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Sebastes fishing in the Gulf of St. Lawrence: evolution of the fishery from 1958 to 1974 and estimation of the maximum equilibrium catch

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1. Introduction.

During the period 1958-1973, the sebastes catches made in the gulf of St Lawrence have taken more and more importance in the total bringing in of this species from the North West Atlantic : in 1958 they represented 7 p.cent of the total catches (41 p.cent for the ICNAF's sector 4), in 1965 32 p.cent (79 p.cent for sector 4) and in 1973 they reached 55 p.cent of the total with 130,000 metric tons (42 p.cent for sector 4).

A major part of those bringings comes from the gulf of St Lawrence (sector 4 RST) ; but after a period of steady increase, since 1968 the catches of redfish decreased and the spectacular increase of tonnage of 1973 has only been obtained by the use of much more efficients technics (pelagic trawl).

The goal of this study is to state precisely this evolution and to make an estimation of the maximum equilibrium catch that can be supported by the fish population under good conditions of exploitation. Therefore, we talked of all the redfish of the gulf of St Lawrence (sector 4 RST) as one unique stock and nothing can apparently go against it (SANDEMAN, 1973).

2. Material and methods.

The datas used for this study were taken out of ICNAF's Statistical Bulletins of the period 1958-1973 and concern the gulf of St Lawrence (sectors 4 R, 4 S, 4 T). They deal with the whole of draggers looking for sebastes as principal species.

Having only datas on the time of fishing per class of ship's tonnages and per types of gears, and the variations between the fishing power being importants, we were brought to standardize the datas. In this way, for each year these datas were grouped per class of tonnages and per fishing gear (bottom trawl or pelagic trawl). The average out puts per fishing day of the different classes vary from 2.2 t/d (class 0-50 dwt) to 14.7 t/d (class 501-900 dwt) for the ones using bottom trawl and from 5.5 t/d (class 51-150 dwt) to 29.9 t/d (class 501-900 dwt) for the ones using pelagic trawl. The boats of the class 51-150 dwt using bottom trawl were chosen as standard draggers because their effort is best represented in this sector. The standardization was done using the Gulland method (1969) and the fishing effort is expressed in number of standard fishing days :

$$\text{Total effort} = \text{Standard class effort X } \frac{\text{total catch}}{\text{standard class catch}}$$

The datas on catches were grouped the same way as the ones on the efforts. They are expressed in metric tons of round fish. The catches per unit of effort are expressed in metric tons of round fish per standard fishing day (t/SFD).

3. Results.

3.1. Evolution of fishing effort (fig.1).

The bottom trawl was the only gear used until 1970 for sebastes fishing. From 1958 to 1961 the fishing effort decreased regularly to a value of 1715 SFD. On the other hand from 1962 to 1970 the increase was important (15200 SFD).

Due to the appearance of the pelagic trawl in 1971, the fishing effort given by the bottom trawl class rapidly decreased : in 1973 it is only of 9,968 SFD which represents a 73 p.cent drop compare to the 1971 value. During this period the total effort went up from 18,800 to 46,300 SFD ; this very important increase is due to the development of sebastes fishing using pelagic trawl : in 1971 the effort of the pelagic trawl class represents only 8 p.cent of the total effort as in 1973 it reaches 78 p.cent of the total effort (36,300 SFD). In 1974 though, we notice a tendancy towards a decrease.

3.2. Evolution of catches (fig.2).

For the bottom trawl class, the evolution of catches was identical to the one of the efforts : from 1959 to 1962, to the decrease of bringing in of 65 p.cent (5,600 t in 1962) corresponded a decrease of efforts. From 1962 to 1968, as for the effort, the increase was important and the catches reached 88,000 t in 1968.

After that year, the diminution of the total bringing in was regular until 1972 (a 14 p.cent drop between 1968 and 1972). The very important tonnage brought in 1973 was due to the remarkable increase of the fishing effort of the boats using pelagic trawl : in 1971, their catches represented only 8 p.cent of the total, in 1973 78 p.cent. In 1974 the drop was so important that their level came back down to what it was in 1966.

