Restricted

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 2698
(B.g.7)

ICNAF Res.Doc. 72/14
(also ICNAF SAC No. 72/13
- Rewritten)

ANNUAL MEETING - JUNE 1972

Assessment of American plaice stocks in ICNAF Divisions 3L and 3N

T. K. Pitt
Fisheries Research Board of Canada
Biological Station, St. John's, Newfoundland

Introduction

The main fishery for American plaice (*Hippoglossoides platessoides*) in ICNAF Subarea 3 occurs in Divisions 3L and 3N and began in the late 1940's with the introduction of the otter trawler. The fishery has remained mainly Canadian, but in 3N, European trawlers, principally those of the USSR and Poland have gradually increased their share of the catch since 1965 so that by 1968 they were taking about 50% of the total (Fig. 1). In recent years plaice have become the major species sought by the Newfoundland otter trawler fleet.

In preparing the assessment of Grand Bank plaice, certain difficulties were encountered because of the frequent inadequacy of the sampling of the commercial fishery for age determinations. The only age-length keys and length measurements available were those based on otolith samples collected at the St. John's Biological Station. Sometimes research data were used when commercial data were lacking or inadequate. Another drawback was the lack of information on discards which probably resulted in an underestimation of the numbers caught at the lower ages included in the commercial landings. In this respect no information was available on catches of plaice by draggers fishing cod primarily for salting; obviously there must have been a fair amount of discards in these operations. However, in spite of these drawbacks, the best available data have been utilized in this assessment which gives an indication of the status of the plaice fishery on the Grand Bank.

Materials and methods

Calculation of numbers caught

Prior to 1970 the USSR and most other European countries reported their flatfish landings merely as "unspecified flounder". At the 1971 Annual Meeting of ICNAF, however, the USSR presented a breakdown of their 1970 flounder landings indicating that in 3N, plaice represented about 47% of the total flounder landings. It was also indicated that this was the approximate proportions in previous years in the latter division.

In a preliminary assessment for the 1971 Annual Meeting (Pitt, 1971), the proportion of plaice in the unspecified flounder landings by European countries from 3N was estimated from the proportion that plaice

was of the total Canadian landings of plaice, yellowtail and witch. However, for the present assessment the revised landings based on the USSR 1970 breakdown of unspecified flounder (Res. Doc. 71/26) were used (Fig. 1). The difference between these and those originally estimated by the Canadian breakdown is indicated in Fig. 2. Division 3L landings were primarily by Canada.

Calculation of effort and catch per unit effort

The calculation of fishing effort was based on the nominal catch per unit effort of plaice by Canada (N) stern trawlers (501-900 tons) (Fig. 3). Since the decline of the haddock fishery in the early 1960's most of Canada (N) effort in 3L and 3N between 75 and 200 metres has been confined to plaice, yellowtail and cod. In calculating the catch per hour for Canada (N) from which total effort was estimated, all tows containing plaice in sufficient numbers to be recorded as a commercial catch on the vessels' log sheet were used. Catches per hour where plaice accounted for more than 50% of the catch were also calculated (Fig. 3).

Separation of stocks

Plaice from Divisions 3L and 3N were treated as separate stocks. Tagging indicated that on the Grand Bank, plaice are relatively sedentary (Pitt, 1969) with minimal migrations noted between the northern and southern parts of the Bank. Thus very few plaice tagged on the eastern slope just north of 46°N (3L) were recovered as far south as 45°30'N (3N). Similarly of the plaice tagged at 45°N, only a minor number were recaptured north of 46°N (3L).

Another reason for separating Grand Bank plaice into two main stocks was the difference in the growth pattern (Fig. 4). Plaice from 3L were consistently smaller at comparable ages than those from 3N and also fewer of the older age groups were caught in 3N.

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

Although 3L and 3N were dealt with separately, there is a strong possibility that 3N depends on 3L for recruitment probably at the pelagic larval level. Vertebral numbers (Pitt, 1963) indicated no significant difference between north and south bank areas. Preliminary results from biochemical research being conducted at the St. John's Station indicated no significant genetic differences between the two ICNAF divisions. Since the adults apparently migrate very little, the intermixing of the areas probably occurs during the larval period.

