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Assessment of American Plaice Stocks in ICNAF Divisions 3L and 3N

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Introduction

The main fishery for American plaice (*Hippoglossoides platessoides*) in ICNAF Subarea 3 occurs in ICNAF Divisions 3L and 3N and began in the late 1940's with the introduction of the otter trawler fleet. The fishery has remained mainly Canadian, but since 1965, European trawlers, principally those of the USSR and Poland, have gradually increased their share of the catch so that by 1968 they were taking about 70% of the total from 3N (Fig. 1). In recent years plaice have become the major species sought by the Newfoundland otter trawler fleet. This document presents for the first time an assessment of this species from the Grand Bank.

Materials and Methods

The total landings (Fig. 1) are calculated values based on Newfoundland data since the European fleet reported the flounder from Subarea 3 merely as "unspecified flounder" in the ICNAF Statistical Bulletins. The amount of plaice represented in this "unspecified flounder" total was calculated from the proportion that this species was of the total Newfoundland catch of plaice, yellowtail and witch from Divisions 3L and 3N.

The calculations of annual numbers caught at each age were based on otolith samples and length frequencies gathered from regular sampling of the commercial fleet by the St. John's Biological Station of the Fisheries Research Board of Canada and the total calculated catches in the two areas. Discards were only roughly estimated because of a general lack of information.

The calculation of effort used in Fig. 5 and Tables 1 and 3 was based on the catch per unit effort of plaice by Newfoundland side trawlers (151-500 tons), since up to 1964 practically all the landings were by this gear (Pitt, 1970). Commercial fishing for plaice in 3N was confined mainly to the southeast and eastern slope of the bank and overlapped very little with the areas normally fished for haddock. Thus, for a considerable part of 3N and practically all of 3L the fishery was concentrated on plaice, cod and redfish. Since redfish are caught beyond the depths occupied by plaice, the otter trawler fishery between 75 and 200 metres in 3L and 3N is almost exclusively for plaice and cod. In calculating the Canada (N) catch per hour on which calculations of total effort were based, the effort from all tows containing plaice in sufficient numbers to be recorded as a commercial catch on the vessel's log sheet were used in the compilation of effort for the individual statistical unit areas as used by the St. John's Biological Station. Actually Canadian trawlers have fished almost exclusively for plaice along the seaward slope of 3N and most of 3L.

The effort calculated from the landings of European factory ships could contain some error since a considerable proportion of their effort was for redfish and hence could include quantities of greysole (witch flounder) in their record of "unspecified flounder".

Separation of stocks

Tagging indicated that plaice on the Grand Bank are relatively sedentary (Pitt, 1969) with minimal migration noted between the northern and southern parts of the bank. Very few plaice tagged just north of 46°N (3L) moved as far south as 45°30'N (3N). Similarly of the plaice tagged at 45°N only a very minor number were recaptured north of 46°N (3L). Hence the Grand Bank was divided into two main stocks.

The other reason for separating the Grand Bank into 2 main stocks was the difference in growth patterns (Fig. 2). Plaice from 3L are consistently smaller at comparable size than those from 3N. Fewer of the old age groups were caught in 3N than in 3L.

The 3N stock is confined to a relatively small area along the southeast and eastern slope of the Grand Bank since the 75 and 200 metre contour are close in this area. In 3L on the other hand the slope is very gradual from 75 and to 200 metres, hence the available area is much greater.

Separation of males and females

From the beginning it seemed evident that it would be necessary to separate the males and females since each produced parameters that were quite different. Growth curves (Fig. 2) produced different parameters for the two sexes and from a study of catch curves it became evident that total instantaneous mortality rates were dissimilar. For the males, fish over 20 years of age rarely occurred, whereas for the females, fish of 25 years or older were frequently encountered. The 50% maturity point for males is about 7 years in 3L and 5 years in 3N. For females it is 14 years in 3L and 12 years in 3N (Pitt, 1966).

Calculation of fishing mortality

The method of "virtual populations" developed by Fry (1949, 1957) and modified by Gulland (1965) and Jones (1964, 1968) was used to estimate fishing mortality (F) for each age of the year-classes included in catches for 1957-67 for 3L and 1956-67 for 3N. The method of calculation is described in detail by Schumacher (1970) and his procedure has been used here. The method requires an estimate of natural mortality and an estimate of E for the older age groups.

