	2015	5049	3361	38			10463	36	6963	4496				11495	41	656	1850				2547	31000	24505
																						33000a	
1984	2332	7386	2408	7			12133	81	5198	7421				12700	1	5938	4049				9988	50600	34821
1985	3204	6904	1357	2			11467	747	7196	5086				13029	2	766	2791				3559	50600	28055
1986*	1983	8466	260				10709	1337	10269	6437				18043	5	1594	2756				4355	55600	33107
1987*	1460	8953	1543				11956	1134	5979	8483				15596	7	1819	4759				6585	50000	34137

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.

YEARS		M.G. > 100' GBV	M.G. > 100' NGBV	M.G. < 100' BCSF	M.G. < 100' OTHERS	F.G. < 65'	FRANCE	TOTAL
	Final allocation	7900	1000	1500	5000		600	16000
1980	Reported catch	8173	975	1232	5069		57	15506
	Ratio (%)	103	98	82	101		10	97
	Final allocation	8400	2000	1500	7500		600	20000
1981	Reported catch	8909	1891	875	9217		16	20908
	Ratio (%)	106	95	58	123		3	105
	Final allocation	12300	3600	1500	12300	700	600	31000
1982	Reported catch	12218	3659	1083	8613	89	10	25672
	Ratio (%)	99	102	72	70	13	2	83
	Final allocation	12300	5600	1500	12300	700	600	33000
1983	Reported catch	10913	5267	716	7437	193	38	24564
	Ratio (%)	89	94	48	60	28	6	74
	Final allocation	37500		1500	10700	300	600	50600
1984	Reported catch	24767		1343	7436	126	7	33679
	Ratio (%)	66		90	69	42	1	67
	Final allocation	26250	11250	1500	10700	300	600	50600
1985	Reported catch	12319	10978	959	4318	66	2	28642
	Ratio (%)	47	98	64	40	22	0	57
	Final allocation	27500	15000	1500	10700	300	600	55600
1986	Reported catch	13136	15594	828	4229	101	0	33888
	Ratio (%)	48	104	55	40	34	0	61
	Final allocation	22750	14750	1500	10700	300		50000
1987*	Reported catch	14603	14343	806	4686	361		34799
	Ratio (%)	64	97	54	44	120		70

NOTE: M.G.= Mobile Gear
F.G.= Fixed Gear
GBV = Gulf Based Vessels
NGBV = Non Gulf Based Vessels
BCSF = By Catch Shrimp Fishery
* = provisional data (weekly quota report Dec.31,1987)

Table 3a. Preliminary catch statistics (t) for redfish in Division 4R in 1987.

CANADA-NEWFOUNDLAND

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	4-5	0	0	0	0	0	2	3	0	13	0	0	0	18
OTB2	1-3	13	0	1	9	16	25	13	15	18	3	0	8	121
	4-5	7	0	1	21	157	55	104	402	78	48	105	191	1169
ST	1-3	0	0	13	4	15	34	3	19	18	16	4	6	132
GNS	1-3	0	0	0	0	3	4	3	1	2	3	1	1	18
LLS	1-3	0	0	0	0	0	0	0	2	0	0	0	0	2
TOTAL		20	0	15	34	191	120	126	439	129	70	110	206	1460

CANADA-MARITIMES

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	1-3	0	0	0	0	0	0	0	0	2	0	2	0	4
	4-5	0	0	0	0	93	378	733	603	447	337	115	0	2706
OTB2	4-5	650	175	0	0	43	677	269	444	443	496	215	533	3945
OTM	4-5	754	209	0	222	409	18	6	116	90	0	41	389	2254
ST	1-3	0	0	0	0	0	11	17	8	7	1	0	0	44
Total		1404	384	0	222	545	1084	1025	1171	989	834	373	922	8953

CANADA-QUEBEC

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB2	4-5	0	0	0	1	2	8	0	76	203	0	0	0	290
OTM	4-5	0	0	0	0	302	0	2	5	248	81	34	580	1252
ST	1-3	0	0	0	0	0	0	1	0	0	0	0	0	1
Total		0	0	0	1	304	8	3	81	451	81	34	580	1543

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Div. total	1424	384	15	257	1040	1212	1154	1691	1569	985	517	1708	11956

NOTE: OTB1 = Bottom trawl, side; OTB2 = Bottom trawl, stern; OTM = Midwater trawl; ST = Shrimp trawl; GNS = Set gillnets; LLS = Set longlines

Table 3b. Preliminary catch statistics (t) for redfish in Division 4S in 1987.

CANADA-NEWFOUNDLAND

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	1-3	0	0	0	0	0	0	0	0	0	0	0	39	39
	4-5	0	0	0	0	0	44	0	0	0	0	0	0	44
OTB2	1-3	0	0	0	0	0	0	0	0	0	0	13	0	13
	4-5	0	0	0	263	50	9	51	38	111	77	187	252	1038
Total		0	0	0	263	50	53	51	38	111	77	200	291	1134

CANADA-MARITIMES

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	1-3	0	0	0	0	0	0	1	0	0	0	0	0	1
	4-5	0	0	0	0	0	444	171	334	407	265	5	0	1626
OTB2	1-3	0	0	0	0	0	0	0	0	0	0	1	0	1
	4-5	14	0	0	20	80	269	715	786	818	251	494	410	3857
OTM	4-5	1	0	0	61	0	0	3	8	19	0	51	108	251
ST	1-3	0	0	0	26	41	32	38	41	32	24	0	0	234
	4-5	0	0	0	0	3	1	5	0	0	0	0	0	9
Total		15	0	0	107	124	746	933	1169	1276	540	551	518	5979

CANADA-QUEBEC

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	1-3	0	0	0	0	0	24	130	76	14	72	0	0	316
OTB2	1-3	0	0	0	0	1	84	229	119	48	20	6	0	507
	4-5	0	0	0	0	240	751	685	543	537	606	85	0	3447
OTM	4-5	0	0	0	0	310	61	228	424	694	977	733	242	3669
ST	1-3	0	0	0	29	52	100	76	63	62	16	2	0	400
GNS	1-3	0	0	0	0	4	32	41	49	13	1	0	0	140
LLS	1-3	0	0	0	0	1	2	1	0	0	0	0	0	4
Total		0	0	0	29	608	1054	1390	1274	1368	1692	826	242	8483

Div. total	15	0	0	399	782	1853	2374	2481	2755	2309	1577	1051	15596

NOTE: OTB1 = Bottom trawl, side; OTB2 = Bottom trawl, stern; OTM = Midwater trawl; ST = Shrimp trawl; GNS = Set gillnets; LLS = Set longlines

Table 3c. Preliminary catch statistics (t) for redfish in Division 4T in 1987.

CANADA-NEWFOUNDLAND

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB2	4-5	0	0	0	0	0	0	0	0	7	0	0	0	7
Total		0	0	0	0	0	0	0	0	7	0	0	0	7

CANADA-MARITIMES

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	1-3	0	0	0	0	0	0	0	17	7	3	0	0	27
	4-5	0	0	0	0	16	0	0	125	0	0	0	0	141
OTB2	1-3	0	0	0	0	1	10	2	5	1	1	1	0	21
	4-5	0	0	0	0	13	365	519	81	190	20	231	9	1428
OTM	4-5	0	0	0	189	0	0	0	0	0	0	0	0	189
SDN	1-3	0	0	0	0	0	0	0	0	0	4	3	0	7
Others	1-3	0	0	0	0	0	0	6	0	0	0	0	0	6
Total		0	0	0	189	30	375	527	228	198	28	235	9	1819

CANADA-QUEBEC

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	1-3	0	0	0	0	1	2	12	2	0	31	1	0	49
OTB2	1-3	0	0	0	1	6	20	39	42	13	36	0	0	157
	4-5	0	0	0	0	111	434	805	628	156	21	0	0	2155
OTM	1-3	0	0	0	0	0	0	0	0	0	2	0	0	2
	4-5	0	0	0	0	169	995	525	251	126	69	1	0	2136
ST	1-3	0	0	0	1	1	1	13	15	0	0	0	0	31
GNS	1-3	0	0	0	1	21	35	50	55	18	2	0	0	182
LLS	1-3	0	0	0	0	4	4	9	22	6	2	0	0	47
Total		0	0	0	3	313	1491	1453	1015	319	163	2	0	4759
Div. total		0	0	0	192	343	1866	1980	1243	524	191	237	9	6585

NOTE: OTB1 = Bottom trawl, side; OTB2 = Bottom trawl, stern; OTM = Midwater trawl; ST = Shrimp trawl; GNS = Set gillnets; LLS = Set longlines; SDN = Danish seine

Table 3d. Preliminary catch statistics (t) for redfish in Divisions 4RST in 1987.

CANADA-NEWFOUNDLAND

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	1-3	0	0	0	0	0	0	0	0	0	0	0	39	39
	4-5	0	0	0	0	0	46	3	0	13	0	0	0	62
OTB2	1-3	13	0	1	9	16	25	13	15	18	3	13	8	134
	4-5	7	0	1	284	207	64	155	440	196	125	292	443	2214
ST	1-3	0	0	13	4	15	34	3	19	18	16	4	6	132
GNS	1-3	0	0	0	0	3	4	3	1	2	3	1	1	18
LL	1-3	0	0	0	0	0	0	0	2	0	0	0	0	2
Total		20	0	15	297	241	173	177	477	247	147	310	497	2601

CANADA-MARITIMES

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	1-3	0	0	0	0	0	0	1	17	9	3	2	0	32
	4-5	0	0	0	0	109	822	904	1062	854	602	120	0	4473
OTB2	1-3	0	0	0	0	1	10	2	5	1	1	2	0	22
	4-5	664	175	0	20	136	1311	1503	1311	1451	767	940	952	9230
OTM	4-5	755	209	0	472	409	18	9	124	109	0	92	497	2694
ST	1-3	0	0	0	26	41	43	55	49	39	25	0	0	278
	4-5	0	0	0	0	3	1	5	0	0	0	0	0	9
SDN	1-3	0	0	0	0	0	0	0	0	0	4	3	0	7
Others	1-3	0	0	0	0	0	0	6	0	0	0	0	0	6
Total		1419	384	0	518	699	2205	2485	2568	2463	1402	1159	1449	16751

CANADA-QUEBEC

Gear	Ton	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OTB1	1-3	0	0	0	0	1	26	142	78	14	103	1	0	365
OTB2	1-3	0	0	0	1	7	104	268	161	61	56	6	0	664
	4-5	0	0	0	1	353	1193	1490	1247	896	627	85	0	5892
OTM	1-3	0	0	0	0	0	0	0	0	0	2	0	0	2
	4-5	0	0	0	0	781	1056	755	680	1068	1127	768	822	7057
ST	1-3	0	0	0	30	53	101	90	78	62	16	2	0	432
GNS	1-3	0	0	0	1	25	67	91	104	31	3	0	0	322
LLS	1-3	0	0	0	0	5	6	10	22	6	2	0	0	51
Total		0	0	0	33	1225	2553	2846	2370	2138	1936	862	822	14785

GRAND TOTAL	1439	384	15	848	2165	4931	5508	5415	4848	3485	2331	2768	34137

NOTE: OTB1 = Bottom trawl,side; OTB2 = Bottom trawl,stern
OTM = Midwater trawl; ST = Shrimp trawl
GNS = Set gillnets; LLS = Set longlines
SDN = Danish seine; Others= Non specified

Table 4. Commercial sampling of Divisions 4RST redfish for 1987: the number of fish measured (/number of fish aged) provided by all the regions and how they were distributed through months and main gears.

DIVISION	GEAR	MONTHS											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
4R	OTB			452/ 64			3821/ 95		1252/ 20	357/ 39	727/ 0		
	OTM	1513/ 0	147/ 0			963/ 30			1252/ 0	2335/ 37	250/ 33		
	ST							247/ 31	356/ 39		253/ 19		
	GN							167/ 35					
4S	OTB						1864/290	4477/245	1175/149	1032/212	4605/359	655/ 81	
	OTM					357/ 65		2620/ 67	1252/ 0	2335/ 38	753/102	2741/ 20	505/ 34
	ST						267/ 25	342/ 91	113/ 0	265/ 26			
4T	OTB						3640/ 33	2076/ 81	559/ 64	250/ 41	696/136		
	OTM					263/ 34	674/107	2874/ 82	119/ 39			255/ 0	
	ST												

NOTE:
OTB = Bottom trawl
OTM = Midwater trawl
ST = Shrimp trawl
GN = Gillnets

Table 5. Divisions 4RST redfish catch-at-age (thousands) and average weight (kg) and length (cm) in the commercial fishery in 1987.

	AVERAGE			CATCH		
AGE	WEIGHT	LENGTH	NB. OBS.	MEAN	STD. ERR.	C.V.
5	0.116	19.837	39	639	162.82	0.25
6	0.159	22.028	144	2790	377.72	0.14
7	0.178	22.933	204	6508	579.33	0.09
8	0.201	23.924	203	9334	695.13	0.07
9	0.215	24.488	131	7144	630.23	0.09
10	0.241	25.426	136	7308	619.04	0.08
11	0.260	26.108	119	6540	581.90	0.09
12	0.312	27.720	112	5258	485.26	0.09
13	0.352	28.884	115	5925	537.45	0.09
14	0.379	29.554	107	5319	490.42	0.09
15	0.406	30.358	141	7859	625.48	0.08
16	0.465	31.691	109	6720	637.54	0.09
17	0.495	32.340	122	8007	706.00	0.09
18	0.525	32.980	103	7453	721.18	0.10
19	0.545	33.430	79	5912	644.08	0.11
20	0.593	34.297	66	5180	641.91	0.12
21	0.591	34.266	62	4905	607.64	0.12
22	0.635	35.087	45	3579	525.44	0.15
23	0.631	35.015	44	3494	535.37	0.15
24	0.641	35.310	59	4591	578.27	0.13
25	0.659	35.601	77	5971	662.27	0.11
26	0.682	35.910	58	4400	552.34	0.13
27	0.716	36.557	71	4890	570.02	0.12
28	0.719	36.538	65	4319	552.39	0.13
29	0.736	36.910	55	3246	472.37	0.15
30+	0.859	38.784	336	16315	747.01	0.05

TOTAL CATCH: 34129 t

Table 6. Analysis of variance of regression of CPUE against dummy variables. The OTM 1972-1974 and ENG 1974 catch and effort data were deleted.

