NOT TO BE CITED WITHOUT
PERMISSION OF AUTHOR

CAFSAC
Research Document 80/31

Variability in abundance of Atlantic redfish derived from Canadian summer groundfish surveys on the Scotian Shelf (1970-1979)

Douglas Clay
Marine Fish Division
Bedford Institute of Oceanography
Dartmouth, Nova Scotia
Canada

Abstract

Redfish (Sebastes marinus mentella) were shown to have had a variable catch history ranging from 84,000 tonnes in 1951 to 12,000 tonnes in 1979. Abundance (or catch rate) was affected by depth with peaks in catch rate at 150, 250 and 350 meters; by bottom temperature with a peak at 6°C; and by time of day with peaks at 1200 and 2130 hrs. Length frequencies from research vessel catches show small fish (<15 cm) to be very rare, although present in occasional catches (indicating their catchability). This lack of apparent recruitment over the last decade and the dependence of the fishery on 1 or 2 age groups (± 30% of catch made up of 15 and/or 16 year olds) indicates an unhealthy fishery which requires careful management. A summary of 10 years of R/V survey data is provided.

Key words: Redfish, Scotian shelf, distribution, abundance, Sebastes marinus mentella.

Résumé

Les prises de sébaste atlantique (Sebastes marinus mentella) ont subi dans le passé de fortes variations, allant de 84,000 tonnes en 1951 à 12,000 tonnes en 1979. L'abondance de l'espèce (ou son taux de capture) est affectée par la profondeur, des taux de capture maxima se trouvant à 150, 250 et 350 mètres; par la température du fond, un maximum se rencontrant à 6°C; et par l'heure du jour, des pics se produisant à 1200 h et 2130 h. Les fréquences de longueur des captures par les navires de recherche démontrent que les petits poissons (<15 cm) sont très rares, bien que présents occasionnellement dans les prises (signe qu'ils sont aptes à être capturés). Ce manque de recrutement apparent durant la dernière décennie et la dépendance de la pêche vis-à-vis 1 ou 2 groupes d'âge (les poissons de 15 et/ou 16 ans constituent environ 30% des prises) sont le signe d'une pêcherie en mauvaise posture, qui doit être gérée avec soin. On donne un résumé des données recueillies sur une période de 10 ans lors de relevés par navires de recherche.

Mots clés: Sébaste, plateau Scotian, distribution, abondance
Sebastes marinus mentella

INTRODUCTION

Redfish (Sebastes marinus, mentella) has been an important fish in removals from the Scotian shelf since the late 1930's when the USA first began the fishery. Canadian landings from this fishery were initially low and only exceeded 1000 tonnes once in the early 50's (Figure 1, Table 1). Since the early 60's there has been a steady increase in Canadian landings from slightly in excess of 1000 tonnes to the present level of around 15,000 tonnes. This makes redfish the fourth most important groundfish in Canadian landings (in tonnage). Although this is an important stock, it has always been an unregulated species in terms of gear - and until 1974 in total allowable catch (TAC).

Good management depends on accurate up to date biological information which is lacking for Scotian shelf redfish. Inadequate sampling from vessels of unspecified codend mesh size, no routine ageing, great variability in random stratified survey results all present difficult obstacles for the assessment of the NAFO divisions 4VWX redfish stock. Clay (MS 1979) showed how with different assumptions the TAC could range between 7,000 and 40,000 tonnes. For these reasons no analytical assessment is being attempted for 1981, in its place analyses are being conducted on the biology and ecology of this species in an attempt to improve the parameters necessary for future stock assessments.

METHODS

The 1979 provisional catch data were taken from ICNAF and NAFO circular letters and Department of Fisheries & Oceans statistics from Maritimes and Quebec region and from Newfoundland region (Tables 2 and 3).

The data used in this study were collected during the summer (July) groundfish cruises on the Scotian shelf (see Halliday and Kohler (MS 1971) for details of random stratified design). The data were summarized by a series of computer programs (STRAT) from St. Andrews Biological Station, Department of Fisheries & Oceans, St. Andrews, New

Table 1. Nominal redfish landings from NAFO division 4VWX in tonnes (live weight).

Year	MARITIMES & QUEBEC	NEWFOUNDLAND	USA	USSR	OTHERS	TOTALS
1930			6*			6*
1931			28*			28*
1932			29*			29*
1933			35*			35*
1934			361*			361*
1935			233*			233*
1936	96*		7195*			7291*
1937	44*		11647*			11691*
1938	217*		8846*			9063*
1939	267*		9799*			10066*
1940	127*		11856*			11983*
1941	17*		10436*			10453*
1942	58*		2208*			2266*
1943	15*		3695*			3710*
1944	12*		4089*			4101*
1945	11*		21886*			21897*
1946	137*		38383*			38520*
1947	195*		26330*			26525*
1948	573*		64367*			64940*
1949	895*		76751*			77646*
1950	678*		59662*			60340*
1951	744*		83315*			84059*
1952	1457*	1588*	31344*			34389*
1953	282	375	19574			20231
1954	1037	-	20895			21932
1955	349	48	9330			9727
1956	240	2	16313			16555
1957	504	4	19990			20498
1958	749	8	31599			32356
1959	611	-	24704			25315
1960	1171	-	36294		18	37483
1961	1869	642	28960	9	4	31484
1962	2976	412	29370	3975		36733
1963	2553	622	23282	12288	7	38752
1964	2020	1025	15641	3659	493	22838
1965	3467	1250	13082	1571	208	19578
1966	7219	2791	16679	13943	204	40836
1967	5502	4354	6415	67	1906	18244
1968	5045	4206	4635	186	954	15026
1969	7792	2958	1142	2152	8260	22304
1970	13294	1999	1949	13218	1119	31579
1971	24953	4355	6261	15591	6221	57381
1972	17231	4638	12365	11858	4208	50300
1973	13388	3100	10751	10601	2333	40173
1974	12688	3051	8891	6696	1511	32837
1975	10422	6603	5465	4849	644	27983
1976	7448	5177	4446	1021	367	18459

Table 1. continued

Year	MARITIMES & QUEBEC	NEWFOUNDLAND	USA	USSR	OTHERS	TOTALS
1977	10115	4597	2876	175	82	17845
1978	9020	4556	2147	152	220	16095
1979[1]	8264	3176	717	122	53	12332
1980						

1. Provisional statistics
* All catch statistics of NAFO subdivision 4 (includes Gulf of St. Lawrence) are combined prior to 1953. It is generally accepted that the redfish fishery in the Gulf of St. Lawrence began in 1953 (Parsons and Parsons, MS 1976) and therefore the catches between 1930 and 1952 are from the Scotian Shelf.

Table 2. Provisional redfish catch statistics for 1979 (taken from ICNAF and NAFO Circular Letters).

	USSR	JAPAN	CUBA	USA	CAN(MQ)[1]	CAN(N)[1]	EEC	TOTAL
Jan				129	60	4		193
Feb				8	25	46		79
Mar				351	199	47		597
Apr				23	366	131		520
May	83			27	620	244	17	991
Jun				25	724	460		1209
Jul			1	46	795	297		1139
Aug	13		1	42	2051	459		2566
Sept	26		3	5	992	1058		2084
Oct		5	4	4	150	190		353
Nov		6		43	702	179		930
Dec				14	1580	61		1655
Totals[2]	122	11	10	718	8264	3176	33	12316

1. Canadian statistics separated by Canada (Maritimes and Quebec) and Canada (Newfoundland).

2. Totals do not always add up to the sum of the monthly catches because the monthly statistics are not complete.

Table 3. Nominal provisional landings for Scotian Shelf Atlantic redfish for 1979 by NAFO subdivision.

NAFO Subdivisions	4Vs		4Vn		4W		4X		4VWX
Month	M&Q[1]	N[2]	M&Q	N	M&Q	N	M&Q	N	Total
Jan	8		29	7	2		25		71
Feb	5		33	49	1		9		97
March	144	19	24	37	27		87	2	340
April	292	279	3		197		6		777
May	153	78	2		255	1	68		557
June	424	149	300	499	572		57		2001
July	572	100	307	361	301		94		1735
Aug	447	242	526	572	166		48		2001
Sept	106	140	581	431	146		26	1	1431
Oct	253	20	76	111	30		21	1	512
Nov	836		304	8	30	1	222		1401
Dec	309			61	40		127		537
Total	3549	1027	2185	2135	1767	2	790	4	11460[3]

1. Department of Fisheries and Oceans provisional statistics from the Maritimes and Quebec region.

2. Department of Fisheries and Oceans provisional statistics from Newfoundland region.

3. The foreign catch (872 tonnes) is not available subdivided by NAFO subdivision.

Brunswick. The data from these summaries were then studied in an attempt to identify any possible sources of variation or bias.

The STRAT programs' results (summarized in Appendix I: Tables 1 through 5) were adjusted in an attempt to remove some of the variability. The years 1975, 1977, and 1978 show extremely high biomass levels in NAFO division 4W (Figure 2). All survey data where one set made up over 90% of the stratum biomass and over 20% of the subdivision total were adjusted. The value was removed and replaced with the mean value of data from the same strata for 3 or more adjacent years. For the analysis of ecological parameters all of the sets and associated data were adjusted to standard tows of 30 minutes duration. The bottom types were found by using the surficial geology maps of the Scotian shelf (King, 1970).

RESULTS & DISCUSSION

After the assessment for 1980 (Clay, MS 1979) it became obvious that the research vessel biomass indices were very important in considering the status of the 4VWX redfish stock. It was pointed out in the above assessment that although 75% of the 1978 4VWX biomass was found in division 4W, 60% of the nominal catch was reported to be from subdivision 4Vs. The distribution of catch in 1979 is slightly different (Tables 2 and 3), with only 40% coming from division 4Vs this year. The minimum trawlable biomass estimates (Figure 2) show wide fluctuations between years and NAFO divisions. The data for each division were then plotted by stratum (Figure 3) to see if the high degree of variation was limited to division level or was apparent between strata and/or at lower levels. Divisions 4W and 4X (E&W) (Figure 3c, d, and e) indicate the variation between strata and between years. A closer investigation shows the increase in biomass in 1978 (Figure 3) to be due to set number 1 of stratum 60 where 6052 fish were taken. If that set is removed and the mean for all years of the stratum is subsituted, the biomass for NAFO division 4W drops from 195,000 tonnes to approximately 30,000 tonnes. A similar investigation for two other years of high biomass in 4W (1975 and 1977) indicates similiar circumstances. Because the subdivisions' variation apparently is the result of large fluctuations between sets, the biomass estimate (Figure 2) for redfish was reworked and adjusted in the above manner (Figure 4). This shows a very different picture compared to the increasing biomass presented in 1979 (Koeller, MS 1979).

The variation described above and adjusted for is similar to that identified by Halliday _et al_. (1971) and Pennington and Grosslein (MS 1978). This variation is a factor of the distribution of redfish. Because the variance is substantically greater than the mean catch/tow of the summer surveys, the distribution must be contagious or clumped (Elliott, 1973). When designing a survey there are several ways of reducing the variation for such distributions. One of these is to increase the sampling unit (possibly to one hour tows) in order to make the distribution appear more random (Elliott, 1973), however Pennington and Grosslein (MS 1978) attempted such a technique and did not see this effect for three other species from Georges Bank. Another method would be to increase the number of samples although this would be prohibitively expensive and the third would be to move to a fixed station type of survey and fish the commercial zones. This latter technique may have special merit when considering redfish abundance surveys. If, as is often hypothesized, the genus *Sebastes* is a non migratory fish then a fixed station survey may reduce variation caused by a moving survey on a fixed population.

If it were deemed necessary to set up a separate redfish survey, then the ecological factors affecting redfish abundance and distribution would be important in its design. The ecological parameters presently available for study are depth, bottom temperature, time of day, and bottom type (surficial geology). Knowing the effect of each of these four parameters will allow for the matching of time and area of the survey to distribution of the fish.

The first of these parameters, depth, is the basis upon which the stratified-random survey is currently designed. In an overview Jean and McCracken (1961) found no redfish at less than 95 m (50 fathoms). Redfish were caught on the outer slopes in about 25% of their sets at between 95 and 185 m (50 to 100 fms) and in most hauls over 185 m (100 fms). On the inner slopes of the Nova Scotian banks redfish were found in about 33% of the hauls-mainly between 100 and 140 m (55 and 75 fms). The present analysis (Figure 5) shows a biomodal (possibly even tri-modal) peak in mean catch per standard tow (30 minutes). The first peak occurring at 150 m depth is due to a few sets with large catches on the inner slopes of the Nova Scotian banks. The second and third peaks at 225 and 325 m respectively are both on the outer slopes of the shelf.

Litvinenko (1974) and Barsukov and Zaharov (1972) identified two species of similar gross morphology with overlapping ranges - *Sebastes fasciatus* a shallow water redfish and *S. mentella* a deepwater redfish. Kenchington (MS 1980) has shown that these two statistically separable species inhabit the Scotian shelf. It is therefore possible that these latter two peaks are the optimal depths of the two respective species or, less likely, the optimal depths of one species in different years. The inner slopes of the shelf banks would be inhabited by (*S. fasciatus*) although the basins often of equal depth do not appear to have redfish populations.

Alverson and Westrheim (1961) found Pacific ocean perch *S. alutus* moved from 50 to 75 m deeper during the winter. Paraketsov (1963) found two peaks of catch rate (at 225 and 325 m) during the summer for *S. alutus* in the Bering Sea while in the winter the fish moved deeper to (300 to 400 m). Such possible behaviour patterns should be born in mind if a non-summer survey were planned for redfish.

Many authors (Hennemuth and Brown, MS 1964; Gulland, MS 1965) have shown redfish length distribution to vary statistically with depth. Hennemuth and Brown (op.cit.) found up to a 7 cm difference in length between 100 m and 200 m, with larger fish generally found in deeper waters.

Bottom temperature (Figure 6) shows major catch rates (over 100 kg per tow) occur between about 3°C and 9°C. These data agree with that of Taning (1949) and Templeman (1959). McLellan (1954 and 1955) shows bottom temperatures in this optimum range over much of the year, especially in northern Banquereau (Strata 44, 45, and 46, Appendix I: Figure 1) and The Gully. The basins on the Scotian shelf are shown to warm up considerably in the summer and late fall, a possible reason why, though the depth is suitable and food available (i.e. euphausiids in Emerald Basin) redfish are not abundant.

