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An evaluation of the status of ICNAF Divisions 3P, 3O and 3LN redfish

by

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Introduction

The recent imposition of catch quotas for most important commercial fishes of the ICNAF area has precipitated concern that fishing pressure on redfish might increase substantially with the diversion of highly versatile mobile fleets to other species as national quotas for regulated species become filled. In view of this it was requested at the 1973 Special ICNAF Meeting that countries submit information on the status of the redfish stocks in Subareas 1-4.

Because of the lack of adequate recent information on the length and age compositions of redfish catches in Subareas 2 and 3, it has not been possible to conduct rigorous analyses of the fisheries in these areas utilizing catch-per-unit effort data or the virtual population method. In this document the status of ICNAF Divisions 3P, 3O and 3LN redfish is evaluated, utilizing a Schaefer yield model to examine commercial catch/effort data and provide approximate estimates of maximum sustainable yield.

Redfish (Sebastes mentella) of ICNAF Divisions 3P and 3O exhibit different growth rates (Sandeman, 1969) and hence are considered separately for assessment purposes. Redfish of the northern and eastern Grand Bank (Divisions 3L and 3N) are considered to constitute a different stock from those of Divisions 3P and 3O (Mead and Sindermann, 1961; Bainbridge and Cooper, 1971). In the absence of adequate evidence to indicate that redfish in Divisions 3L and 3N constitute distinct stocks, data for Divisions 3LN redfish have been combined for the purposes of this report.

Trends in landings

Redfish in ICNAF Subareas 2 and 3 were heavily exploited during the late 1950's with a peak catch of approximately 299,000 metric tons in 1959, the bulk of which was taken from the Northern Newfoundland Banks and Labrador (ICNAF Divisions 3K and 2J). Catches in this northern region declined dramatically during the early 1960's and in recent years have averaged less than 20,000 m.tons annually. Landings from the south coast of Newfoundland (Divisions 3Ps and 3Pn) increased gradually from less than 5000 tons in 1959 to about 15,000 tons in 1964, with a substantial increase since 1965 reaching a peak of 37,000 tons in 1970 (Fig. 1; Table 1). Since 1960 redfish landings from the southwest slope of the Grand Bank (Division 3O) have fluctuated between 6000 and 20,000 tons per year (Fig. 2; Table 2) and landings from Divisions 3LN between 8000 and 35,000 tons per year (Fig. 3; Table 3).

During 1955-71 exploitation of redfish in these areas was almost exclusively by otter trawl. In Division 3P Newfoundland tonnage class 4 trawlers (151-500 tons) were the main participants in the redfish fishery until 1966. In 1967 non-member countries caught slightly more than 50 percent of the redfish taken in 3P; during 1969-71 USSR vessels took approximately 65 percent of the total catch (Table 1). More than a dozen countries participated in the Grand Bank redfish fishery (Divisions 3O and 3LN) during 1955-71 but USSR vessels were by far the largest contributors to the total catch (about 52 percent of the total during this period).

Standardization of effort

Entries for redfish catches and hours fished, where redfish represented more than 50 percent of the total fish caught, were selected from the ICNAF Statistical Bulletins for the years 1955-71 and tabulated by country, vessel tonnage class and month for each year. Catches per hour fished were then calculated for each month.

Division 3P

In Division 3P Canada (Newfoundland) vessels of 151-500 tons fished most consistently and most heavily during 1955-68. Hence the Canada (Newfoundland) tonnage class 4 otter trawler hour was selected as the standard unit of effort for this period and total standard hours were estimated by dividing the catch per unit effort of Canada (Newfoundland) tonnage class 4 into the total catch of all countries. In more recent years (1969-71), USSR vessels of tonnage class 4 were most heavily involved in this fishery and for these years catch and effort data for USSR class 4 trawlers were used in conjunction with the Canada (Newfoundland) catch and effort data after conversion of USSR effort to the standard Canada (Newfoundland) otter trawler hour. This conversion factor was obtained by plotting catches per hour fished for USSR tonnage class 4 trawlers against catches per hour for Canada (Newfoundland) tonnage class 4 trawlers for each month for each area in which both fished at least 100 hours. A straight line drawn through the origin gave a conversion factor of 0.52 (Fig. 4). The average catch per hour (standard) in each year for 1969-71 was then obtained by dividing the redfish catches by these two vessel classes by the adjusted effort. The effort for redfish by all trawlers was estimated by dividing these values into the total yearly catches by all countries, resulting in estimates of total effort for the entire fleet in standard Canada (Newfoundland) tonnage class 4 trawler hours.

Division 3O

Although Canada (Newfoundland) catches in most years represented only a small percentage of the total redfish catch in 3O, the Canada (Newfoundland) tonnage class 4 otter trawler was most consistently represented in the redfish effort data for 3O during 1955-71 and the catch per hour for this vessel class was used as the standard unit of effort for the whole period. USA vessels were heavily involved in the 3O redfish fishery during 1955-64 but they reported effort in days fished and no adequate conversion factor could be obtained to convert their catch per day to the catch per hour of Canada (Newfoundland) or USSR vessels. USSR tonnage class 4 and class 7 (> 1800 tons) otter trawlers did not fish concurrently in 3O to any large extent; in some years class 4 trawlers fished 3O and in other years class 7. In the absence of a conversion factor between these two vessel classes, it was not possible to use the USSR effort data as the standard.

For 1958, 1959, 1962 and 1963 the average catch per hour for Canada (Newfoundland) tonnage class 4 vessels was divided into the total yearly catches by all countries, resulting in estimates of total effort for the entire fleet in standard Canada (Newfoundland) class 4 trawler hours.

For the two years (1961 and 1967) in which Canada (Mainland) vessels were significantly represented in the effort data, the effort was adjusted to that of Canada (Newfoundland) class 4 vessels by a conversion factor of 1.15 (Fig. 4). This was obtained by plotting catches per hour fished for Canada (Mainland) tonnage class 4 trawlers against catches per hour for similar Canada (Newfoundland) vessels for each month for each area in which both fished at least 100 hours and drawing a straight line through the origin. The standard catches per hour in 1961 and 1967 were then derived by dividing the redfish catches for both vessel classes by the adjusted effort. Total effort for these years was estimated by dividing these values into the total catches.