REGRESSION OF MULTIPLICATIVE MODEL

Multiple R.............0.654
Multiple R squared.....0.428

ANALYSIS OF VARIANCE

Source of variation	DF	Sums of squares	Mean squares	F	p-value
Intercept	1	1.504E0001	1.504E0001		
Regression	46	3.800E0001	8.435E-001	28.723	< 0.001
Ton. class	1	2.651E0000	2.651E0000	90.266	< 0.001
Months	11	3.824E0000	3.476E-001	11.837	< 0.001
Divisions	2	1.760E0000	8.798E-001	29.960	< 0.001
Years	28	1.858E0001	6.637E-001	22.601	< 0.001
Gears	4	3.651E0000	9.128E-001	31.083	< 0.001
Residuals	1769	5.195E0001	2.937E-002		
TOTAL	1816	1.058E0002			

Table 7. Regression coefficients from regression of ln(CPUE) against dummy variables. The 1972-1974 midwater trawl and the 1974 Engel high lift trawl data were deleted

Category		Code	Variable	Coefficient	Std. Error	No. Obs.
Ton. class	(3)	4	Intercept	-0.613	0.087	1816
Jul.	(4)	7				
4R	(5)	41				
1959	(6)	59				
OTB-side	(8)	101				
Ton. class	(3)	5	1	0.305	0.032	402
Jan	(4)	1	2	0.441	0.066	72
Feb		2	3	0.553	0.083	39
Mar		3	4	0.022	0.142	15
Apr		4	5	0.159	0.077	49
May		5	6	-0.105	0.050	115
Jun		6	7	-0.002	0.038	236
Aug		8	8	0.026	0.037	254
Sep		9	9	-0.001	0.038	248
Oct		10	10	-0.053	0.039	230
Nov		11	11	-0.139	0.041	197
Dec		12	12	0.007	0.048	129
4S	(5)	42	13	0.052	0.022	685
4T		43	14	-0.196	0.032	297
Years	(6)	60	15	-0.042	0.116	24
		61	16	-0.142	0.129	18
		62	17	-0.368	0.138	17
		63	18	0.322	0.111	29
		64	19	0.430	0.120	24
		65	20	0.466	0.114	25
		66	21	0.527	0.103	48
		67	22	0.707	0.103	51
		68	23	0.690	0.098	62
		69	24	0.346	0.094	79
		70	25	0.141	0.092	104
		71	26	0.132	0.093	88
		72	27	0.087	0.095	83
		73	28	-0.056	0.096	71
		74	29	-0.154	0.099	52
		75	30	-0.074	0.092	155
		76	31	-0.088	0.106	58
		77	32	-0.151	0.106	48
		78	33	0.039	0.109	45
		79	34	0.157	0.108	43
		80	35	0.518	0.110	40
		81	36	0.707	0.104	75
		82	37	0.666	0.104	76
		83	38	0.529	0.106	60
		84	39	0.555	0.105	69
		85	40	0.284	0.099	108
		86	41	0.339	0.102	99
		87	42	0.181	0.098	144
OTB-stern	(8)	102	43	-0.001	0.034	320
OTM		130	44	0.439	0.042	232
ENG-side		991	45	0.133	0.059	119
ENG-stern		992	46	0.089	0.048	406

Table 8. Predicted catch rates (1959-1987) from regression of ln(CPUE) against dummy variables. The 1972-1974 midwater trawl and the 1974 Engel high lift trawl catch and effort data were deleted from the data series.

	CATCH		CATCH RATE		
YEAR	Weight	Prop.	Mean	S.E.	Effort
1959	16978	0.392	0.630	0.062	26942
1960	12218	0.389	0.604	0.060	20225
1961	10391	0.394	0.546	0.062	19033
1962	6585	0.208	0.435	0.053	15139
1963	19794	0.361	0.870	0.081	22747
1964	29700	0.162	0.968	0.100	30687
1965	48827	0.242	1.005	0.096	48600
1966	65215	0.332	1.069	0.086	60993
1967	70036	0.261	1.280	0.105	54719
1968	90963	0.394	1.259	0.095	72225
1969	88875	0.494	0.893	0.063	99535
1970	87588	0.556	0.727	0.049	120451
1971	79406	0.531	0.721	0.049	110128
1972	80329	0.280	0.689	0.050	116602
1973	130164	0.144	0.597	0.044	218067
1974	63489	0.202	0.541	0.042	117344
1975	65401	0.820	0.587	0.035	111436
1976	37983	0.706	0.578	0.046	65721
1977	15840	0.494	0.543	0.043	29194
1978	13591	0.585	0.656	0.054	20704
1979	15304	0.596	0.738	0.061	20735
1980	14832	0.803	1.059	0.090	14006
1981	20549	0.856	1.281	0.090	16049
1982	26429	0.869	1.230	0.075	21487
1983	24505	0.859	1.073	0.069	22845
1984	34821	0.734	1.101	0.068	31630
1985	28055	0.908	0.840	0.044	33407
1986	33107	0.877	0.887	0.049	37317
1987	34137	0.851	0.758	0.039	45038

Average C.V. for the Mean: 0.078

Standards used: Tonnage class 4
Month July
Division 4S
Gear Engel high lift, stern

Table 9. Average weight (kg) of redfish caught per set, and biomass estimates (t) for Divisions 4R, 4S and 4T, from summer research surveys on the Lady Hammond.
NOTE : * Depth range in fathoms - strata not sampled

	Strata	Depth*	1984	1985	1986	1987
4R	801	151-200	148.7	170.1	316.0	246.0
	802	≥ 201	50.8	140.5	71.7	237.2
	809	151-200	645.9	287.7	357.5	1572.5
	810	151-200	549.3	643.9	711.9	600.5
	811	101-200	410.7	204.9	436.3	418.4
	812	101-200	276.0	282.5	301.4	233.9
	813	101-200	264.0	74.6	50.8	219.5
	820	51-100	1.6	6.7	1.9	15.5
	821	51-100	2.9	1.5	5.4	6.5
	822	51-100	3.4	3.0	1.9	2.2
	823	51-100	3.9	31.4	1.4	1.8
	824	51-100	150.8	79.9	1.5	0.3
	Division biomass		114354	80668	92606	147446
4S	803	≥ 201	120.5	190.5	89.5	327.0
	804	≥ 201	299.9	254.6	103.4	145.2
	805	151-200	114.8	70.9	162.8	86.3
	806	151-200	102.7	284.2	68.6	161.3
	807	151-200	420.0	193.3	167.5	302.0
	808	151-200	256.1	209.0	227.3	385.2
	814	101-150	101.7	556.9	246.8	116.6
	815	101-150	142.1	321.2	394.0	520.6
	816	101-150	100.6	183.5	198.9	48.1
	817	101-150	155.9	91.4	69.5	91.8
	818	101-150	376.4	298.2	299.0	250.3
	819	101-150	755.9	220.8	530.1	510.6
	825	51-100	-	298.7	16.4	-
	826	51-100	-	-	-	-
	827	51-100	-	59.2	20.3	179.4
	828	51-100	-	1.0	2.7	5.5
	829	51-100	-	44.2	2.5	2.8
	830	51-100	215.9	3.8	9.1	1.7
	831	51-100	-	36.8	5.0	203.0
	832	51-100	-	20.2	5.1	44.5
	Division biomass		197114	234870	186309	250463
4T	401	101-150	494.7	131.9	305.3	429.5
	402	101-150	345.8	267.5	210.0	334.5
	403	101-150	-	99.8	244.2	350.5
	404	151-200	929.3	466.1	151.4	597.7
	405	151-200	411.2	144.7	132.1	146.5
	406	151-200	347.6	144.7	127.8	90.4
	407	≥ 201	515.1	196.5	82.7	79.3
	408	≥ 201	272.2	131.8	82.1	46.0
	Division biomass		114627	53070	41083	52598

Table 10. Average weight (kg) of redfish caught per set, and biomass estimates (t) for Divisions 4R, 4S and 4T from winter research surveys on the Gadus Atlantica.
NOTE: * Depth range in fathoms - strata not sampled

	Strata	Depth*	1978	1979	1980	1981	1983	1984	1985	1986	1987	1988
4R	801	151-200	34.17	42.53	0.75	0.55	95.47	79.75	88.50	33.50	3.25	5.00
	802	≥ 201	87.70	672.37	332.67	1271.58	184.09	496.44	354.50	336.57	147.00	191.00
	809	151-200	197.10	403.60	165.92	73.25	156.43	69.40	402.16	86.43	27.83	9.84
	810	151-200	985.97	2442.76	261.56	254.42	1129.40	683.75	804.67	461.00	163.00	166.30
	811	101-150	458.95	1040.12	288.56	173.00	63.21	60.50	1042.96	1127.69	36.35	86.30
	812	101-150	106.32	173.70	6.75	2.36	34.09	115.50	81.93	107.25	2.02	4.44
	813	101-150	58.36	3.41	1.39	1.22	73.83	14.45	28.80	39.44	0.15	2.01
	820	51-100	24.38	12.60	39.75	0.00	5.43	10.00	11.90	1.48	0.60	1.83
	821	51-100	2.49	7.80	3.19	1.25	25.23	5.90	2.30	1.83	7.42	1.46
	822	51-100	0.15	3.80	0.97	0.54	3.33	0.53	4.91	4.80	0.06	1.32
	823	51-100	2.04	0.45	0.50	-	3.80	25.00	4.33	-	-	-
	824	51-100	-	0.45	0.00	0.05	1.90	2.18	4.00	0.75	-	0.30
Division biomass			62927	128968	31640	50958	45821	46619	88701	69401	9805	12634
4S	803	≥ 201	53.67	-	107.56	129.00	11.72	12.53	56.53	307.21	28.56	18.21
	804	≥ 201	3.78	-	11.50	6.67	8.00	9.30	7.17	-	7.20	-
	805	151-200	-	-	3.62	9.25	4.50	-	-	-	-	-
	806	151-200	3.02	-	4.27	2.13	2.40	-	-	-	-	-
	807	151-200	122.78	13.16	2.07	4.13	9.70	6.52	12.33	14.80	9.22	5.03
	808	151-200	77.27	118.83	25.67	10.00	193.75	42.90	29.17	48.85	14.06	102.43
	814	101-150	195.04	1.51	0.63	1.75	42.93	5.00	116.04	0.00	2.40	0.90
	815	101-150	5.22	19.86	5.83	19.86	161.20	424.44	68.30	7.50	9.36	3.55
	816	101-150	3.67	17.56	3.53	0.44	74.31	8.25	12.38	-	-	2.24
	817	101-150	-	-	1.65	0.03	0.07	-	-	-	-	-
	818	101-150	13.83	-	2.00	0.87	2.73	-	-	-	-	-
	819	101-150	10.32	81.94	5.70	3.75	10.33	7.40	67.21	21.96	14.58	2.97
	825	51-100	-	-	0.25	0.11	3.60	-	-	-	-	-
	826	51-100	-	-	0.00	0.00	0.00	-	-	-	-	-
	827	51-100	0.85	-	0.05	0.40	3.80	0.30	0.04	0.00	-	0.56
	828	51-100	0.79	-	2.00	0.00	0.13	-	-	-	-	-
	829	51-100	2.5	1.59	0.07	0.40	2.13	0.38	-	-	1.50	1.47
	830	51-100	2.83	-	0.02	0.58	3.63	1.30	3.30	0.02	0.17	0.02
	831	51-100	0.27	-	0.00	0.20	-	-	-	-	-	-
	832	51-100	-	-	0.25	0.00	0.00	-	-	-	-	-
	833	51-100	0.00	-	0.00	0.00	0.50	0.00	1.50	-	-	0.00
	834	51-100	-	-	0.05	0.05	-	-	-	-	-	-
Division biomass			21279	13524	20706	24326	39735	47330	26650	51686	7490	9316
4T	401	101-150	19.96	-	1.13	-	33.50	1.00	-	3.00	-	1.75
	402	101-150	-	11.84	0.57	-	107.00	2.17	-	-	-	-
	404	151-200	18.37	-	2.50	-	7.00	4.83	-	19.83	-	3.25
	405	151-200	-	8.63	0.55	-	3.10	8.67	-	-	4.25	3.25
	406	151-200	-	-	-	2.00	-	-	-	-	-	-
	407	≥ 201	13.83	-	12.50	-	16.25	14.17	-	81.50	-	9.43
	408	≥ 201	-	20.65	3.80	-	18.25	7.43	-	-	6.93	4.13
Division biomass			1264	1750	952	112	4672	1587	0	4546	552	910

Table 11. Estimates from the non-equilibrium Schaefer model.