Natural mortality. Catch curves for both commercial and research data for 1953-55 for both stocks gave estimates of instantaneous total mortality of 0.27 to 0.34 for males and 0.19 to 0.22 for females. Fishing effort at the time was very low so a natural mortality rate of 0.25 for males and 0.15 for females appeared to be reasonable estimates.

Estimates of Z from survival rates of virtual populations plotted against the corresponding effort (Fry, 1957), i.e.

$$Z = cF + M$$

gave values of M for males - 3L = 0.31, 3N = 0.27 and for females - 3L = 0.15 and 3N = 0.16.

A few trial values for F for some of the older age groups suggested an F of 0.45 giving an E of 0.64 for males and 0.75 for females. These gave values for $E(1-e^{-Z})$ of 0.324 and 0.338 for males and females respectively.

Calculation of yield per recruit curves

Yield per recruit curves using partial recruitment as indicated in Tables 1-4 were calculated for males and females on the basis of 500,000 recruits each of males and females being available to the fishery at age 5. The yield values for these were then combined and an average yield per recruit calculated (Fig. 3). Age 5 was chosen as an age when plaice would be large enough so that predation by larger fish would perhaps be minimal and after which the estimated value of M would probably be relatively constant. In addition, for purposes of comparison, yield per recruit curves were plotted using percent from maximum yield for both partial and knife-edge recruitment as indicated in Fig. 4.

Results and Discussion

Generally speaking the average values of F for all age groups in 3L remained at a relatively low level until 1967 (Tables 1-2 and Fig. 5). For some reason the average F's for males were slightly higher than the females since 1963. For 3N the average F estimates for males and females did not increase significantly until 1965. The trends of average values of F in relation to fishing effort are shown in Fig. 5.

The regression of these average estimates of F on annual fishing effort gave highly significant correlations (Fig. 5); however, for each plot positive intercepts were calculated. Since only one type of gear was used to fish plaice and also since plaice apparently do not have marked seasonal distribution patterns, it was felt that the calculation of effort as described in a previous section is probably a fairly good estimation of fishing intensity. The values of F for the early years appear too high in proportion to the fishing effort and it is possible that there could have been an underestimation of effort at this time. While it is realized that the relationship between F and effort cannot be extended too far, the extrapolation of the regression of F on effort was used here to give a projection of the possible fishing mortality in 1968 and 1969.

The yield per recruit at various levels of fishing mortality give a general indication of the status of the American plaice fishery in Divisions 3L and 3N. The shape of the yield curves is somewhat different for the two stocks mainly because of the relatively slow growth rate in 3L compared to that of the 3N stock.

Division 3L stock

In 1967 a fishing effort of about 60 thousand hours gave a fishing mortality of 0.34 to 0.38 (Tables 1-2). This fishing rate was about 80% of the maximum yield per recruit (Fig. 4A). The landings per hour by the Canada (N) fleet were about 600 Kg (Fig. 6). In 1968 and 1969 effort levels of 68 and 100 thousand hours respectively probably increased the fishing mortality to between 0.40 and 0.45 in 1968 and > 0.50 in 1969. If the projection for 1969 is at all realistic the yield per recruit would increase by about 10% from 1967 in spite of an almost doubling of the effort. In 1969 the landings per hour dropped to 400 Kg. In this area it appears that 85-90% of the yield is obtained at a fishing rate of 0.35.

Division 3N stock

In 1967 a fishing effort of about 58 thousand hours gave a fishing mortality of between 0.43 and 0.45 which for the combined (Male and Female) yield per recruit curve (Fig. 3B) is beyond the maximum point. The landings per hour in 1967 were about 600 Kg (Fig. 6). The effort was up to 74 thousand hours in 1968, but declined to around 50 thousand hours in 1969. The landings per hour declined from about 475 Kg in 1968 to less than 400 Kg in 1969. In 3N, taking an approximate average rate for males and females, 80-90% of the yield is caught at a fishing mortality rate of 0.30 (Fig. 4).

For both stocks year-classes of comparatively equal strength enter the fishery each year, which on the plus side helps insure a stable stock provided fishing pressure is not too great. However, if the stock is reduced to a low level, the return to an economically fishable size would be slow even with a very drastic reduction in fishing effort because of the low growth rate. Furthermore, it is not known what the effects of a large reduction in the spawning stocks would have on the populations.

Division 3L stock can probably withstand heavier fishing pressure than that of 3N since it is not confined to such a small area as the latter. However, the higher rate of growth in 3N will in part compensate for this. It would appear that in the light of the present information landings from 3L should probably not exceed the 1967 total of 40 thousand tons annually, perhaps even less than this. Landings from 3N probably should not be more than the 1965 point of about 25 thousand tons.

