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Update on the status of Redfish in Division 30

by

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Abstract

Nominal catches have ranged between 3,000 t and 35,000 t since 1960. Up to 1986 catches averaged 13,000 t, increased to 35,000 t by 1988 and declined subsequently to 3,000 t in 1995 due to reductions in foreign allocations. Foreign fleets, which predominantly fish outside the 200 mile EEZ, have historically accounted for most of catch but Canada has increased its activity in the area since 1995 accounting for about 80% of the 9,000 t catch in 1996. Standardized commercial catch rate indices are not considered reflective of stock abundance inside the EEZ. For fleets fishing outside the EEZ where most of the effort was located, they show a declining trend since the early to mid 1980s. RV surveys show different trends seasonally and do not adequately measure size groups that comprise the main portion of the stock exploited by the fishery which makes it difficult to interpret recent declines in survey estimates in relation to what is happening to the stock as a whole. There is concern that there has been little sign in recent surveys of size groups smaller than 17 cm despite using a shrimp trawl which is very effective at catching small fish.

Résumé

Les prises nominales ont oscillé entre 3 000 t et 35 000 t depuis 1960. La valeur moyenne a été de 13 000 t jusqu'en 1986, a augmenté à 35 000 t en 1988 et chuté à 3 000 t en 1995 suite à la baisse des allocations étrangères. Les flottilles étrangères, qui pêchent surtout à l'extérieur de la ZEE de 200 milles, étaient antérieurement à l'origine de la plupart des captures, mais le Canada a accru ses activités dans cette région depuis 1995 et les bateaux canadiens ont capturé 80 % des prises de 1996, qui s'élevaient à 9 000 t. Les indices des taux de capture commerciaux normalisés ne sont pas jugés représentatifs de l'abondance des stocks dans la ZEE. Dans le cas des flottilles pêchant à l'extérieur de la ZEE, où la plus grande partie de l'effort était concentrée, ils indiquent une tendance à la baisse entre le début et la moitié des années 1980. Les relevés par NR font état de tendances variables en fonction de la saison et ne permettent pas de déterminer adéquatement les groupes de tailles qui constituent la plus grande partie du stock exploité par la pêche et cela complique l'interprétation des baisses récentes des estimations des relevés dans le contexte de l'évolution globale du stock. On s'inquiète du fait que les derniers relevés font peu état des groupes de tailles inférieures à 17 cm, cela en dépit de l'utilisation d'un chalut à crevette, très efficace pour la capture des petits poissons.

DESCRIPTION OF MANAGEMENT REGULATIONS AND THE FISHERY

Management regulations

A TAC of 16,000 t was first implemented on this stock in 1974. The TAC was increased in 1978 to 20,000 t on the assumption that the stock was healthy and generally remained at that level through to 1987. The TAC for 1988 was reduced to 14,000 t and remained unchanged until 1994 when it was reduced to 10,000 t as a precautionary measure and maintained at that level to 1997. In addition to catch regulation, a small fish protocol at 22 cm was implemented inside the 200 mile limit for this stock in 1995. The 1997 TAC (10,000 t) is divided into a Canadian quota (7,045 t), a French quota (1,500 t) and a Foreign Quota (1,455 t). About 10% of the stock area lies outside Canada's 200 mile Exclusive Economic Zone (EEZ).

Nominal Catches and the fishery

Nominal catches have ranged between 3,000 t and 35,000 t since 1960 (Table 1, Fig. 1). Up to 1986 catches averaged 13,000 t, increased to 27,000 t in 1987 with a further increase to 35,000 t in 1988, exceeding TACs by 7,000 t and 21,000 respectively. Catches declined to 13,000 t in 1989, and were about this amount annually through to 1993. Catches subsequently declined to about 3,000 t in 1995 and were partly due to reductions in foreign allocations since 1993. In 1996, catch increased sharply to about 9,000 t due to increased Canadian activity. Up to the end of the third quarter in 1997, about 2,000 t had been taken by Canada.

The increased catches in 1987 and 1988 were due primarily to increased activity outside the 200 mile EEZ by countries who were not contracting parties of NAFO (primarily Panama and South Korea) and had no bilateral agreements with Canada. Canadian surveillance estimates of non-reported catch, which have ranged from 200 t to 23,500 t are included in catch statistics since 1983 (Table 2). A further explanation of these are given in Shelton and Atkinson (1994). There hasn't been any activity in the area outside the 200 mile EEZ by non-NAFO fleets since 1994.

Russia predominated in this fishery up until 1993 and generally caught its share (about 50%) of the total non-Canadian allocation, which accounted for about 2/3 of the TAC. From 1982 to 1993 Russian catches were between 3,800 t to 8,700 t. From 1994-1995 Russia had taken less than 500 t. and had no effort in 1996. Cuba has not participated in the fishery in this area since 1993. Portugal, which began fishing outside the EEZ in 1992 took 2,900 t in 1994, a reduction of 2,000 t from their 1993 catch, and about 1,800 t in each of 1995 and 1996. Russia, Cuba and Japan fished throughout the stock area after the implementation of the EEZ through agreements with Canada. Other non-Canadian catches, including those of Portugal, were taken in the limited stock area outside 200 miles. Canada, which has had limited interest in a fishery in Div. 30 because of small sizes of redfish encountered in trawlable areas, landed less than 200 t annually from 1983-1991. In 1994, Canada took 1,600 t due to improved markets related to lobster bait, but declined to about 100 t in 1995. The Canadian catch increased to about 7,200 t in 1996 as a result of a successful undertaking by a number of enterprises to discover areas of prime market fish (>28 cm). These catches were taken from September to December.

The fishery has occurred primarily in the second and third quarters of the year since 1983 (Table 3a). The prominent means of capture from the mid-1970s to the early 1980s was the bottom

otter trawl (Table 3b). Since 1984 there has been an increase in the use of the midwater trawl but the bottom trawl catches still dominate. The Canadian fleet primarily uses bottom trawling.

AVAILABLE DATA

Commercial catch rates

Catch and effort data for 1959 to 1993 were extracted from ICNAF/NAFO Statistical Bulletins and were combined with provisional 1994-1995 NAFO data and 1994-1996 Atlantic region data compiled by various DFO regional statistics branches. Initially selected from this database were observations where redfish comprised more than 50% of the total catch and were therefore considered to be redfish directed.

These data were analysed with a multiplicative model (Gavaris 1980) to derive a standardized catch rate series. The effects included in the model were a combination country-gear-tonnage class category type (CGT), month, and a category type representing the amount of bycatch associated with each observation. For this effect five groups were arbitrarily established : (>50% <=60%), (>60% <=70%), (>70% <=80%), (>80% <=90%) and (>90%) where each group corresponds to the percentage of redfish relative to the total catch associated with each observation. In the usual manner, catch or effort data of less than 10 units were eliminated prior to analysis in addition to any categories with less than five samples except in the year category type. For all analyses hours fished was the measure of effort and an unweighted regression was run because of unknown percentages of prorating prior to 1984.

Previous catch rate analyses of this stock (Power et al., 1995) suggested different trends in the catch rate series derived for Canada only and for countries that have only fished outside the EEZ. Accordingly, separate standardizations of available catch rate data were conducted as follows: (i) Canada only, (ii) countries which have fished both inside and outside the EEZ (Russia and Cuba) and (iii) countries which have only fished outside the EEZ (Japan, Poland, Portugal and South Korea).

The analysis of Canadian catch rates (Table 4) resulted in a significant overall regression explaining 55% of the variability in the data, however, the month category type was not significant ($P > .05$). The catch rate index (Table 5, Fig. 2a) shows much interannual variability over the 1959-1995 period but without any discernible trend with time. The analysis is based on limited data between 1982 and 1995. Catch rates have fluctuated particularly wide in recent years, dropping dramatically between 1990 and 1992, increasing substantially from 1993 to 1994 and declining steeply between 1994 and 1996.