	1987 estimates	1988 estimates
Virgin stock biomass (B_∞)..............	577,664 t	578,796 t
Maximum equilibrium yield (MEY)..........	63,535 t	64,040 t
Catchability coefficient (q).............	2.35 x 10^{-6}	2.22 x 10^{-6}
Equilibrium effort$_{mey}$ (f_{mey}).............	93,574 hrs	99,851 hrs
Equilibrium 2/3 effort$_{mey}$ (2/3 f_{mey}).....	62,382 hrs.	66,567 hrs
Equilibrium CPUE at f_{mey}.................	0.679 (t/hr)	0.641 (t/hr)
Equilibrium CPUE at 2/3 f_{mey}.............	0.905 (t/hr)	0.855 (t/hr)
Equilibrium catch at 2/3 f_{mey}............	56,476 t	56,925 t
Fishing mortality (F) at 2/3f_{mey}.........	0.147	0.148
F_{1987}*..................................	0.088	0.100

* F_{1987} = catchability coefficient x standardized effort

Table 12. Approximate statistics from the linear theory on the parameters of the non-equilibrium version of the Schaefer model estimated from the 1959-1987 commercial data.

Parameter	Estimated value	Standard Error	t-value
B_{∞}	578,798 t	159,159 t	3.64*
MEY	64,040 t	8,361 t	7.66**
q	2.2161E-6	5.1413E-7	4.31**

Correlation matrix of the estimated parameters:

	B	MEY	q
B_{∞}	1.00		
MEY	-0.88*	1.00	
q	-0.96*	0.76*	1.00

* : significant at $p < 0.01$
** : significant at $p < 0.001$

Table 13. Results from the non-equilibrium Schaefer model for the period 1959 to 1987.

Year	Biomass (t)	Observed Yield (t)	Predicted Yield (t)	Residuals
1959	287,357	16,978	18,688	-1,710
1960	322,880	12,218	16,034	-3,816
1961	376,781	10,391	16,829	-6,438
1962	415,050	65,855	14,582	-7,997
1963	448,685	19,794	23,203	-3,409
1964	467,473	29,700	32,125	-2,425
1965	473,972	48,827	50,551	-1,724
1966	462,709	65,215	61,418	3,797
1967	444,425	70,036	53,595	16,441
1968	437,045	90,963	68,549	22,414
1969	417,647	88,875	88,475	400
1970	383,378	87,588	97,443	-9,855
1971	345,272	79,406	82,207	-2,801
1972	325,209	80,329	82,070	-1,741
1973	306,410	130,164	131,522	-1,358
1974	238,211	63,489	62,558	931
1975	237,726	65,401	59,698	5,703
1976	240,209	37,983	37,304	679
1977	265,951	15,840	18,867	-3,027
1978	310,995	13,591	15,493	-1,902
1979	357,798	15,034	17,514	-2,480
1980	398,087	14,832	19,041	1,791
1981	436,302	20,549	16,096	4,453
1982	464,162	26,429	22,569	3,860
1983	479,848	24,505	24,625	-120
1984	489,788	35,759	34,371	450
1985	488,670	27,827	36,165	-8,110
1986	486,285	33,107	40.076	-6,969
1987	481,116	34,385	47,576	-13,191
1988	470,702			

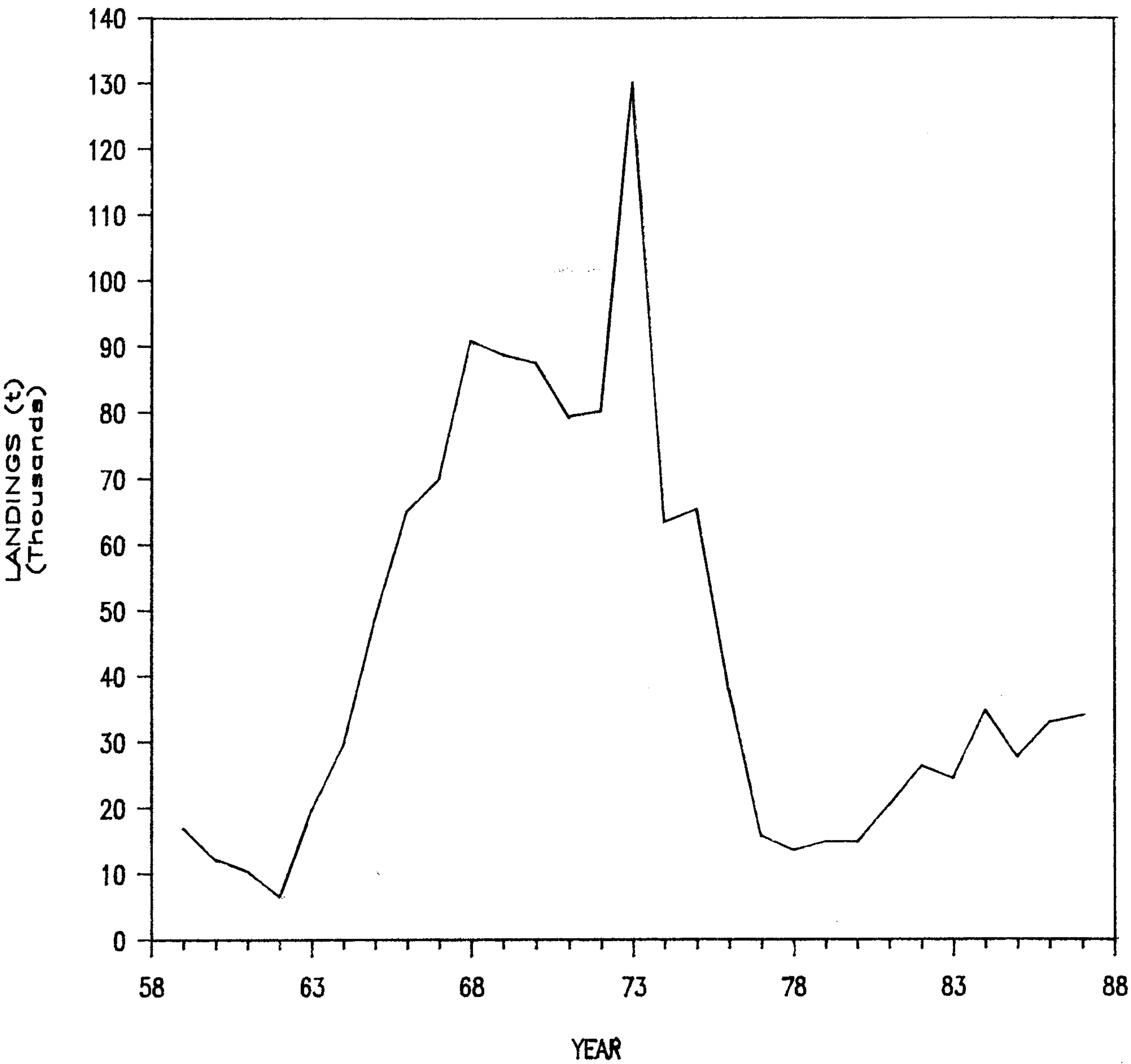


Figure 1. Historical landings for Divisions 4RST redfish commercial fishery.

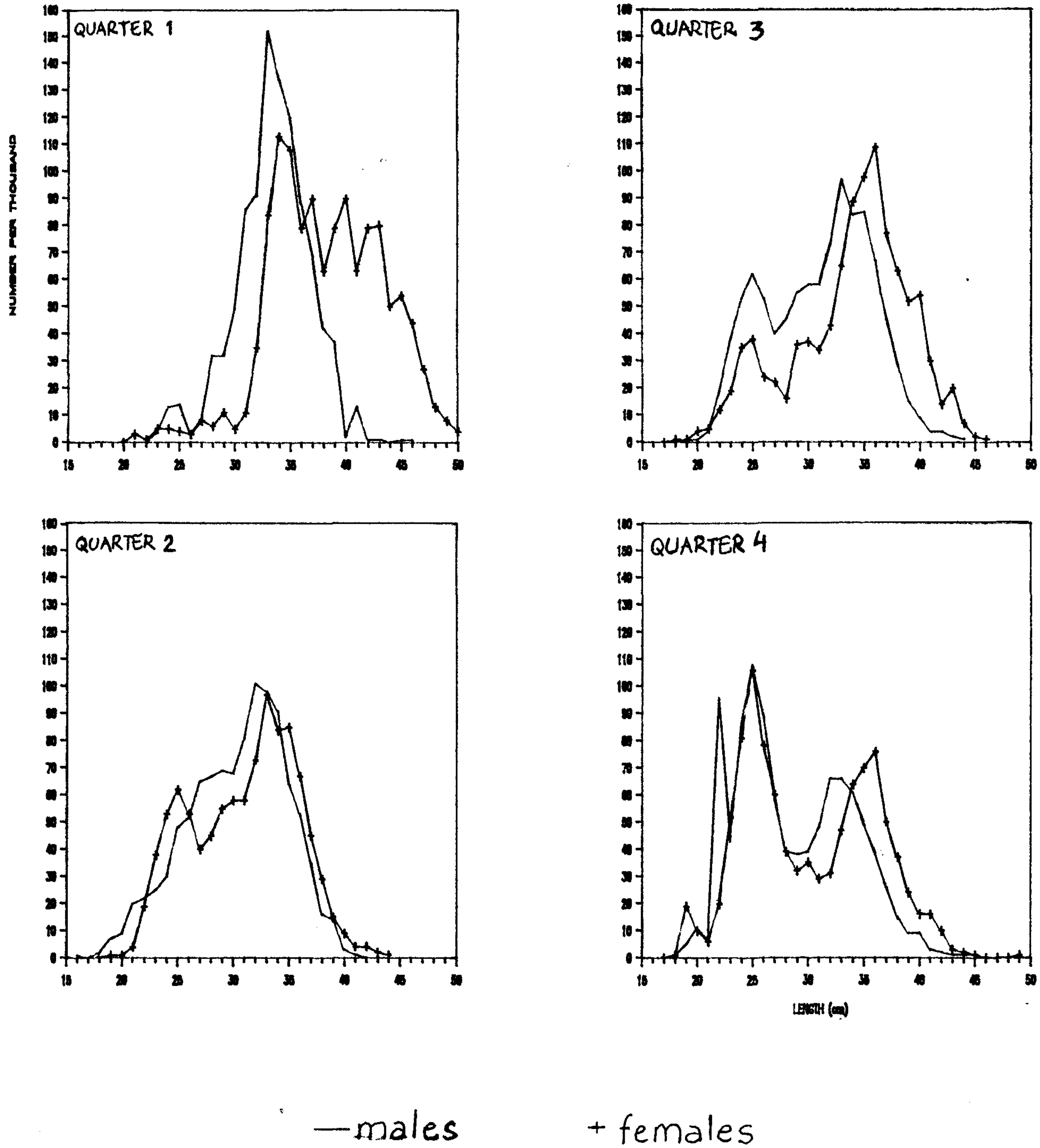


Figure 2. Quarterly length frequencies from commercial redfish fishery in NAFO Divisions 4RST.

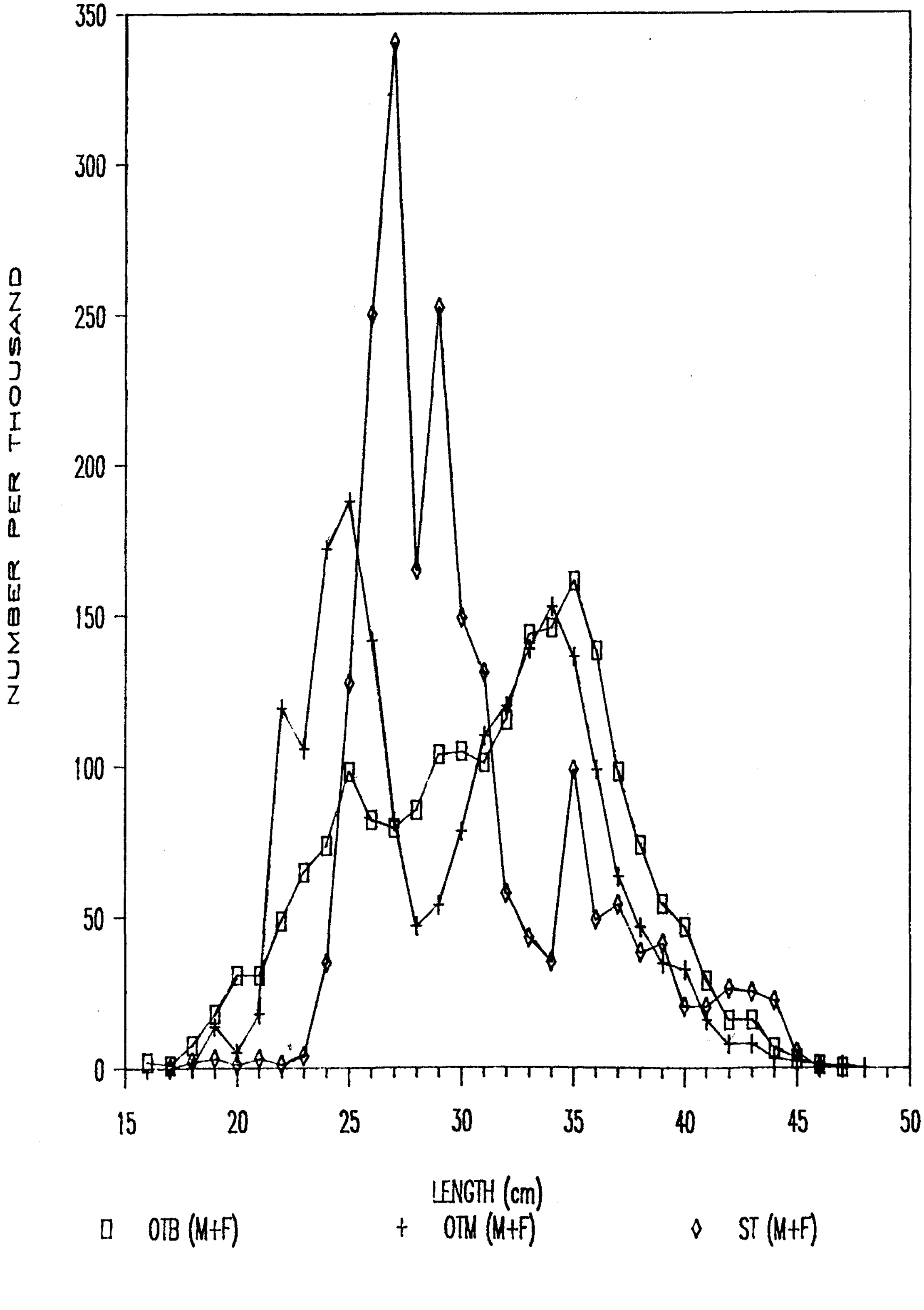


Figure 3. Annual length frequencies for the bottom (OTB), midwater (OTM) and shrimp trawl (ST), male and female combined.