References

Beverton, R.J.H., and S. J. Holt. 1966. Manual of methods for fish stock assessment. Part II. Table of yield function. FAO Fish. Tech. Paper No. 38.

Fry, F.E.J. 1949. Statistics of lake trout fishery. Biometrics 5, 1, 26-67.

1957. Assessments of mortalities by use of vertical populations. MS Meeting ICNAF/ICES/FAO. Lisbon 1957.

Gulland, J. A. 1965. Estimates of mortality rates. Annex to Arctic Fisheries Working Group Report. ICES, C.M. 1965(3) (mimeo.).

Jones, R. 1961. The assessment of long-term effects of change in gear selectivity and fishing effort. Mar. Res. No. 2, 1-19.

1968. Appendix to the Report of the Northwest Atlantic Working Group. ICES, C.M. 1968(20) (mimeo.).

Pitt, T. K. 1966. Sexual maturity and spawning of the American plaice, *Hippoglossoides platessoides* (Fabricius) from Newfoundland and Grand Bank areas. J. Fish. Res. Bd. Canada 23: 651-672.

1969. Migrations of American plaice on the Grand Bank and in St. Mary's Bay 1954, 1959 and 1961. J. Fish. Res. Bd. Canada 26: 1301-1319.

1970. Trends in the American plaice fishery in ICNAF Subarea 3. Int. Comm. Northw. Atlant. Fish. Redbook III: 103-110.

Schumacher, A. 1970. Bestimmung der fischereilichen Sterblichkeit beim Kabeljaubestand vor Westgrönland. Ber. Deutschen Wiss. Komm. Meeresforsch., 21(1-4): 248-259.

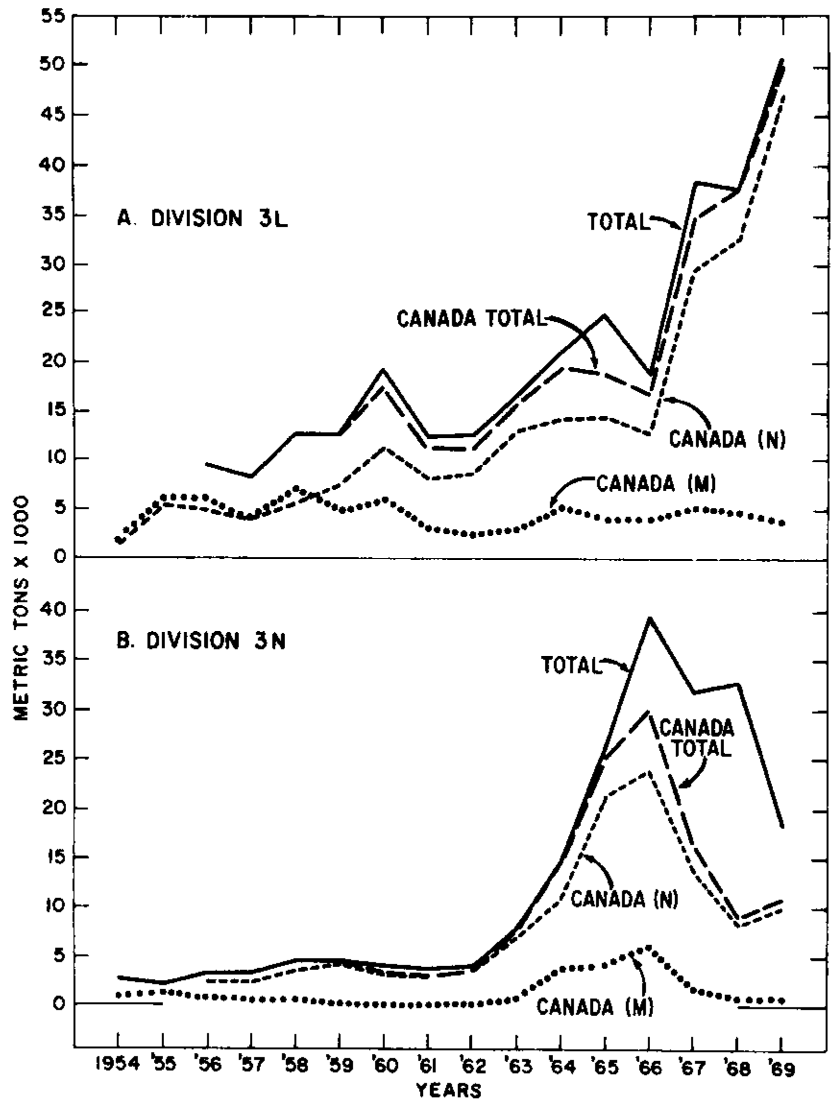

Fig. 1. A. Landings of American plaice in ICNAF Division 3L.
B. Landings of American plaice in ICNAF Division 3N.