3.3. Evolution of productivity (fig.3).

From 1958 to 1972, the evolution of CPUE was roughly parallel to the one of bringing in : the increase from 1958 to 1959 is explained by the parallel increase of catches. Same thing from 1959 to 1962, the CPUE drop (55 p.cent) brought a diminution of bringing in the more so as the fishing effort equally dropped until 1961. Between 1962 and 1967 the increase of the productivity and effort lead to a new increase of catches.

Finally between 1967-68 and 1972 CPUE and bringing steadily dropped and it was only in 1974 that the effort was sufficient (development of pelagic trawl) to bring again an increase of catches. On the other hand in 1974, the effort and productivity having dropped, the drop of bringing in was important.

4. Estimation of maximum equilibrium catch.

The datas on effort and catches can be used in a simple model of fisheries to calculate a maximum equilibrium catch corresponding to the conditions of exploitation during the period studied.

The FOX model (1970) was chosen because the values of catches per unit of effort in function of the effort given by the method of LE GUEN and WISE (1967) ajust better to an exponentiel curve. This method, developped for the SCHAEFER mode (1954) was used in this case for the FOX model : the estimation of the parameters of the model is obtained by calculating the best correlation existing between the logarithm of the catches per unit of effort and efforts corrected by the system of moving averages.

The CPUE of a given year depends not only on the effort developped during that year but equally on the effort developped during the preceding years (GULLAND, 1968), and the equation of the regression curve corresponding to the best correlation between the logarithm of a year and the average standard effort over n years will give the best estimation of the parameters of the model (LE GUEN and WISE, 1967). In this very case, the best correlation was obtained for a standard effort calculated on a 10 year basis (fig.4).

The equation of the equilibrium curve is

$$LnU = a - bf \quad , \quad U = U_{\infty}\, e^{-bf}$$

where U and f are the catches per unit of effort and the effort corresponding to the equilibrium ; U is the maximum theoretical value of CPUE ; a and b are constants.

The estimation of the equilibrium curve obtained is :

$$LnU = 2.2356 - 7.04 \cdot 10^{-5} f$$

$$U = 9.352\, e^{-7.04 \cdot 10^{-5} f}$$

The estimation of the equilibrium catch curve is therefore :

$$Y_E = U_{\infty} f\, e^{-bf}$$

$$Y_E = 9.379\, f\, e^{-7.04 \cdot 10^{-5} f}$$

The graph is represented on fig.5. The maximum equilibrium catch obtained that way is of 48,869 which corresponds to an effort of 14,205 SFD.

5. Conclusion and discussion.

The results show that the fishing effort increases during all the period studied. Ever since 1971, the increase is much more rapid and corresponds to the apparition of the pelagic trawl as the effort of the bottom trawl class has decreased since that year.

The increase of catches, specially in 1972, is due to a considerable increase of the effort, as the CPUE regularly drops since 1967.

The FOX model, for the period studied, gives an estimation of the maximum equilibrium catch of 50,000 tons for a fishing effort of 14,000 SFD. If the conditions of application of the model do not undergo major variations, its extrapolation can give a prediction on the evolution of fishing. The augmentation of fishing effort finally brings a drop of CPUE and catches ; the level reached by the bringing in in 1973 (130,000 t) could not be maintained except for a very strong increase of effort. Besides, in 1974, the bringing in has dropped down to 63,000 t (ICNAF, 1975).

On the other hand, according to DAGET and LE GUEN (1974), too intense an exploitation can affect the recruting which becomes insufficient to insure a come back to the maximum level of the stock in case of a total stop of fishing.

Finally, SANDEMAN (1973) noticing the weak abundance of the age classes not recruted for fishing shows that this would lead us to suppose that fishing industry could support catches from 90 to 40,000 tons.

The results were obtained from a simple mathematical model, besides their lack of precision, they indicate however in which direction the stock of sebastes evoluates in the gulf of St Lawrence.