Time of day, the third parameter, again supports data from other regions and species of the genus Sebastes. The largest catch occurs during daylight hours (1200 hrs) (Figure 7) with a second minor peak occuring between 2100 and 2200 hrs. At least the largest peak is probably associated with diurnal euphausiid migrations (vertical). (During feeding studies conducted by the author on redfish from the Scotian shelf in the past 2 years euphausiids were found to make up over 90% of all food items.)

Redfish appear to hold only a very loose association for bottom type (surficial geology). Although the five major bottom types (King, 1970) are well represented in the surveys, redfish catches with over 10 kg are virtually absent on the gravelly sands of the banks. The highest individual catches were recorded on LeHave clay, Sambro sand, and Emerald silt respectively. The highest rates of catch (over 10 kg were on Emerald silts (40%) and the Scotian shelf drift (30%). This however may be an auto correlation based more on the bottom type-depth relationship than on a fish-bottom type relationship. Until an analysis of variance is carried out on these data little can be said except, if a relationship exists it is very weak.

One last valuable piece of information available from research vessel surveys is the length composition of the catch. Because small mesh liners are used ($\pm$ 10 mm) the catch, it is hoped, will be representative of the population. The length frequencies (1975-1979) for NAFO division 4Vn show little pattern in the form of up coming year-classes (Figure 8). The mode at 19 cm in 1977 may be the same year-class as the large mode at 22-23 cm in 1979. However, in general there would appear to be a lack of fish below 30 cm or using age-length data from Clay and Clay (MS 1980) below 15 years of age. This is a potentially very dangerous situation if 4Vn is a unit stock and this indicates recruitment failure. There is one other possible explanation, larvae spawned in 4Vn could be carried away to other areas and immigration of older fish may occur from these and/or other areas possibly from the Gulf of St. Lawrence.

Bearing in mind the options for recruitment from division 4Vn, an inspection of the length frequencies (1970-1979) for the neighbouring division 4Vs (Figure 9) is necessary. This area appears to have an abundance of younger fish (under 25 cm) under 12 years of age. Possibly, the missing recruitment from 4Vn? There is a current moving the surface water from 4Vn out on the shelf past Sable Island and around to 4Vs - possibly bringing with it the pelagic larvae. The effects of the heavy fishing in 1971 are apparent in 1972 and later years. After the heavy fishing period 1971-1974 the length frequency is less stable and the stock in this area appears to have moved to greater dependence on one or two individual year-classes. The 1972 year-class (14-15 cm in 1977, 17-18 cm in 1978, and 20 cm in 1979) seems to be the only sign of a strong year-class. The effect of the strong year-class in 1964 or 1965 (modes 18-19 cm in 1970 through to 30 cm in 1978) appears to be disappearing - a possible reason why the proportion of the catch from 4Vs dropped from 60% in 1978 to 40% in 1979.

The next set of length frequencies (1970-1979) are from NAFO division 4W (Figure 10). This series is remarkable in its relative consistency over the entire decade. Except for 1979 and the small mode at 15 cm (1977) there have been no recruits (under 12 years) in this area. The middle-aged composition of the stock has remained steady despite both the lack of recruits and the heavy 4W fishery which only let up in 1976 (Figure 11). Many of the fish represented in these length frequencies are from strata 60 (see Appendix I: Figure 1 and Table 3) - an inshore strata. It has been hypothesized that the redfish of the "inshore holes" are smaller than those offshore because they grow more slowly. Neither the 1977 nor the 1978 data on age and growth support this hypothesis and the growth rate in strata 60 is almost identical to that off the slope. Kenchington (MS 1980) has found S. fasciatus to be the predominant redfish species [1] on the Scotian shelf over the range of depths covered by the groundfish surveys and therefore these fish are probably not a separate species - although the 4W inshore population may well be a separate stock.

The length frequencies from division 4X(E) show a population without recruitment between 1975 and 1978 (Figure 12). The young fish (15-22 cm) in 1979 are not readily explained - the size of the sample indicates that one set of small fish could affect this population distribution. The length frequencies from division 4X(W) show what might be the 1965±2 year-class (Figure 13). Except for this year-class (starting mode 20 cm 1975) there is little cause for optimism in recruitment in either part of division 4X.

RELEVANCE FOR STOCK ASSESSMENT

The data presented above make it obvious that the unadjusted minimum trawable biomass estimates are extremely unreliable for redfish and should not be used as predictive tools. The adjusted figures do not provide an optimistic outlook as the catch has been reduced to 25% of its 1970 levels and no upward trend is visible in the biomass estimates (a possible query exists for 4Vn in 1979). The TAC set for 1979 was not reached - in fact a serious short fall occurred (40%). It is probable that the TAC for 1980 will also not be met. The commercial CPUE figures (see Clay, MS 1979) are of little value as the major vessel size involved in this fishery - the OTB-4 class - provide a very steady catch rate of approximately 0.5 tonnes per hour. Clay (MS 1979) put forward two hypotheses for this. The first hypothesis suggest the vessels must fish at an economic rate of return or they switch to another species - the catch rate may be maintained at a set level by the schooling nature of these fish, a factor which coupled with modern

[1] Although throughout this paper the redfish has been called Sebastes marinus mentella - it should probably be called S. fasciatus.

electronics allows them to be exploited economically until the last school is removed. The second possibility considered was the experience of the crews - fishermen on older vessels who know the stocks well are able to find fish even when they occur at very low concentrations. To these two possibilities, a third can now be added - that the biomass level has remained essentially constant over the last 6 to 8 years.

The ecological data suggest some ways of possibly standardizing groundfish cruises. It may be necessary to standardize the catches in any year to one time of day - and between years to one temperature. Such techniques may lead to groundfish cruises that can be modified by various adjustments and/or stratification schemes for investigations of individual species.

The length frequency data for divisions 4VWX show several middle-aged to old stocks of redfish. Few if any recruits are visible although at times young fish are caught in large numbers. This state of affairs does not bode well for the medium term future of this stock (5-10 years). It is important to note that 2 or 3 year-classes (age groups 15 and 16) make up $\pm$ 30% of the catch. This does not indicate a fishery dependent on a few strong year-classes, but a fishery where the new recruits support the fishery and are removed very quickly once they enter the fishery.

The catch has fallen steadily over the past 10 years. This is partly due to restrictions of various sorts, however, the restrictions are often lagging the reductions. Such reduction could be an indication of declining stocks - such as has been found in the Gulf of Maine. Unfortunately there does not appear to be a "salvation year class" in the wings such as the Gulf of Maine's 1971 year-class. I feel serious consideration must be given to a drastic reduction in TAC for 1981 - consideration that cannot wait for another year.

Acknowledgements

Diane Beanlands and Pat Simpson assisted in much of the data extraction and compilation.

REFERENCES

Alverson, D.L. and S.J. Westrheim. (1961). A review of the taxonomy and biology of the Pacific Ocean perch and its fishery. ICNAF Sel. Pap. No. 3:12-27.

Barsukov, V.V. and G.P. Zaharov. (1972). [Morphological and biological peculiarites of the American sea perch.] Trudi Polyarnoi N-i Proiekti Instituta Morskogo Rybnogo Hozyaistva i Okeanographic, Vipusk 28. (In Russian).

Clay, D. (MS 1979). Atlantic redfish (Sebastes mentella) in ICNAF divisions 4VWX: A stock assessment and an estimate of the total allowable catch (TAC) for 1980. CAFSAC Research Document 79/41.

Clay, H. and D. Clay. (MS 1980). Age, growth, and removals at age for Atlantic redfish from the Scotian Shelf. CAFSAC Research Document 80/32.

Elliott, J.M. (1973). Some methods for the statistical analysis of samples of benthic invertebrates. Freshw. Biol. Assoc., U.K., Sci. Pub. 25. pp 148.

Gulland, J.A. (MS 1965). The use of redfish statistical data by depth zones. ICNAF Res. Doc. 65/28. Serial No. 1488.

Halliday, R.G. and A.C. Kohler. (MS 1971). Groundfish survey programs of the St. Andrews Biological Station, Fisheries Research Board of Canada - objectives and characteristics. ICNAF Res. Doc. 71/35. Serial No. 2520.

Halliday, R.G., A.C. Kohler and M.D. Grosslein. (1971). Comparisons of abundance indices from research vessel surveys and commerical statistics for cod and haddock in ICNAF Subarea 4. ICNAF Redbook 1971 (III):229-238.

Hennemuth, R.C. and B.E. Brown. (MS 1964). Relationship of length distribution of redfish to depth of catch. ICNAF Res. Doc. 64/87. Serial No. 1383.

Jean, Y. and F.D. McCracken. (1971). Incidental catches of redfish in cod and haddock surveys off the southern Canadian mainland during the years 1957 to 1959. ICNAF Spec. Pub. No. 3: 142-147.

Kenchington, T. (MS 1980). Species and stocks of redfish in NAFO divisions 4VWX. CAFSAC Research Document 80/30.

King, L. (1970). Surficial geology of the Halifax-Sable Island map area. Marine Sciences Paper No. 1. Geological Survey of Canada. pp 16. plus map.

Koeller, P.A. (MS 1979). Biomass estimates from Canadian research vessel surveys, Div. 4VWX, 1970-1978. CAFSAC Res. Doc. 79/14.

Litvinenko, N.I. (1974). [The colouration and other morphological characteristics permitting the differentiation between young Sebastes fasciatus Storer, 1852 and young S. mentella Travin, 1951 (Scorpaenidae). Unknown journal .4 (87): 689-692. (In Russian). (Translation available from Walter Ivantsoff).

McLellan, H.J. (1954). Bottom temperatures on the Scotian shelf. J. Fish. Res. Bd. Canada. 11(4):404-408.

McLellan, H.J. (1955). Changes in bottom temperatures on the Scotian shelf. J. Fish. Res. Bd. Canada. 12(3):375-386.

Paraketsov, I.A. (1963). [On the biology of Sebastodes alutus in the Bering Sea.] In: Soviet fisheries investigations in northeastern Pacific Ocean, Part 1: 305-312. (In Russian). (Translation available from: Clearinghouse Fed. Sci. Tech. Inform., Springfield, Va., USA as TT 67-51203.)

Parsons, L.S. and D.G. Parsons. (MS 1976). Status of the Gulf of St. Lawrence redfish stock. Offshore Groundfish Advisory Committee, January 11, 1976. (Mimeo).

Pennington, M.R. and M.D. Grosslein. (MS 1978). Accuracy of abundance indices based on stratified-random trawl surveys. ICNAF Res. Doc. 78/77. Serial No. 5264.

Taning, A.V. (1949). On the breeding places and abundance of the redfish (Sebastes) in the North Atlantic. J. du Conseil. (ICES) 16:85-95.

Templeman, W. (1959). Redfish distribution in the North Atlantic. Bull. Fish. Res. Bd. Can., No. 120. pp 173.

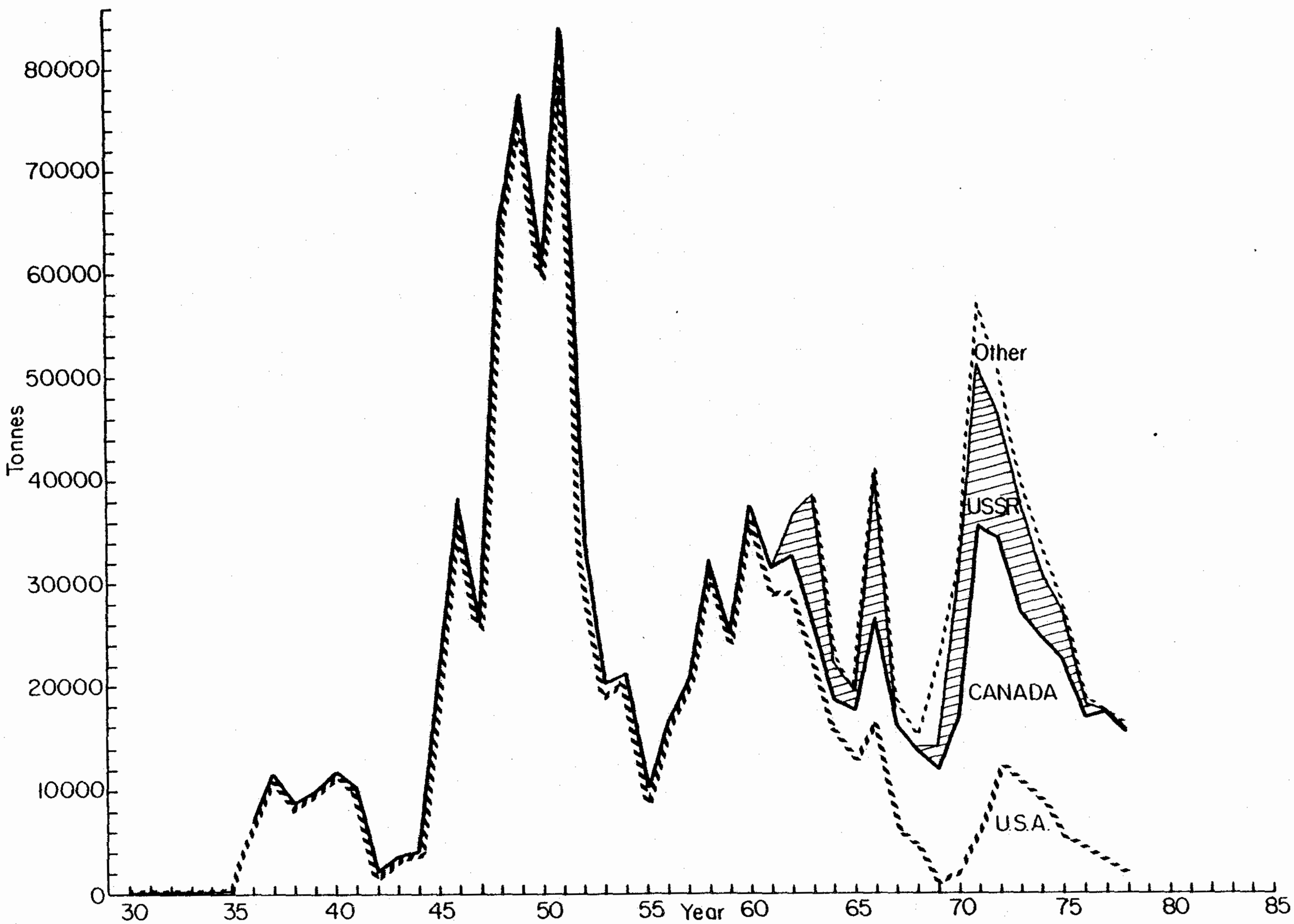


Figure 1. Atlantic redfish nominal landings for NAFO divisions 4VWX (Scotian Shelf and Bay of Fundy). Landings are subdivided by country.