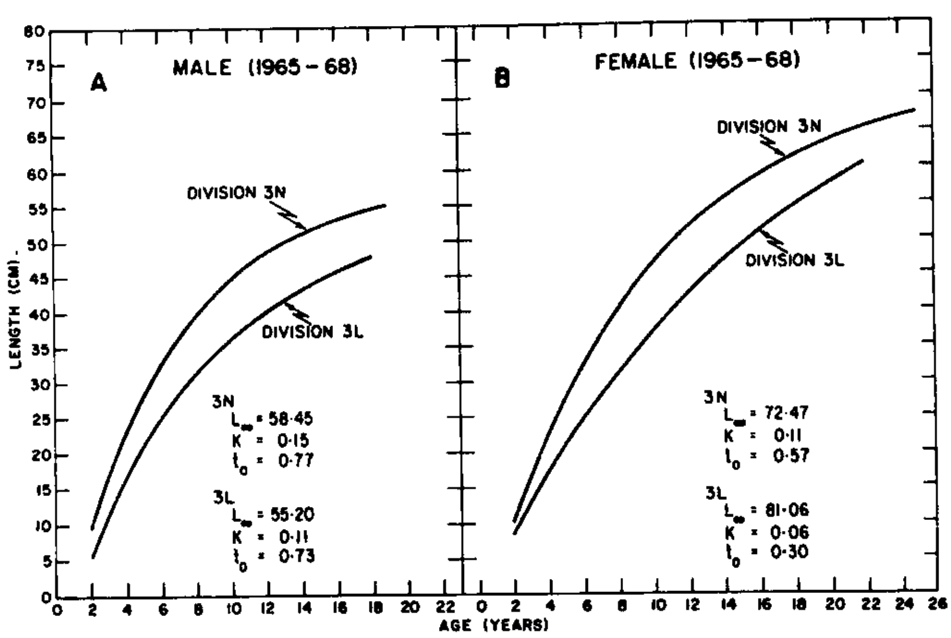

Fig. 2. A. Growth curves of male American plaice from ICNAF Divisions 3L and 3N.
B. Growth curves of female American plaice from ICNAF Divisions 3L and 3N.