Separation of males and females

From the beginning, the necessity of separating males and females appeared evident since each produced parameters that were quite different. Growth curves (Fig. 4) indicated that the males were smaller at corresponding ages from about age 7 or 8. Females generally live longer than the males; very few 20-year-old males were encountered whereas females up to age 30 were sometimes encountered (Fig. 5 and 6). The 50% maturity point of males is at age 7 (about 25 cm) in 3L and age 5 (about 27 cm) in 3N, whereas for females it is 14 years (43 cm) and 12 years (50 cm) in 3L and 3N respectively (Pitt, 1966). The commercial length frequencies indicated a preponderance of males at the lower size ranges which produced higher values of F at younger age groups than for the females but the explanation for this is not forthcoming at present. Some commercial and research figures are shown to illustrate this (Fig. 7).

Calculation of fishing mortality

The method developed by Fry (1949, 1957) and modified by Gulland (1965) and Jones (1961, 1968) was used to estimate fishing mortality (F) for each age of the year-classes included in the catches of 1955-68 for 3L and 1956-68 for 3N. The methods of calculation are described in detail by Schumacker (1970) and his procedure was used here. The method requires an estimation of natural mortality (M) and an estimate of (E) for the older age groups.

The best estimates of natural mortality were 0.25 for males and 0.20 for females (Pitt, 1972). In the assessment presented at the 1971 Meeting values of 0.25 and 0.15 for males and females respectively were used.

A few trial values of F for some of the older age groups suggested an F of 0.45 giving an E of 0.64 for males and 0.69 for females. These gave values of E ($1-e^{-Z}$) of 0.324 and 0.331 for males and females respectively.

Because of the absence of male plaice beyond age 14 in the 1970 commercial catches, estimates of F for 1968 for fully recruited males in 3L (Table 1) were derived from calculated stock size at the beginning of 1968 and the catch in 1968. This method was also used to get estimates of F for 1969 and 1970 for the fully recruited age groups (Table 5).

Calculation of yield per recruit

Yield per recruit curves using the partial recruitment values of Tables 1 to 4 were calculated for the males and females for both areas on the basis of 500,000 recruits each of males and females at age 3. The yield curves were then combined to give an average yield per recruit (Fig. 8). The weights of fish used in calculating yield per recruit were average weights calculated from 1967-68 commercial age-length curves.

Yield per recruit at various values of F for fully recruited age groups for males, females and combined male and female are presented (Fig. 8) for both divisions as well as the average yield curve for combined male and female showing percent of maximum yield (Fig. 9).

The optimal fishing levels were calculated in the method suggested by Gulland (1972).

Estimation of stock size

Stock size was calculated for age 10 and over from 3L and for age 8 and over from 3N. Males and females were calculated separately and combined for presentation here to give some indication of total stock size (Tables 6 and 7).

Results

Fishing mortality and yield per recruit curves

Generally speaking, estimates of F at corresponding ages were higher for the males than for the females. This can perhaps be attributed to the greater vulnerability of males at smaller sizes and earlier ages than the females.

The regression of the average value of F for all age groups and for those fully recruited on the annual fishing effort (Fig. 10 and 11) gave highly significant correlations. However, for each plot of total average F positive intercepts were produced. Since only one type of gear

was used to fish plaice and also since plaice probably do not have marked seasonal distributional patterns, it was felt that the calculation of effort was probably a good measure of fishing intensity. The values of F calculated for the early years appear to be too high in proportion to the level of fishing effort. It is also possible that effort was underestimated in those early years. The other possible reason why the regression line did not pass through the origin is the possibility that M was too low. However M would have to be increased drastically to produce an appreciable lowering in the values of F. Standard errors of the estimates were all about 0.04.

The estimates of F for 1969 and 1970 from stock size and catches for fully recruited age groups compared with those estimates from the fitted lines of Fig. 10 and 11 are shown in Table 5. For all estimates except the 1969 3N males the F's from the fitted line were higher than the calculated values; the disparity between the two being greater in 3L.