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Years	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Effort (stand. days fished)	2 735	2 679	2 271	1 715	2 080	5 942	8 278	10 531	11 508	10 930	15 927	16 402	19 463	18 837	21 283	46 247	27 250
Catch (metric tons)	10 452	16 173	9 818	6 831	5 608	18 731	28 571	47 193	62 984	88 141	85 694	84 106	77 788	75 739	75 739	128 152	60 100
Catch/effort	3.82	6.04	4.32	3.98	2.70	3.15	3.45	4.48	5.47	6.24	5.53	5.22	4.32	4.13	3.56	2.77	2.21

Tabl. I - Effort (standardized days fished), catch (metric tons) and catch/effort statistics for ICNAF Divisions 4 RST redfish.

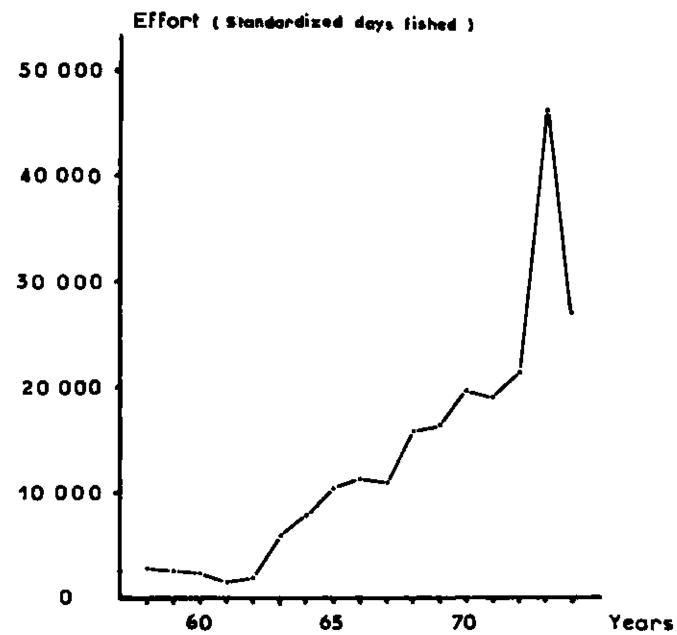

Fig. 1 - Trends in effort (standardized days fished) for redfish in Divisions4 RST during 1958-1974.

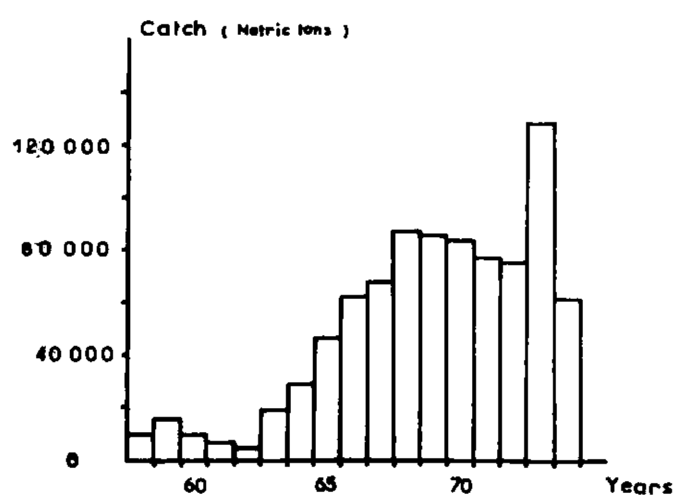

Fig. 2 - Trends in nominal catches (metric tons) for redfish in Divisions4 RST during 1958-1974.