Effort for USSR tonnage class 4 trawlers in 1964 and 1965 was adjusted to that of Canada (Newfoundland) class 4 vessels by applying the conversion factor of 0.52 (Fig. 4) and the standard catch per hour was derived by dividing the annual catches by these vessels by the adjusted effort. During 1966 and 1969-71 USSR vessels of tonnage class 7 were represented most consistently in the effort data. However, there was insufficient comparative data to derive a factor for conversion to Canada (Newfoundland) tonnage class 4 vessels. In the absence of any evidence to the contrary it was assumed that USSR and Polish vessels of tonnage class 7 follow similar fishing practices and would have similar fishing efficiency. The redfish catches per hour fished for Polish tonnage class 7 trawlers were plotted against redfish catches per hour for Canada (Newfoundland) class 4 trawlers for each month for each area in which both fished at least 100 hours (Fig. 4). A straight line drawn through the origin gave a conversion factor of 1.23. The relatively low conversion factor is attributed to the different fishing practices of these vessels. Catches by the Canada (Newfoundland) vessels contained a very high percentage of redfish (about 90 percent) whereas the catches by the Polish (and USSR) vessels contained a significantly higher percentage of other groundfish species. A comparison of groundfish catches per hour would give a much higher conversion

factor. For 1966 and 1969-71 redfish effort by tonnage class 7 USSR vessels was adjusted to that of Canada (Newfoundland) tonnage class 4 vessels by applying the conversion factor of 1.23. The standard catch per hour was derived by dividing the total redfish catches by these vessels by the adjusted effort.

The annual effort in 30 for redfish by all trawlers was estimated by dividing the yearly standard catches per hour into the total catches by all countries, resulting in estimates of total effort for redfish by the entire fleet in standard Canada (Newfoundland) tonnage class 4 trawler hours.

No effort could be estimated for 1955, 1956, 1957, 1960 and 1968 because of insufficient data.

Divisions 3LN

USSR and Polish vessels of tonnage class 7 were most consistently represented in the effort data for 1957-71. In the absence of adequate data to provide a conversion factor, it was assumed that these vessels are similar in effective fishing intensity as indicated by the analyses of Brown et al. (1973) for Subarea 5 and Statistical Area 6. The standard unit of effort selected was the USSR-Polish tonnage class 7 otter trawler hour. The effort for redfish by all trawlers was estimated by dividing the standard catch per hour into the total redfish catches by all countries, resulting in estimates of total effort for redfish in standard USSR-Polish tonnage class 7 otter trawler hours. No effort could be estimated for 1955, 1956, 1964, 1967 and 1968 because of insufficient data.

Trends in effort and catches per unit effort

Division 3P

Total effort was less than 5000 standardized hours (Newfoundland tonnage class 4) during 1955-58, increased fairly sharply from about 5000 hours in 1959 to more than 25,000 hours in 1962, remained relatively steady (about 20,000 hours) from 1963 to 1965 but increased rather sharply from 1966 to 1970, with the exception of 1968 when effort decreased to less than 20,000 hours (Fig. 1). Catch per hour was relatively high during 1955-58 (.91 to 1.0 tons), decreased from .74 tons in 1959 to about .5 tons in 1962, increased sharply to .9 tons in 1965 and then declined gradually to .62 tons in 1971.

Division 3O

Effort was low from 1958 to 1962 (between 4000 and 12,000 hours), increased sharply to 47,000 hours in 1965, decreased to about 18,000 hours in 1966 and subsequently fluctuated between 15,000 and 30,000 hours (Fig. 2). Standard catch per hour values declined sharply from 1.3 tons in 1958 to about .4 tons in 1965, then increased to 1.0 tons in 1969 and subsequently declined to about .7 tons in 1971.

Divisions 3LN

Effort was relatively low in 1957 and 1958 (approximately 12,000 and 8000 hours), increased sharply to 28,500 hours in 1959 (standardized to USSR-Polish tonnage class 7 vessels), subsequently decreased to less than 15,000 hours in 1963, apparently fluctuated between 12,000 and 18,000 hours from 1963 to 1970, then increased sharply to a high of 32,000 hours in 1971 (Fig. 3). Catch per hour fluctuated irregularly during 1957-71.

Yield-effort relationship

The Schaefer yield model (Schaefer, 1954) was used to derive estimates of maximum sustainable yield (MSY) from these catch and fishing effort data. The Schaefer model assumes logistic population growth and symmetric yield curves with the maximum sustainable yield value occurring at 50 percent of the maximum stock size. Curves fitted in this manner supposedly represent the equilibrium or long-term average expected yields. Gulland (1961) and Brown et al. (1973) have pointed out that, when there are large and consistent changes in fishing effort, a direct plot of catch per unit effort against effort will not give the relation to be expected under stable conditions. In such situations the catch per unit effort in any year will depend not only on the effort in that year but on the effort in as many preceding years as the oldest fish in the stock has been vulnerable to fishing (Gulland, 1961). Gulland suggested a method of averaging effort over the mean number of years that a year-class contributes significantly to the catch.

A given year-class of redfish contributes significantly to commercial catches over many years, the duration of its contribution being dependent upon the intensity of commercial fishing and variations in recruitment. However, the catch per unit effort in any year depends mainly upon the effort in most recent years, to which most of the fish in the stock have been exposed (Gulland, 1961). To take account of this effect, running averages of total effort were made over 6-year periods (the previous 5 years and year i) and the catch per unit effort values for each year were plotted against the 6-year running averages of effort (Fig. 5-7).

There was no consistent pattern to the catch per unit effort-mean effort relation for Division 3O. Estimated standard catches per hour were relatively high during recent years despite increased effort. A re-examination of these catch per unit effort values indicated that the factor used for conversion of USSR tonnage class 7 catch per hour to that of Canada (Newfoundland) tonnage class 4 vessels was probably too low, resulting in too high estimates of standard catch per hour in recent years. In the absence of a more adequate conversion factor, a regression line was not fitted to the catch per hour-mean effort data for Division 3O redfish and an equilibrium catch curve could not be derived.