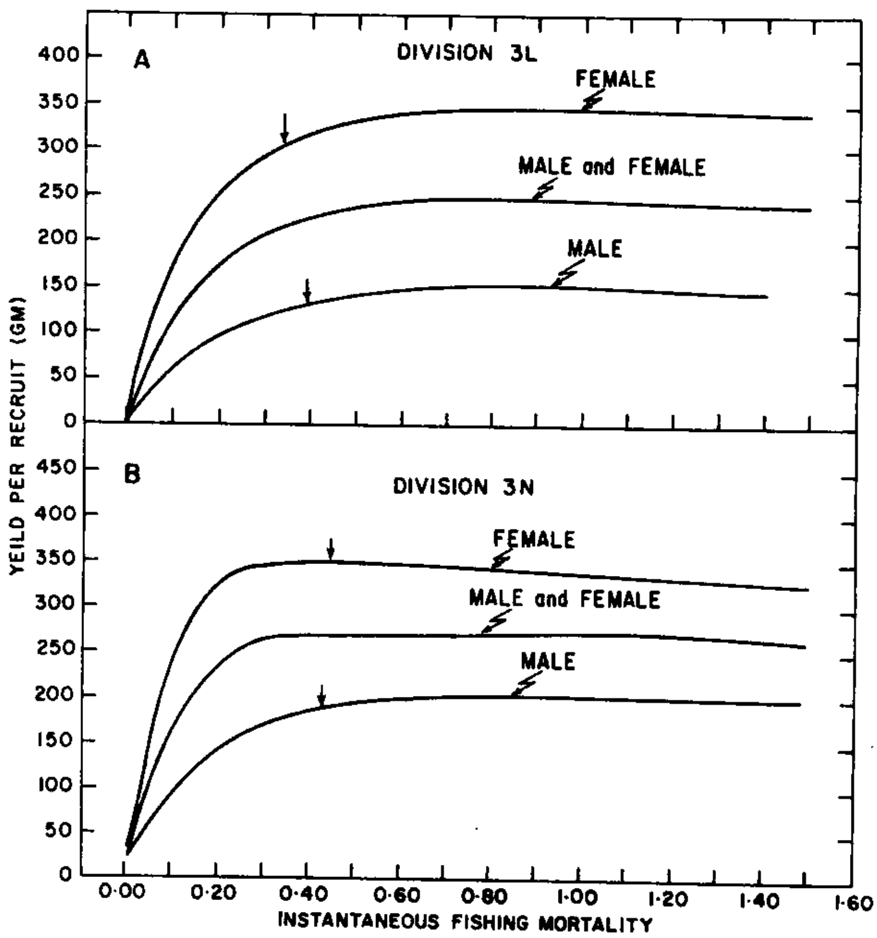

Fig. 3. Yield per recruit with partial recruitment as shown in Tables 1-4 for A, ICNAF Division 3L and B, ICNAF Division 3N with the 1967 level of fishing indicated on the curves. (Axis is in F values for fully recruited age groups.)

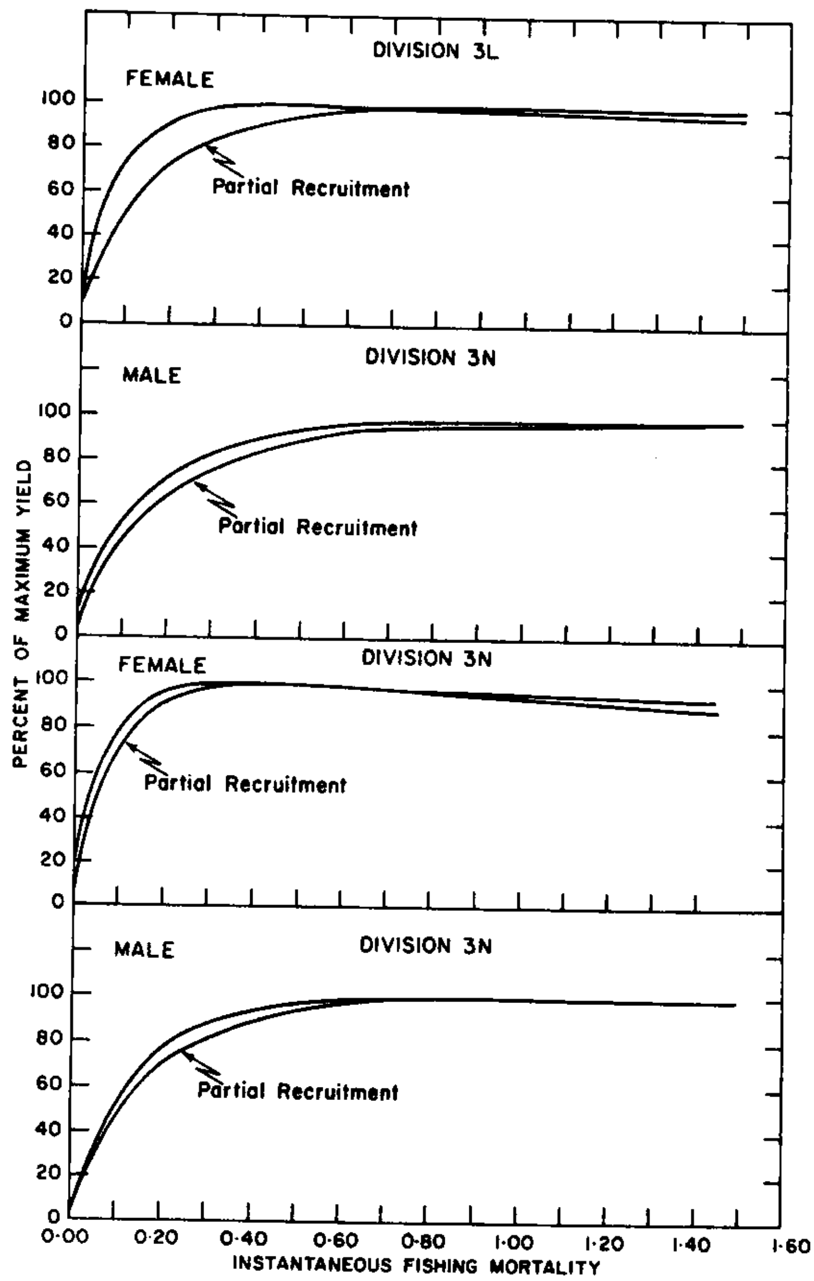

Fig. 4. Comparison of yield per recruit with partial recruitment with yield per recruit assuming knife-edge recruitment from FAO Tables (Beverton and Holt, 1966). t_c for 3L male = 9.3 years, female = 9.1 and for 3N, male = 6.4 years, female = 7.1 years.)