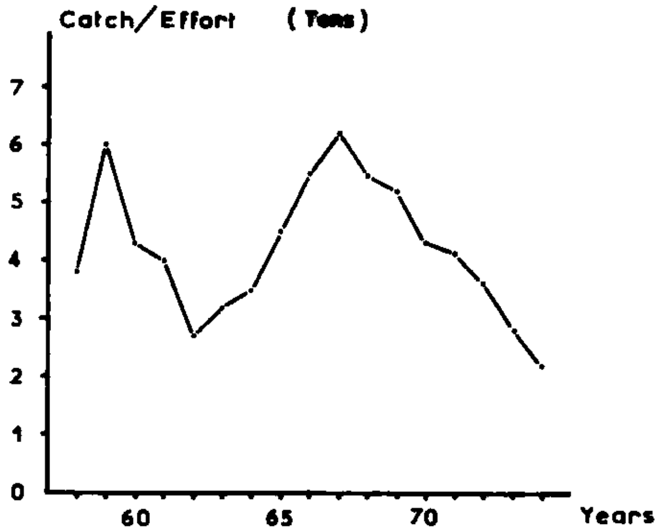

Fig. 3 - Trends in catches per unit effort (metric tons per standardized days fished) for redfish in Divisions 4 RST during 1958-1974.

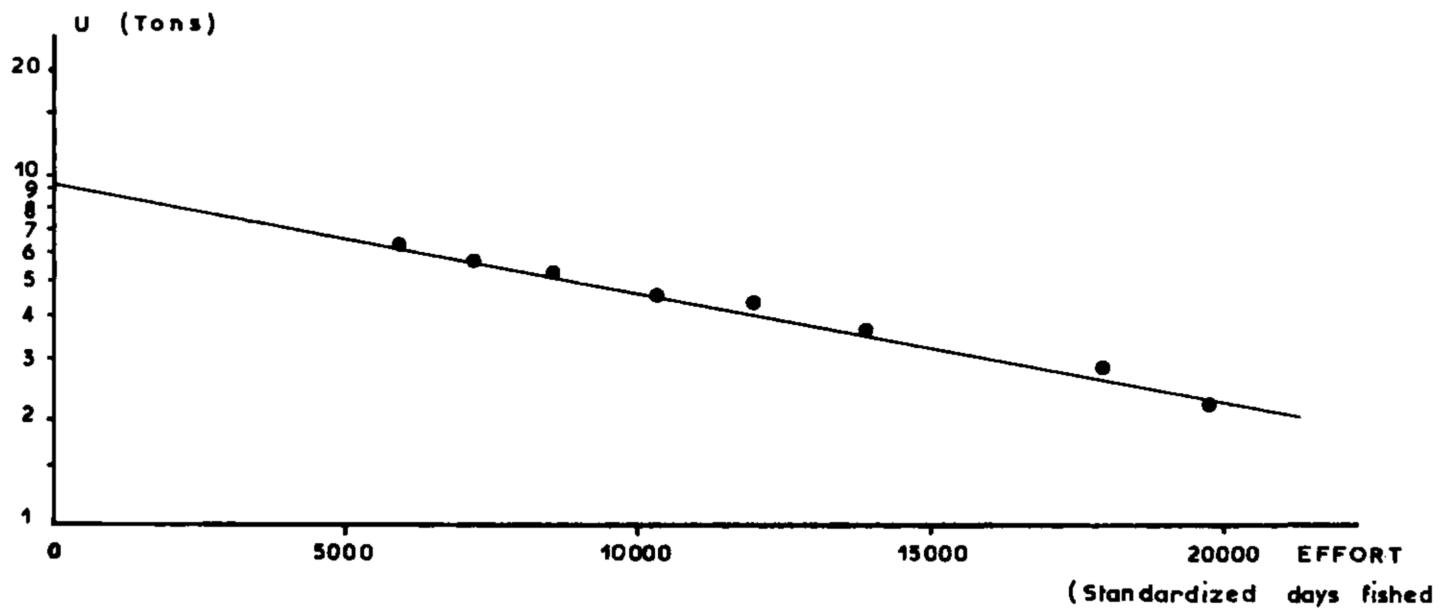

Fig. 4 - Relation between logarithm of standardized catch per day and mean effort (10 years running average) for Divisions 4 RST redfish.