Least squares linear regressions relating catch per hour to mean effort were computed for Divisions 3P and 3LN redfish. The standardized catch per unit effort values for 3P indicate an increase in redfish abundance in that area during the mid-1960's while effort was relatively steady. It is possible that a number of good year-classes recruited to the fishery during this period. Because of this dramatic change in catch per unit effort values, only the 1965 to 1971 data were used for fitting the 3P regression line.

The parameters of the linear regressions of catch per unit effort against mean effort for Divisions 3P and 3LN were converted to those of the equilibrium yield versus effort parabolas which are depicted in Fig. 8-9. The estimates of maximum sustainable yields from the Schaefer model are approximately 23,000 metric tons for Division 3P redfish and approximately 20,000 tons for Divisions 3LN redfish. Catches of redfish in 3P exceeded the MSY level in 1967 and during 1969-71. Catches of redfish in 3LN were above the MSY level during 1959-62 and in 1969 and 1971.

Discussion

The estimates of maximum sustainable yield presented here must be regarded as preliminary and viewed with caution. The catch and effort data from which the estimates were derived are far from satisfactory. Furthermore, yield is greatly affected by recruitment. We have no real measures of recruitment for any of the areas considered in this report. A cursory examination of commercial length frequencies obtained from ICNAF Sampling Yearbooks for the period under consideration (Fig. 10-12) indicates that recruitment has been variable in these areas, more so in Division 3P than on the Grand Bank. Recruitment in Division 3P is assumed to be higher during 1965-71 than during the 1959-64 period. For this reason only the 1965-71 data have been considered when deriving the equilibrium yield curve for 3P redfish. A recent research cruise to Division 3P in February of 1973, utilizing a lined otter trawl, revealed a predominance of 20-24 cm redfish (Fig. 13). Although we have no quantitative measures of recruitment, it appears that another relatively good year-class (possibly 1966) will soon recruit to the commercial fishery in 3P.

Another source of error in the maximum sustainable yield estimates derived in this report is the occurrence of diurnal variation in availability of redfish to the otter-trawl gear, a phenomenon well documented by Steele (1957), Konstantinov and Scherbino (1958), Templeman (1959), Beamish (1966) and Sandeman (1969b). The degree to which this pronounced diurnal vertical migration of redfish will bias attempts to use catch per unit effort by otter trawl as indices of abundance is not known. The recent switch to exploitation by midwater trawlers in the Gulf of St. Lawrence has resulted in greatly increased catches per unit of effort. In order to utilize otter trawl catch per unit of effort data to estimate maximum sustainable yields, it is necessary to assume that all redfish in a stock, although exhibiting diurnal variation in availability, have, on the average, an equal probability of capture by the bottom gear.

Despite these important qualifications it appears that the recent levels of redfish catches in Divisions 3P and 3LN are above the maximum sustainable yield level. An increase in fishing pressure on redfish in these areas, as a result of diversion of the mobile fleets when quotas for regulated species become filled, would seem inadvisable at this time. Catch limitations to prevent such an expansion until better knowledge of the effects of the fisheries on these redfish stocks becomes available should be given serious consideration. Previous experience has indicated that redfish stocks are very slow in rebuilding after a period of intense exploitation, e.g. Gulf of Maine (Kelly et al., 1973).

It should be noted that levels of sampling of the commercial redfish catches in recent years have been inadequate. In order for meaningful assessments to be performed, more adequate length and age sampling of the commercial catches must be implemented.

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Table 1. Nominal catches (metric tons) of redfish by country, from ICNAF Division 3P, 1955-71.

Year	Can (M&Q)	Can (N)	Fr (St.P&M)	Fr (M)	Ger (Fed)	Japan	Poland	Spain	UK	USA	USSR	Non-mem	Total	Standard catch/hr (Kg)	Standardized effort (hrs fished)
1955	393	2,975								1,323			4,691	996	4,856
1956	100	2,715								460			3,275	1,020	3,211
1957	147	2,023			2					215			2,387	998	2,392
1958	226	3,093			8					183			3,510	911	3,853
1959	235	2,571							2	883	83		3,774	733	5,149
1960	1,789	4,720	67						5	2,644			9,225	573	16,099
1961	1,256	7,877	266						1	376			9,776	611	16,000
1962	838	8,698	498						4	3,400	1		13,439	512	26,248
1963	349	12,019	323				2		5	1,048	1		13,747	682	20,157
1964	104	12,807	599						24	228	45		13,807	692	19,952
1965	329	17,122	779	6	12				11	474			18,733	905	20,699
1966	2,133	15,984	1,758	9					16	209	759		20,868	874	23,876
1967	548	12,038	1,583				117		7	125	1,216	16,357	31,991	804	41,034
1968	226	6,695	984							196	3,939	1,844	13,884	780	17,800
1969	387	8,214	638				780			23	22,009		32,051	736	43,548
1970	463	10,304	1,225			937	154	34			24,153		37,270	707	52,716
1971	242	5,284	1,404			2,466	58				18,046		27,500	619	44,426
Totals	9,765	135,139	10,124	15	22	3,403	1,111	34	75	11,787	70,252	18,201	259,928		

Table 2. Nominal catches (metric tons) of redfish by country, from ICNAF Division 3O, 1955-71.

Year	Can (M&Q)	Can (N)	Fr (St.P&M)	Ger (E)	Japan	Poland	Rom	UK	USA	USSR	Non-mem	Total	Standard catch/hr (Kg)	Standardized effort (hrs fished)
1955	274	68							8,080			8,422		
1956	401	50							5,564			6,015		
1957	238	78							2,031			2,347		
1958	246	1,786		2					4,037			6,071	1,303	4,659
1959	745	963						2	7,230	328		9,268	1,092	8,487
1960	93	97	30					1	4,609	200		8,030		
1961	855	142	147					10	7,704	2,536		11,394	936	12,173
1962	380	666	285						325	5,901		7,557	793	9,530
1963	352	1,803	549			25		2	2,881	3,568		9,180	576	15,938
1964	316	1,004	260					3	1,675	12,786		16,044	514	31,214
1965	13	190	106					3		19,300		19,612	418	46,919
1966	9	98	41			452		5	7	14,667	26	15,305	825	18,552
1967	128	517	210			1		23		17,707	451	19,037	659	28,888
1968		52	6						2	6,364		6,424		
1969	26	160	3			345				15,344		15,878	1,003	15,831
1970	190	98			51		58			12,795		13,192	787	16,762
1971	136	29	2	50	1,132	225	2			18,216		19,792	710	27,876
Totals	4,402	7,801	1,639	52	1,183	1,048	60	49	44,145	129,712	477	189,568		

Table 3. Nominal catches (metric tons) of redfish by country, from ICNAF Divisions 3LN, 1955-71.