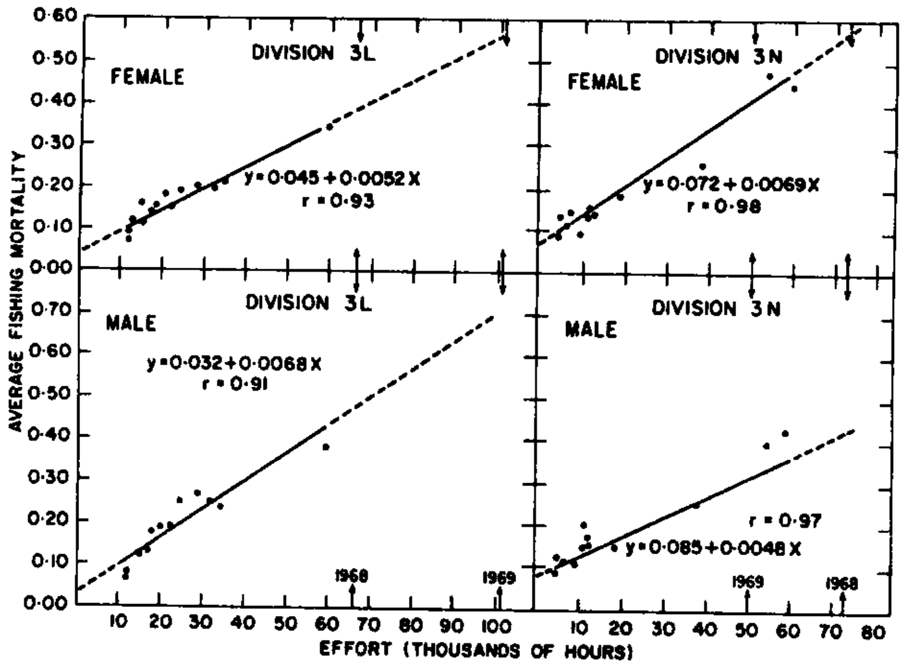

Fig. 5. Regressions of mean annual fishing mortality female age groups on fishing effort for ICNAF Divisions 3L and 3N. (Effort shown in Tables 1 and 3.)