The regression analysis conducted on catch rates for Russia and Cuba was significant ($P < .05$) and explained 62% of the variability in catch rates (Table 6). The catch rate index (Table 7, Fig. 2b) shows much interannual variability prior to 1977. The index shows a steady increase from 1978 to 1982, a general decline to 1994 and a substantial increase in 1995. The analysis is based on limited data since 1993.

The annual update to the databases did not provide any further information than was available for the 1995 assessment for those countries that have fished outside the EEZ. The catch rate index (Fig. 2c, reproduced from Power et al. 1995) shows a steady decline from 1984 to 1993. Fishing was

sporadic by these countries prior to 1984. Although Portugal represents the predominant foreign fleet since 1993, there are no effort data in hours fished in the NAFO database to supplement the data analysis.

In summary, the analysis of catch rates by the Canadian fleet are not considered indicative of overall trends in the resource. Until recently, Canada has not accounted for a major portion of the reported catches from Division 3O and has only fished within the 200 mile EEZ. The recent dramatic fluctuations cannot be accounted for by the biology of redfish. The trend in the two foreign fleet catch rate series are similar and, based on the available data, indicate a general decline from the early to mid 1980s to about 1994. The catch rates of the fleets that have fished outside is probably indicative of a decline in the proportion of the stock outside the EEZ where most of that effort had occurred.

Catch at Length

Length distributions sampled from 1995-1996 fisheries from Canadian port sampling and observer data, and data available from the 1995 Portuguese fisheries by Portuguese observers (Godhino et al., 1996) were weighted by monthly landings to derive a catch-at-length by country for Div. 3O. For 1996, only the Nfld. data that was available in time for the assessment in September were used.

The length-weight relationships used were:

$$\begin{aligned} \text{WT (males)} &= 0.01659 \text{ Forklength}^{2.9548} \\ \text{WT (females)} &= 0.013272 \text{ Forklength}^{3.0210} \end{aligned}$$

In addition, relative length distributions (per mille) were available from the 1996 Portuguese fishery (Alpoim et. al., 1997).

The data (Fig. 3) indicate a mode at about 22 cm in the Canadian and Japanese catches in 1995. Portuguese catches for 1995 were bimodal with peaks at about 29 cm and 38 cm. These fish were much larger than the 'traditional' smaller sizes taken in Division 3O relative to other divisions. Additional sampling information indicates the samples were obtained from 200-800 m. It is likely that the larger fish taken by Portuguese vessels were from deeper water. It is also reported the Portuguese fleet fishes in the vicinity of the border with Div. 3N which, to some extent, may also account for the distribution differences with Japanese and Canadian samples. The 1996 Canadian samples indicated a preponderance of fish greater than 22 cm with a mode at about 25 cm. The 1996 Portuguese samples showed a much broader range of lengths from about 25 cm to 42 cm with modes at 30 cm and 38 cm.

Research vessel surveys

Stratified random groundfish surveys have been conducted in the spring and autumn in Division 3O since 1991, with coverage of depths to 730 m. In addition, a summer survey was conducted in 1993. From 1991 to spring 1995 an Engel 145 otter trawl was used (1.75 n. mi. standard tow) and from 1995 fall onwards a Campelen 1800 shrimp trawl (0.75 n. mi. standard tow). Comparative fishing trials have been conducted between the two gears but the analysis has not been finalized to apply conversion factors to the pre-Campelen data. This new gear has a similar catchability for redfish greater than 20 cm, but an increasingly greater catchability for redfish from 20 cm to 8 cm.

The series of mean weight per standard tow (Table 8a and 8b) exhibits large fluctuations in estimates between seasons and years for some strata, not uncommon for bottom trawl surveys for redfish. The spring survey biomass index (Table 8a, Fig. 4) increased steadily from about 7,000 t in 1992 to 112,000 t in 1996 but declined sharply to 16,000 t in 1997. Over half the 1995 spring estimate of 84,000 t was accounted for by two large catches of about 5,000 kg each in a relatively small stratum. Similarly, about 70,000 t of the 1996 spring estimate of 118,000 was due to the influence of one large set of about 10,000 kg. The 1993 summer survey index, at 52,000 t, was similar to the level estimated from the 1993 spring survey (42,000 t) although there were four key strata not sampled. The autumn survey biomass index has ranged between 16,000 t and 126,000 t from 1991 to 1996. The autumn index increased gradually from 1991 through 1993 (although the 1992 autumn survey only covered depths down to 370 m [200 fathoms]) but declined slightly in 1994 before increasing significantly in 1995. The index declined sharply in 1996 but the extent of the decline is unknown because four important strata were not sampled.

These results are difficult to interpret. Stratum by stratum estimates indicate that the increases during the spring surveys occurred over a great deal of the area and depths where redfish generally reside. In most surveys, the densities outside the 200 mile EEZ were generally lower than inside. Differences between the spring and fall surveys may be related to changes in availability within the Division at different times of the year.

Size distribution in terms of mean number per tow at length from the spring surveys (Fig. 5) indicate a bimodal distribution in 1991 with modes at 11 cm and 20 cm corresponding to about the 1988 and 1984 year classes respectively. The 20 cm mode progresses at about a cm per year up to 1994 (at 23 cm) and cannot be traced any further. The 11 cm mode is not pronounced until it reaches 17-18 cm in 1994, after which it progresses by about 2 cm per year to 1996 (at 21 cm). The 1997 distribution also shows a predominant mode at 21 cm. Size distribution from the autumn surveys indicate a bimodal distribution in 1991, similar to the spring survey, with modes at 13 cm and 21 cm. The 21 cm mode only progresses to 23 cm by 1994 after which it is no longer discernable. The 13 cm mode progresses to a 17 cm mode in 1992 but only increments to 19 cm by the 1995 survey. The 1996 survey shows a predominant mode at 21 cm.

Overall, size distributions of the survey catches indicate only a narrow range of sizes caught each year in Division 30. Generally fish smaller than about 10 cm and larger than about 25 cm are absent in survey catches from 1991-1997 which cover strata down to 732 m (400 fathoms). It is well documented that the Engel survey gear (eg. Power MS 1994, Power MS 1995) and the Campelen survey gear (e.g. Power et al. MS 1996) can catch both smaller (than 10 cm) and larger (than 25 cm) redfish. Length sampling from the commercial fisheries reveal a higher proportion of fish greater than 25 cm compared to the survey catches. Therefore, it appears that fish sizes outside this range are generally unavailable to the gear in this area. The reasons for this are unknown but may be related to distribution relative to trawlable bottom.

Industry Perspectives

The increased activity in 1996 for some Canadian enterprises was motivated by a need to find fish of marketable size in light of the moratorium in Unit 1 and was based on the premise that there were larger fish in deeper water in Div. 30. The experience of this fishery was different from other

Canadian fisheries but there was reasonable success in finding good concentrations of acceptable size fish, primarily from October to December. The knowledge from the Russian fishing experience in the area available to some Canadian enterprises suggests that water temperature influences fishing success. Up to September in 1997, there were reports of much greater mixtures of small fish with with the large fish in the area and there are indications that catch rates are lower than in 1996. This fishery is still considered to be in the learning stage.

PROGNOSIS

Research surveys in spring have a ten fold increase in abundance from 1991 to 1996 followed by a sudden decline in abundance to pre-1993 levels in 1997. In comparison, the autumn surveys have shown more stability over the time period with the exception of the large 1995 estimate. Given that the surveys are not measuring the main portion of the stock exploited by the fishery, the recent declines in the survey estimates therefore, do not appear to be related to fishing. The surveys only monitor pre-recruit size groups and while the recent declines should be viewed with concern, it is difficult to interpret these events in relation to what is happening to the stock as a whole. There is also some concern that there has been little sign in the recent surveys of size groups smaller than 17 cm despite using a shrimp trawl which is very effective at catching small fish.