Year	Can (M&Q)	Can (N)	Fr (St.P&M)	Fr (M)	Ger (Fed)	Ger (E)	Ice	It	Japan	Poland	Rom	Sp	UK	USA	USSR	Non-mem	Total	Standard catch/hr (Kg)	Standardized effort (hrs fished)
1955	92	263												4,003			4,362		
1956	102	176											3	7,226			7,507		
1957	41	1,275											33	2,502	17,232		21,083	1,721	12,250
1958	300	1,863												5,959	12,947		21,069	2,686	7,844
1959	317	1,465			8,794	843	3,585						20	8,370	21,191		44,585	1,560	28,580
1960	384	1,994	156		4,837		853	2					526	7,978	9,832	1,448	28,010	1,160	24,147
1961	329	2,412	434		3,552		93			1,961			114	8,623	5,635		23,175	1,104	20,992
1962	889	5,973	152		134					2,229			107	10,530	1,420		21,434	886	24,192
1963	199	4,556	231		12					1,534			66	8,169	6,330		21,097	1,475	14,303
1964	139	1,224	86		199		3			704			73	2,791	2,655		8,104		
1965	362	2,542	107		1,852					1,198			134	298	7,000		13,493	832	16,218
1966	108	1,352	191	6	143		292			2,710			57	131	6,133	5,853	16,974	1,368	12,408
1967	81	361	152	12	68					4,523			92	24	18,003	8,313	27,188		
1968	116	546	100	22						241			10		16,469	1,783	17,613		
1969	25	267	57	4						247				10	22,068		23,069	1,280	18,023
1970	80	332	7						571	67	220				12,926		14,388	1,352	10,642
1971	88	530	6		9	6,299			2,214	607	50	37	8		24,043		34,353	1,073	32,016
Totals	2,650	27,131	1,679	44	19,600	7,142	4,826	2	2,785	16,043	270	37	1,243	66,614	148,542	17,397	347,504		

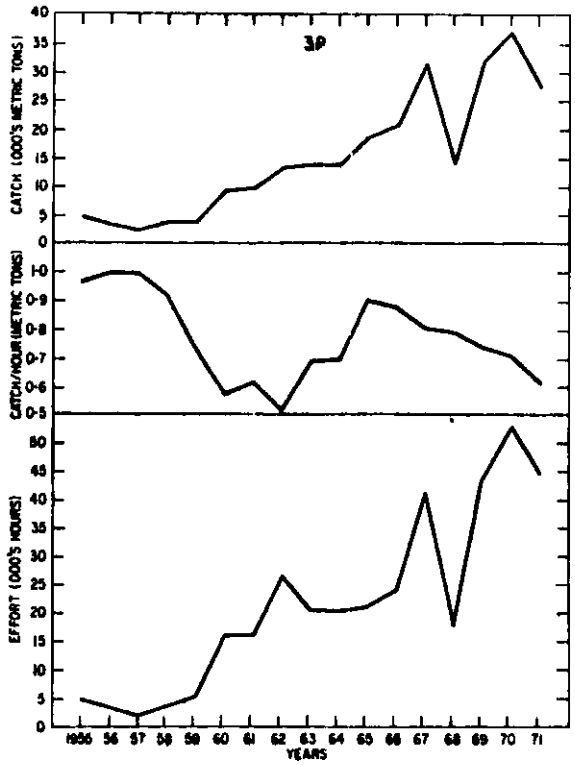

Fig. 1. Trends in nominal catches, effort and catches per unit effort in standard trawler units - Canada (Nfld.) tonnage class 4 - for redfish in Division 3P during 1955-71.

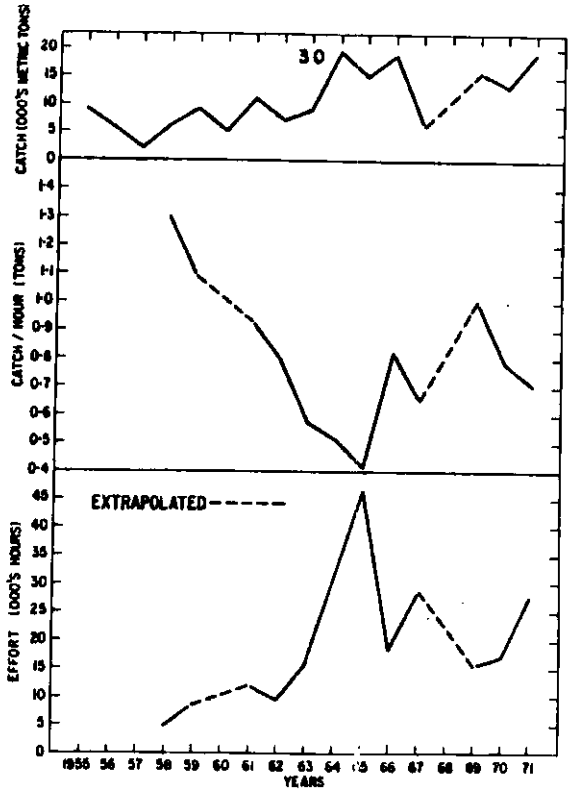

Fig. 2. Trends in nominal catches, effort and catches per unit effort in standard trawler units - Canada (Nfld.) tonnage class 4 - for redfish in Division 3O during 1955-71.