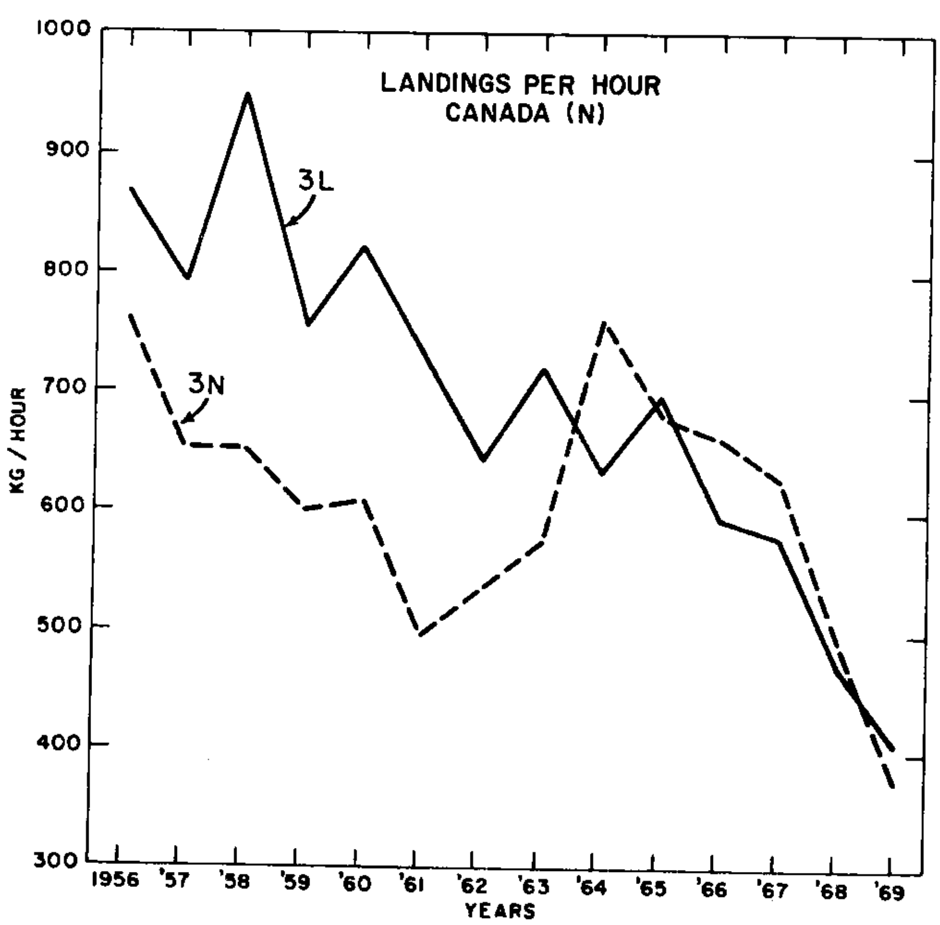

Fig. 6. Plaice landings per hour's trawling of Newfoundland trawlers in Newfoundland side trawler units.

Table 1. Estimates of fishing mortality of male plaice, ICNAF Division 3L.
(Total fishing effort listed at the bottom.)

M = 0.25

Age \ Year	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	% from fully recruited age groups (1963-67)
7	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01	0.01	0.02	0.01	2
8	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.02	0.02	0.08	0.02	0.01	0.02	0.03	0.02	4
9	0.02	< 0.01	< 0.01	0.01	0.02	0.02	0.05	0.02	0.09	0.12	0.05	0.04	0.05	13
10	0.02	0.02	0.03	0.02	0.04	0.08	0.06	0.06	0.06	0.20	0.14	0.06	0.18	25
11	0.03	0.04	0.02	0.09	0.05	0.09	0.07	0.10	0.14	0.26	0.21	0.15	0.38	43
12	0.13	0.11	0.04	0.08	0.09	0.18	0.08	0.16	0.26	0.37	0.33	0.25	0.60	68
13	0.09	0.16	0.10	0.25	0.09	0.26	0.33	0.19	0.31	0.34	0.55	0.70	0.44	100
14	0.13	0.08	0.14	0.23	0.53	0.15	0.37	0.38	0.51	0.33	0.55	0.72	0.83	100
15	0.24	0.20	0.14	0.30	0.49	0.38	0.21	0.70	0.52	0.65	0.34	1.21*	0.58	100
16	0.11	0.20	0.14	0.24	0.45	0.72	0.46	0.19	0.64	0.83	0.55	0.46	0.70	100
Mean 7-16	0.08	0.08	0.07	0.13	0.18	0.19	0.17	0.19	0.25	0.25	0.24	0.27	0.38	
Fishing effort (Thousands of hours)	12.1	12.5	12.8	17.9	18.1	22.5	15.9	20.4	24.5	32.1	34.6	27.8	59.6	

* Not used in calculating mean.

Table 2. Estimates of fishing mortality of female plaice, ICNAF Division 3L.

M = 0.15

Age \ Year	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	% from fully recruited age groups (1963-67)
8	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	2
9	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.02	0.02	< 0.01	0.04	4
10	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.03	0.02	0.01	< 0.01	0.06	0.03	0.04	0.06	9
11	0.02	0.03	0.02	0.02	0.02	0.04	0.03	0.02	0.02	0.09	0.04	0.02	0.08	12
12	0.03	0.04	0.03	0.04	0.03	0.07	0.07	0.04	0.07	0.13	0.09	0.06	0.14	23
13	0.07	0.04	0.08	0.08	0.10	0.09	0.11	0.08	0.13	0.09	0.17	0.12	0.17	33
14	0.09	0.06	0.02	0.20	0.11	0.21	0.14	0.16	0.18	0.20	0.19	0.21	0.41	57
15	0.06	0.10	0.14	0.09	0.16	0.16	0.18	0.21	0.18	0.20	0.23	0.34	0.48	70
16	0.13	0.19	0.14	0.17	0.20	0.22	0.23	0.26	0.23	0.22	0.42	0.34	0.73	100
17	0.12	0.18	0.13	0.25	0.17	0.29	0.21	0.30	0.39	0.04*	0.23	0.38	0.55	100
18	0.12	0.11	0.31	0.29	0.36	0.16	0.40	0.48	0.25	0.47	0.28	0.43	0.74	100
19	0.16	0.19	0.22	0.36	0.40	0.33	0.25	0.41	0.44	0.41	0.56	0.30	0.60	100
20	0.15	0.19	0.41	0.37	0.42	0.30	0.47	0.45	0.49	0.38	0.44	0.47	0.62	100
Mean 8-20	0.07	0.09	0.12	0.14	0.15	0.15	0.16	0.18	0.18	0.19	0.21	0.21	0.34	