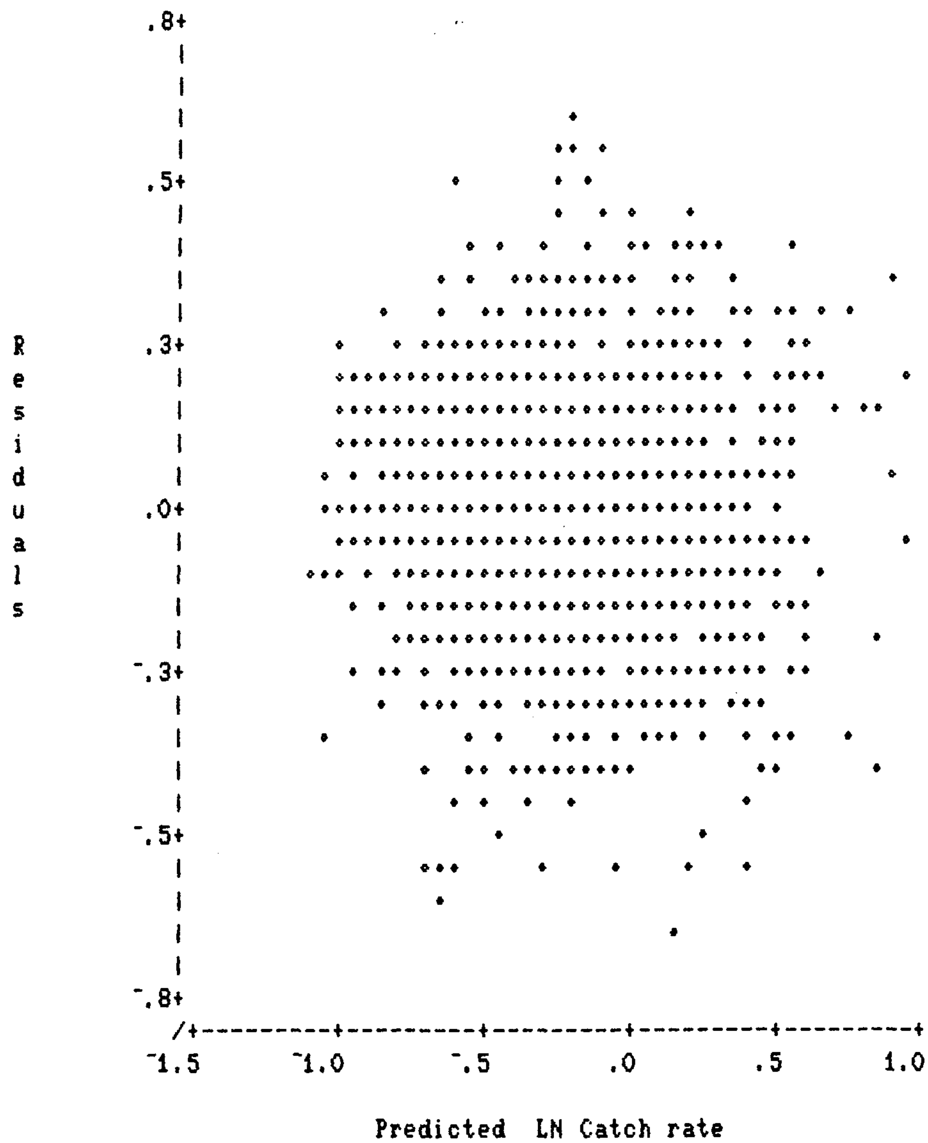


Figure 4. Residuals vs predicted catch rates from multiplicative analysis of commercial catch and effort data for redfish in NAFO Divisions 4RST (1959-1987).

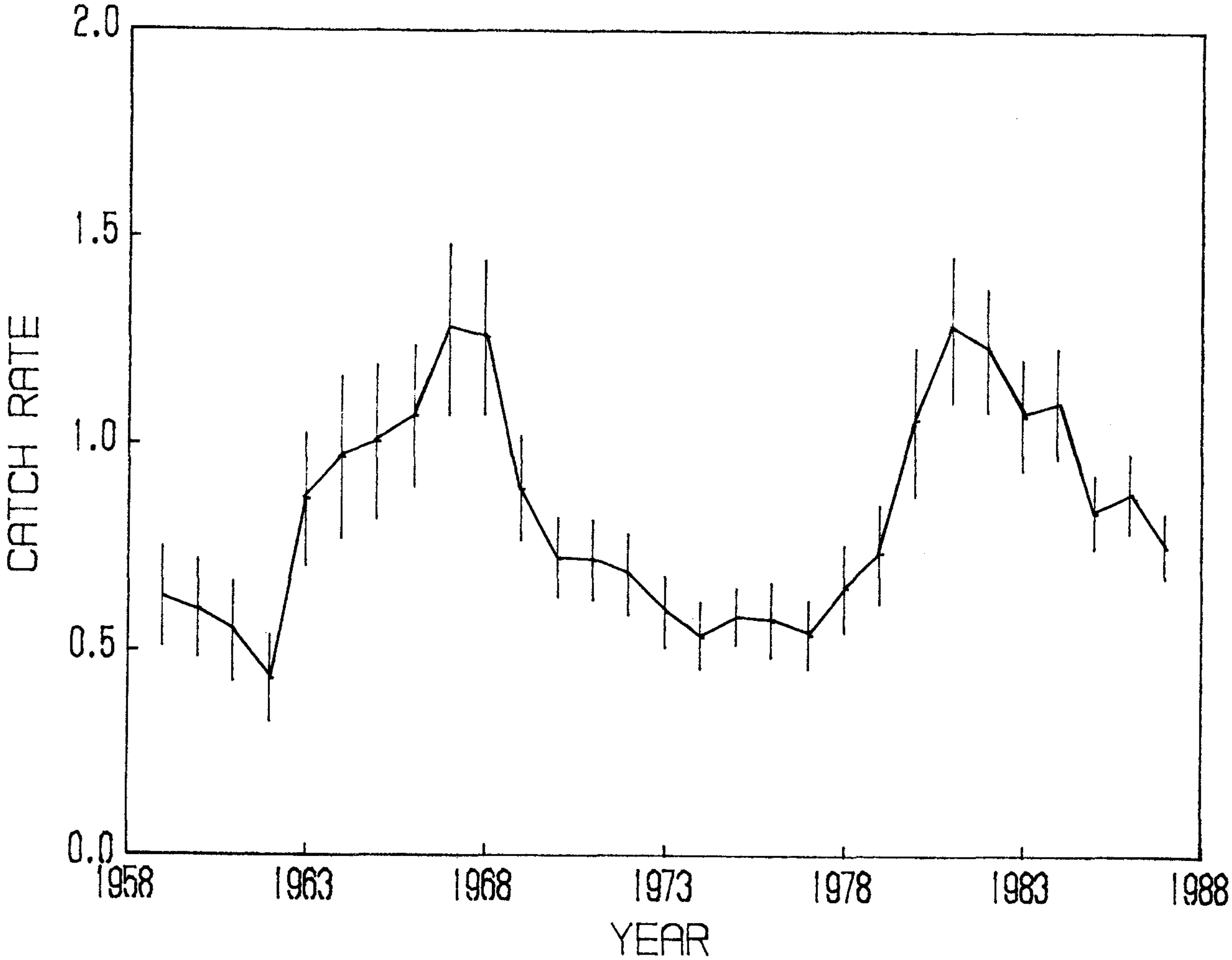


Figure 5. Standardized catch rates for Divisions 4RST redfish commercial fishery, with approximate 95% confidence intervals.

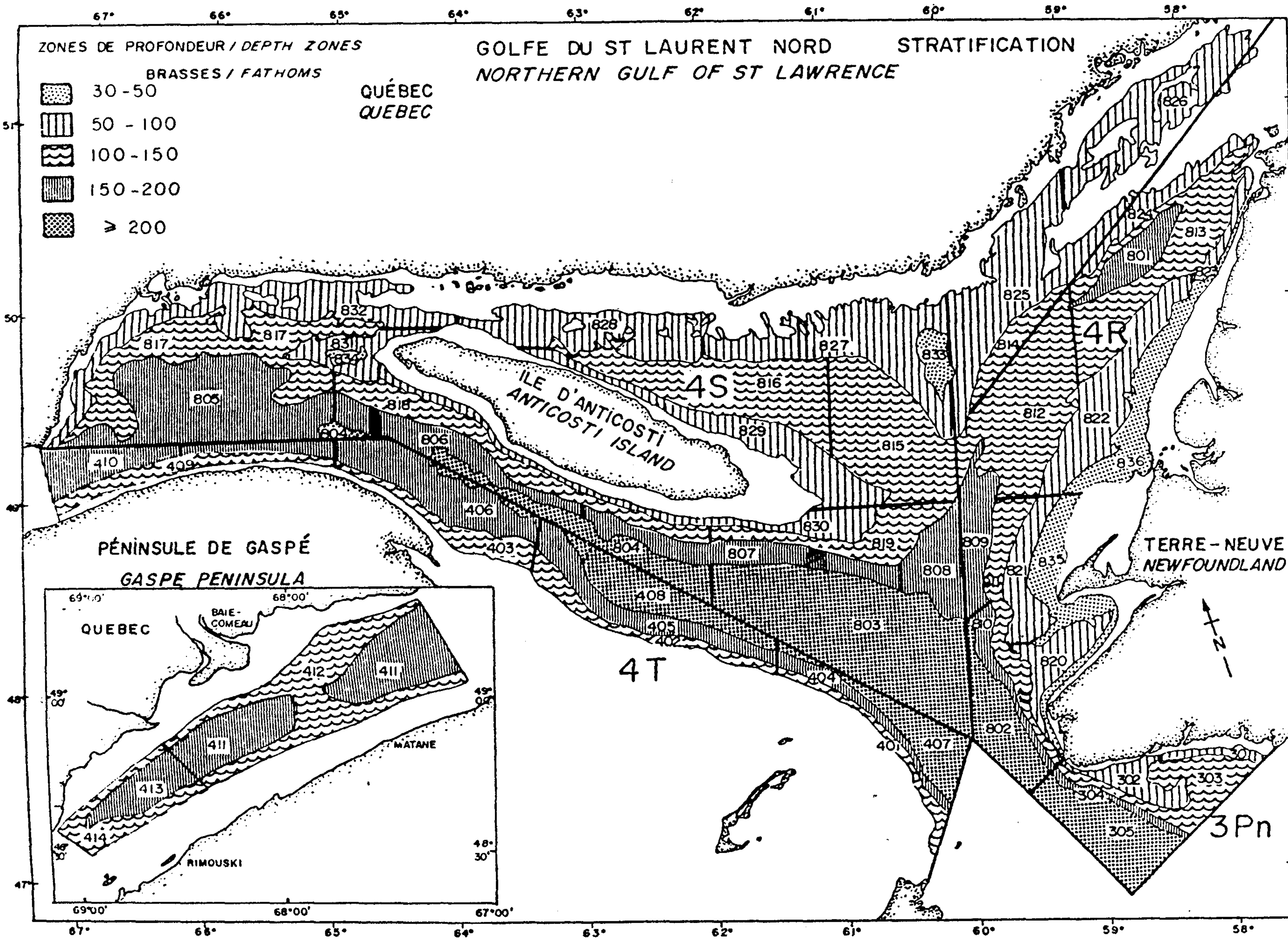


Figure 6. Stratification scheme used for the groundfish research surveys in Divisions 4RST and Subdivision 3Pn.