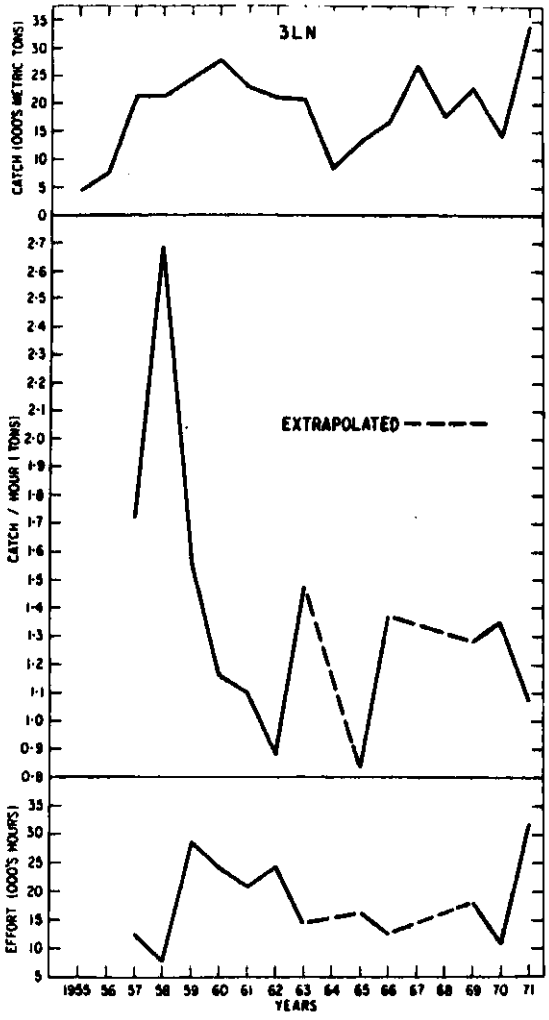

Fig. 3. Trends in nominal catches, effort and catches per unit effort in standard trawler units - USSR-POLD tonnage class 7 - for redfish in Divisions 3LN during 1955-71.

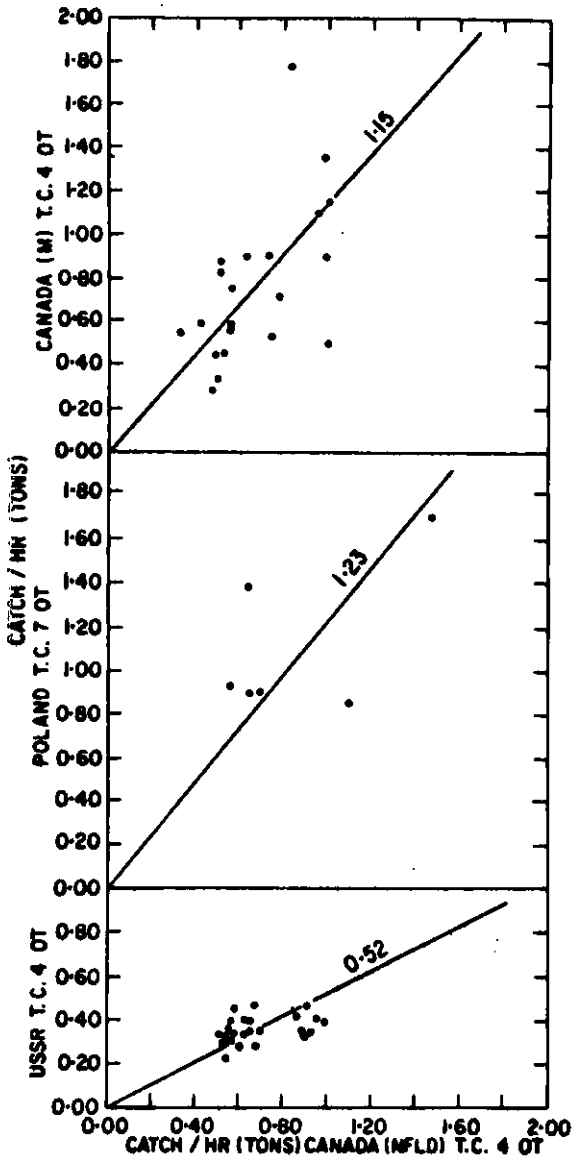

Fig. 4. Relation of redfish catches per hour fished by USSR tonnage class 4, Poland tonnage class 7, and Canada (Mainland) tonnage class 4 trawlers and the corresponding catches per hour of Canada (Nfld.) tonnage class 4 trawlers.

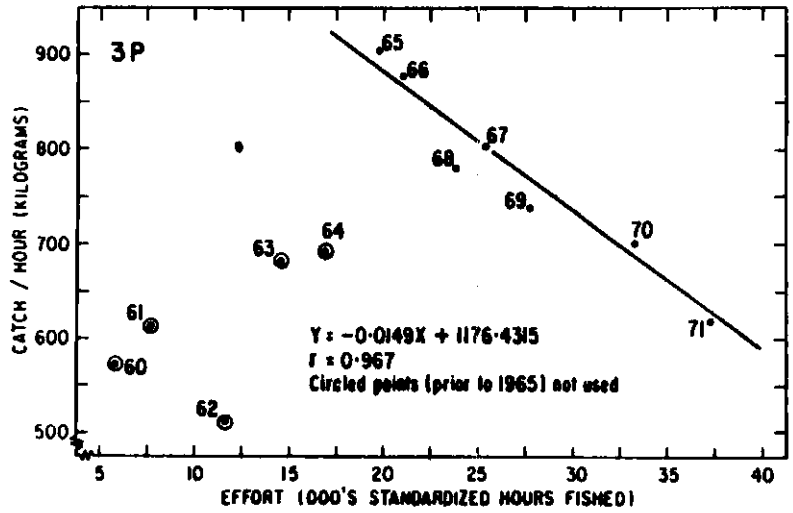

Fig. 5. Relation between standardized catch per hour and mean effort during the past six years for Division 3P redfish.