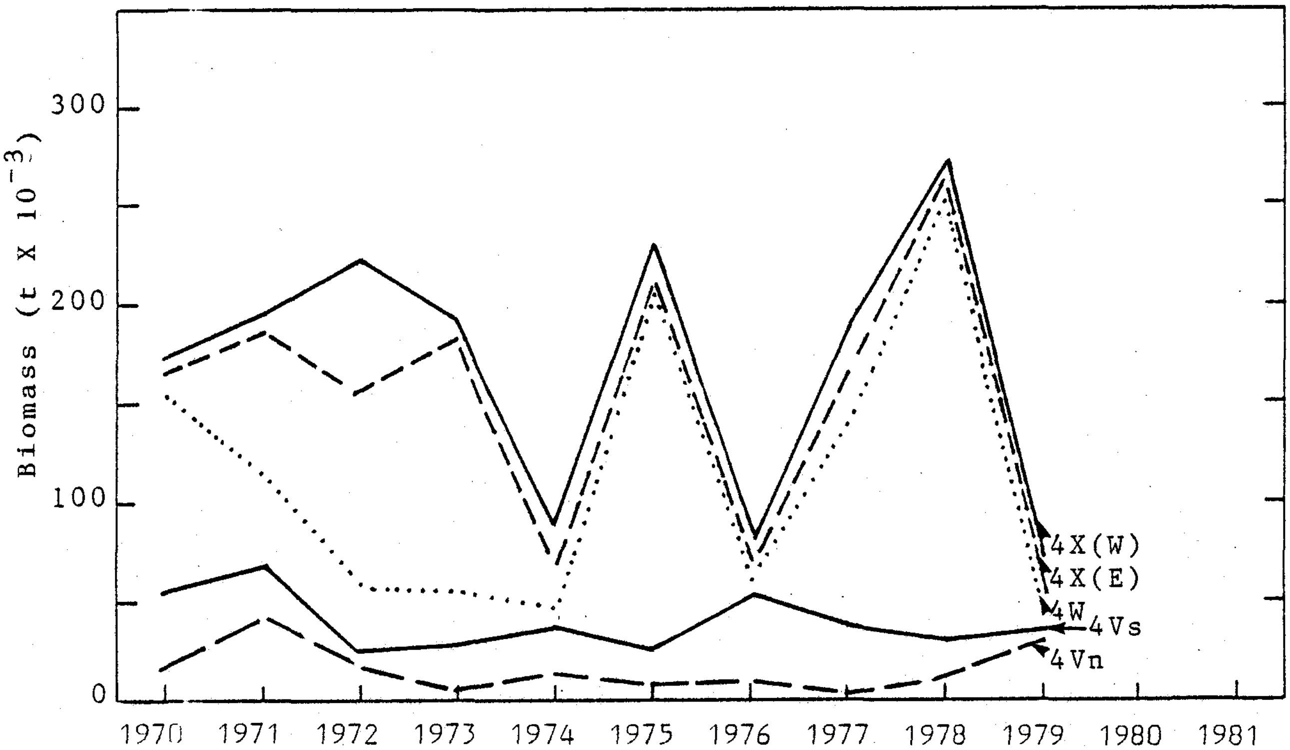


Figure 2. Atlantic redfish biomass estimates for the Scotian Shelf as calculated from Canadian R/V surveys. The data is unadjusted and divided by NAFO subdivisions.

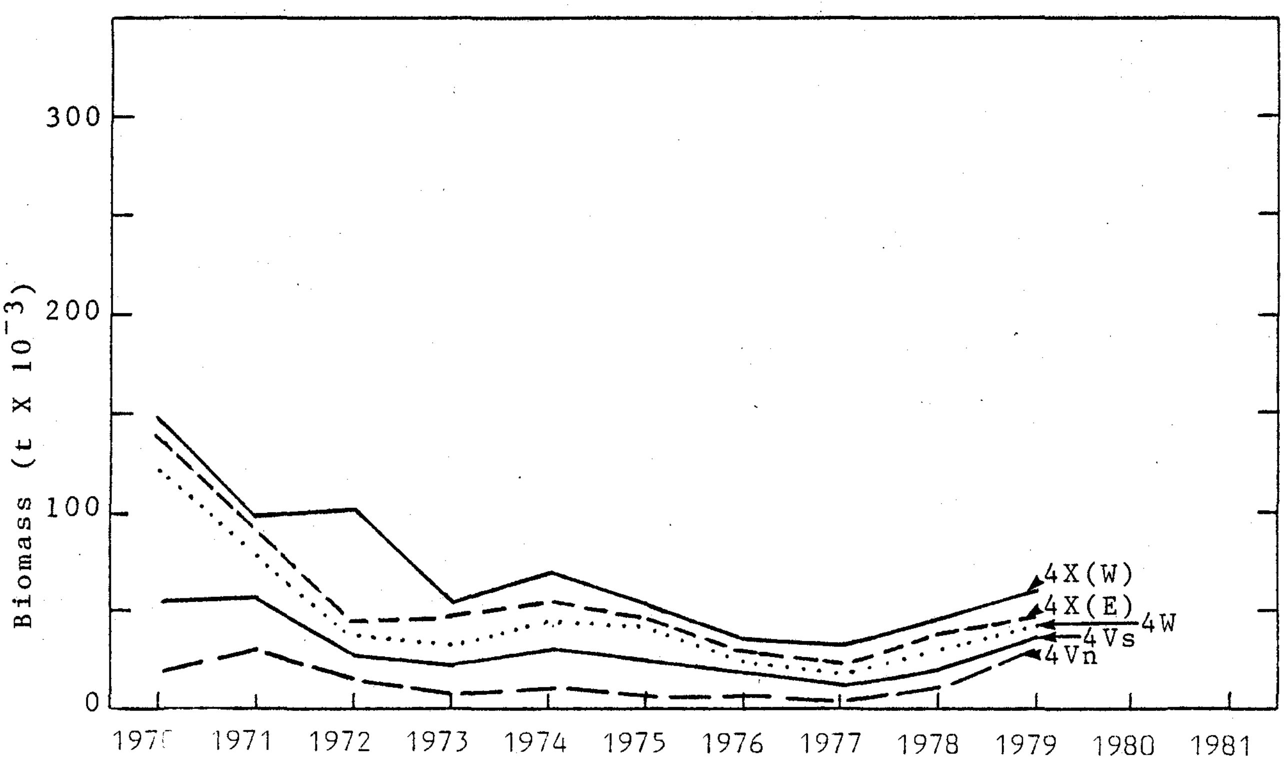


Figure 4. Atlantic redfish biomass estimates for the Scotian Shelf as calculated from adjusted data of Canadian R/V surveys. The data, adjusted to remove some extreme between set variation, is plotted by NAFO subdivisions.

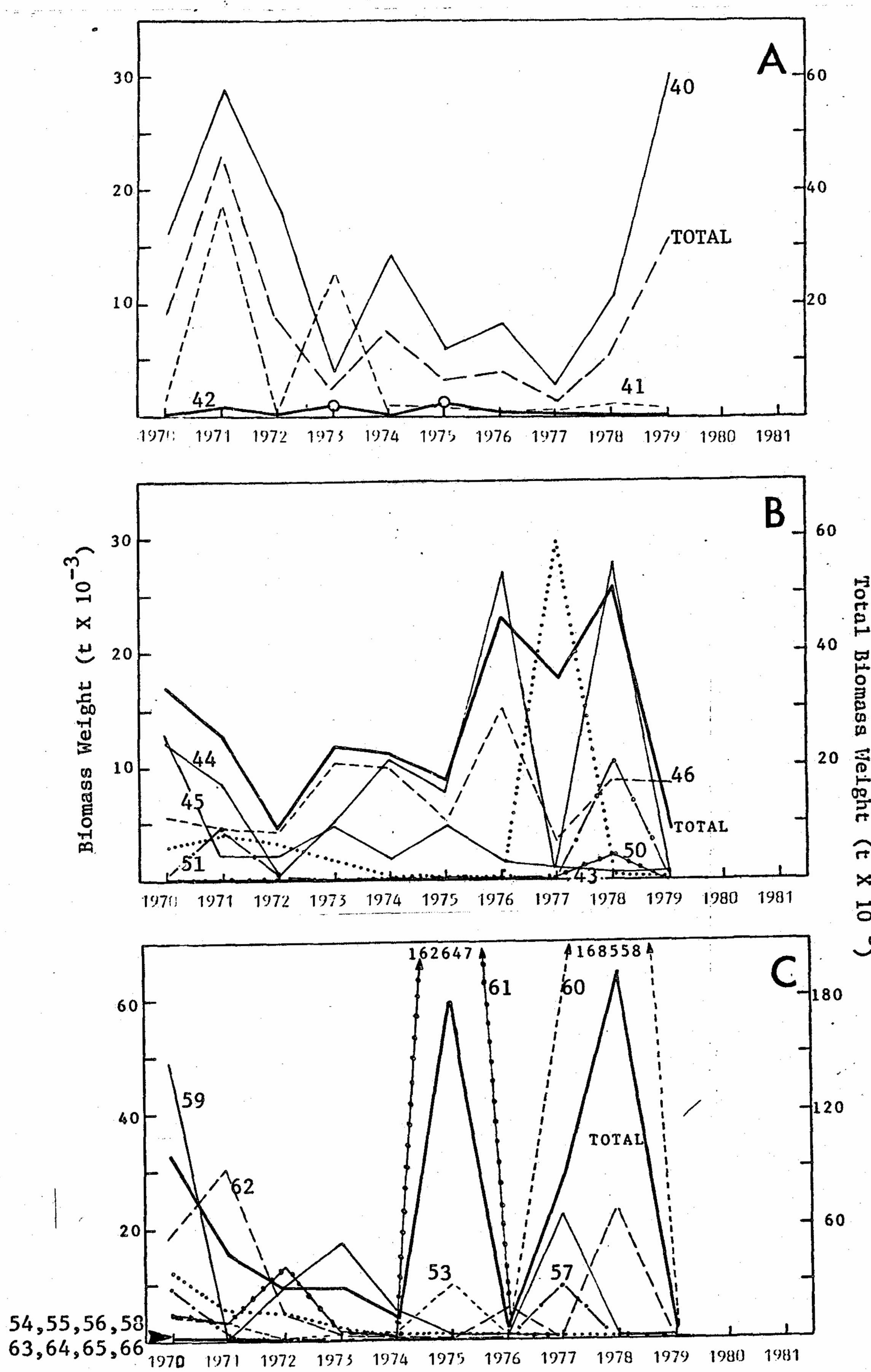


Figure 3. Biomass estimates for Atlantic redfish from NAFO divisions 4Vn-(a), 4Vs-(b), 4W-(c), 4X(E)-(d), and 4X(W)-(e). Each division total (solid line) is broken down into stratum components (numbered).

Figure 3. Biomass estimates for Atlantic redfish from NAFO divisions 4Vn-(a), 4Vs-(b), 4W-(c), 4X(E)-(d), and 4X(W)-(e). Each division total (solid line) is broken down into stratum components (numbered).

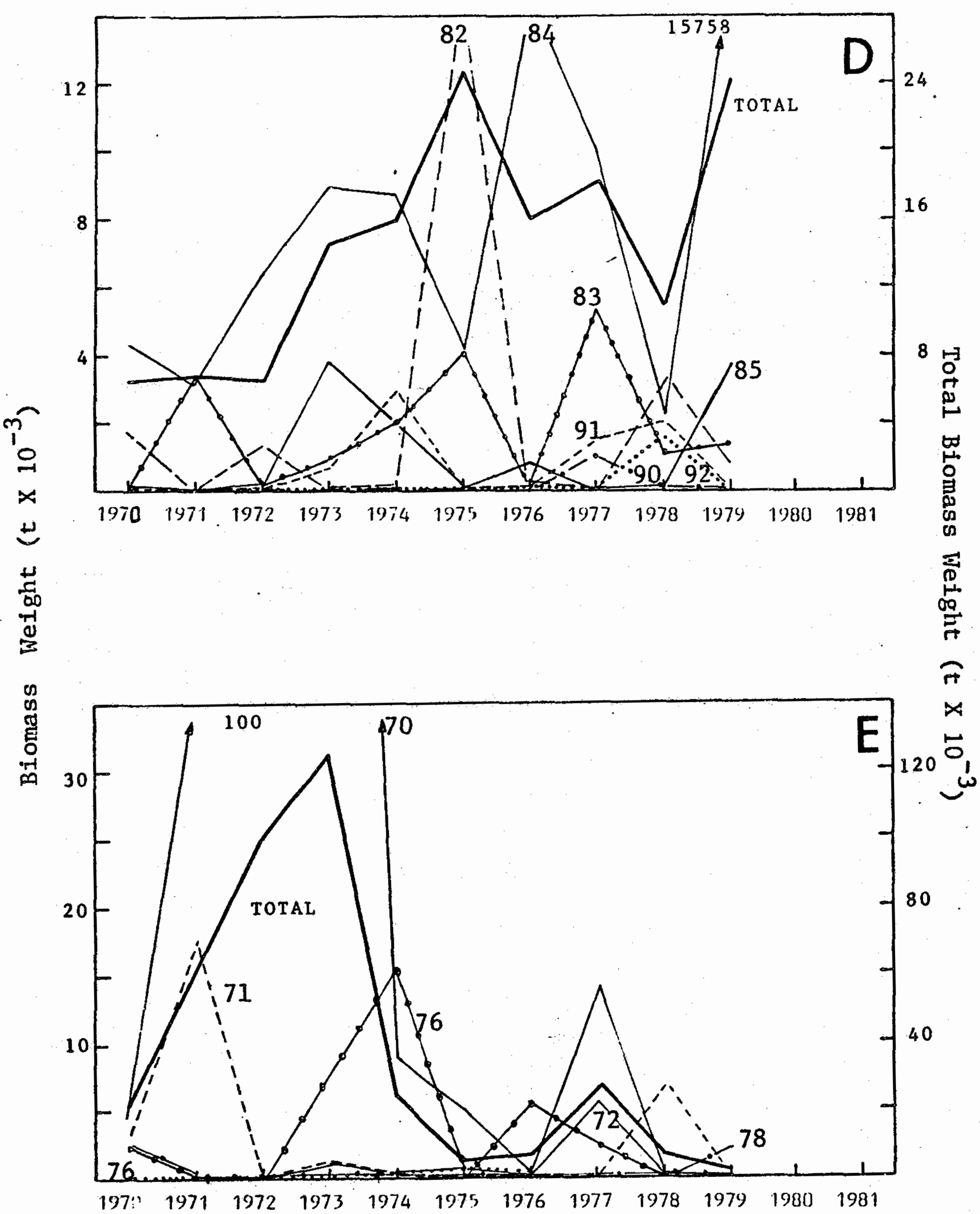


Fig. 5. Distribution of total fishing effort, fishing effort catching over 1 kg of Atlantic redfish in a 30 minute tow, and mean catch (kg) of redfish by depth from R/V surveys on the Scotian shelf. The solid line represents the total fishing effort, the dotted line the effort when redfish in the catch is greater than 1 kg and the broken line the mean catch.