It is still not possible to describe overall trends in total stock size, or estimate the current size of the fishable portion of the population, nor is it possible to determine current fishing mortality rate. On the assumption that the pre-recruits measured by the survey in recent years have now largely passed through the size range measurable by these surveys but remained in Div. 3O, they represent an addition to the exploitable stock of about 100,000 tons. Thus, catches of about 10,000 tons are not likely to generate fishing mortality above $F_{0.1}$.

The length at which half the females are sexually mature (L_{50}) is about 29 cm (11 inches). Given that generally the shallower the depth fished the smaller the size composition, caution is warranted because a greater proportion of immature females may be captured if fishing is concentrated in shallower water (less than 375 m (205 fathoms)).

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Table 1. Nominal catches (t) and TACs of redfish in Div. 30.

Year	Canada	Non-Canadian	Total	TAC
1960	100	4,900	5,000	
1961	1,000	10,000	11,000	
1962	1,046	6,511	7,557	
1963	2,155	7,025	9,180	
1964	1,320	14,724	16,044	
1965	203	19,588	19,791	
1966	107	15,198	15,305	
1967	645	18,392	19,037	
1968	52	6,393	6,445	
1969	186	15,692	15,878	
1970	288	12,904	13,192	
1971	165	19,627	19,792	
1972	508	15,609	16,117	
1973	133	8,664	8,797	
1974	91	13,033	13,124	16,000
1975	103	15,007	15,110	16,000
1976	3,664	11,684	15,348	16,000
1977	2,972	7,878	10,850	16,000
1978	1,841	5,019	6,860	16,000
1979	6,404	11,333	17,737	20,000
1980	1,541	15,765	17,306	21,900
1981	2,577	10,027	12,604	20,000
1982	491	10,869	11,360	20,000
1983	7	7,333	7,340	20,000
1984	167	16,811	16,978	20,000
1985	104	12,756	12,860	20,000
1986	141	10,914	11,055	20,000
1987	183	26,987	27,170	20,000
1988	181	34,611	34,792	14,000
1989	27	13,229	13,256	14,000
1990	155	14,087	14,242	14,000
1991	28	8,433	8,461	14,000
1992	1,219	14,049	15,268	14,000
1993	698	15,022	15,720	14,000
1994 ^a	1,624	3,804	5,428	10,000
1995 ^a	122	3,037	3,159	10,000
1996 ^a	7,215	1,990	9,205	10,000
1997 ^b	1,888		1,888	10,000

^a Provisional^b Provisional to Oct. 1, 1997

Table 2. Nominal catches (t) of redfish in Div. 3O by country and year (1994-1996 are provisional).

Country	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Canada (M)	4	29	48	5	24	5	18	27	4	27	21	779	4	2125
Canada (N)	3	138	56	136	159	176	9	128	24	1192	677	845	118	5090
France	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Japan	1	1258	661	1162	1074	1606	1724	1406	226	125	159	-	264	132
Portugal	-	-	-	-	-	22	12	83	3	1468	4794	2918	1935	-
Spain	-	25	630	45	26	4	-	4	-	-	-	26	22	-
Russia	5670	7262	5905	6099	7152	4921	4517	3811	4427	5845	6887	60	416	-
Cuba	1460	1316	806	3006	2859	2753	2138	2750	2748	2776	665	-	-	-
USA	-	-	104	2	-	-	-	-	-	-	-	-	-	-
Korea(S)	-	-	-	-	1726	1805	2638	833	129	1935	17	-	-	-
EEC/EU	-	-	-	-	-	-	-	-	-	-	-	-	-	1803
OTHER ^b	200	6950	4650	600	14150	23500	2200	5200	900	1900	2500	800	400	-
Total	7340	16978	12860	11055	27170	34792	13256	14242	8461	15268	15720	5428	3159	9150
TAC	20000	20000	20000	20000	20000	14000	14000	14000	14000	14000	14000	10000	10000	10000

^aProvisional^bEstimates of non-reported catch (by Canadian Surveillance)

Table 3a. Nominal reported catches (t) of redfish in Div. 3O by month and year (not including surveillance estimates).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1983	254	355	2904	1227	71	156	576	938	319	1	73	266	7140
1984	219	155	2	32	85	257	446	3210	2799	1882	435	506	10028
1985	1522	-	453	239	118	252	227	1711	1486	350	35	1817	8210
1986	707	-	427	593	69	710	3491	3712	58	1	319	368	10455
1987	102	40	1052	37	1010	757	2001	4142	429	344	1326	1780	13020
1988	15	1	493	684	915	1	1755	3922	1286	1057	915	248	11292
1989	228	585	224	6	674	1411	1143	3311	2737	666	51	20	11056
1990	108	23	257	26	1220	2474	1534	1571	1002	686	28	113	9042
1991	17	47	96	1	713	2054	2346	1118	830	338	-	1	7561
1992	0	57	14	10	635	3262	2520	1808	896	1261	797	2108	13368
1993	226	14	754	817	2089	1601	1887	2068	1809	829	630	496	13220
1994 ^a	60	93	742	1609	236	83	-	68	1000	540	19	178	4628
1995 ^a	7	125	145	2	45	28	56	765	645	824	107	10	2759
1996 ^a	-	-	85	109	160	-	-	25	1060	2660	1603	1513	7215

^aProvisional (1996 for Canada only)

Table 3b. Nominal reported catches (t) of redfish in Div. 3O by gear (not including surveillance estimates).

Year	Otter Trawls			Misc	Total
	Bottom	Midwater	Gillnets		
1983	5217	1923	-	-	7140
1984	7451	2577	-	-	10028
1985	4431	3778	-	1	8210
1986	5231	5224	-	-	10455
1987	8601	4419	-	-	13020
1988	6692	4596	-	4	11292
1989	7026	4030	-	-	11056
1990	5501	3537	-	4	9042
1991	4625	2936	-	-	7561
1992	10046	3292	1	29	13368
1993	11997	1214	-	9	13220
1994 ^a	3085	1498	26	19	4628
1995 ^a	2166	525	26	42	2759
1996 ^a	6881	334	-	-	7215

^aProvisional (1996 for Canada only).

Table 4. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized catch rate series for Redfish in Div. 30. Effort is measured in hours fished. Only Canadian data were utilized in the analysis. (1995-1996 based on are preliminary data).