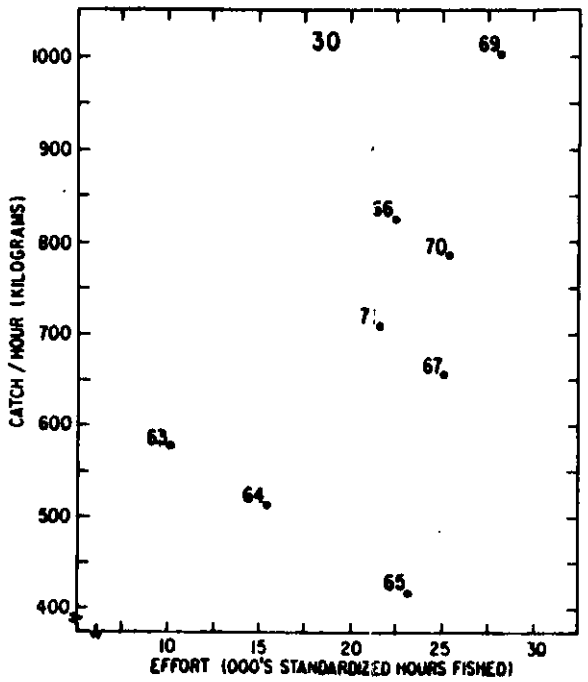

Fig. 6. Relation between standardized catch per hour and mean effort during the past six years for Division 3O redfish.

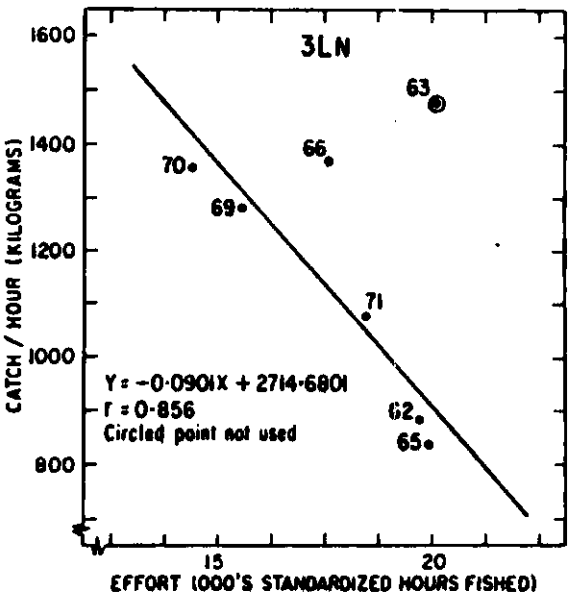

Fig. 7. Relation between standardized catch per hour and mean effort during the past six years for Divisions 3LN redfish.

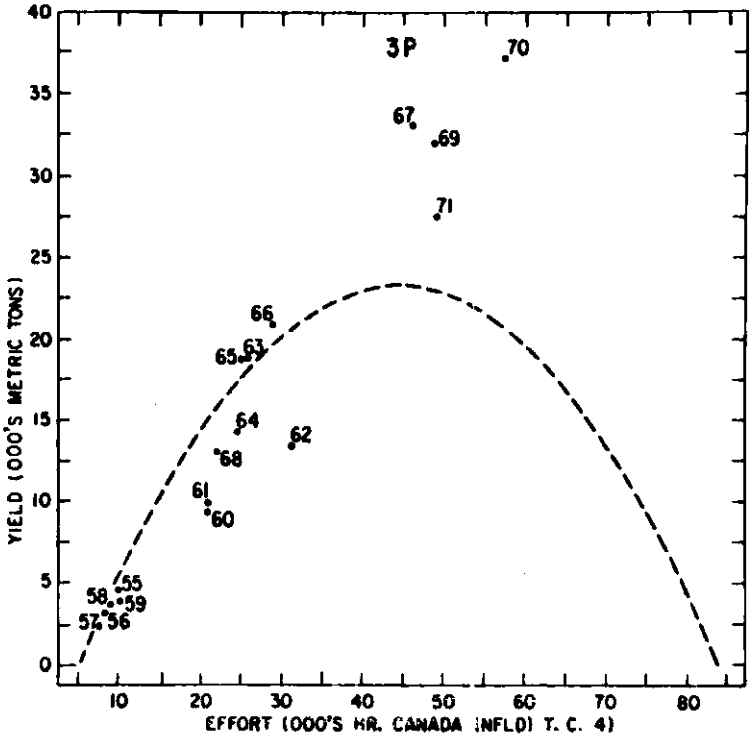

Fig. 8. Yield curve derived from the catch per unit effort/effort relation for Division 3P redfish.