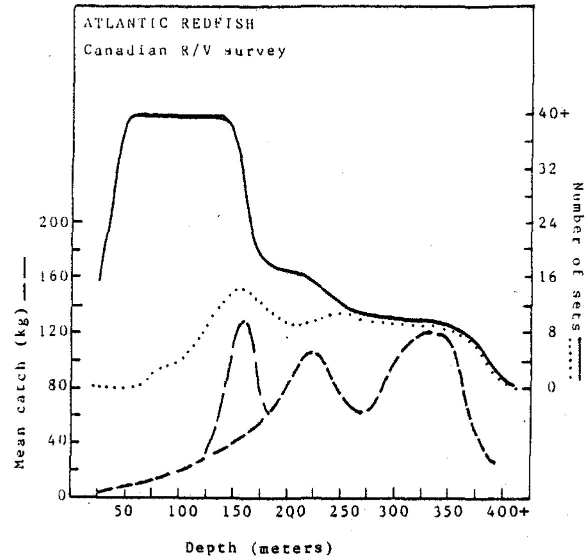


Fig. 6. Distribution of total fishing effort, catching over 1 kg of Atlantic redfish in a 30 minute tow, and mean catch (kg) of redfish by bottom temperatures from R/V surveys on the Scotian shelf. (Key symbols are same as for Figure 5).

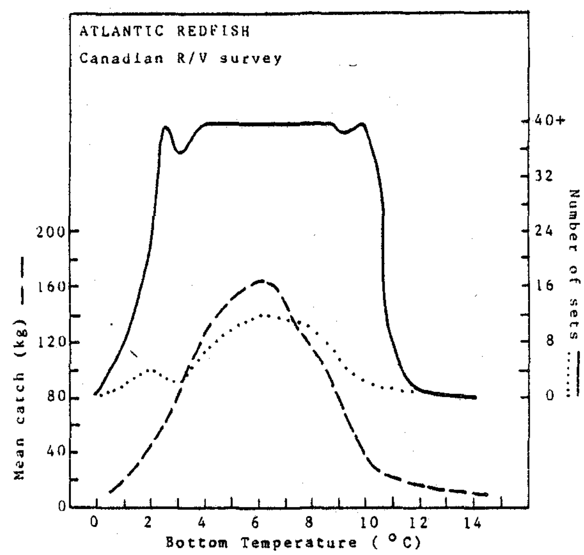
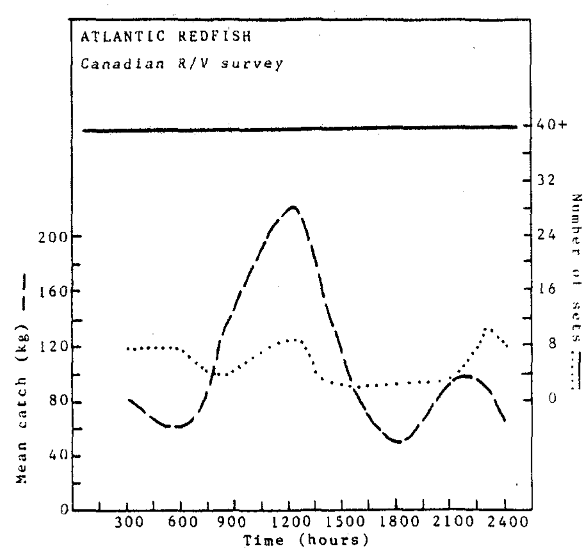


Fig. 7. Distribution of total fishing effort, fishing effort catching over 1 kg of Atlantic redfish in a 30 minute tow, and mean catch (kg) of redfish by time of day (Atlantic standard time) from R/V surveys on the Scotian Shelf. (Key symbols are same as for Figure 5).



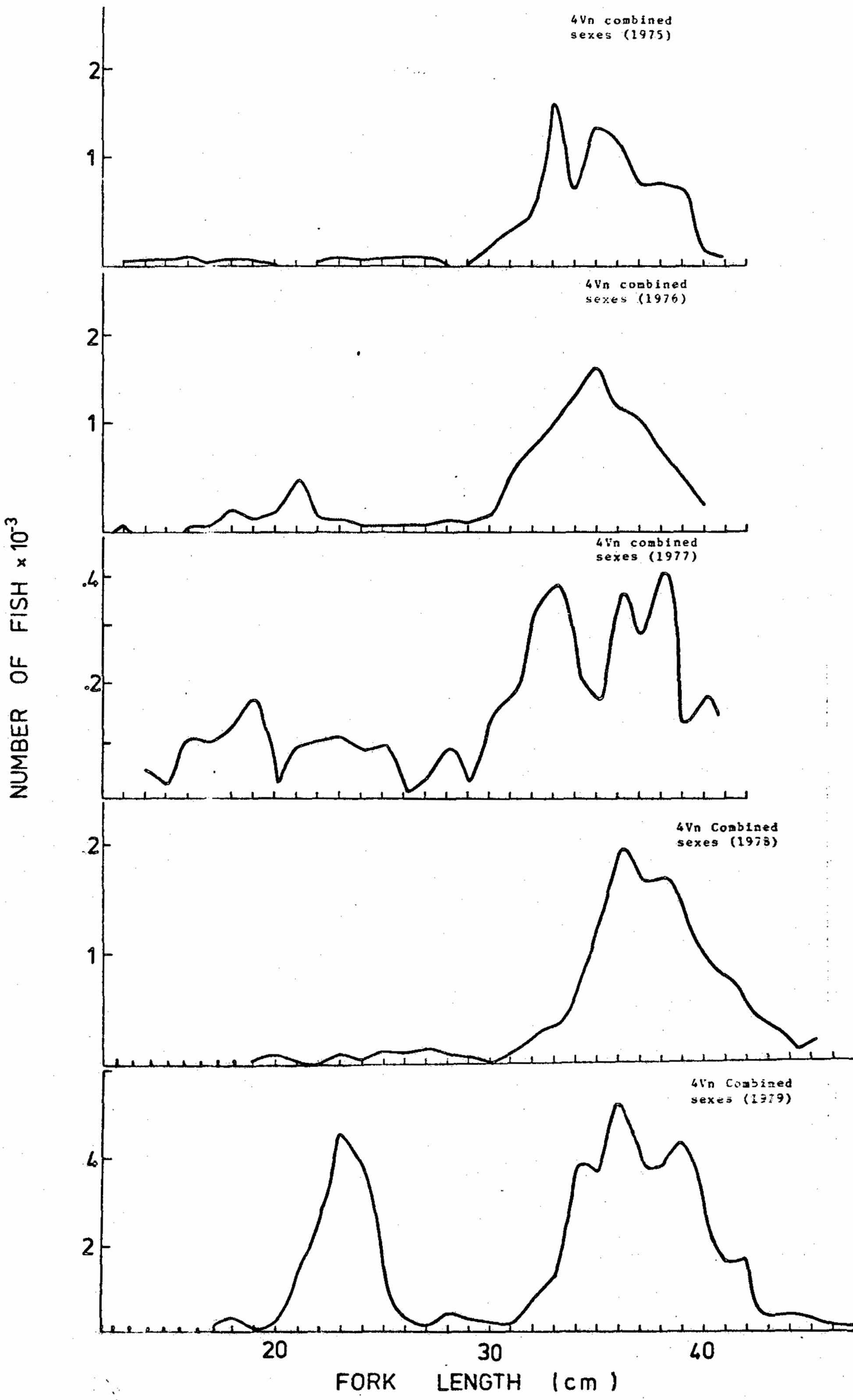


Figure 8. Length frequencies of Atlantic redfish from NAFO division 4Vn (1975-1979).

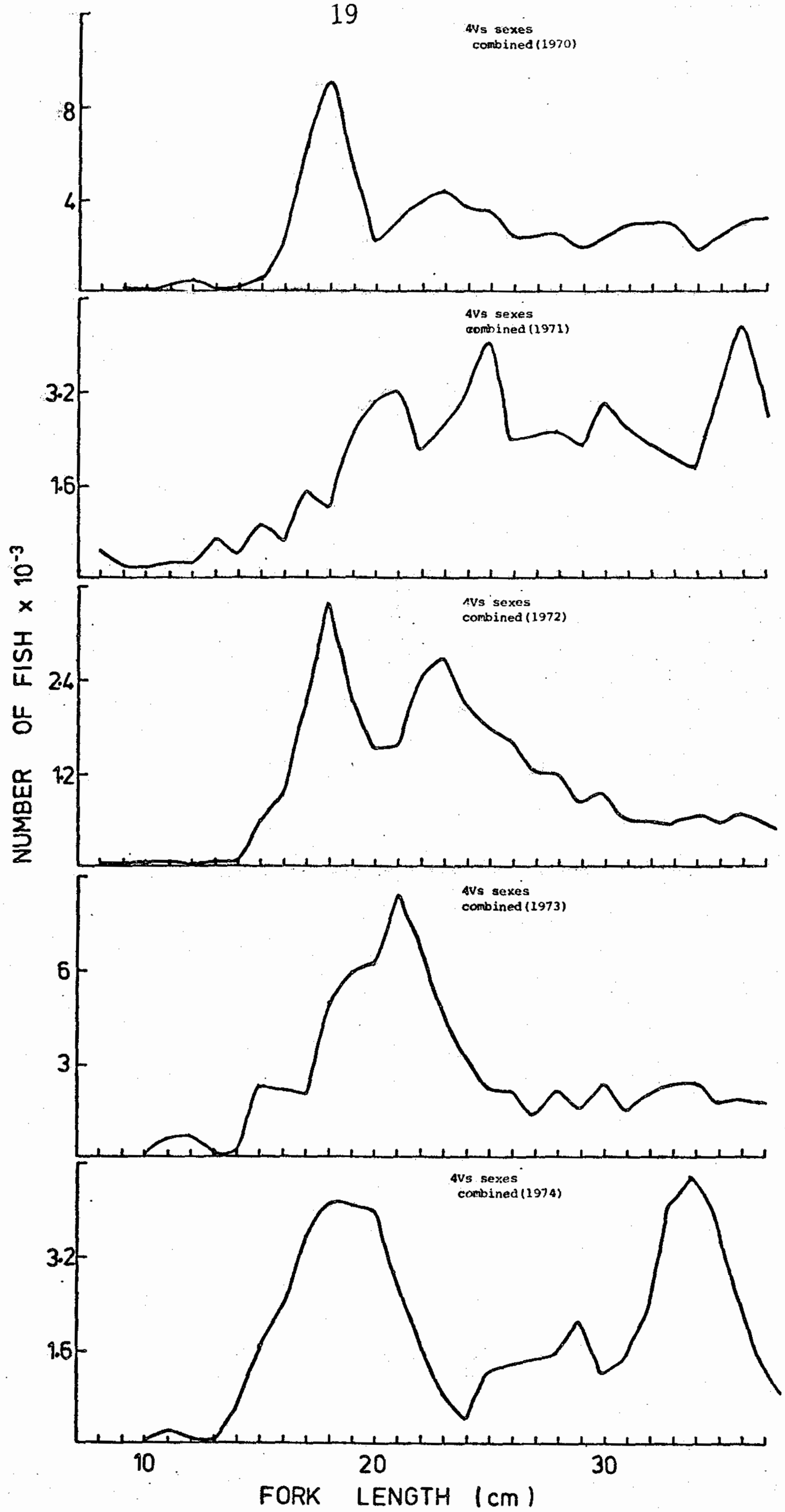


Figure 9. Length frequencies of Atlantic redfish from NAFO division 4Vs (1970-1979).

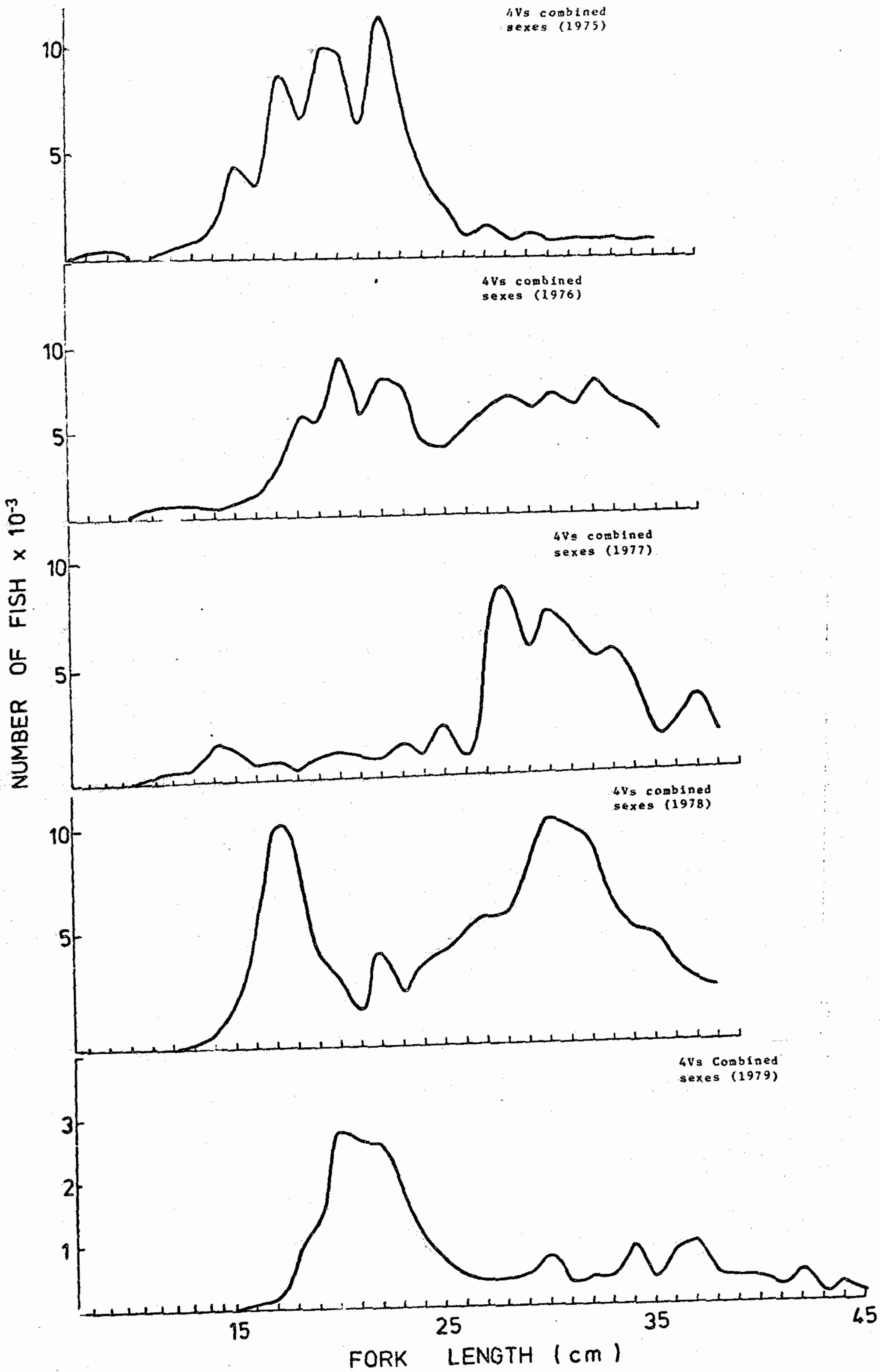


Figure 9. Continued.