REGRESSION OF MULTIPLICATIVE MODEL					CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
MULTIPLE R.....	0.743									
MULTIPLE R SQUARED.....	0.552				(4)	67	27	-0.019	0.289	7
ANALYSIS OF VARIANCE						69	28	-0.694	0.446	2
SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE		70	29	-0.350	0.383	3
INTERCEPT	1	6.322E0	6.322E0			71	30	-0.050	0.565	1
REGRESSION	52	4.314E1	8.296E-1	3.156		72	31	-0.356	0.315	6
Country;Gear;TC	6	4.815E0	8.025E-1	3.052		73	32	-0.220	0.574	1
Month	9	1.654E0	1.837E-1	0.699		74	33	-0.688	0.381	3
Bycatch PCT	4	4.598E0	1.149E0	4.372		75	34	-0.896	0.334	4
Year	33	1.917E1	5.810E-1	2.210		76	35	-0.484	0.271	12
RESIDUALS	133	3.496E1	2.629E-1			77	36	-0.427	0.259	15
TOTAL	186	8.442E1				78	37	-0.403	0.251	13
REGRESSION COEFFICIENTS						79	38	0.166	0.265	17
CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.	80	39	-0.355	0.283	10
Country;Gear;TC	3125	INTERCEPT	0.294	0.280	186	81	40	-0.255	0.276	10
Month	7					82	41	-0.460	0.387	3
Bycatch PCT	95					84	42	-0.182	0.424	2
Year	59					85	43	0.158	0.396	3
(1)	2114	1	-0.100	0.211	20	86	44	-0.286	0.584	1
	2125	2	0.189	0.189	18	87	45	-0.086	0.434	2
	3114	3	-0.018	0.132	74	88	46	0.276	0.569	1
	3124	4	-0.280	0.258	6	90	47	0.154	0.583	1
	3155	5	0.670	0.236	12	92	48	-1.124	0.355	6
	27125	6	0.426	0.174	15	93	49	-0.431	0.467	2
(2)	3	7	-0.556	0.269	7	94	50	0.960	0.406	4
	4	8	-0.412	0.267	7	95	51	-0.242	0.633	1
	5	9	-0.143	0.189	15	96	52	-0.520	0.300	18
	6	10	-0.026	0.177	17					
	8	11	-0.003	0.155	25					
	9	12	-0.054	0.149	26					
	10	13	-0.156	0.155	30					
	11	14	-0.219	0.194	17					
	12	15	-0.224	0.225	9					
(3)	55	16	-0.796	0.215	12					
	65	17	-0.463	0.217	9					
	75	18	-0.338	0.197	10					
	85	19	-0.303	0.125	36					
(4)	60	20	-0.112	0.420	2					
	61	21	-0.029	0.308	6					
	62	22	-0.395	0.280	7					
	63	23	-0.315	0.276	8					
	64	24	-0.107	0.359	4					
	65	25	0.113	0.430	2					
	66	26	-0.750	0.565	1					

Table 5. Standardized catch rate series for Div. 30 redbfish from a multiplicative model utilizing hours fished as a measure of effort. Only Canadian data were utilized in the analysis.

YEAR	PREDICTED CATCH RATE				CATCH	EFFORT
	LN TRANSFORM		RETRANSFORMED			
	MEAN	S.E.	MEAN	S.E.		
1959	0.2938	0.0784	1.472	0.406	59	40
1960	0.1815	0.1676	1.258	0.496	60	48
1961	0.2643	0.1045	1.411	0.446	61	43
1962	-0.1017	0.0689	0.996	0.258	62	62
1963	-0.0209	0.0671	1.081	0.276	63	58
1964	0.1871	0.1221	1.294	0.440	64	49
1965	0.4065	0.1971	1.552	0.659	65	42
1966	-0.4560	0.3081	0.620	0.320	66	107
1967	0.2750	0.0612	1.457	0.356	67	46
1969	-0.4000	0.1972	0.693	0.294	69	100
1970	-0.0567	0.1036	1.024	0.322	70	68
1971	0.2435	0.3072	1.248	0.644	71	57
1972	-0.0622	0.0983	1.021	0.314	72	71
1973	0.0737	0.3425	1.034	0.559	73	71
1974	-0.3938	0.1147	0.727	0.240	74	102
1975	-0.6018	0.0977	0.595	0.182	75	126
1976	-0.1704	0.0405	0.943	0.189	76	81
1977	-0.1337	0.0470	0.975	0.210	77	79
1978	-0.1097	0.0518	0.997	0.225	78	78
1979	0.4598	0.0393	1.773	0.349	79	45
1980	-0.0609	0.0456	1.050	0.223	80	76
1981	0.0387	0.0444	1.160	0.243	81	70
1982	-0.1660	0.0926	0.923	0.275	82	89
1984	0.1114	0.1598	1.177	0.454	84	71
1985	0.4517	0.0991	1.706	0.526	85	50
1986	0.0078	0.2629	1.008	0.486	86	85
1987	0.2082	0.1708	1.290	0.513	87	67
1988	0.5698	0.3155	1.722	0.898	88	51
1990	0.4478	0.2868	1.546	0.775	90	58
1992	-0.8305	0.0720	0.480	0.127	92	192
1993	-0.1375	0.1801	0.909	0.370	93	102
1994	1.2533	0.1215	3.760	1.276	94	25
1995	0.0514	0.3577	1.004	0.552	95	95
1996	-0.2258	0.0431	0.891	0.184	96	108

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.344

Table 6. ANOVA results and regression coefficients from a multiplicative model utilized to derive a standardized catch rate series for Redfish in Div. 30. Effort is measured in hours fished. Countries which have fished both inside and outside the EEZ (Russia and Cuba) were used in the analysis.

REGRESSION OF MULTIPLICATIVE MODEL					CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
MULTIPLE R.....										
MULTIPLE R SQUARED.....										
					(4)	65	27	0.275	0.451	2
						69	28	0.509	0.318	4
						70	29	0.244	0.308	6
						71	30	0.643	0.291	7
						72	31	0.255	0.270	8
						73	32	0.498	0.322	4
						74	33	0.667	0.360	3
						75	34	0.542	0.404	2
						76	35	0.855	0.256	11
						77	36	0.654	0.272	8
						78	37	0.286	0.261	10
						79	38	0.665	0.248	15
						80	39	0.766	0.241	16
						81	40	0.826	0.246	13
						82	41	1.051	0.241	16
						83	42	0.700	0.240	17
						84	43	0.595	0.241	16
						85	44	0.545	0.253	12
						86	45	0.510	0.258	12
						87	46	0.588	0.247	14
						88	47	0.566	0.247	14
						89	48	0.370	0.255	12
						90	49	0.173	0.262	9
						91	50	0.094	0.272	7
						92	51	0.372	0.329	11
						93	52	0.249	0.344	13
						94	53	0.296	0.659	1
						95	54	0.780	0.562	2

ANALYSIS OF VARIANCE				
SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	6.650E1	6.650E1	
REGRESSION	54	7.379E1	1.366E0	6.600
Country;Gear;TC	7	1.018E1	1.454E0	7.022
Month	11	6.412E0	5.829E ⁻¹	2.815
Bycatch PCT	4	9.774E0	2.444E0	11.802
Year	32	1.495E1	4.673E ⁻¹	2.257
RESIDUALS	221	4.576E1	2.070E ⁻¹	
TOTAL	276	1.860E2		

REGRESSION COEFFICIENTS					
CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
Country;Gear;TC	20127	INTERCEPT	0.494	0.222	276
Month	7				
Bycatch PCT	95				
Year	59				
(1)	4127	1	-0.040	0.129	19
	4157	2	-0.097	0.114	32
	20114	3	-1.451	0.219	14
	20157	4	-0.144	0.082	55
	34126	5	-0.339	0.371	3
	34127	6	-0.016	0.280	14
	34157	7	-0.539	0.409	5
(2)	1	8	-0.315	0.149	16
	2	9	-0.393	0.172	11
	3	10	-0.208	0.128	26
	4	11	-0.589	0.127	24
	5	12	-0.130	0.131	23
	6	13	-0.042	0.123	29
	8	14	-0.062	0.112	35
	9	15	-0.125	0.121	28
	10	16	-0.242	0.163	12
	11	17	-0.349	0.156	14
	12	18	-0.315	0.135	23
(3)	55	19	-0.820	0.152	19
	65	20	-0.519	0.119	30
	75	21	-0.421	0.104	33
	85	22	-0.394	0.089	46
(4)	60	23	0.608	0.521	1
	62	24	0.700	0.448	2
	63	25	0.969	0.445	2
	64	26	0.515	0.562	1

Table 7. Standardized catch rate series for Div. 30 redfish from a multiplicative model utilizing hours fished as a measure of effort. Only countries which have fished both inside and outside the EEZ (Russia and Cuba) were used in the analysis.