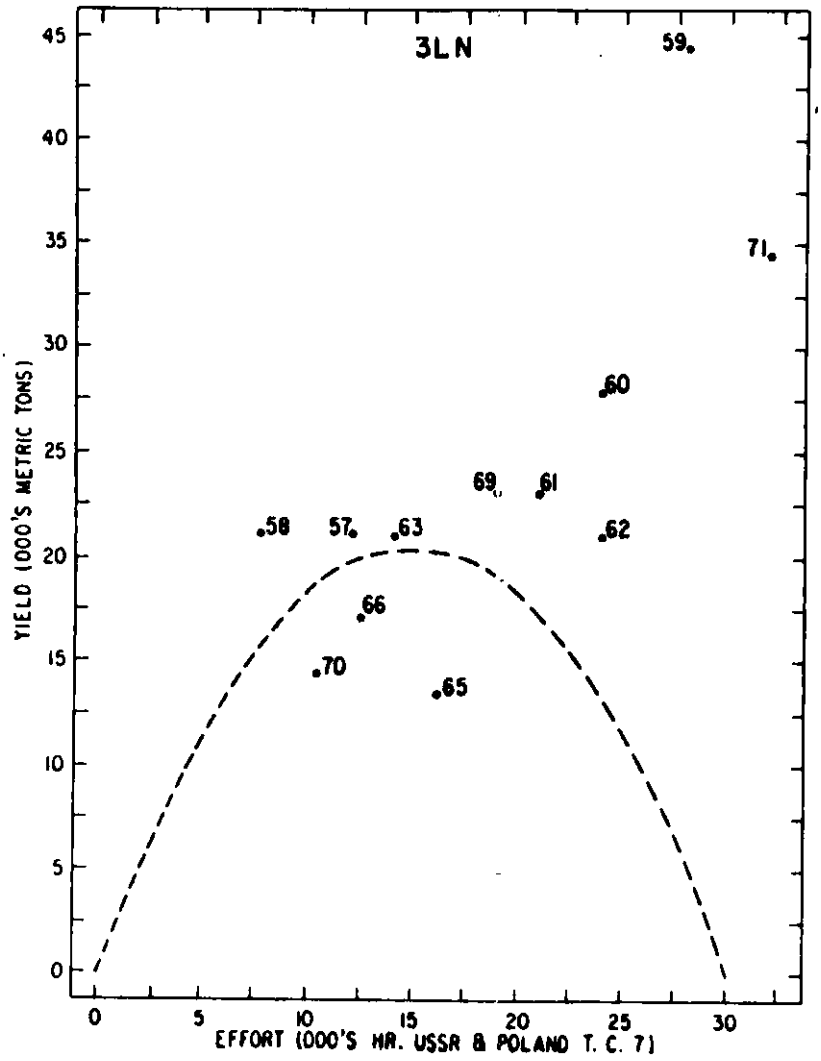

Fig. 9. Yield curve derived from the catch per unit effort/effort relation for Divisions 3LN redfish.

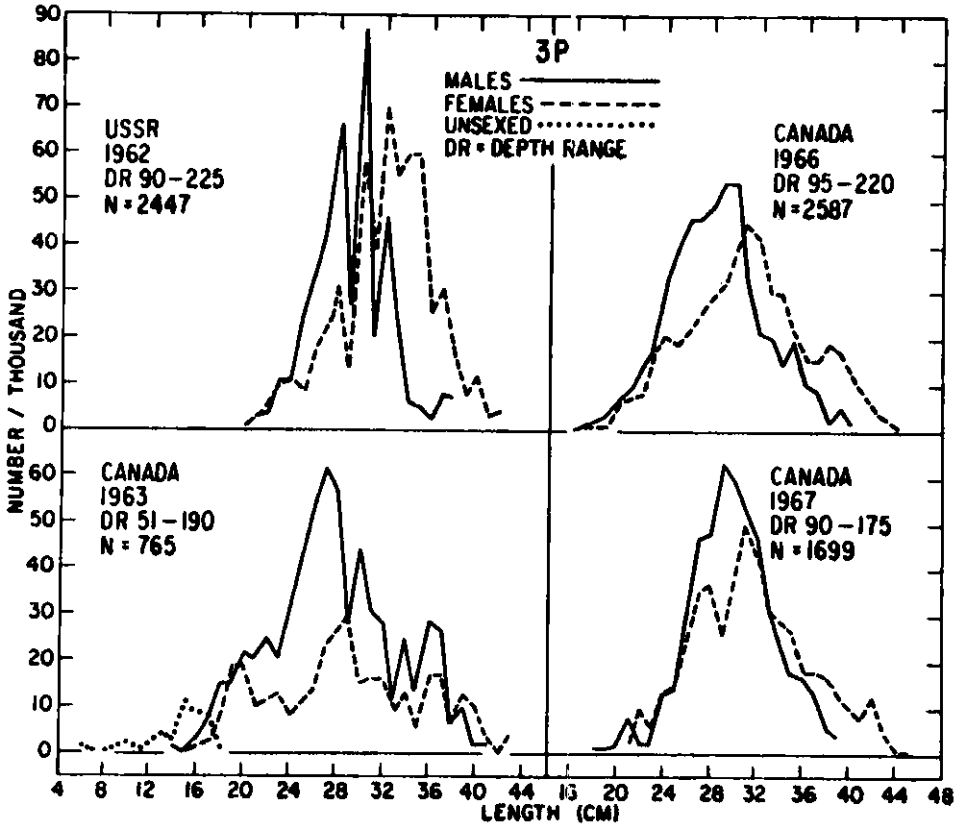

Fig. 10. Commercial otter trawl length frequencies for Division 3P redfish.