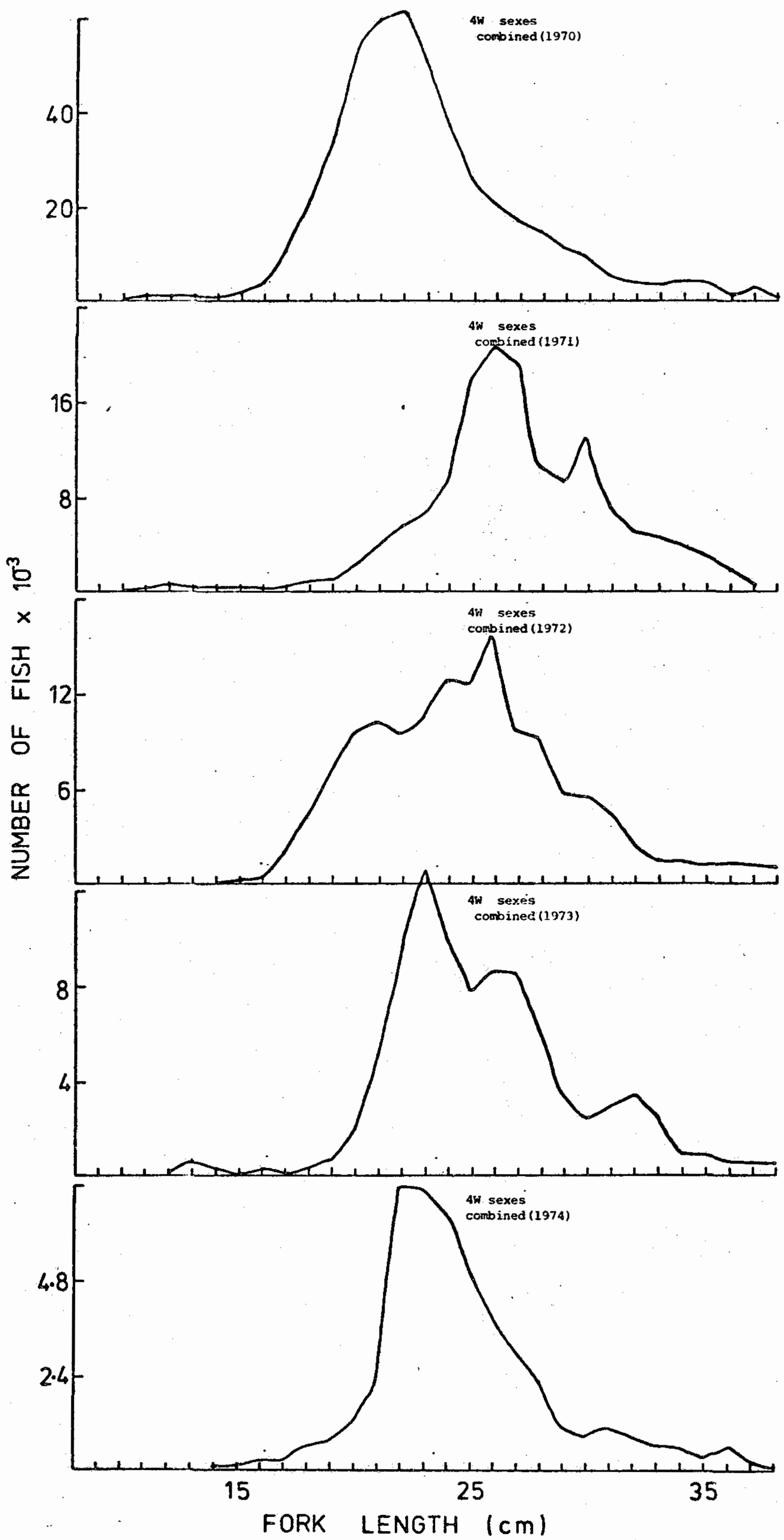


Figure 10. Length frequencies of Atlantic redfish from NAFO division 4W (1970-1979).

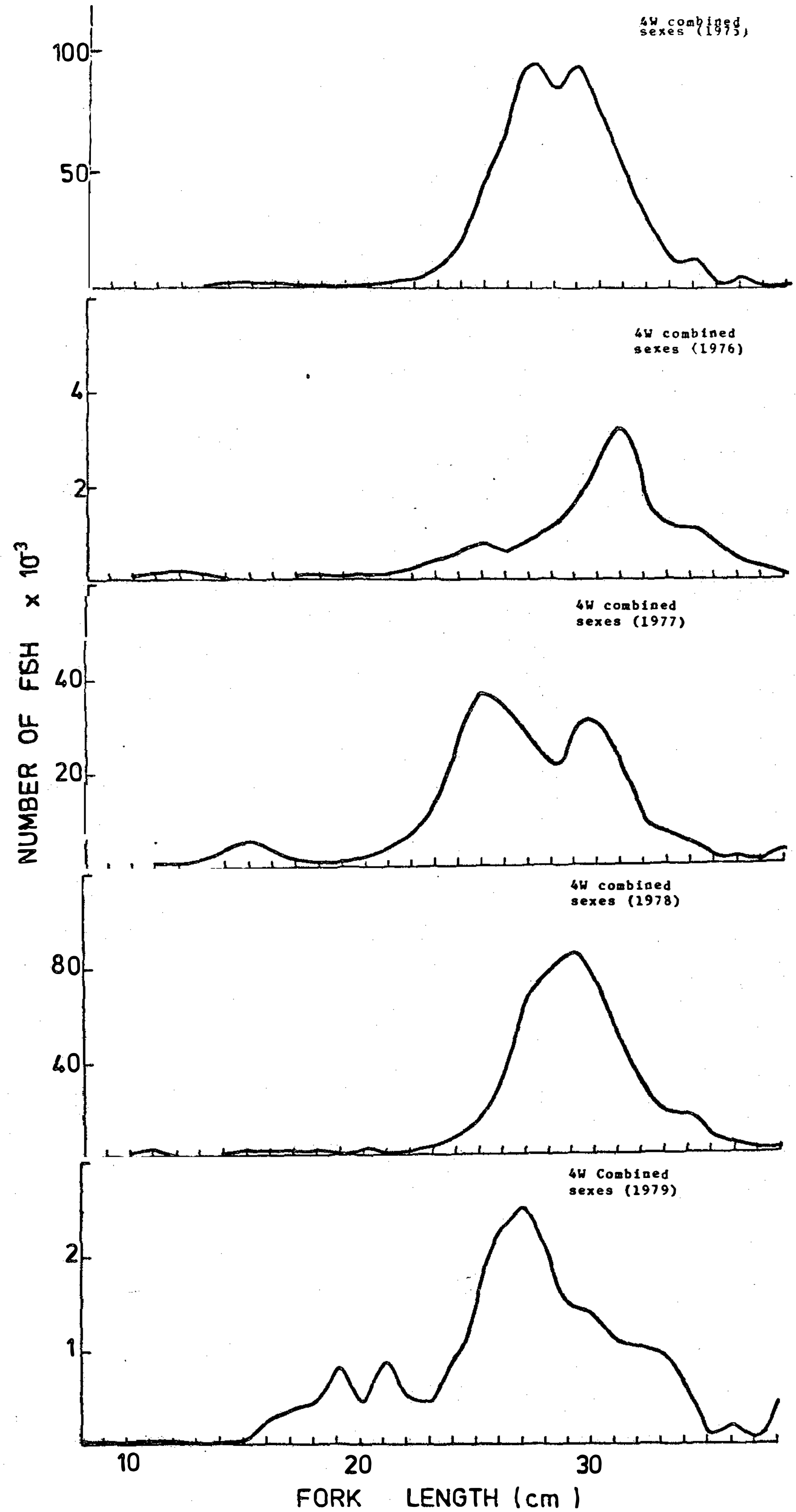


Figure 10. Continued.

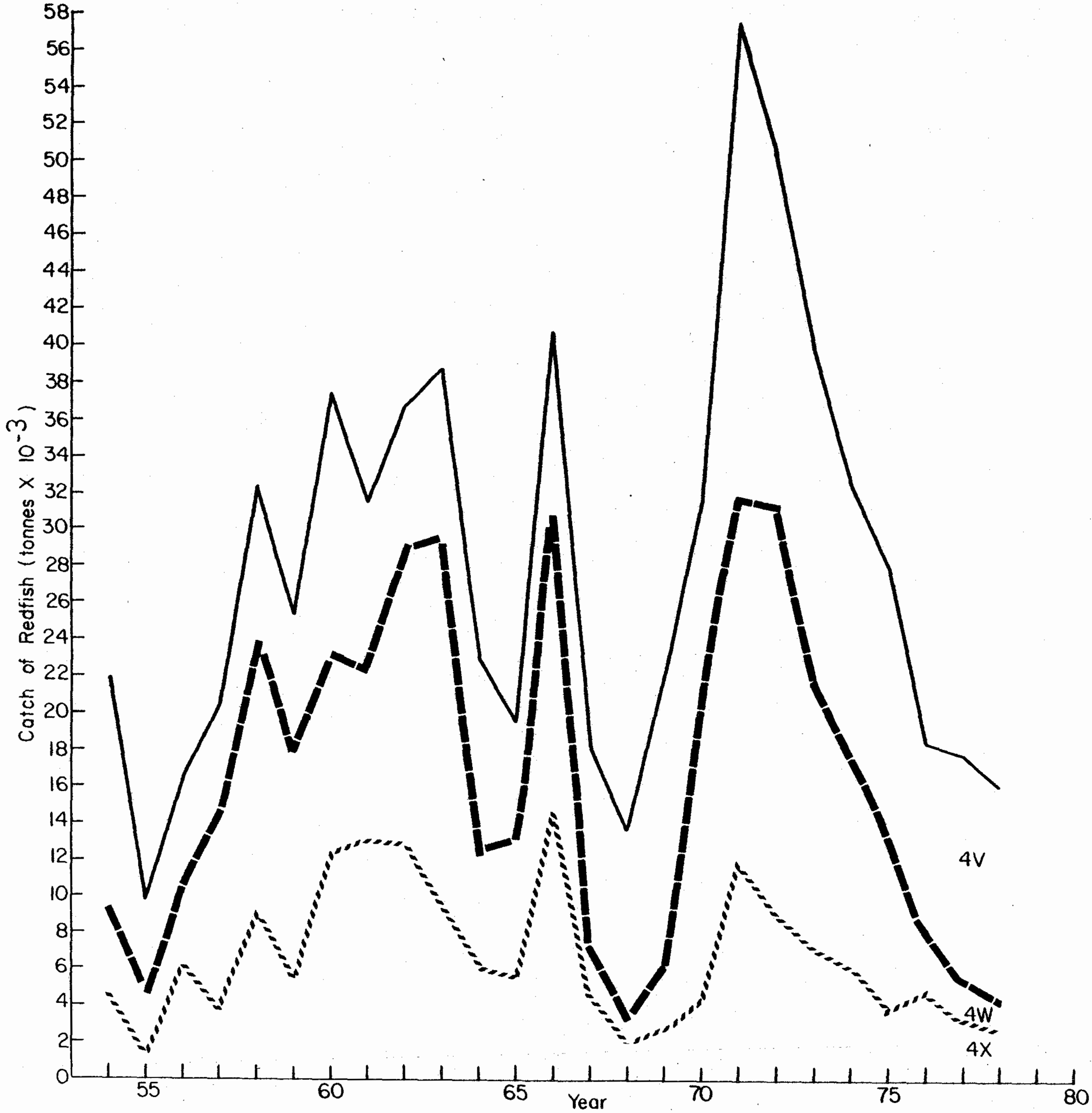


Figure 11. Atlantic redfish nominal landings for the Scotian Shelf and Bay of Fundy. Landings are divided by NAFO divisions.