A comparison with the values presented at the 1971 ICNAF Annual Meeting (Pitt, 1971) (Table 5) indicates that the new assessment generally gave lower estimates of F. Some of this can be attributed to the increase in the value of M for females from 0.15 to 0.20. The tables of F presented at the 1971 Annual Meeting erroneously contained some initial values of F calculated from the assumed value of E ($1-e^{-Z}$). These were eliminated in the revised tables. The inclusion of the 1970 data and the revised numbers landed in 3N, as previously mentioned, also tended to reduce the mean values of F.

Catch per unit effort

Except for a slight rise in 1963-65 the catch per hour of Canada (N) trawlers in 3L has declined steadily since 1958 from about 1200 kg per hour to 450 kg in 1970 and 430 kg in 1971 (total plaice, Fig. 3). The slight increase in 1963-65 can probably be attributed to the introduction of the stern trawler and the greater demand for this species.

Up to 1962 the main effort in 3N was for haddock. At this time the effort for plaice was relatively low; however, some large catches were made on the virgin stock at the southern part of the bank. With the reduction in the haddock stocks, effort was diverted to plaice and the fleet began fishing previously unfished concentrations along the eastern slope. It was probably this diversion of effort and the introduction of the more efficient stern trawlers that resulted in the increase in catch per hour in the mid-1960's. However, from the peak of about 950 kg (total plaice) in 1964 the catch per hour has declined very rapidly to about 340 kg in 1970 and 281 kg in 1971 (Fig. 3).

Stock size (Tables 6 and 7)

For 3L the stock size calculations indicate that the total stock size remained relatively stable until 1966, when an apparent rapid increase occurred in 1967 and 1968. However, since the most recent years and the younger age groups produce the most unreliable estimates of F from virtual population analyses this may not be real. The size of the fully recruited stock 15 years and up in 3L has however, been reduced by more than a half. In 3N there appears to have been a gradual increase in the total stock size since 1956-62 and then a more rapid increase in the total stock to a higher level. The size of the fully recruited stock in 3N remained roughly at the same level until 1964 when it appeared to increase. This period corresponds to an increase in the catch per unit effort as just noted which was attributed to a diversion of the effort to previously unexploited areas. If only a portion of the stock was being fished prior to 1964-65, the stock size calculated represented a portion of the stock only. In 3L, on the other hand, the whole area has been fished fairly evenly since the start of the fishery.

Discussion

Division 3L

Even with the big disparity between the estimated values of F for the fully recruited males and females in 1968, 0.92 and 0.50 respectively, the position on the yield curve ranges from 80 to 85% of the maximum yield. (Fig. 9). The optimum F in 3L occurs at 0.50 which is about 80% of the maximum yield. In 1968 total landings were about 37 thousand tons. The 1969 catch of about 50 thousand tons gave probable fishing mortality rates of 0.89 to 1.0 for males and 0.67 to 0.55 for the females (Table 5); thus apparently well beyond the "optimum yield". For 1970 with 40 thousand tons landed the ranges of F were apparently 0.65 to 0.95 for males and 0.48 to 0.65 for females again above the optimal level, but less than 90% of the maximum.

The catch per hour by Canada (N) trawlers (Fig. 3), which accounts for 90-95% of the catch has declined drastically especially since 1967. The 1971 landings by Canada (N) in 3L were down slightly to about 34.5 thousand tons with the catch per hour declining only slightly from 450 kg in 1970 to 431 kg per hour in 1971.

It is suggested that the landings of plaice from 3L should not exceed 40 thousand tons and possibly should be even lower at 35 thousand tons. This is close to the 1967 level (F = 0.55 for males and 0.46 for females) with total landings at 37.5 thousand tons.

Division 3N

For 3N the 1967 and 1968 estimates of males and females were in the 0.46 to 0.52 range (Table 5) with landings of 25 and 21 thousand tons. The levels of fishing in these years were apparently beyond the calculated optimal value (0.40) (Fig. 9). The probable values of F in 1969 when 15 thousand tons were landed were males 0.44 and females 0.37 or close to the optimum F. In 1970 with 20 thousand tons landed probable F levels were 0.50 to 0.59 for males and 0.48 to 0.57 for females, again beyond the optimal level.