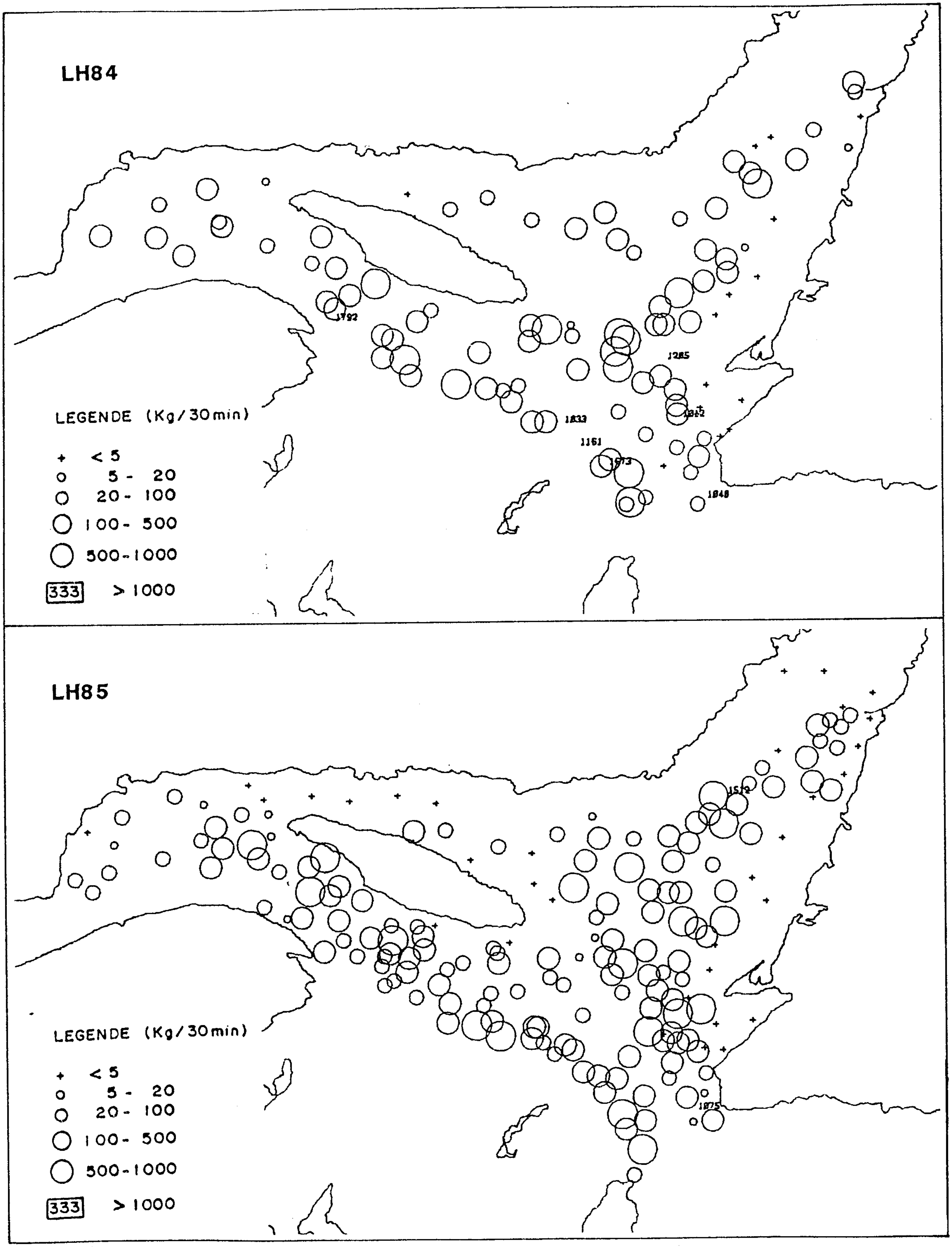
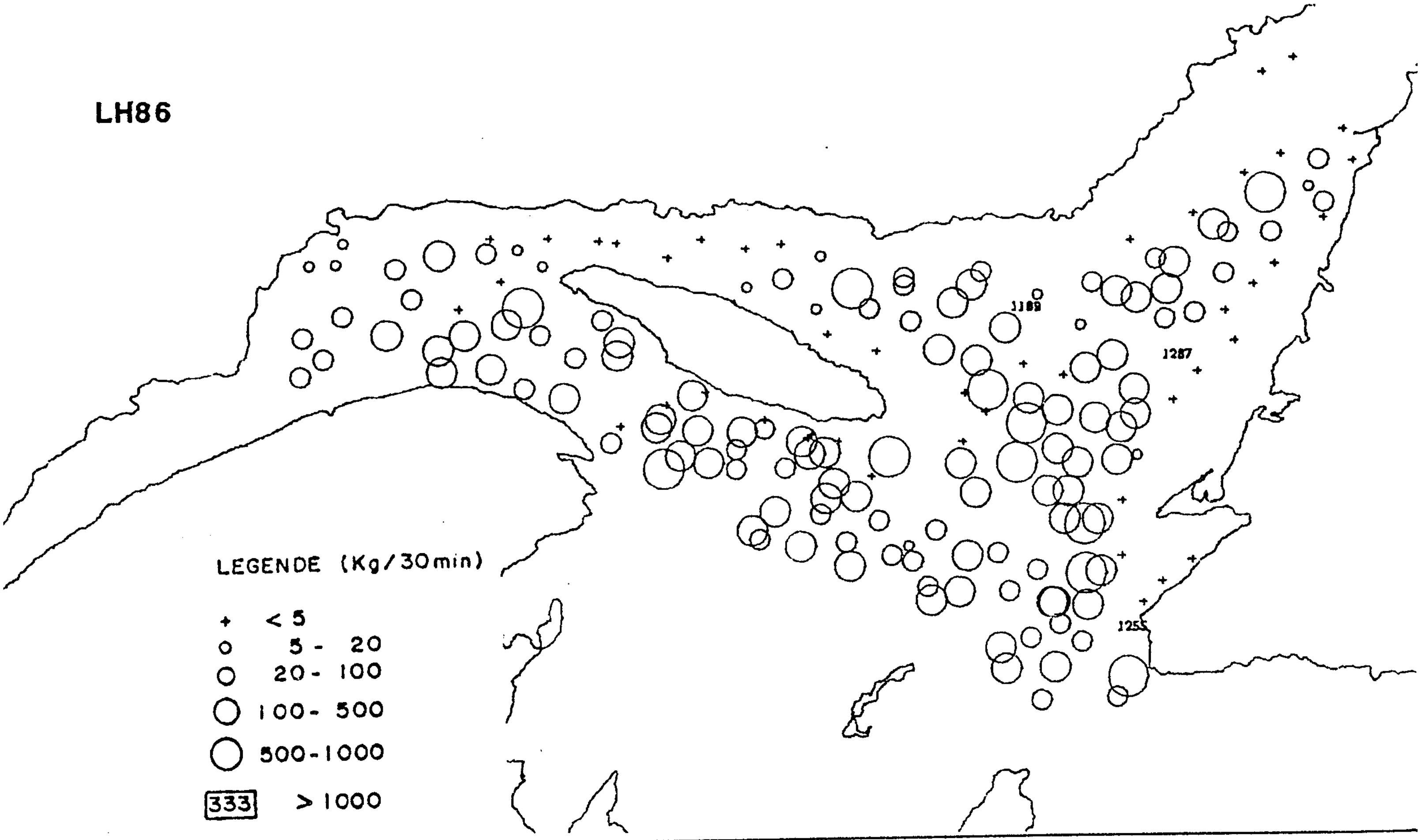


Figure 7. Distribution and catch rate (kg/30 min tow) of redfish from summer research surveys in Divisions 4RST.



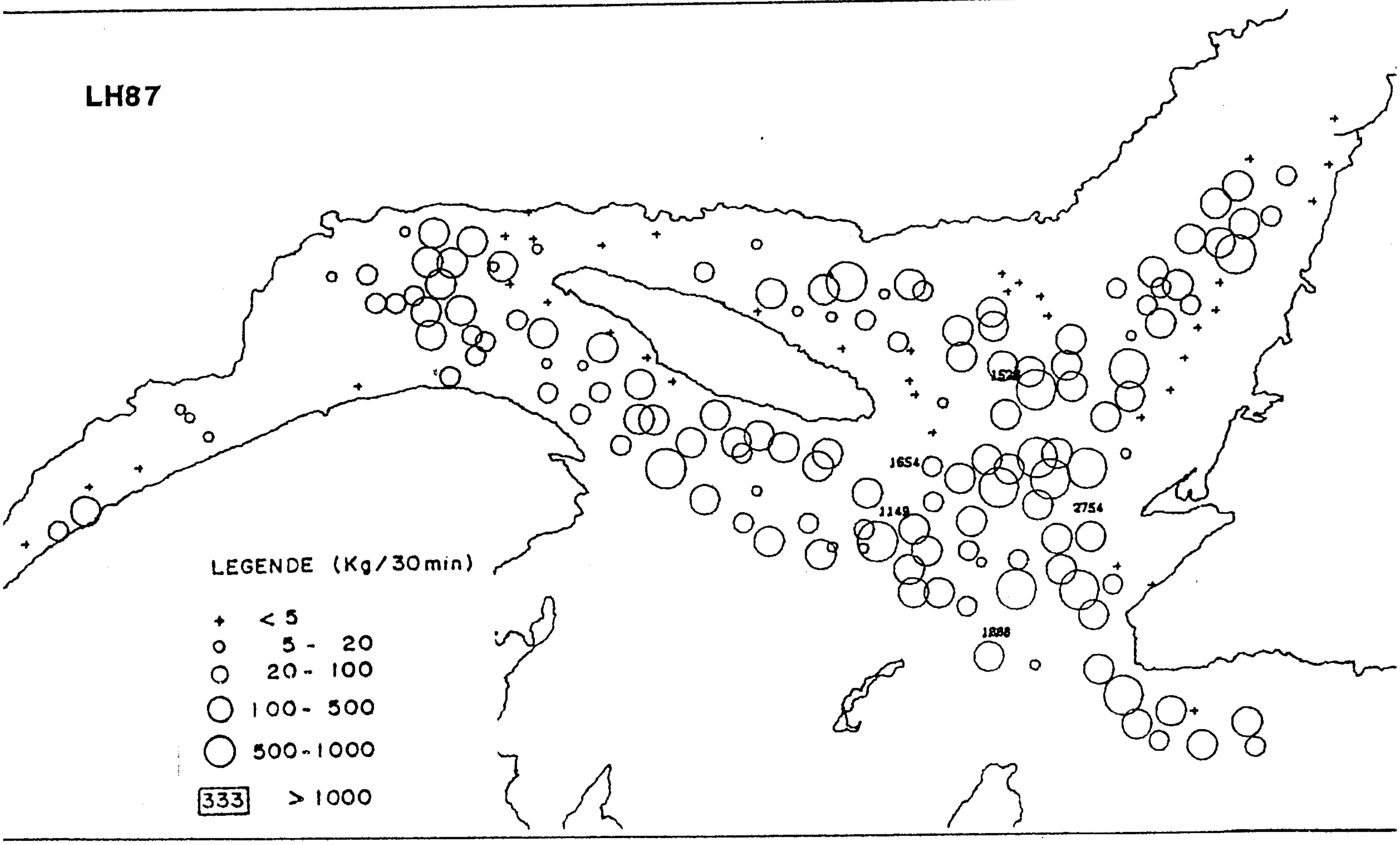


Figure 7. (continued).

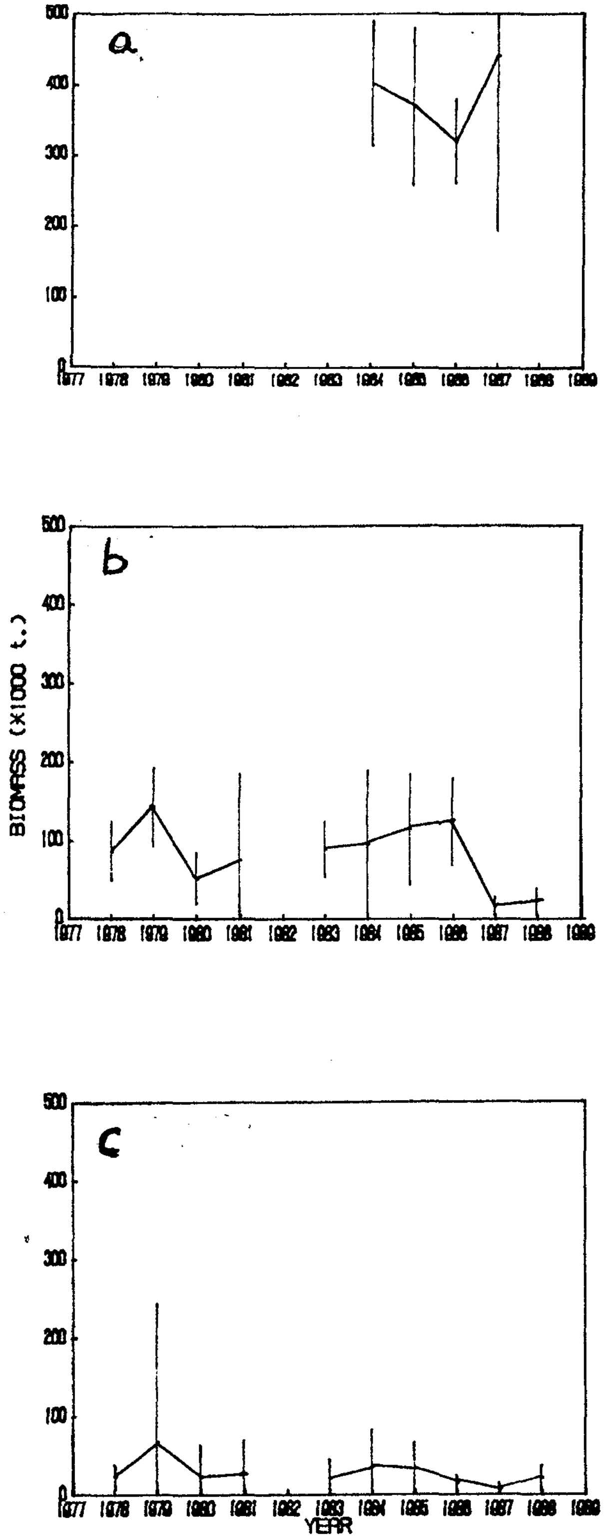


Figure 8. Minimum exploitable biomass of redfish in Divisions 4RST as estimated from the summer (a) and winter (b) research surveys. The biomass estimation for Subdivision 3Pn (c) is presented as complementary information.