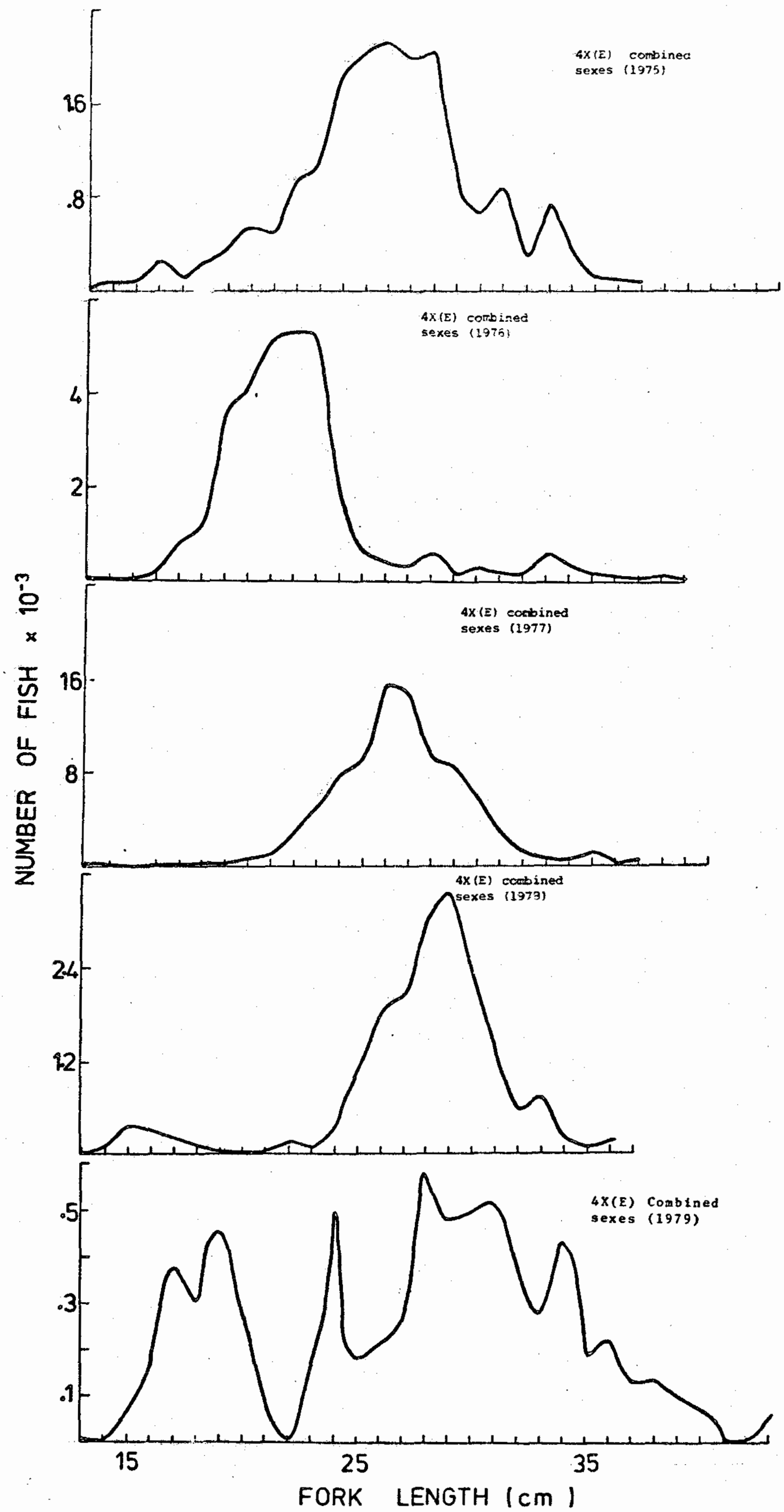


Figure 12. Length frequencies of Atlantic redfish from NAFO division 4X(E) (1975-1979).

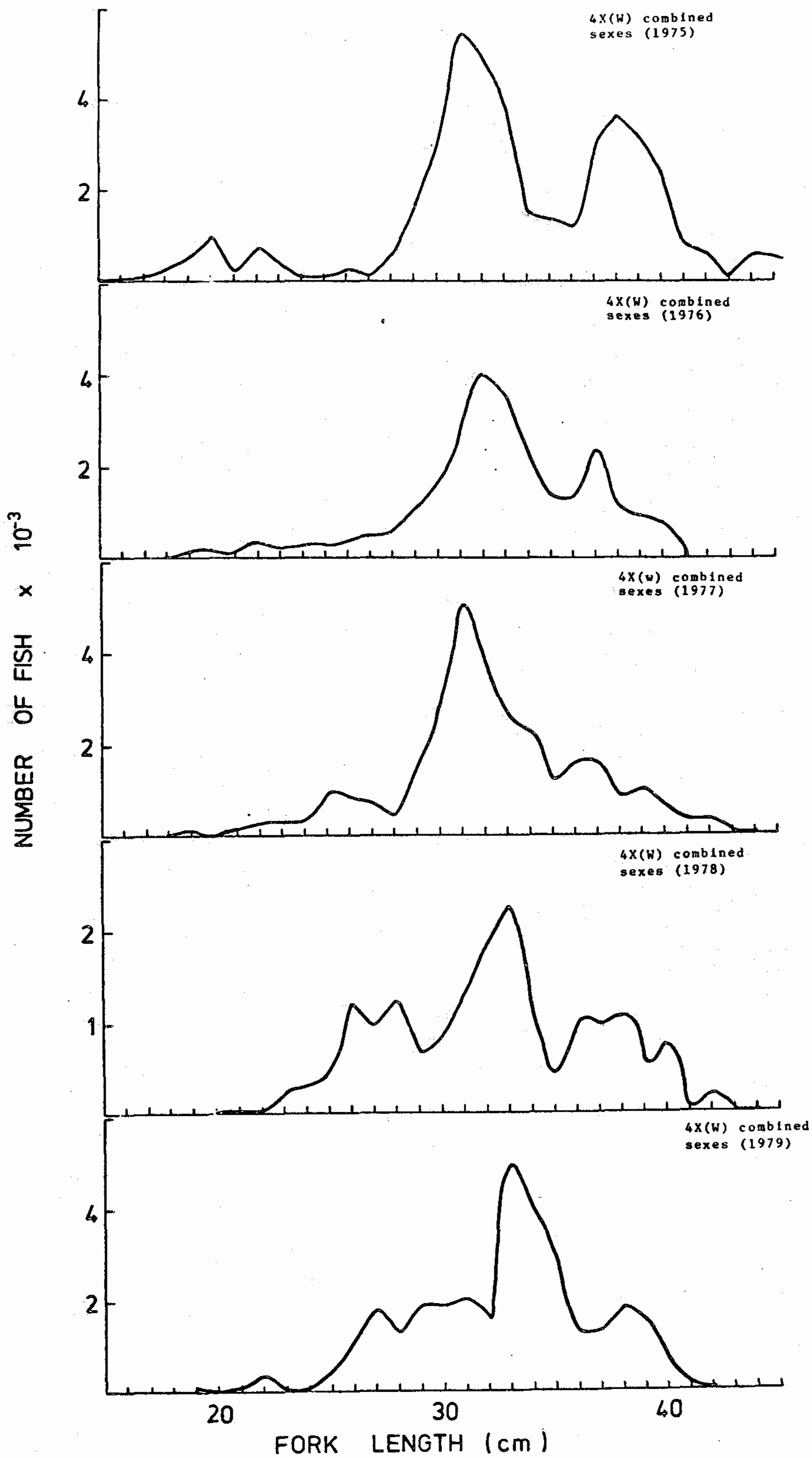


Figure 13. Length frequencies of Atlantic redfish from NAFO division 4X(W) (1975-1979).

APPENDIX I

Summary of Canadian summer groundfish cruise data for the Atlantic redfish (1970-1979).

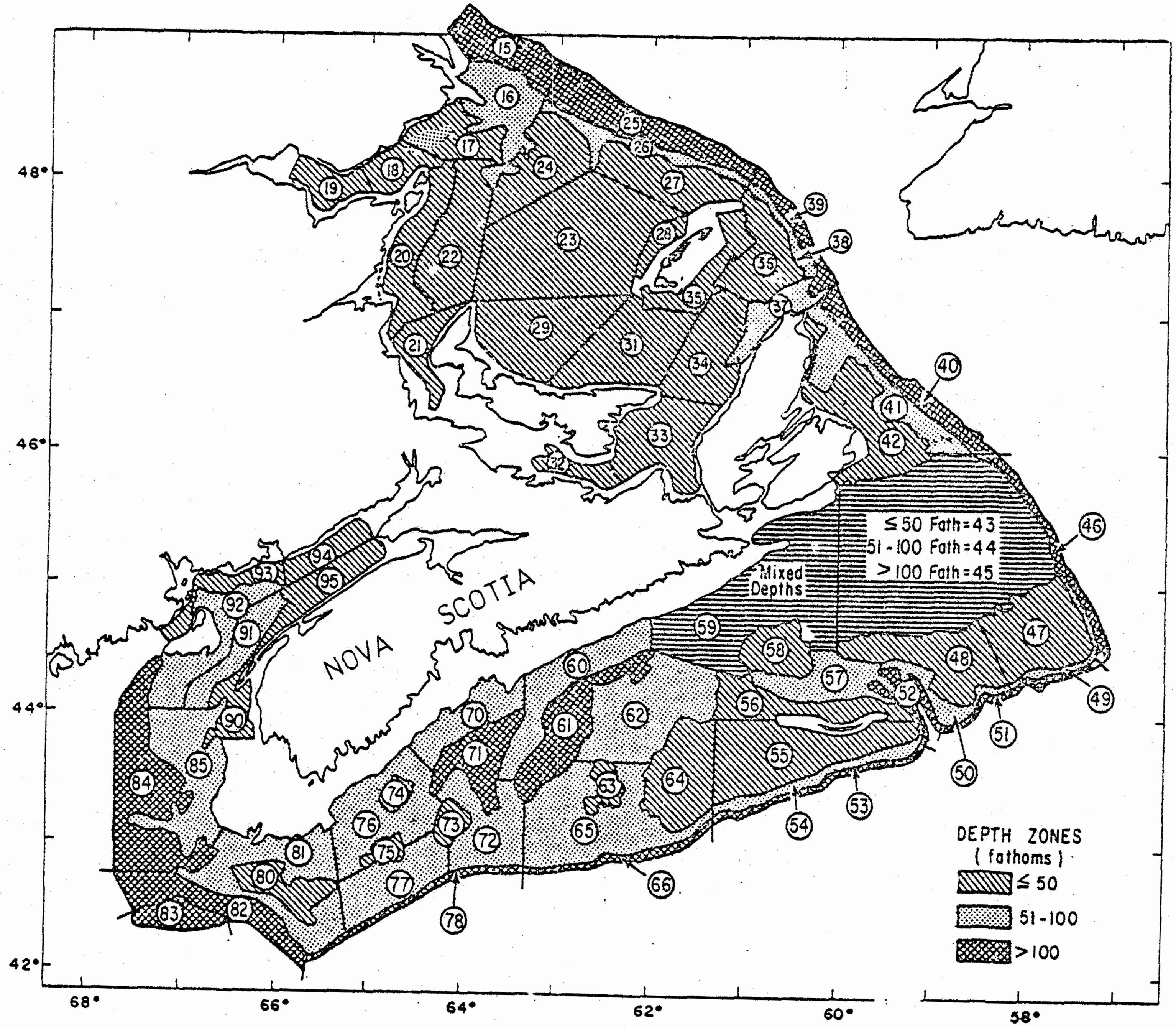


Figure 1. Map of strata used for Canadian groundfish cruises on the Scotian Shelf. (after Halliday and Kohler, MS 1971).

Table 1 . Canadian Research Vessel cruise data for redfish in NAFO division 4Vn from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. (x10^{-6})	Biomass Weight (tonnes)	
1970	40	4	373.50±194.41	32.16	34.26	16767.9	
	41	4	68.50±73.43	22.57	6.80	1890.9	
	42	3	0.00	0.00	0.00	0.00	
1971	40	2	548.13±255.4	****	50.3	28205.2	
	41	2	373.63±501.2	****	37.1	17632.5	A[1]
	42	2	1.09±1.55	****	0.16	78.0	
1972	40	2	884.82±748.3	****	81.2	18220.1	
	41	2	0.00	0.00	0.00	0.00	
	42	2	0.00	0.00	0.00	0.00	
1973	40	3	108.42±33.29	27.48	9.9	3893.7	
	41	2	55.07±77.89	22.81	5.5	1277.3	
	42	3	0.34±0.59	32.00	0.05	****	
1974	40	3	375.9±300.8	27.81	34.4	14934.8	
	41	3	13.27±17.13	15.61	1.3	106.4	
	42	3	0.00	0.00	0.00	0.00	
1975	40	3	101.69±43.04	36.48	9.3	6786.3	
	41	3	0.61±1.06	14.50	0.06	****	
	42	3	0.97±1.69	16.33	0.14	****	
1976	40	3	120.92±17.19	34.42	11.09	7832.9	
	41	1	0.00	0.00	0.00	0.00	
	42	2	0.00	0.00	0.00	0.00	
1977	40	3	44.4±42.68	33.53	4.07	2706.2	
	41	4	4.89±9.78	17.79	0.48	51.1	
	42	2	0.00	0.00	0.00	0.00	
1978	40	3	139.09±133.4	36.82	12.76	10701.1	
(July)	41	3	****	****	****	595.6	
	42	3	0.00	0.00	0.00	0.00	
1978	40	3	46.86	38.37			
(Nov-Dec)	41	3	0.00	0.00			
	42	3	0.32	19.00			
1979	40	3	557.58±276.54	32.80	51.14	30211.6	
(July)	41	3	1.62±2.81	21.40	0.16	32.2	
	42	3	0.00	0.00	0.00	0.00	

1. A - indicates stratum where adjustment was carried out. If 1 set contributes over 90% of the biomass of a stratum and 20% of the biomass of a subdivision, then an adjustment was carried out before plotting on Figure 4 . (see text for details).