* Not used in calculating mean.

Table 3. Estimates of fishing mortality of male plaice, ICNAF Division 3N.
(Total fishing effort listed at the bottom.)

M = 0.25

Age \ Year	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	% from fully recruited age groups (1963-67)
5								< 0.01	< 0.01	< 0.01	0.01	< 0.01	5
6	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.01	0.04	0.04	0.07	0.04	10
7	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.04	0.09	0.12	0.11	0.13	24
8	0.07	0.06	0.07	0.04	0.05	0.06	0.02	0.04	0.08	0.21	0.34	0.12	38
9	0.11	0.12	0.19	0.13	0.12	0.07	0.07	0.06	0.16	0.31	0.25	0.26	50
10	0.10	0.16	0.13	0.28	0.19	0.12	0.05	0.07	0.19	0.37	0.59	0.41	81
11	0.14	0.21	0.28	0.23	0.30	0.17	0.13	0.13	0.14	0.29	0.48	0.55	100
12	0.06	0.32	0.27	0.45	0.37	0.17	0.15	0.23	0.10	0.23	0.83	0.94	100
13	0.12	0.17	0.81*	0.37	0.24	0.25	0.22	0.29	0.25	0.35	0.44	0.44	100
14	0.19	0.20	0.29	0.38	0.26	0.23	0.35	0.53	0.31	0.44	0.43	0.94	100
Mean 6-14	0.09	0.13	0.15	0.21	0.17	0.12	0.11	0.16	0.15	0.26	0.40	0.43	
Fishing effort	4.7	4.9	10.6	12.6	10.2	6.4	9.4	11.9	18.7	38.1	54.0	58.9	

Thousands of hours

* Not used in calculation of mean

Table 4. Estimates of fishing mortality of female plaice, ICNAF Division 3N.

M = 0.15

Age \ Year	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	% from fully recruited age groups (1963-67)
5							< 0.01	< 0.01	< 0.01	0.02	0.03	< 0.01	2
6						< 0.01	0.02	0.02	0.02	0.04	0.13	0.10	14
7	< 0.01	0.01	0.02	< 0.01	0.02	< 0.01	< 0.01	0.03	0.08	0.13	0.18	0.16	27
8	0.03	0.05	0.05	0.03	0.03	0.02	0.02	0.03	0.08	0.19	0.21	0.23	35
9	0.04	0.03	0.11	0.07	0.04	0.05	0.03	0.05	0.13	0.20	0.28	0.23	42
10	0.06	0.11	0.06	0.09	0.08	0.08	0.04	0.06	0.21	0.35	0.25	0.27	55
11	0.03	0.14	0.08	0.09	0.17	0.15	0.06	0.10	0.07	0.29	0.80	0.35	76
12	0.11	0.07	0.14	0.12	0.10	0.15	0.09	0.09	0.11	0.47	0.49	1.02	100
13	0.09	0.12	0.07	0.15	0.22	0.06	0.15	0.13	0.07	0.34	0.50	0.58	100
14	0.18	0.14	0.18	0.06	0.15	0.24	0.16	0.30	0.13	0.32	0.60	-	100
15	0.23	0.25	0.15	0.16	0.06	0.11	0.15	0.25	0.48	0.28	0.52	1.65*	100
16	0.07	0.25	0.36	0.17	0.18	0.10	0.22	0.18	0.30	0.55	1.02	0.59	100
17	0.20	0.27	0.36	0.46	0.18	0.21	0.06	0.28	0.16	0.66	-	0.66	100
18	0.04	0.20	0.25	0.41	0.65	0.21	0.25	0.18	0.27	0.54			100
Mean 7-18	0.09	0.14	0.14	0.15	0.16	0.12	0.10	0.14	0.18	0.36	0.48	0.45	

* Not used in calculation of mean.