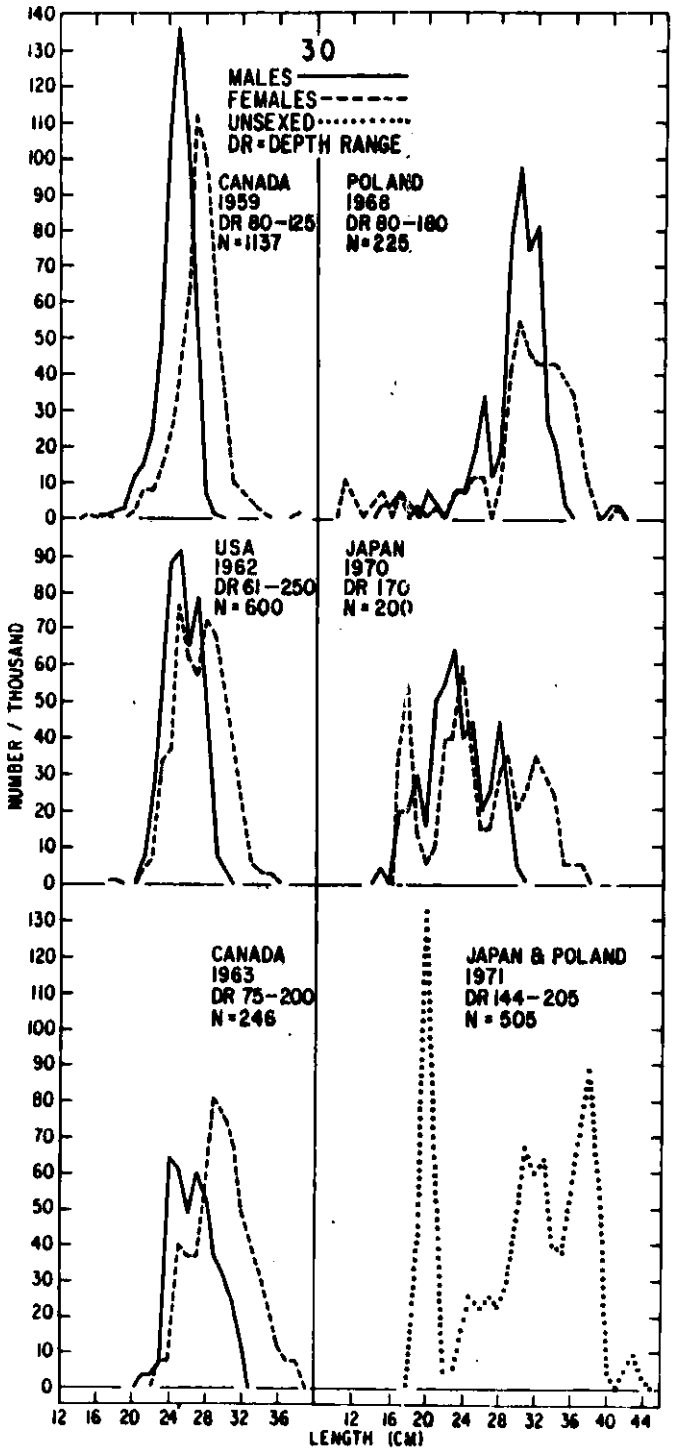

Fig. 11. Commercial otter trawl length frequencies for Division 3O redfish.

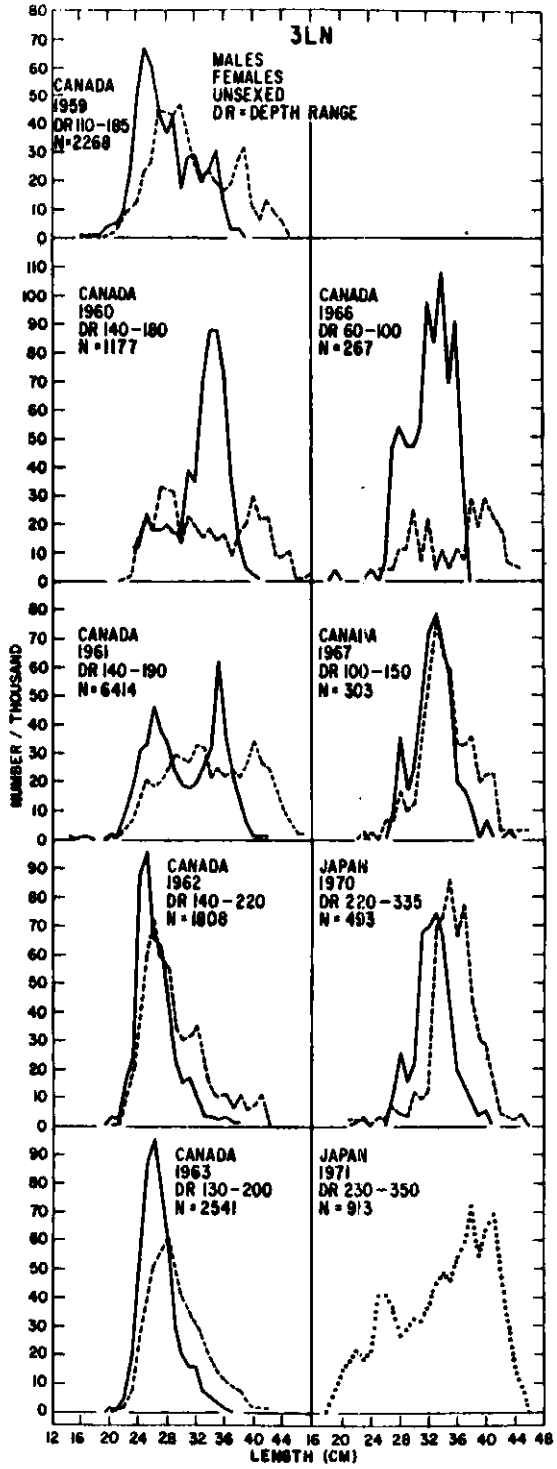

Fig. 12. Commercial otter trawl length frequencies for Divisions 3LN redfish.

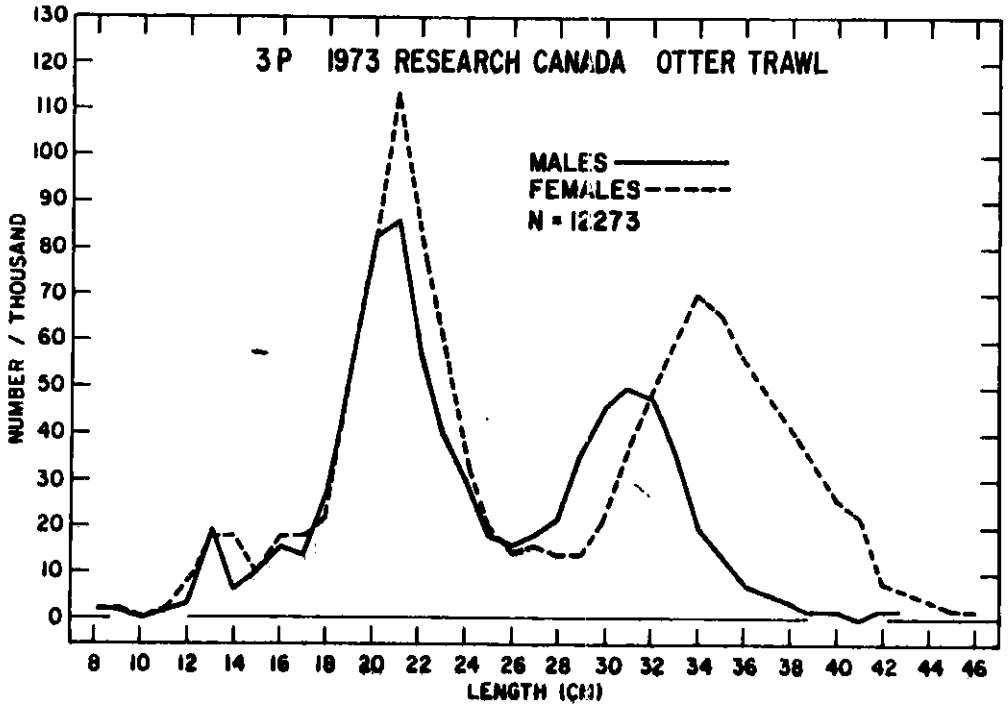

Fig. 13. Canada (Nfld.) 1973 research length frequency for Division 3P redfish.