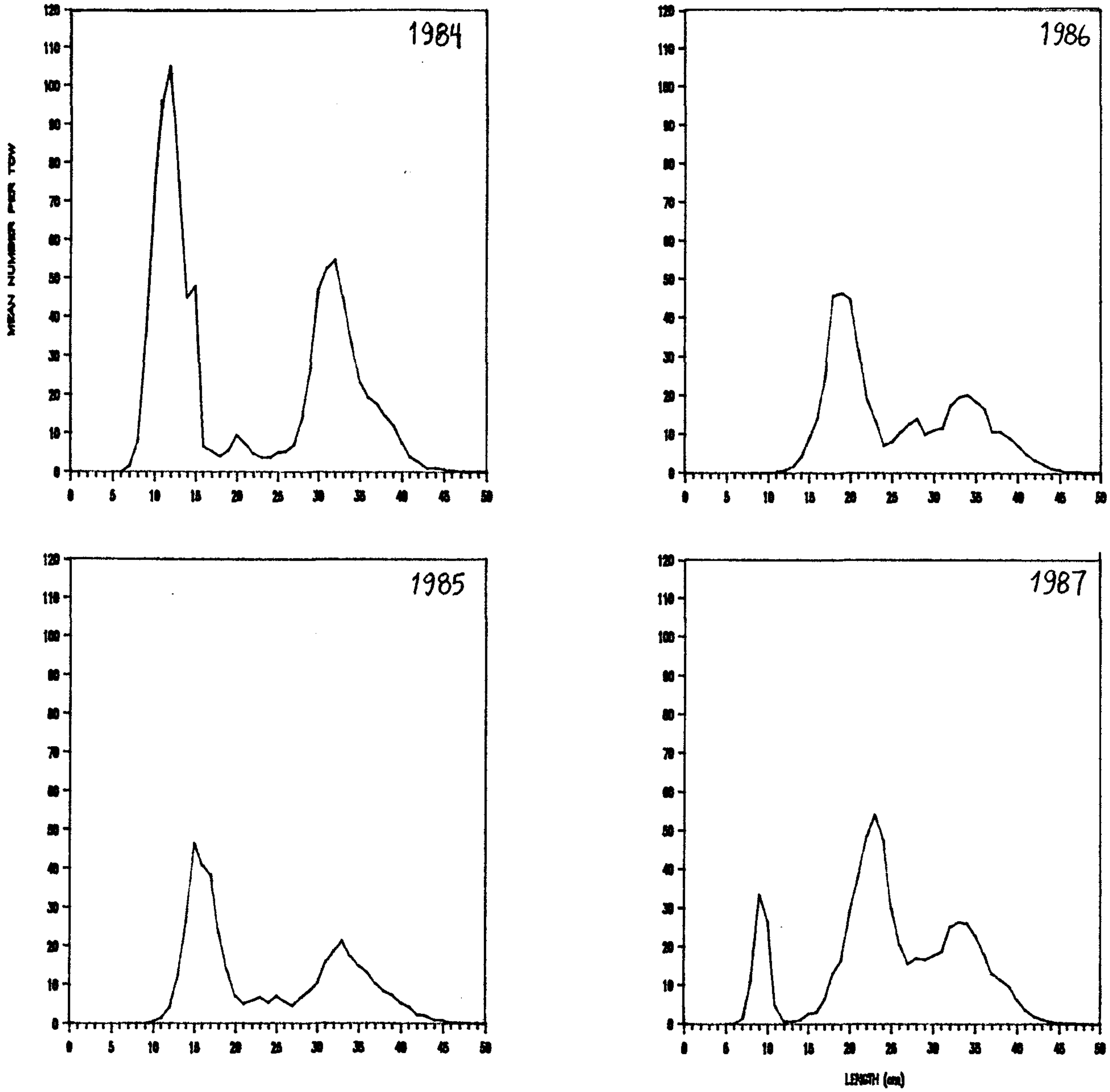
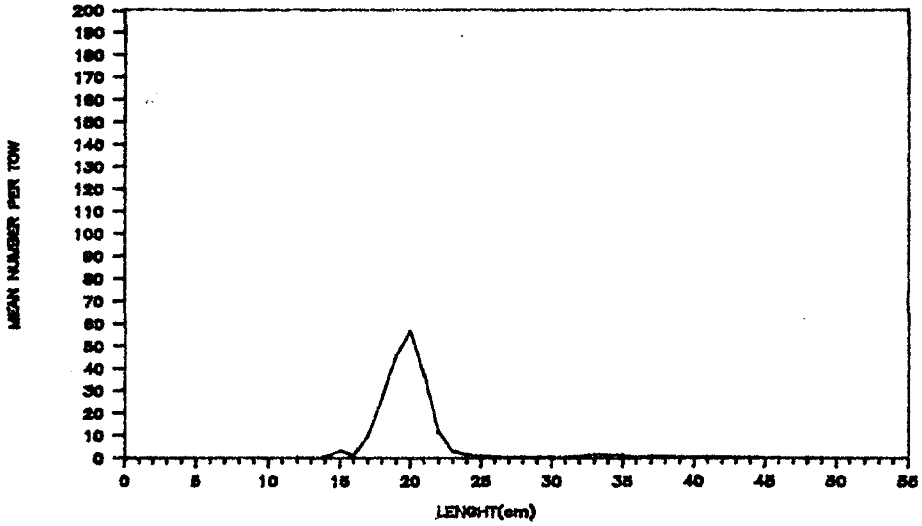
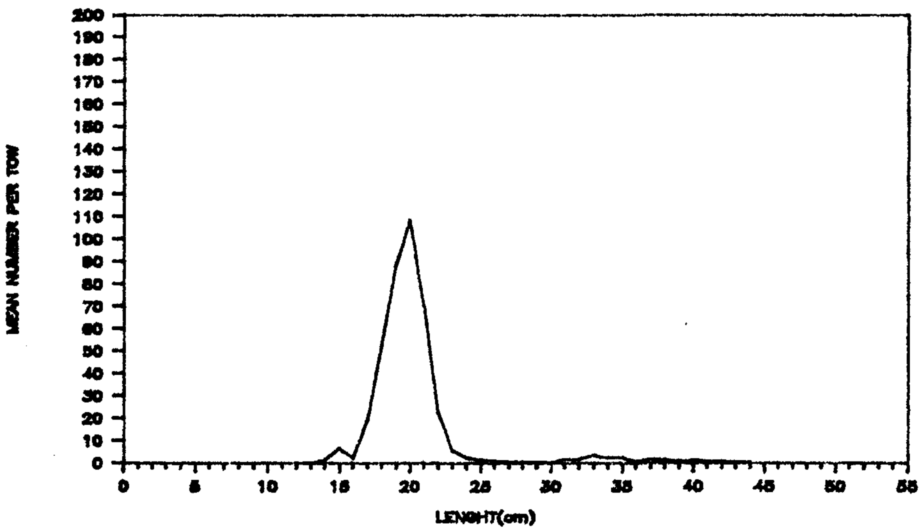


Figure 9. Length frequency distributions for Divisions 4RST redfish from summer research surveys.

ESTUARY 1987



ESTUARY 1987 (183m<DEPTH<274m)



ESTUARY 1987 (274m<DEPTH<366m)

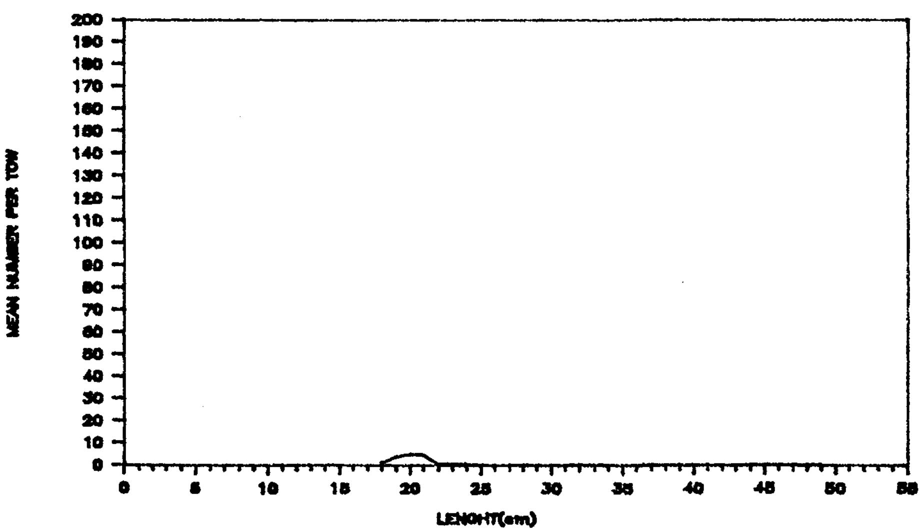


Figure 10. Length frequency distributions of redfish caught in the new zone (strata 409 to 414) during the 1987 summer research survey in Divisions 4RST.

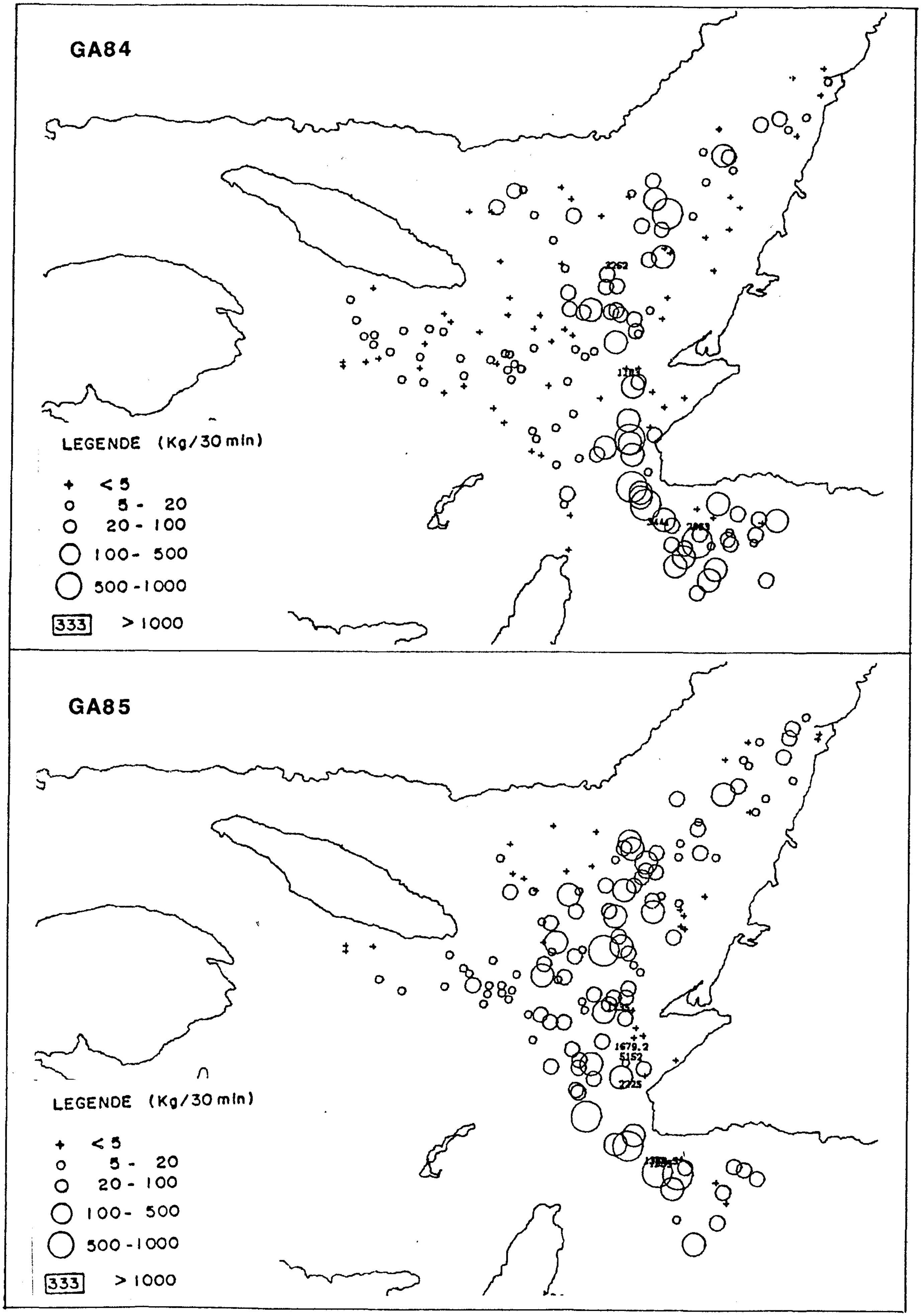


Figure 11. Distribution and catch rate (kg/30 min tow) of redfish from winter research surveys in Divisions 4RST and Subdivisions 3Pn.