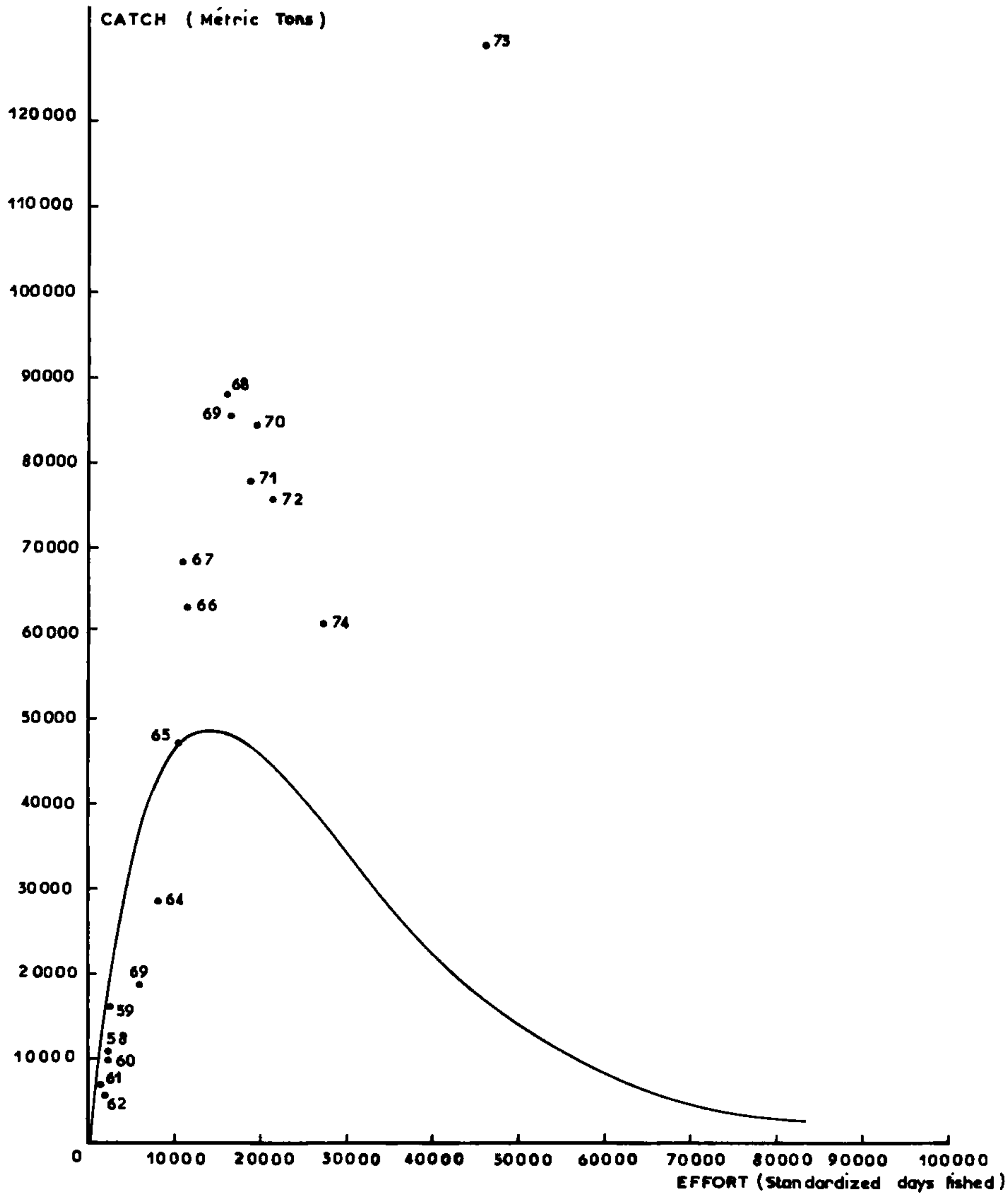

Fig. 5 - Yield curve derived from the catch per unit effort relation for Divisions 4 RST redfish.