YEAR	LN TRANSFORM		RETRANSFORMED		CATCH	EFFORT
	MEAN	S.E.	MEAN	S.E.		
1959	0.4939	0.0492	1.774	0.390	59	33
1960	1.1020	0.2402	2.960	1.371	60	20
1962	1.1940	0.1689	3.364	1.329	62	18
1963	1.4626	0.1631	4.414	1.716	63	14
1964	1.0091	0.2834	2.640	1.314	64	24
1965	0.7690	0.1700	2.198	0.871	65	30
1969	1.0028	0.0664	2.925	0.743	69	24
1970	0.7380	0.0587	2.254	0.539	70	31
1971	1.1373	0.0529	3.369	0.766	71	21
1972	0.7492	0.0373	2.304	0.442	72	31
1973	0.9923	0.0636	2.899	0.721	73	25
1974	1.1613	0.0973	3.375	1.030	74	22
1975	1.0355	0.1290	2.929	1.021	75	26
1976	1.3488	0.0318	4.207	0.746	76	18
1977	1.1480	0.0393	3.429	0.675	77	22
1978	0.7798	0.0325	2.381	0.426	78	33
1979	1.1594	0.0282	3.488	0.583	79	23
1980	1.2603	0.0234	3.867	0.589	80	21
1981	1.3203	0.0261	4.101	0.660	81	20
1982	1.5447	0.0198	5.149	0.723	82	16
1983	1.1936	0.0228	3.619	0.545	83	23
1984	1.0890	0.0219	3.261	0.481	84	26
1985	1.0391	0.0294	3.090	0.527	85	28
1986	1.0038	0.0301	2.982	0.515	86	29
1987	1.0819	0.0248	3.233	0.507	87	27
1988	1.0603	0.0231	3.167	0.479	88	28
1989	0.8638	0.0279	2.595	0.432	89	34
1990	0.6670	0.0314	2.128	0.375	90	42
1991	0.4003	0.0362	1.626	0.307	91	56
1992	0.8657	0.0673	2.550	0.652	92	36
1993	0.7432	0.0798	2.241	0.622	93	41
1994	0.7899	0.3988	2.001	1.150	94	47
1995	1.2735	0.2816	3.442	1.708	95	28

AVERAGE C.V. FOR THE RETRANSFORMED MEAN: 0.256

Table 8a. Mean weight (kg) of redfish caught per standard tow in Division 30 during spring and summer Canadian research surveys from 1991 - 1997. ("---" indicates strata not sampled). Estimates from 1991-1995 are based on an Engels 145 trawl. Estimates from 1996-1997 are based on a Campelen trawl.

STRATUM	Depth (m)	Area* sq. n. mi	1991 Spring	1992 Spring	1993 Spring	1993 Summer	1994 Spring	1995 Spring	1996 Spring	1997 Spring
329	093-183	1721	0.08	0.00	0.00	---	4.70	0.07	0.00	1.01
332	093-183	1047	0.13	0.24	0.00	---	0.00	129.68	11.90	0.28
333	185-274	151(147)	84.18	303.73	1195.53	---	3859.26	83.51	120.42	20.23
334	275-366	92(96)	95.99	32.75	234.80	---	152.82	30.98	219.97	33.87
335	275-366	58	2.77	59.00	134.54	3845.49	1260.90	184.85	2445.79	58.72
336	185-274	121	6.68	60.30	557.00	134.57	699.95	5194.17	161.82	7.73
337	093-183	948	4.44	1.77	0.95	---	0.00	198.92	0.05	0.09
339	093-183	585	0.00	0.00	0.00	---	0.00	0.00	0.00	0.00
354	093-183	474	0.00	0.00	221.80	149.61	0.00	0.00	0.01	0.00
355	185-274	103	0.64	0.36	851.25	55.10	392.48	99.88	4916.31	7.49
356	275-366	61	9.90	104.43	494.82	2287.02	120.13	333.29	515.78	7.50
717	367-549	93(166)	597.91	87.75	110.03	---	489.23	113.34	191.18	534.69
718	550-731	111(134)	49.39	8.30	101.90	---	208.85	7.65	27.15	14.98
719	367-549	76	27.68	11.85	192.85	1815.75	887.30	79.65	79.53	59.59
720	550-731	105	12.44	68.18	10.18	35.87	19.12	17.10	129.06	21.01
721	367-549	76	21.65	49.03	143.25	1247.77	25.40	1114.63	68.23	20.90
722	550-731	93	149.13	13.37	39.94	56.22	159.32	6.20	25.38	12.16
Upper			120.04	79.25	243.40	1008.21	779.24	284.29	1209.99	189.48
Mean			18.20	15.22	93.50	597.47	164.87	186.74	135.27	18.99
Lower			-83.63	-48.81	-56.38	126.72	-449.50	89.19	-939.44	-151.50
TOTAL BIOMASS (metric tons)			8082	6759	41518	52338	74391	84261	111854	15721

*NOTE: In brackets are revised areas based on a redrawn stratification scheme implemented in 1994.

Table 8b. Mean weight (kg) of redfish caught per standard tow in Division 30 during autumn Canadian research surveys from 1991 - 1997. ("---" indicates strata not sampled). Estimates from 1991-1994 are based on an Engels 145 trawl. Estimates from 1995-1996 are based on a Campelen trawl.

STRATUM	Depth (m)	Area* sq. n. mi	1991 Autumn	1992 Autumn	1993 Autumn	1994 Autumn	1995 Autumn	1996 Autumn
329	093-183	1721	0.00	0.00	0.00	0.00	0.98	0.00
332	093-183	1047	0.00	14.12	0.97	14.90	31.46	0.17
333	185-274	151(147)	16.75	125.93	29.15	216.43	107.01	---
334	275-366	92(96)	1168.88	420.61	348.03	175.26	506.80	---
335	275-366	58	393.74	755.40	301.02	806.07	187.70	332.17
336	185-274	121	6.00	284.58	291.29	204.57	49.73	9.05
337	093-183	948	37.95	38.30	7.77	4.30	55.45	0.00
339	093-183	585	0.00	0.00	0.00	0.00	0.00	0.00
354	093-183	474	0.00	214.50	0.00	0.00	785.26	15.58
355	185-274	103	70.30	193.90	39.13	392.40	237.04	37.85
356	275-366	61	40.15	673.55	47.70	231.30	387.60	145.49
717	367-549	93(166)	---	---	1539.17	400.90	588.78	---
718	550-731	111(134)	---	---	203.82	---	409.37	---
719	367-549	76	318.02	---	993.30	555.71	413.97	656.38
720	550-731	105	---	---	57.63	146.35	16.48	572.55
721	367-549	76	55.13	---	106.00	18.95	1666.67	87.32
722	550-731	93	8.80	---	202.57	28.90	125.80	103.91
Upper			274.18	163.42	127.90	111.33	971.94	86.17
Mean			37.19	65.24	64.02	51.46	151.87	30.54
Lower			199.80	-32.93	0.13	-8.42	-668.20	-25.08
TOTAL BIOMASS (metric tons)			15649	26256	28423	22700	125579	22974

*NOTE: In brackets are revised areas based on a redrawn stratification scheme implemented in 1994.