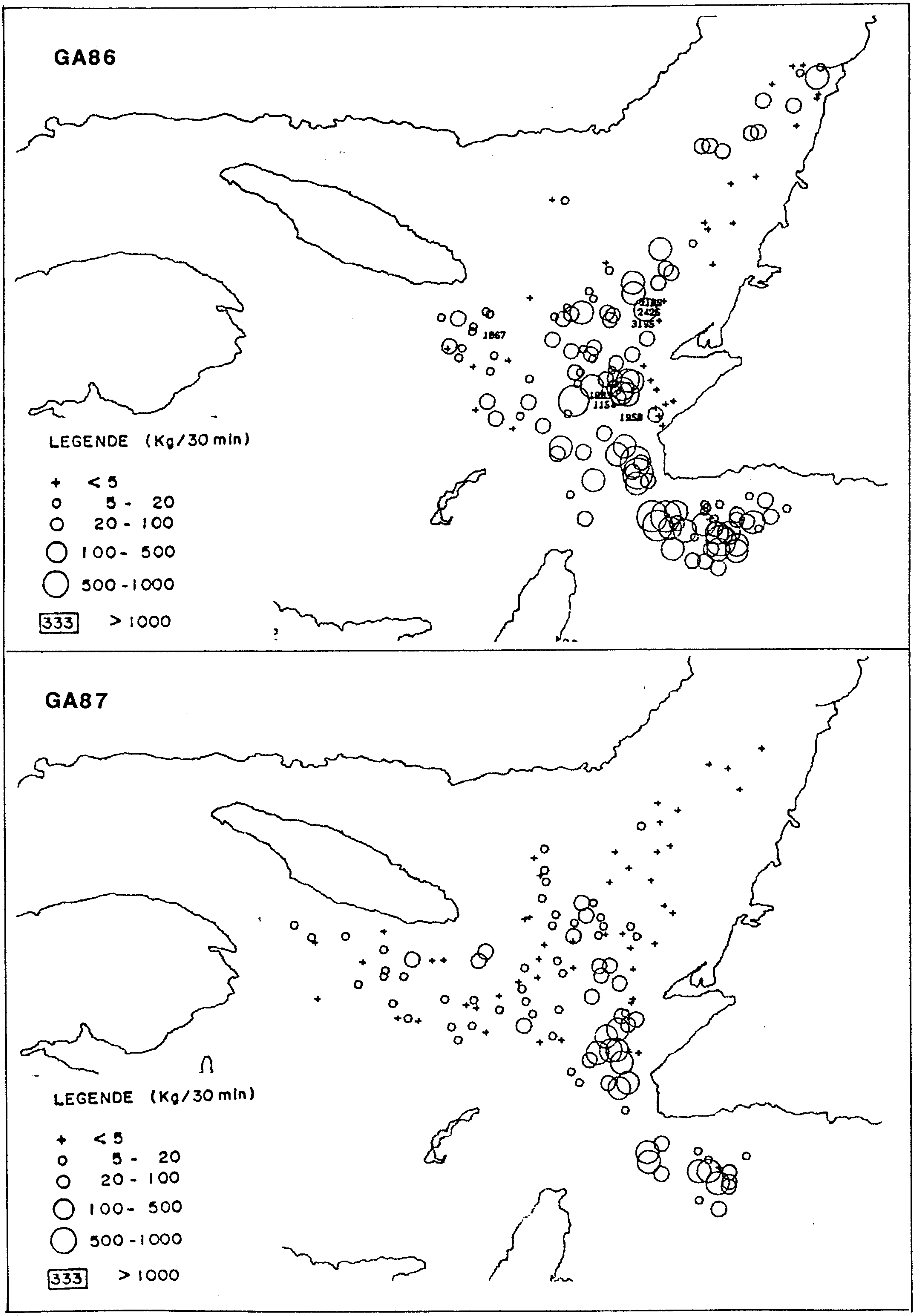


Figure 11. (continued).

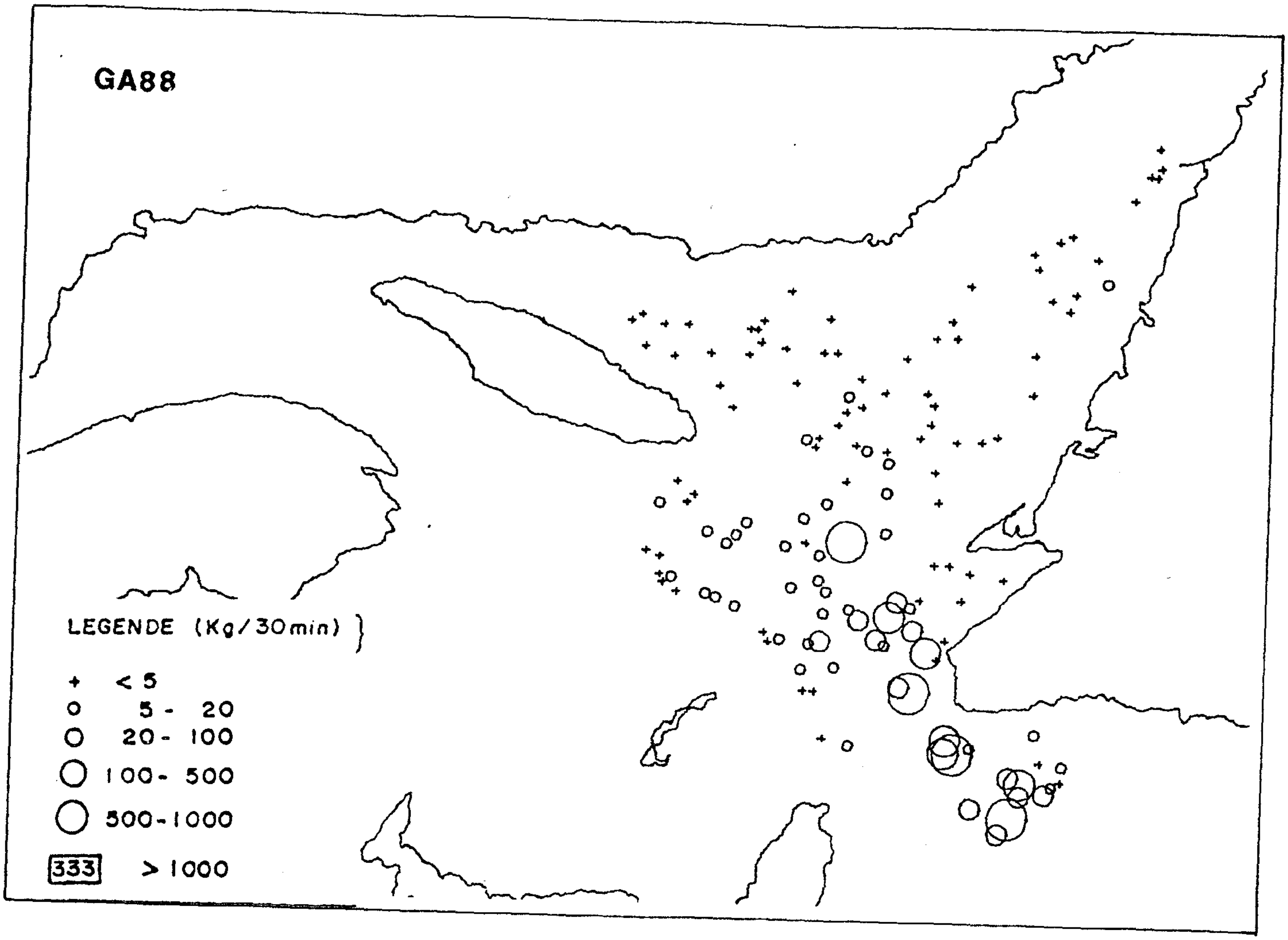


Figure 11. (continued).

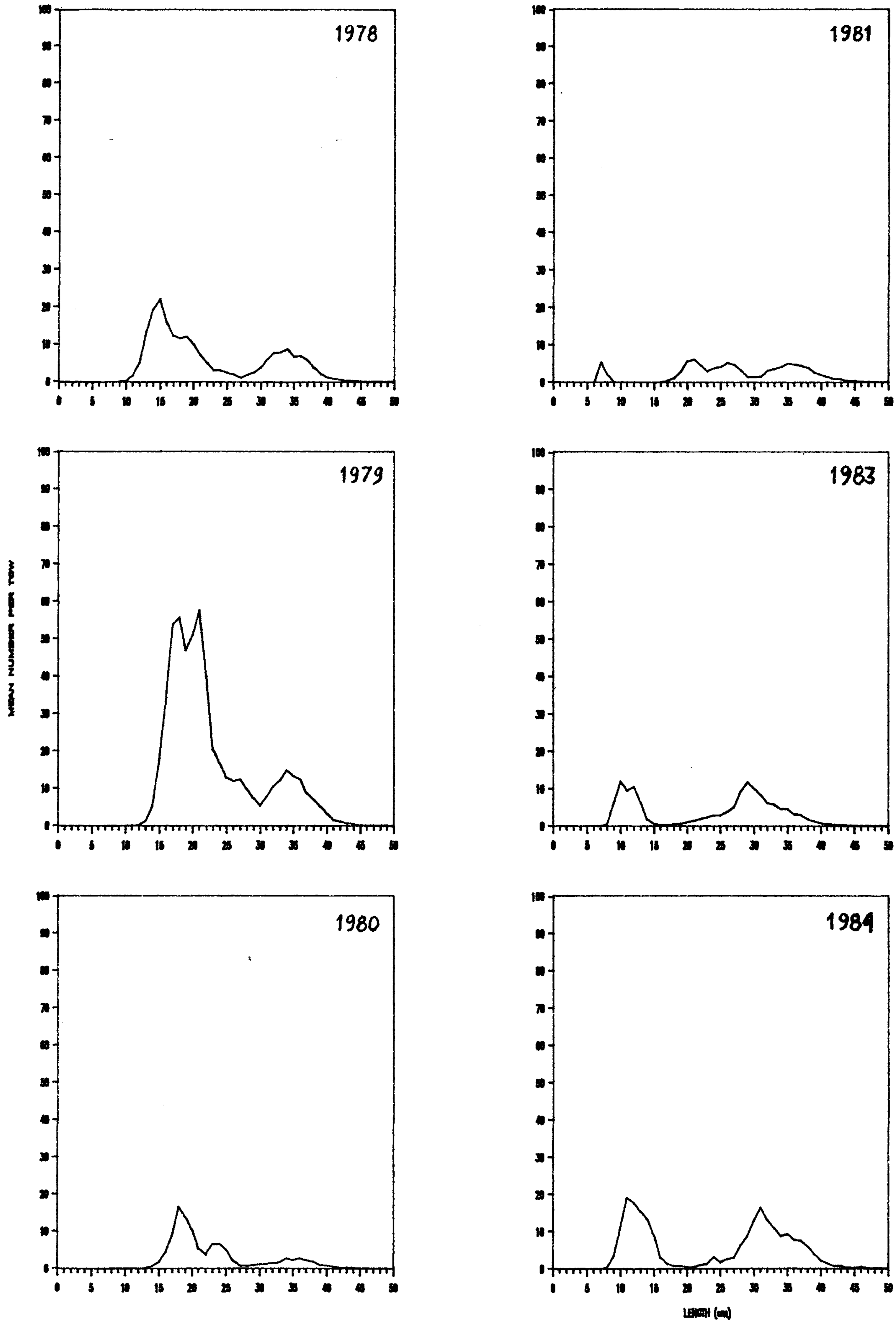


Figure 12. Length frequency distributions for Divisions 4RST redfish from winter research survey.

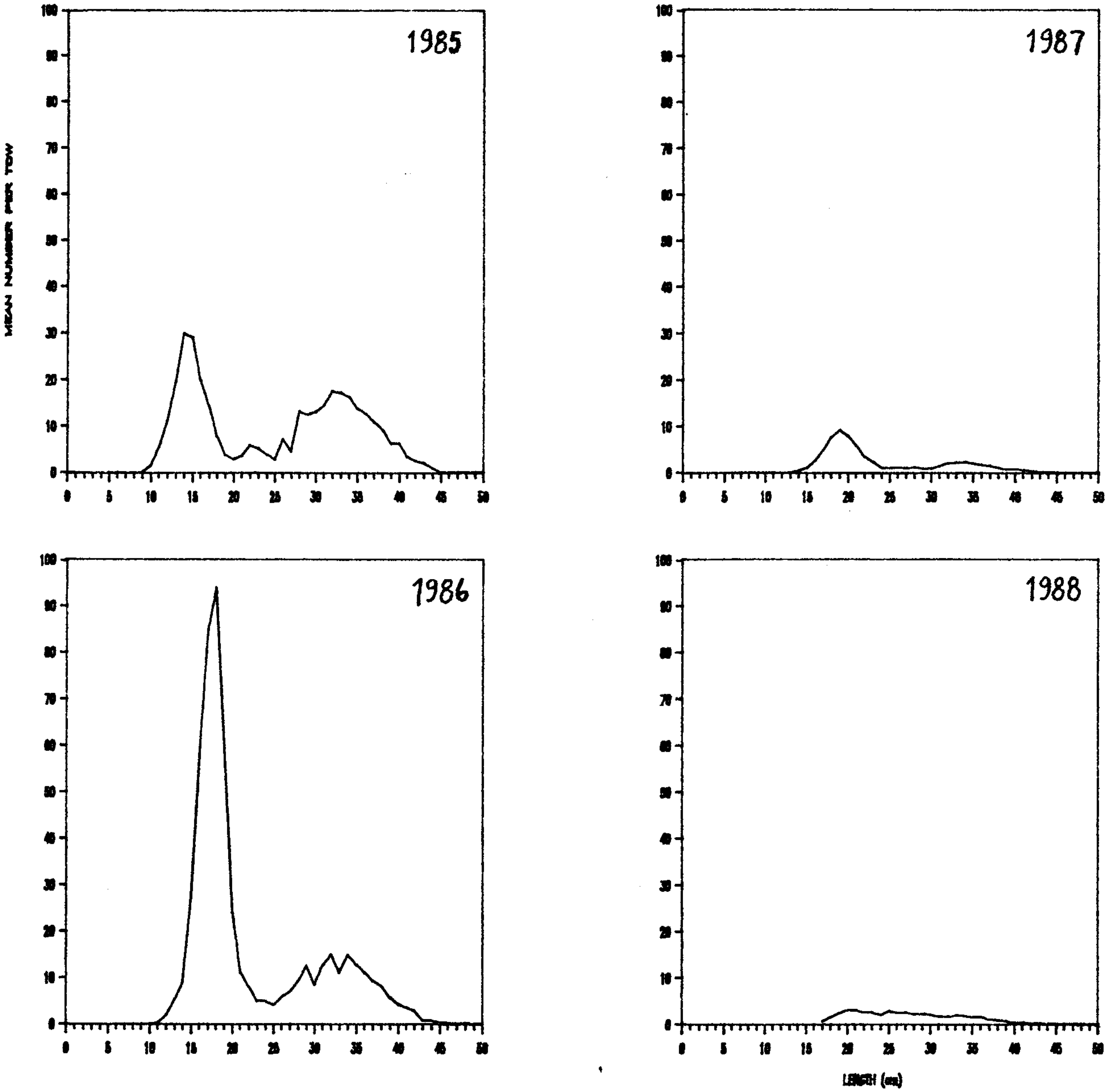


Figure 12. (continued).