Table 2. Canadian Research Vessel cruise data for redfish in NAFO division 4Vs from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)	
1970	43	4	0.00	0.00	0.00	0.00	
	44	4	106.33±95.44	24.67	41.43	12050.1	
	45	4	136.50±185.88	37.78	13.86	12911.1	
	46	2	296.26±95.80	30.75	14.44	6654.8	
	47	4	0.00	0.00	0.00	0.00	
	48	5	4.43±9.91	24.21	0.64	167.8	
	49	2	31.02±43.87	32.74	0.44	261.5	
	50	2	0.00	0.00	0.00	0.00	
	51	1	50.31	17.87	0.73	47.9	
	52	2	553.28±444.23	20.21	18.95	2783.1	
1971	43	2	0.00	0.00	0.00	0.00	
	44	2	38.28±54.14	****	14.9	8736.2	A
	45	2	105.74±146.0	****	10.7	2165.4	
	46	2	275.43±36.16	****	13.4	4658.1	
	47	2	0.00	0.00	0.00	0.00	
	48	2	0.00	0.00	0.00	0.00	
	49	2	154.58±218.6	****	2.2	1028.4	
	50	2	3.40±4.81	****	0.13	36.9	
	51	2	934.31±1263.6	****	13.6	4571.1	
	52	2	275.18±26.18	****	9.4	4637.6	
1972	43	4	0.00	0.00	0.00	0.00	
	44	5	3.27±5.90	****	1.27	374.8	
	45	5	62.37±56.32	****	6.3	2049.6	
	46	3	223.09±168.86	****	10.9	4062.6	
	47	6	0.00	0.00	0.00	0.00	
	48	5	0.00	0.00	0.00	0.00	
	49	2	0.00	0.00	0.00	0.00	
	50	3	0.00	0.00	0.00	0.00	
	51	2	25.47±32.72	****	0.37	42.6	
	52	2	441.46±292.69	****	15.1	2954.6	
1973	43	4	2.16±2.9	20.64	0.28	28.6	
	44	4	53.6±75.7	23.59	20.9	5729.6	A
	45	4	188.6±345.5	23.40	19.1	5223.7	A
	46	3	721.6±609.1	25.67	35.2	11307.9	
	47	5	0.00	0.00	0.00	0.00	
	48	4	0.24±0.49	23.00	0.03	****	
	49	2	42.05±33.34	31.53	0.60	300.8	
	50	2	0.00	0.00	0.00	0.00	
	51	2	0.00	0.00	0.00	0.00	
	52	2	112.03±62.7	26.32	3.84	1334.1	
1974	43	8	0.16±0.45	37.00	0.02	20.4	
	44	6	50.8±106.5	31.4	19.8	11587.0	A

Table 2. Canadian Research Vessel cruise data for redfish in NAFO division 4Vs from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)	
	45	5	61.7±123.6	23.68	6.3	1587.8	
	46	3	674.3±592.7	23.61	32.9	9030.6	
	47	7	0.00	0.00	0.00	0.00	
	48	5	0.00	0.00	0.00	0.00	
	49	3	0.78±1.35	31.00	0.01	5.6	
	50	3	0.00	0.00	0.00	0.00	
	51	2	9.67±13.68	20.81	0.14	33.6	
	52	2	8.89±6.68	20.95	0.3	64.2	
1975	43	4	10.9±21.9	30.65	1.4	679.7	
	44	4	135.9±247.5	20.32	52.9	7885.7	
	45	4	92.4±117.6	28.58	9.4	4221.1	
	46	3	554.9±475.7	22.2	27.0	5779.7	
	47	4	1.04±2.08	21.4	0.17	33.4	
	48	4	0.00	0.00	0.00	0.00	
	49	2	0.00	0.00	0.00	0.00	
	50	3	0.00	0.00	0.00	0.00	
	51	2	19.4±25.8	19.3	0.28	37.9	
	52	2	17.2±14.7	21.7	0.59	111.3	
1976	43	1	4.67	13.25	0.61	22.9	
	44	4	138.2±251.1	29.32	53.8	27060.9	A
	45	3	44.1±52.5	24.38	4.5	1507.7	
	46	3	992.7±1374.3	24.78	48.4	15889.3	A
	47	3	0.31±0.53	31.00	0.05	****	
	48	4	0.82±0.57	24.43	0.12	34.9	
	49	3	0.39±0.67	24.00	0.005	****	
	50	3	0.61±0.54	17.74	0.02	****	
	51	2	1.09±1.5	22.5	0.016	****	
	52	2	14.0±19.8	26.28	0.48	179.8	
1977	43	3	1.11±1.92	27.00	0.15	72.7	
	44	4	13.9±21.5	22.04	5.4	1358.3	
	45	5	44.4±43.3	21.41	4.5	998.9	
	46	3	166.4±144.2	26.87	8.1	3599.3	
	47	3	0.39±0.67	31.00	0.06	****	
	48	4	0.00	0.00	0.00	0.00	
	49	3	23.7±40.98	23.36	0.34	88.01	
	50	3	1.09±1.89	23.33	0.04	13.9	
	51	1	4.67	22.50	0.07	17.0	
	52	2	1691.2±2360.1	30.59	57.9	29255.0	A
1978	43	4	3.02±5.38	30.14	0.39	180.8	
(July)	44	4	160.2±311.82	29.22	62.4	27986.2	

Table 2. Canadian Research Vessel cruise data for redfish in NAFO division 4Vs from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. (x10^{-6})	Biomass Weight (tonnes)	
	45	4	17.06±26.37	26.96	1.7	701.3	
	46	3	802.7±984.68	20.64	39.1	8803.4	A
	47	4	0.00	0.00	0.00	0.00	
	48	4	0.00	0.00	0.00	0.00	
	49	1	0.00	0.00	0.00	0.00	
	50	3	88.5±153.24	33.24	3.36	2070.0	
	51	2	1826.15±2576.1	29.54	26.6	12044.3	A
	52	2	14.1±17.19	25.93	0.48	183.1	
1978	43	2	0.00	0.00	0.00	0.00	
(Nov-Dec)	44	3	1.30±2.25	24.50	0.52	129.9	
	45	5	49.3±42.4	19.67	5.16	903.6	
	46	3	153.3±73.8	29.45	7.7	4120.7	
	47	0					
	48	1	0.00	0.00	0.00	0.00	
	49	0					
	50	1	0.00	0.00	0.00	0.00	
	51	0					
	52	1	283.65	25.16	9.99	4575.8	
1979	43	4	0.00±0.00	0.00	0.0	0.0	
(July)	44	4	0.67±1.35	20.75	0.26	****	
	45	4	24.80±43.91	20.36	2.52	259.9	
	46	3	390.21±158.45	27.87	19.02	8160.3	
	47	4	0.00	0.00	0.00	0.0	
	48	4	0.00	0.00	0.00	0.0	
	49	2	0.55±.77	25.00	0.01	****	
	50	3	0.00	0.00	0.00	0.0	
	51	3	149.83±159.29	24.45	2.19	624.2	
	52	2	4.63±6.55	18.22	0.16	17.6	

Table 3. Canadian Research Vessel cruise data for redfish in NAFO division 4W from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)	
1970	53	2	1730.7+2314.7	25.28	44.5	12144.3	A
	54	3	2.4+4.16	12.57	0.12	****	
	55	7	0.00	0.00	0.00	0.00	
	56	5	0.00	0.00	0.00	0.00	
	57	2	308.5+379.96	27.63	24.8	9438.5	A
	58	3	0.00	0.00	0.00	0.00	
	59	3	891.4+813.9	21.84	278.5	48711.9	A
	60	2	126.7+176.6	26.78	16.9	5679.5	
	61	3	230.65+309.7	23.01	26.4	5390.2	
	62	3	427.1+463.3	23.03	89.7	18175.4	A
	63	2	1.25+1.77	20.67	0.04	****	
	64	4	0.29+0.58	18.00	0.04	****	
	65	6	0.43+0.78	24.16	0.10	****	
	66	2	11.42+14.78	27.04	0.25	81.8	
1971	53	2	496.3+668.5	29.71	12.8	5657.9	A
	54	2	5.7+4.33	13.54	0.28	****	
	55	6	0.00	0.00	0.00	0.00	
	56	4	0.00	0.00	0.00	0.00	
	57	2	89.8+127.04	23.48	7.2	1737.6	
	58	3	0.00	0.00	0.00	0.00	
	59	2	4.4	22.30	1.37	136.7	
	60	2	100.8+25.7	26.04	13.4	3910.8	
	61	2	54.7+61.9	28.78	6.3	2393.8	
	62	3	504.6+871.6	27.02	105.98	30765.2	A
	63	2	0.97+1.37	16.50	0.03	****	
	64	3	0.00	0.00	0.00	0.00	
	65	5	0.00	0.00	0.00	0.00	
	66	2	218.7+307.8	23.46	4.9	1073.1	
1972	53	3	328.12+536.96	****	8.4	4842.4	A
	54	3	1.03+1.78	****	0.05	****	
	55	7	0.00	0.00	0.00	0.00	
	56	6	0.00	0.00	0.00	0.00	
	57	2	0.00	0.00	0.00	0.00	
	58	3	0.97+1.69	****	0.06	42.3	
	59	4	104.9+189.4	****	32.8	9827.6	A
	60	2	13.8+19.4	****	68.3	500.3	
	61	2	397.5+533.7	****	1.15	13253.5	A
	62	4	157.01+284.5	****	32.9	5003.3	
	63	2	3.13+4.42	****	0.09	37.5	
	64	5	0.00	0.00	0.00	0.00	
	65	5	0.00	0.00	0.00	0.00	
	66	3	16.2+26.43	****	0.36	21.8	

Table 3. Canadian Research Vessel cruise data for redfish in NAFO division 4W from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)	
1973	53	3	232.56	28.00	5.9	2078.7	
	54	3	0.00	0.00	0.00	0.00	
	55	6	0.00	0.00	0.00	0.00	
	56	5	7.91±11.5	26.83	0.75	280.6	
	57	2	18.04±19.7	31.31	1.45	756.7	
	58	3	0.00	0.00	0.00	0.00	
	59	4	198.8±351.4	25.52	62.1	17553.2	A
	60	2	90.07±80.8	23.25	12.02	2472.1	
	61	2	61.1±21.3	24.39	7.0	1886.8	
	62	3	18.5±31.2	28.80	3.9	1513.6	
	63	2	0.00	0.00	0.00	0.00	
	64	3	2.76±4.79	27.89	0.36	118.6	
	65	3	0.00	0.00	0.00	0.00	
	66	3	45.1±40.8	24.08	1.01	399.4	
1974	53	3	120.2±124.8	27.85	3.09	1205.9	
	54	3	0.00	0.00	0.00	0.00	
	55	7	2.9±7.61	20.74	0.60	78.9	
	56	5	0.00	0.00	0.00	0.00	
	57	3	21.6±37.44	23.44	1.74	386.7	
	58	3	0.00	0.00	0.00	0.00	
	59	4	73.2±63.12	25.82	22.9	6816.9	
	60	1	111.13	23.41	14.8	2685.0	
	61	2	11.5±9.81	22.82	1.3	219.8	
	62	4	15.07±11.3	23.22	3.2	530.96	
	63	2	0.00	0.00	0.00	0.00	
	64	3	0.00	0.00	0.00	0.00	
	65	5	0.41±0.92	10.50	0.1	****	
	66	3	40.96±33.98	14.02	0.92	22.2	
1975	53	3	164.1±270.2	30.23	4.22	1789.7	
	54	3	7.55±13.08	24.00	0.37	84.98	
	55	6	0.00	0.00	0.00	0.00	
	56	5	1.92±4.3	21.82	0.18	33.2	
	57	2	0.00	0.00	0.00	0.00	
	58	3	0.00	0.00	0.00	0.00	
	59	4	3.99±3.81	27.77	1.25	469.1	
	60	2	335.0±473.8	25.62	44.7	11757.4	A
	61	2	4836.4±6837.2	27.48	554.0	162646.8	A
	62	5	21.4±14.9	26.49	4.5	1427.4	
	63	2	0.00	0.00	0.00	0.00	
	64	6	0.00	0.00	0.00	0.00	
	65	4	0.00	0.00	0.00	0.00	
	66	3	22.8±37.7	15.73	0.51	37.4	

Table 3. Canadian Research Vessel cruise data for redfish in NAFO division 4W from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. $(x10^{-6})$	Biomass Weight (tonnes)	
1976	53	2	2.19±3.09	17.50	0.06	****	
	54	2	1.17±1.65	15.00	0.06	****	
	55	7	0.00	0.00	0.00	0.00	
	56	4	1.46±2.06	21.50	0.14	25.9	
	57	2	0.97±1.37	19.00	0.08	****	
	58	3	4.86±4.46	26.87	0.32	105.8	
	59	3	11.08±4.60	27.09	3.46	1113.5	
	60	2	7.47±5.07	26.65	0.997	314.0	
	61	2	1.84±2.61	24.25	0.21	52.8	
	62	6	61.59±136.82	30.01	12.9	6121.1	A
	63	2	0.00	0.00	0.00	0.00	
	64	5	0.00	0.00	0.00	0.00	
	65	4	0.00	0.00	0.00	0.00	
	66	2	17.99±25.44	20.57	0.40	65.4	
1977	53	3	3.43±4.29	14.40	0.09	8.82	
	54	3	0.00	0.00	0.00	0.00	
	55	7	0.00	0.00	0.00	0.00	
	56	6	0.31+0.75	12.00	0.03	****	
	57	2	473.49±257.73	22.94	38.1	10457.0	A
	58	3	0.00	0.00	0.00	0.00	
	59	4	243.53+388.4	26.38	76.1	22876.9	A
	60	2	1186.11±1677.4	26.02	158.2	54413.7	A
	61	2	0.73±1.03	29.00	0.08	****	
	62	4	1.94±2.50	24.10	0.41	89.7	
	63	2	0.00	0.00	0.00	0.00	
	64	5	0.00	0.00	0.00	0.00	
	65	5	0.14+0.32	27.00	0.30	****	
	66	3	7.45±6.59	14.15	0.17	9.35	
1978 (July)	53	3	15.88+2.02	17.62	0.41	50.9	
	54	3	17.89±30.98	16.41	0.89	77.0	
	55	7	0.00	0.00	0.00	0.00	
	56	6	0.00	0.00	0.00	0.00	
	57	2	68.91+97.45	26.25	5.55	1761.1	
	58	3	0.00	0.00	0.00	0.00	
	59	4	0.00	0.00	0.00	0.00	
	60	2	3074.14+4212.2	28.26	410.1	168558.2	
	61	2	3.31±1.93	31.15	0.38	189.3	
	62	4	288.51±535.4	27.78	60.6	23371.0	
	63	2	0.00	0.00	0.00	0.00	
	64	5	0.00	0.00	0.00	0.00	
	65	5	0.60+0.91	18.85	0.14	****	
	66	2	0.80±1.13	22.50	0.018	****	