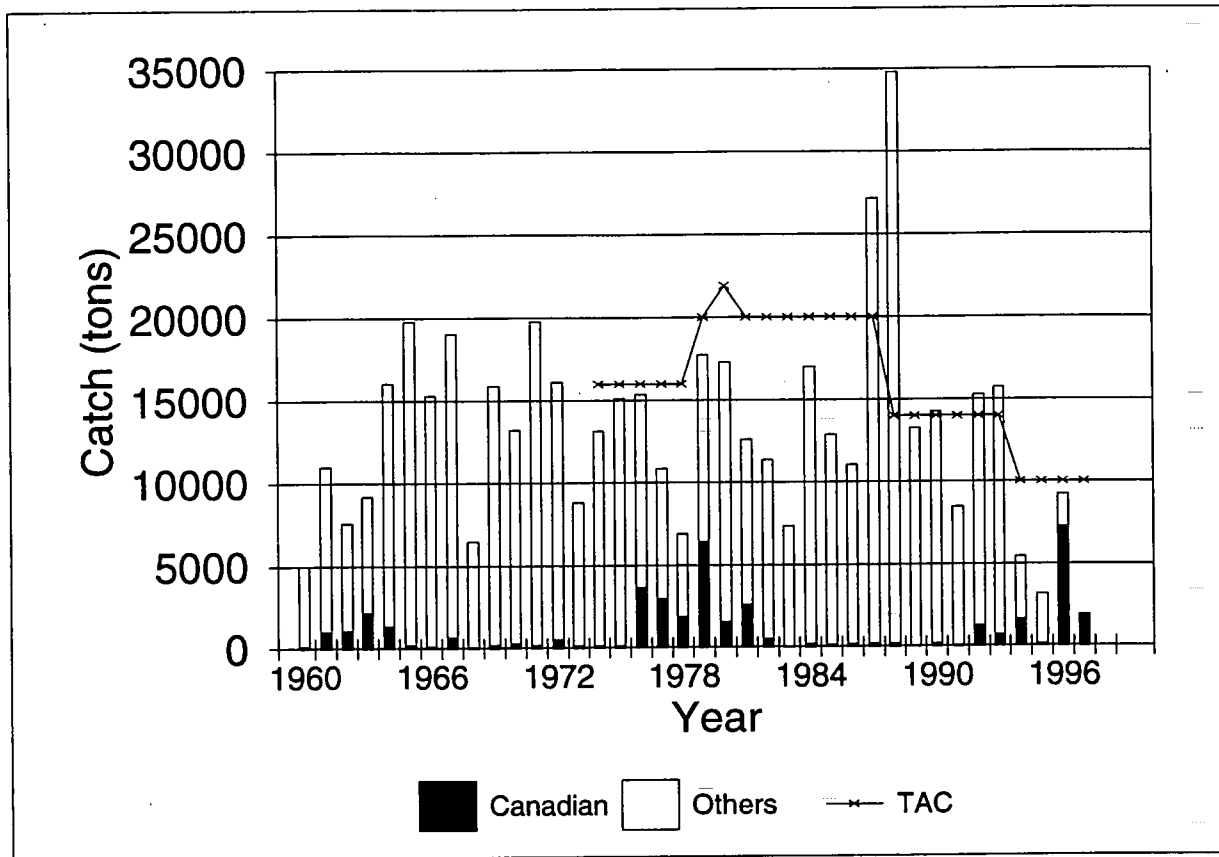


Fig. 1. Nominal catches and TACs of Division 30 redfish

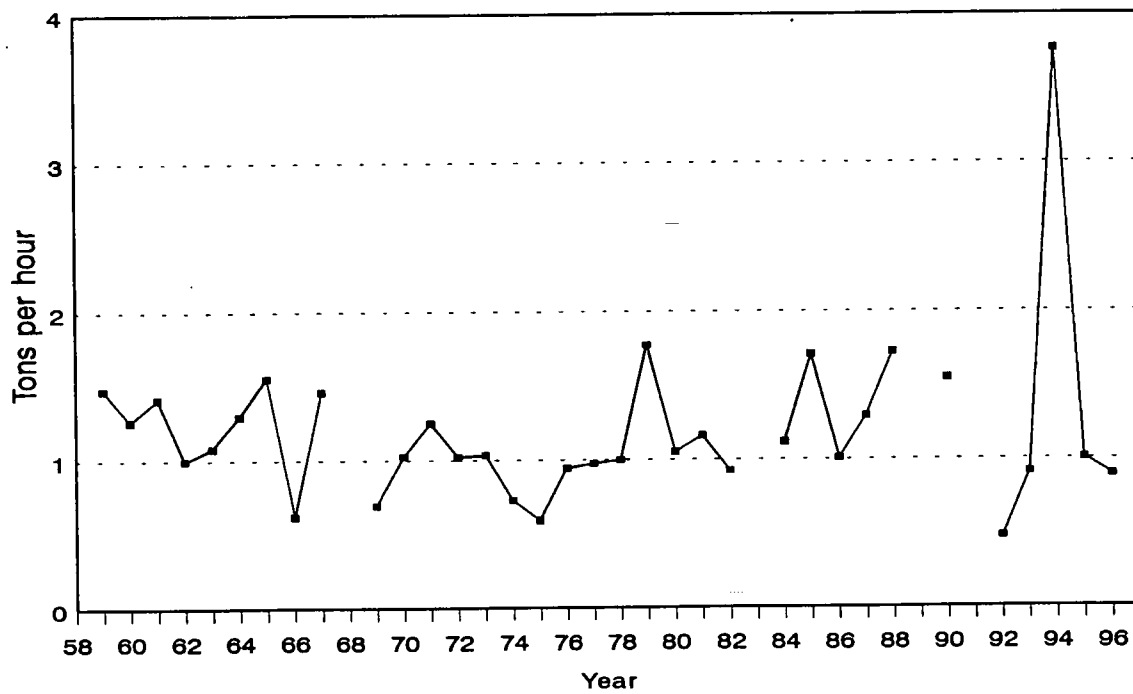


Fig. 2a. Standardized CPUE for redfish Div. 30 for Canada fishing inside the EEZ based on hours fished.

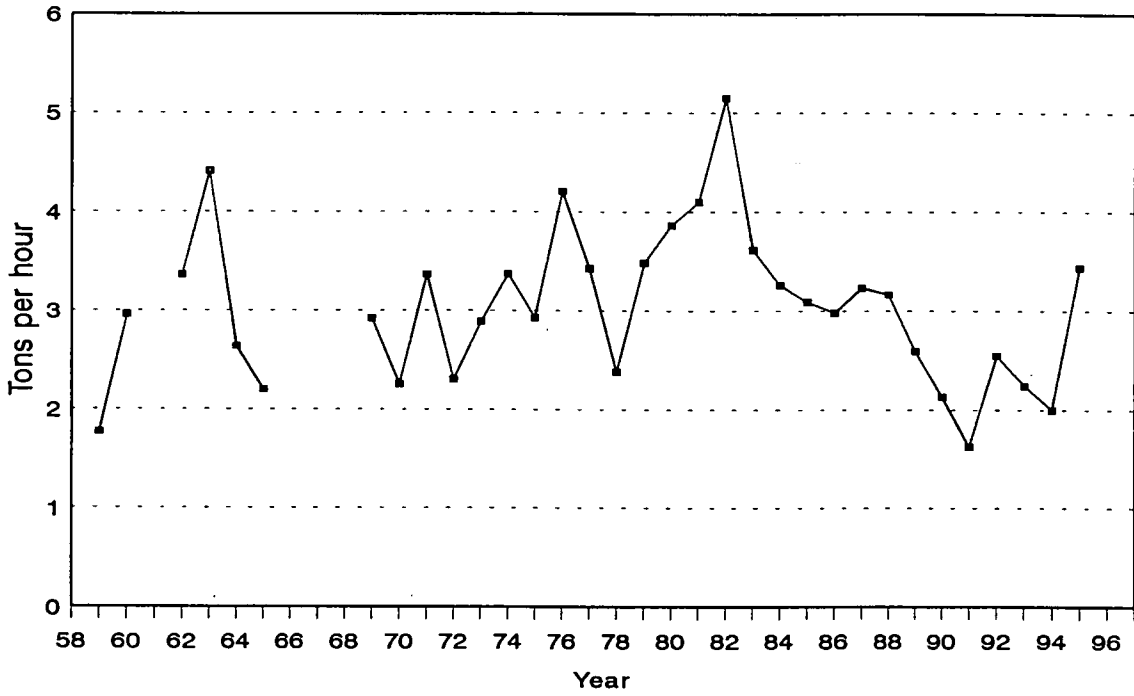


Fig. 2b. Standardized CPUE for redfish Div. 30 for countries that fished inside and outside the EEZ (Russia and Cuba) based on hours fished.