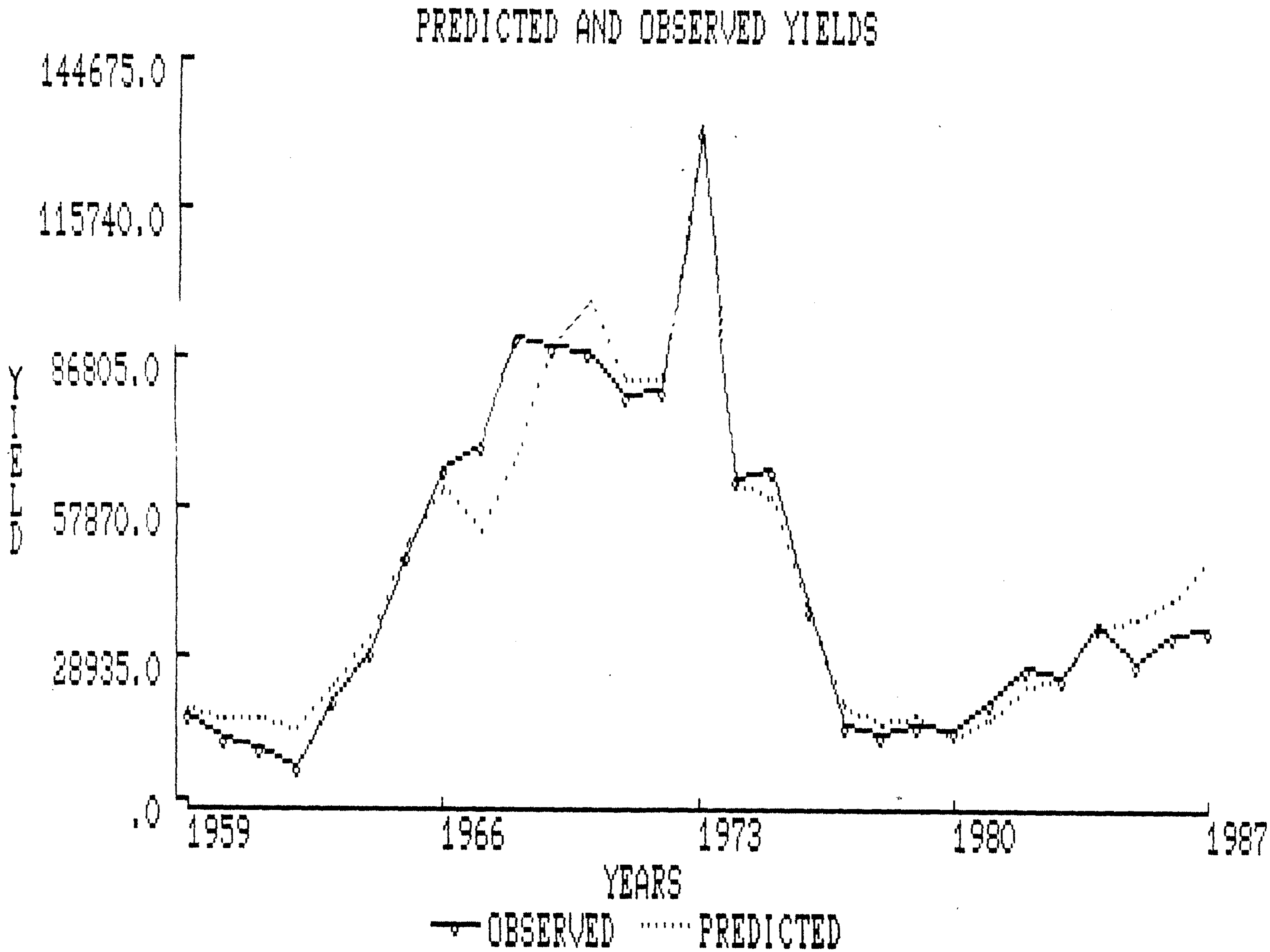


Figure 13. Comparison between the observed annual yields and the yield values predicted by the non-equilibrium Schaefer model.

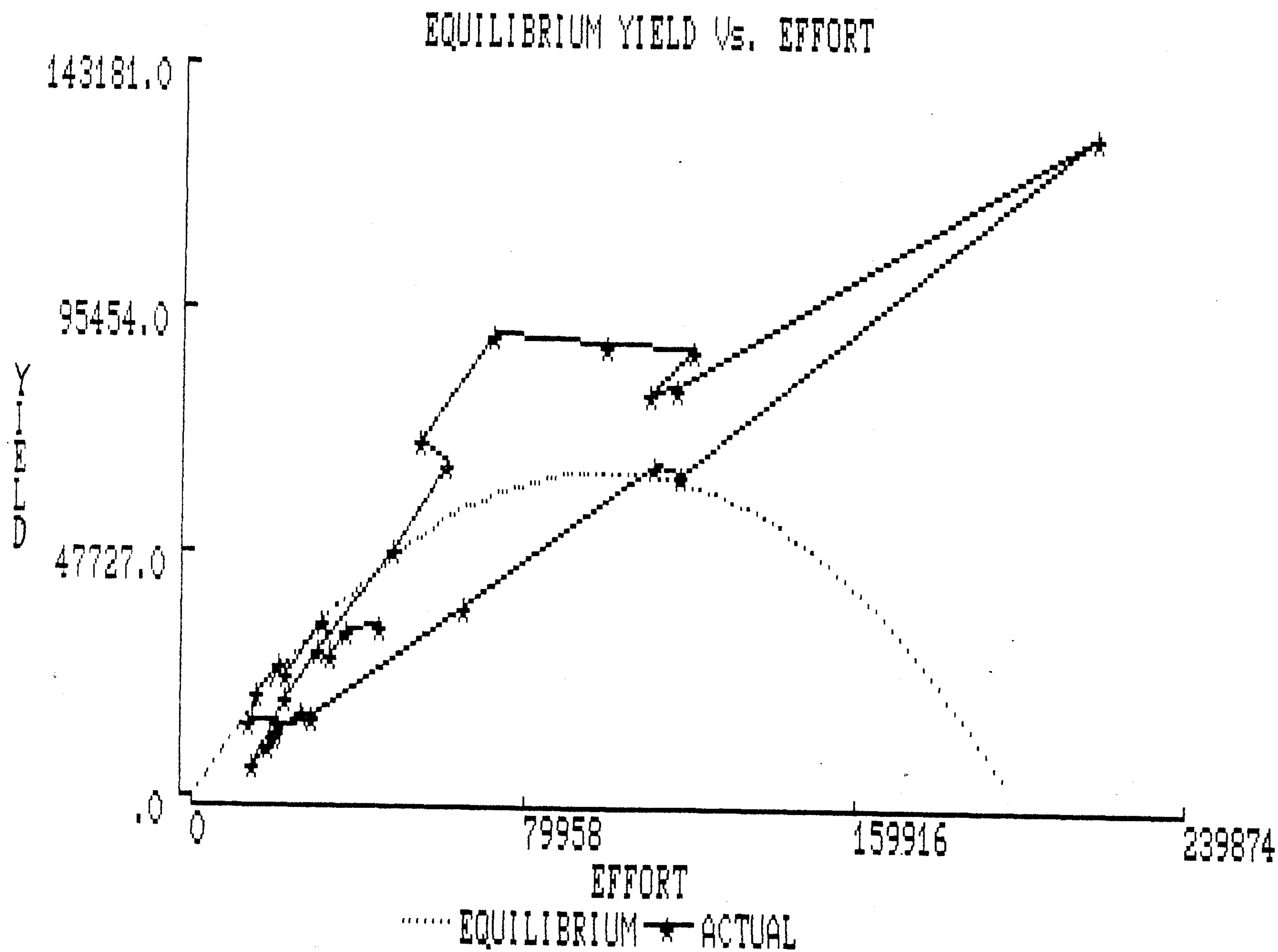


Figure 14. Transient trajectory and equilibrium Schaefer curve for Divisions 4RST redfish.

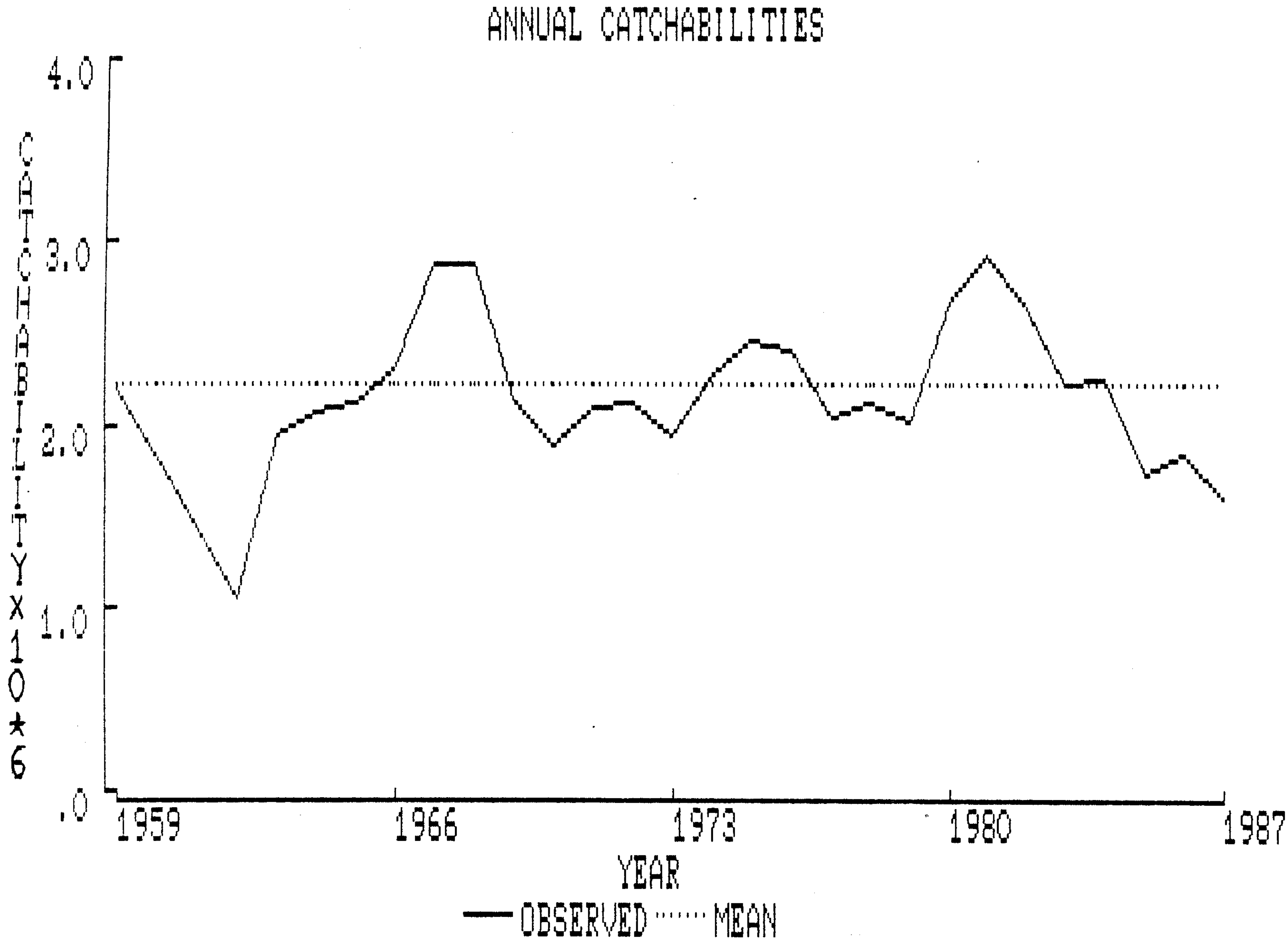


Figure 15. Yearly catchabilities coefficients for Divisions 4RST redfish. The straight line represents the catchability coefficient estimated by Schaefer production model assuming non-equilibrium conditions.