Table 3 . Canadian Research Vessel cruise data for redfish in NAFO division 4W from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)
1978 (Nov-Dec)	53	3	64.18±101.8	27.06	1.70	734.3
	54	4	0.00	0.00	0.00	0.00
	55	5	0.00	0.00	0.00	0.00
	56	3	0.00	0.00	0.00	0.00
	57	2	0.00	0.00	0.00	0.00
	58	6	0.00	0.00	0.00	0.00
	59	6	31.37±64.38	25.56	10.1	3295.3
	60	4	723.42±1385.01	26.61	99.3	34982.0
	61	4	7.43±12.03	26.88	0.88	344.4
	62	8	102.69±206.97	26.85	22.2	8090.8
	63	4	0.00	0.00	0.00	0.00
	64	6	0.00	0.00	0.00	0.00
	65	7	0.67±1.38	22.43	0.16	32.0
	66	3	1.90±2.45	21.63	0.04	8.98
1979 (July)	53	3	15.40±20.87	17.21	0.40	37.5
	54	3	0.36±.63	8.00	0.02	0.0
	55	7	0.00	0.00	0.00	0.0
	56	6	0.52±1.26	25.33	0.05	16.3
	57	2	2.67±.86	26.23	0.21	44.0
	58	3	0.61±1.06	20.00	0.04	0.0
	59	4	6.76±6.04	28.18	2.11	904.9
	60	2	111.89±134.79	27.30	14.93	6217.9 A
	61	2	17.39±19.08	24.00	1.99	645.3
	62	4	0.76±.51	28.84	0.16	108.5
	63	2	0.00	0.00	0.00	0.0
	64	5	1.75±3.91	30.75	0.23	112.7
	65	5	2.54±5.12	28.89	0.60	276.0
	66	3	10.40±11.84	16.34	0.23	24.5

Table 4. Canadian Research Vessel cruise data for redfish in NAFO division 4X(E) from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)	
1970	70	1	229.7	25.36	21.0	5493.9	
	71	2	133.2±141.6	22.31	13.3	2637.0	
	72	2	0.00	0.00	0.00	0.00	
	73	2	0.83±1.18	29.50	0.02	11.0	
	74	2	0.51±0.73	18.00	0.008	****	
	75	2	0.00	0.00	0.00	0.00	
	76	2	65.6±92.8	25.10	9.6	2282.3	
	77	2	0.00	0.00	0.00	0.00	
	78	2	174.6±226.3	31.26	4.0	2327.4	
	80	4	0.00	0.00	0.00	0.00	
	81	5	0.00	0.00	0.00	0.00	
1971	70	2	2809.4±3474.9	21.61	256.6	43817.9	A
	71	2	1000.5±1374.8	22.33	99.7	17859.4	A
	72	2	0.00	0.00	0.00	0.00	
	73	2	9.9±6.60	18.66	0.26	25.6	
	74	2	0.00	0.00	0.00	0.00	
	75	2	0.00	0.00	0.00	0.00	
	76	2	1.9±2.75	27.25	0.28	142.6	
	77	2	2.2±3.09	18.00	0.27	****	
	78	2	23.3±16.5	12.93	0.54	11.2	
	80	4	0.00	0.00	0.00	0.00	
	81	3	0.58±1.01	36.00	0.11	108.6	
1972	70	2	4253.5±5659.6	****	388.5	100677.2	A
	71	2	22.7±24.7	****	2.26	402.7	
	72	2	1.75±2.48	****	0.22	****	
	73	2	0.00	0.00	0.00	0.00	
	74	2	0.00	0.00	0.00	0.00	
	75	2	0.00	0.00	0.00	0.00	
	76	2	0.00	0.00	0.00	0.00	
	77	2	0.76±1.08	****	0.09	****	
	78	3	68.54±92.2	****	1.58	44.2	
	80	4	0.00	0.00	0.00	0.00	
	81	4	0.00	0.00	0.00	0.00	
1973	70	2	5026.5±7044.6	24.94	459.1	113327.0	A
	71	2	49.7±16.31	27.26	4.9	1833.3	
	72	2	45.5±62.53	25.40	5.6	1559.5	
	73	2	0.00	0.00	0.00	0.00	
	74	2	1.9±2.65	13.00	0.03	****	
	75	2	1.8±2.61	12.75	0.03	****	
	76	2	196.5±256.9	25.96	28.8	8408.8	A
	77	2	0.00	0.00	0.00	0.00	
	78	2	69.0±23.4	20.38	1.6	351.4	
	80	3	0.00	0.00	0.00	0.00	
	81	4	0.31±0.62	14.00	0.06	****	

Table 4 . Canadian Research Vessel cruise data for redfish in NAFO division 4X(E) from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)	
1974	70	3	281.03±220.3	26.67	25.7	7959.8	
	71	2	7.11±0.77	24.31	0.71	163.5	
	72	2	2.27±1.15	13.23	0.28	****	
	73	2	0.00	0.00	0.00	0.00	
	74	2	0.00	0.00	0.00	0.00	
	75	2	0.46±0.65	18.00	0.007	****	
	76	2	1047.7±1112.9	17.38	153.7	15319.9	A
	77	2	1.25±1.77	14.00	0.15	****	
	78	3	5.95±5.54	16.66	0.14	9.6	
	80	3	0.00	0.00	0.00	0.00	
	81	4	14.9±28.42	18.43	2.8	465.3	
1975	70	2	178.9±244.7	26.22	16.3	5025.5	A
	71	2	0.92±1.30	25.00	0.09	45.9	
	72	2	0.00	0.00	0.00	0.00	
	73	2	0.00	0.00	0.00	0.00	
	74	2	0.00	0.00	0.00	0.00	
	75	2	0.00	0.00	0.00	0.00	
	76	2	0.00	0.00	0.00	0.00	
	77	2	0.00	0.00	0.00	0.00	
	78	3	10.21±12.4	15.21	0.24	8.4	
	80	3	0.00	0.00	0.00	****	
	81	4	9.47±13.1	24.96	1.8	712.9	
1976	70	3	9.41±2.52	26.62	0.86	288.3	
	71	1	2.92	30.33	0.29	96.9	
	72	1	0.00	0.00	0.00	0.00	
	73	2	0.00	0.00	0.00	0.00	
	74	2	0.00	0.00	0.00	0.00	
	75	2	0.00	0.00	0.00	0.00	
	76	3	188.77±325.28	21.69	27.7	5931.6	A
	77	2	0.00	0.00	0.00	0.00	
	78	3	4.57±4.09	16.73	0.10	6.7	
	80	4	0.00	0.00	0.00	0.00	
	81	4	4.38±8.75	29.50	0.81	407.1	
1977	70	2	607.6±859.3	27.35	55.5	18273.0	A
	71	2	6.52±0.97	18.87	0.65	72.7	
	72	2	146.9±183.0	25.57	18.2	5613.8	A
	73	2	0.00	0.00	0.00	0.00	
	74	1	0.00	0.00	0.00	0.00	
	75	3	0.00	0.00	0.00	0.00	
	76	4	56.48±105.74	24.83	8.3	2357.6	A
	77	2	2.63±3.71	23.67	0.32	107.0	
	78	3	131.43±209.53	22.33	3.0	620.8	
	80	4	0.00	0.00	0.00	0.00	
	81	2	0.00	0.00	0.00	0.00	

Table 4. Canadian Research Vessel cruise data for redfish in NAFO division 4X(E) from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)
1978 (July)	70	2	8.75±5.30	23.62	0.8	190.31
	71	2	171.43±216.15	28.27	17.1	7429.2 A
	72	3	1.54±2.66	13.00	0.2	****
	73	2	16.82±22.33	14.81	0.44	20.9
	74	2	0.00	0.00	0.00	0.00
	75	2	0.00	0.00	0.00	0.00
	76	1	0.00	0.00	0.00	0.00
	77	2	0.00	0.00	0.00	0.00
	78	4	4.45±3.97	15.30	0.10	5.3
	80	3	0.00	0.00	0.00	0.00
	81	4	0.42±0.83	17.50	0.80	****
1978 (Nov-Dec)	70					
	71					
	72					
	73					
	74					
	75					
	76					
	77					
	78					
	80					
	81					
1979 (July)	70	2	24.61±34.80	23.76	2.25	549.4
	71	2	2.89±2.79	22.79	0.29	48.4
	72	3	1.70±2.15	23.55	0.21	85.1
	73	2	0.00	0.00	0.00	0.0
	74	2	0.00	0.00	0.00	0.0
	75	2	1.64±2.32	15.00	0.03	0.0
	76	1	1.17	18.00	0.17	0.0
	77	3	0.00	0.00	0.00	0.0
	78	3	180.41±272.51	29.70	4.17	2257.7
	80	4	0.00	0.00	0.00	0.00
	81	4	0.27±.55	43.00	0.05	101.8

Table 5 . Canadian Research Vessel cruise data for redfish in NAFO division 4X(W) from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)
1970	82	2	0.00	0.00	0.00	0.00
	83	2	2.06+2.91	31.75	0.11	54.3
	84	2	37.07±49.33	31.23	8.3	4383.7
	85	2	2.43±3.44	34.40	0.38	229.0
	90	2	1.17±1.65	23.50	0.07	****
	91	2	31.17±0.77	33.54	2.12	1765.3
	92	3	0.39±0.67	17.00	0.04	****
	93	1	0.67	21.00	0.035	****
	94	2	0.00	0.00	0.00	0.00
	95	2	0.00	0.00	0.00	0.00
1971	82	1	0.00	0.00	0.00	0.00
	83	2	87.5+24.75	33.79	4.62	3419.5
	84	2	24.8±11.91	31.62	5.58	3146.4
	85	2	0.58±0.82	37.00	0.09	91.6
	90	2	2.6±3.71	24.50	0.16	52.2
	91	2	1.5±2.15	24.25	0.10	25.9
	92	2	3.9±5.5	24.88	0.42	104.8
	93	2	0.00	0.00	0.00	0.00
	94	2	0.97+1.37	26.00	0.04	20.1
	95	2	0.00	0.00	0.00	0.00
1972	82	2	23.95+33.9	****	2.5	1476.7
	83	2	2.19±3.09	****	0.12	69.3
	84	3	438.47±351.55	****	98.5	64998.9
	85	2	4.38±6.19	****	0.69	274.8
	90	2	0.88±1.24	****	0.05	26.1
	91	3	0.34±0.59	****	0.02	****
	92	4	0.55±1.10	****	0.06	****
	93	3	0.00	0.00	0.00	0.00
	94	2	0.00	0.00	0.00	0.00
	95	2	0.00	0.00	0.00	0.00
1973	82	2	0.49+0.69	12.00	0.05	****
	83	2	27.71±11.69	33.81	1.46	1001.2
	84	3	70.95±63.36	32.23	15.9	9153.2
	85	3	54.93±65.01	29.71	8.63	3841.1
	90	2	1.17±1.65	37.00	0.07	69.6
	91	3	15.72±14.61	31.66	1.07	750.4
	92	3	2.46±1.00	29.75	0.27	72.4
	93	3	0.00	0.00	0.00	0.00
	94	2	0.00	0.00	0.00	0.00
	95	2	0.00	0.00	0.00	0.00

Table 5. Canadian Research Vessel cruise data for redfish in NAFO division 4X(W) from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. ($x10^{-6}$)	Biomass Weight (tonnes)	
1974	82	2	1.38+1.95	36.67	0.14	95.3	
	83	2	66.72±78.89	33.15	3.52	2130.4	
	84	3	70.53±49.54	32.01	15.85	8875.2	
	85	3	22.17±38.39	31.78	3.48	2061.2	A
	90	2	2.39±3.37	18.17	0.14	23.7	
	91	3	38.89±66.64	38.66	2.65	3012.0	A
	92	3	5.05±2.89	24.17	0.54	149.7	
	93	3	0.49±0.84	29.00	0.026	****	
	94	2	0.00	0.00	0.00	0.00	
	95	2	0.00	0.00	0.00	0.00	
1975	82	2	111.55+157.76	39.93	11.54	14662.3	A
	83	2	125.96±77.60	31.40	6.65	4203.1	
	84	3	23.54±16.71	34.92	5.29	4374.3	
	85	3	0.00	0.00	0.00	0.00	
	90	3	14.77+14.17	22.19	0.88	****	
	91	3	6.93±6.59	26.21	0.47	****	
	92	3	182.18±289.96	32.12	19.64	****	
	93	3	0.53±0.48	19.16	0.028	****	
	94	2	0.00	0.00	0.00	0.00	
	95	2	0.00	0.00	0.00	0.00	
1976	82	5	7.96+14.7	****	0.82	293.5	
	83	1	0.00	0.00	0.00	0.00	
	84	3	99.93+118.3	****	22.46	14768.4	A
	85	3	10.5±18.2	****	1.65	824.5	
	90	3	0.00	0.00	0.00	0.00	
	91	1	10.00	****	0.68	284.2	
	92	5	3.67+1.5	****	0.39	210.8	
	93	3	1.58±1.8	****	0.08	42.6	
	94	2	0.00	0.00	0.00	0.00	
	95	2	0.51	****	0.03	****	
1977	82	2	0.00	0.00	0.00	0.00	
	83	2	150.07+137.0	33.61	7.92	5529.7	
	84	3	76.32±66.9	32.45	17.15	10316.7	
	85	3	0.00	0.00	0.00	0.00	
	90	1	43.17	28.16	2.57	1044.1	
	91	5	32.87+51.3	31.84	2.24	1512.3	A
	92	3	3.18±4.5	26.55	0.34	166.7	
	93	3	0.00	0.00	0.00	0.00	
	94	2	0.00	0.00	0.00	0.00	
	95	2	0.00	0.00	0.00	0.00	

Table 5. Canadian Research Vessel cruise data for redfish in NAFO division 4X(W) from 1970-1979 (inclusive).

Year	Stratum	No. Sets	No. Fish/Set	Mean Length	No. (x10^{-6})	Biomass Weight (tonnes)	
1978 (July)	82	2	57.17±80.85	31.56	5.91	3439.3	A
	83	2	22.75±17.32	37.07	1.20	1124.4	
	84	2	13.42±14.02	34.96	3.01	2228.7	
	85	3	1.75±1.38	30.43	0.28	170.7	
	90	3	2.13±1.85	32.69	0.13	96.5	
	91	3	55.13±79.16	32.03	3.76	2090.5	A
	92	3	31.82±49.13	29.58	3.43	1893.3	
	93	3	0.42±0.72	29.00	0.02	****	
	94	2	0.00	0.00	0.00	0.00	
	95	1	0.00	0.00	0.00	0.00	
1979 (July)	82	3	20.36±28.89	29.97	2.11	1057.9	A
	83	2	35.64±35.56	33.29	1.89	1553.3	
	84	3	90.28±107.74	33.67	20.29	15758.0	A
	85	3	38.43±66.56	31.46	6.04	3987.7	A
	90	2	0.00	0.00	0.00	0.0	
	91	3	9.33±11.49	26.13	0.64	212.2	
	92	4	0.22±.44	36.00	0.02	23.6	
	93	3	0.00	0.00	0.00	0.0	
	94	2	0.00	0.00	0.00	0.0	
	95	1	0.00	0.00	0.00	0.0	