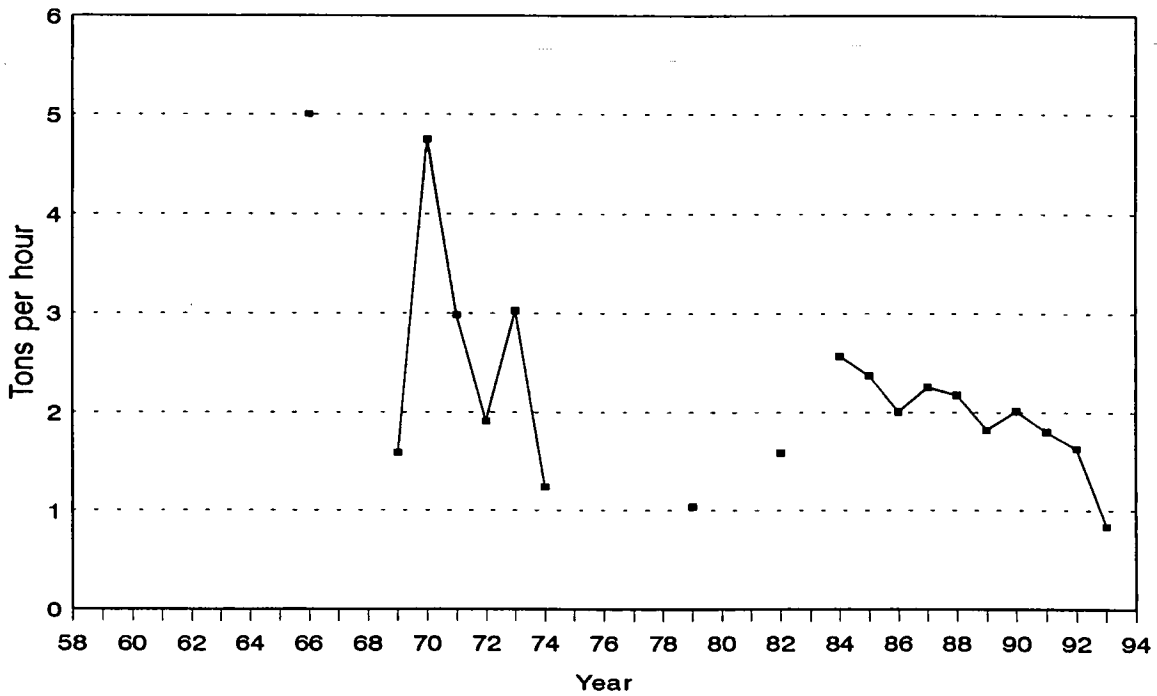


Fig. 2c. Standardized CPUE for redfish Div. 30 for countries that fished outside the EEZ based on hours fished.

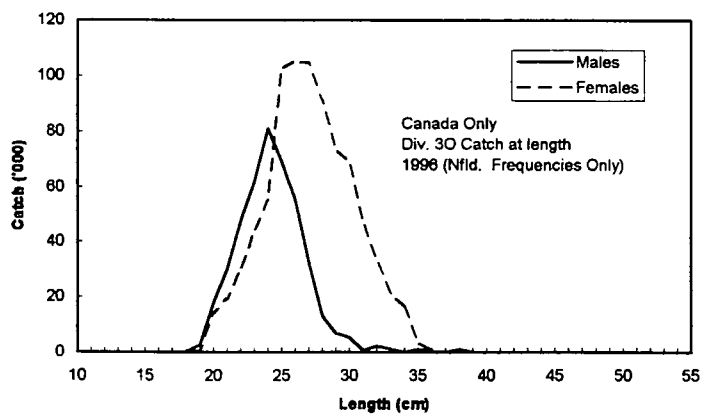
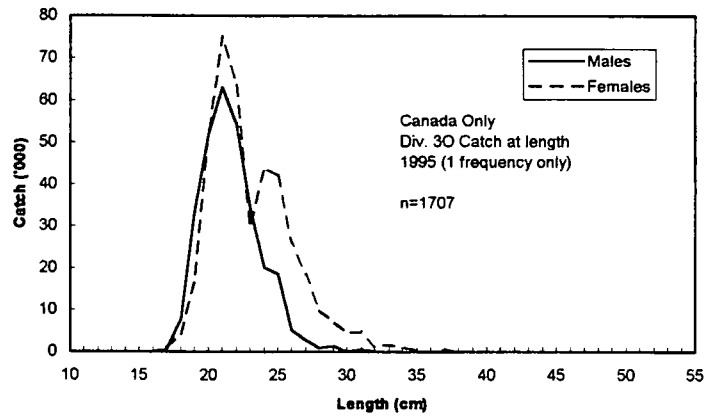
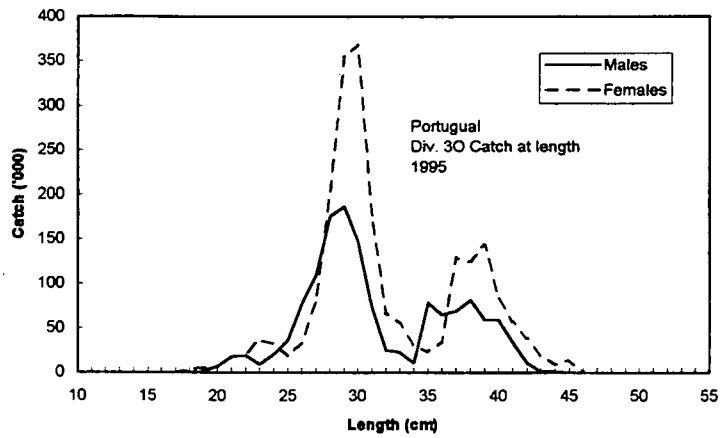
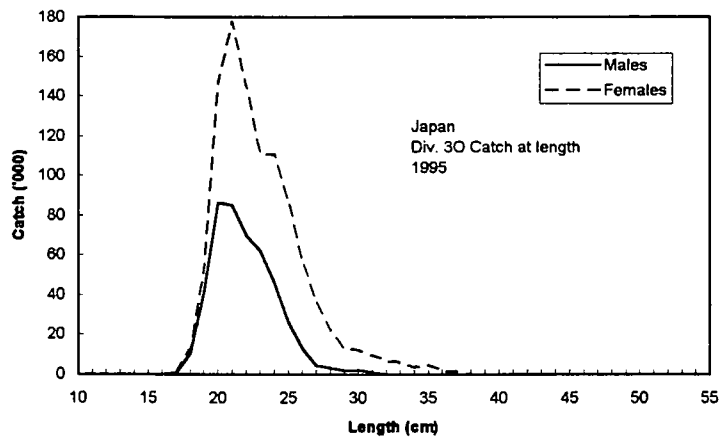


Figure 3 : Estimated commercial catch-at-length of Div. 30 redfish.

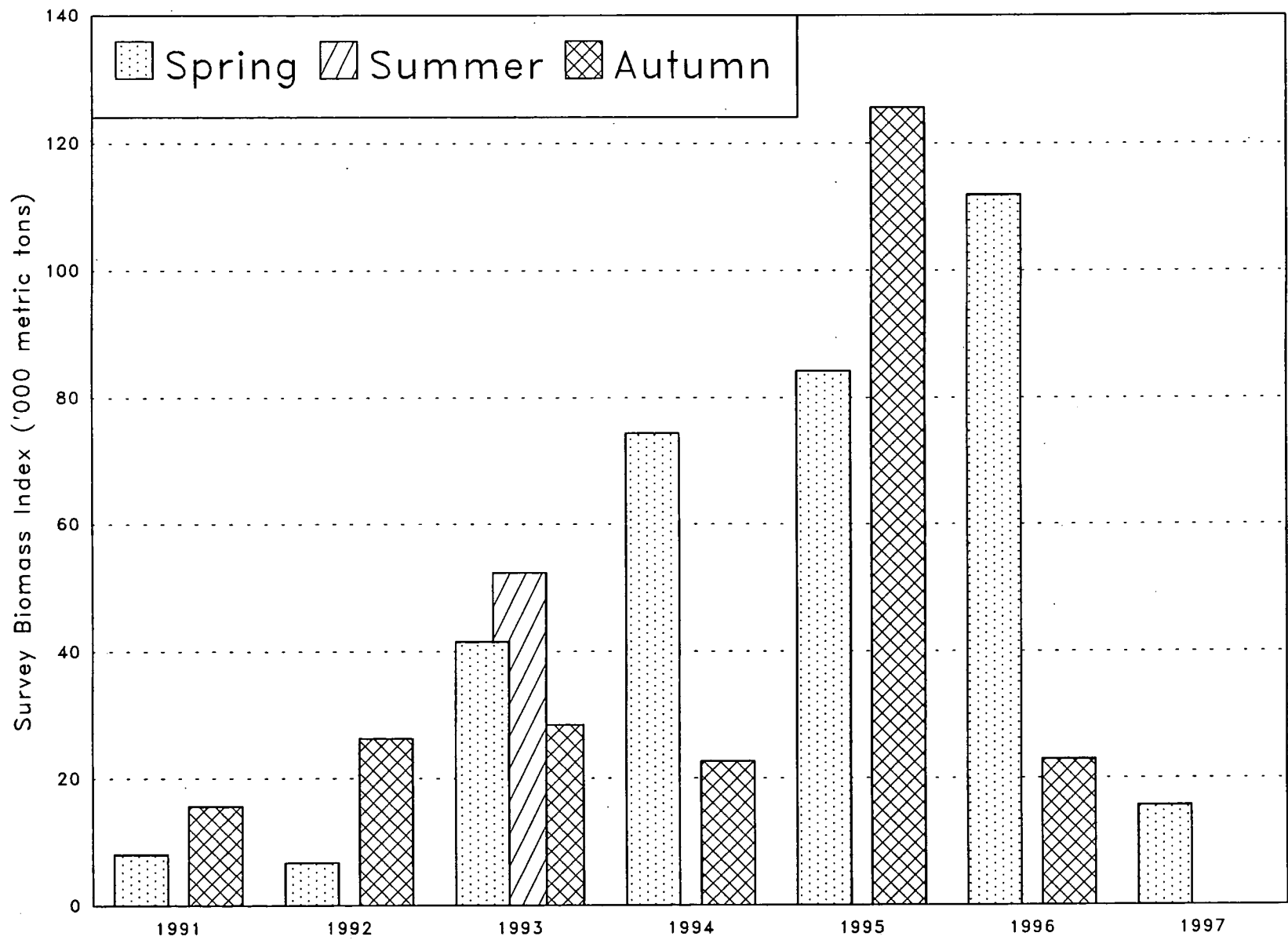


Fig. 4. Research survey biomass index for Div. 30 redfish from 1991–1997. (1991–1995 Spring surveys used Engel 145 trawl; 1995 Autumn–1997 survey used Campelen 1800 trawl (see text for details).

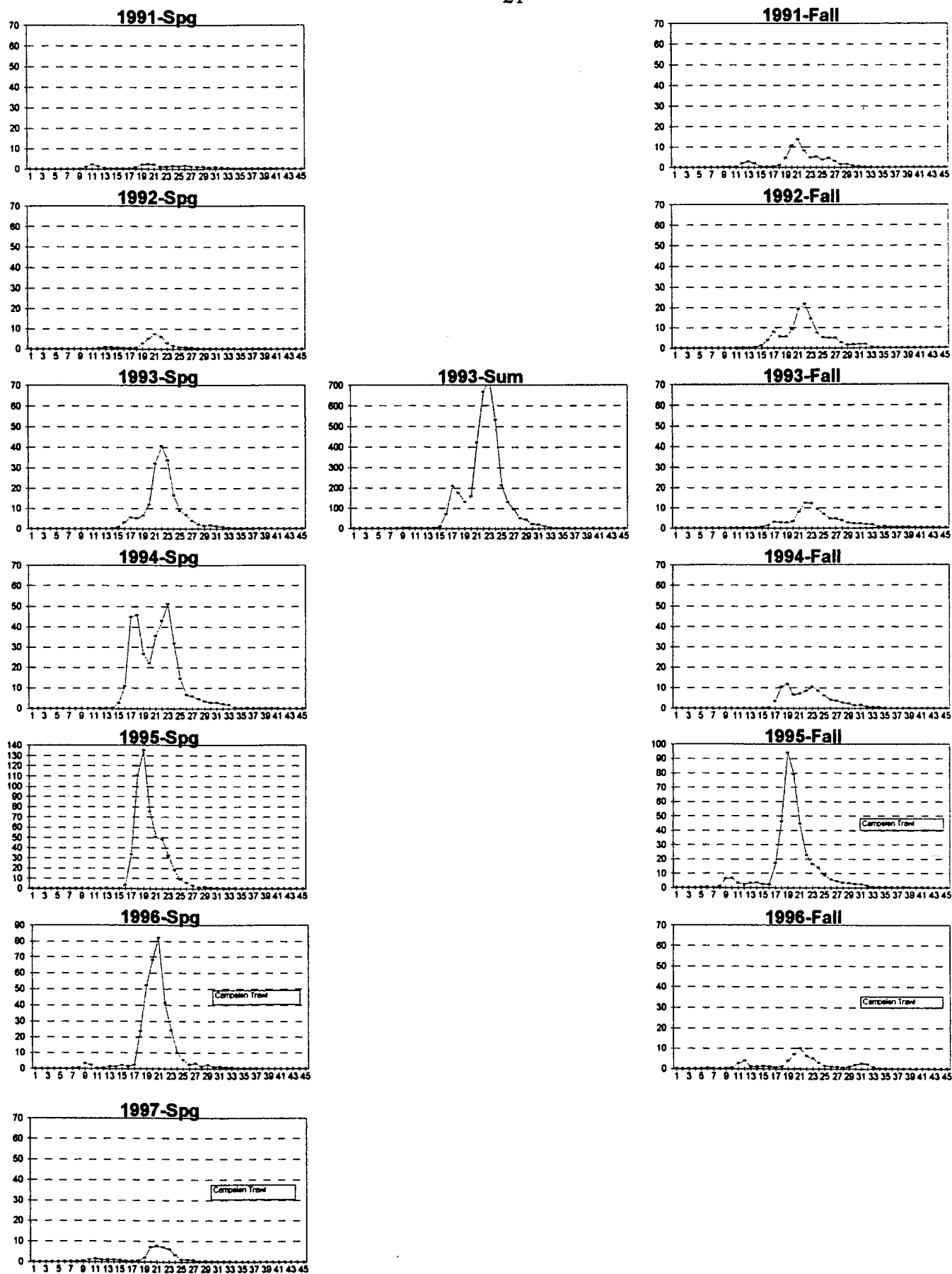


Fig. 5. Length frequencies from stratified-random research to Div. 30 for 1991-1997. Plotted are mean number per standard tow. X-axis unit is centimetres. The 1991-1995 Spring survey was conducted with an Engels 145 trawl (1.75 n. mi. tow). The 1995 Fall surveys and onward were conducted with a Campelen trawl (0.75 n. mi. tow).