The catch per hour by Canada (N) has declined very rapidly since 1964 and slipped to 280 kg in 1971 (Fig. 3) with Canada (N) which normally takes more than 50% of the catch, landing 8 thousand tons.

A total landing of not more than 20 thousand tons is suggested at the most and even 15 thousand tons may be more realistic.

General

Minimal fluctuation in year-class strength apparently occurs with probably no complete failure as reported in some species. This is on the plus side and helps preserve a stable stock provided fishing pressure is not too great. However, because of the slow rate of growth of this species, the restoration of the fishable biomass is relatively slow. Furthermore, it is not known what effects a drastic reduction in the spawning stocks would have on the population. This may be doubly important in the case of a stock like 3N which probably depends on recruitment from the more northerly 3L stock.

References

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

1957. Assessments of mortalities by use of virtual 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.).

1972. Scientific advice on catch levels. Document to ICNAF Mid-Year Assessment Meeting.

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 North-Western Working Group. ICES, C.M. 1968(20) (mimeo.).

Pitt, T. K. 1963. Vertebral numbers of American plaice, *Hippoglossoides platessoides* in the Northwest Atlantic. Fish. Res. Bd. Canada 20: 1159-1181.

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.

1971. Assessment of American plaice stocks in 3L and 3N. Inter. Comm. Northw. Atlantic Fish., Ann. Meet., Ser. No. 2596, Res. Doc. 71/111.

1972. Estimates of natural mortality coefficients of American plaice. Inter. Comm. Northw. Atlantic Fish., Ann. Meet., Ser. No. 2699, Res. Doc. 72/15.

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

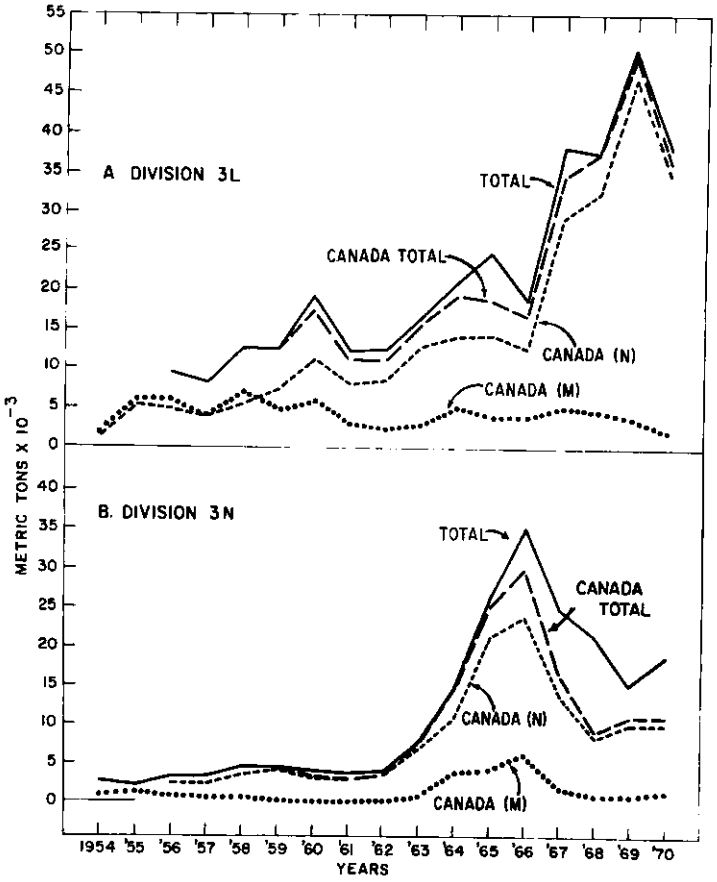

Fig. 1. A. Landings of American plaice in ICNAF Division 3L.
B. Landings of American plaice in ICNAF Division 3N.

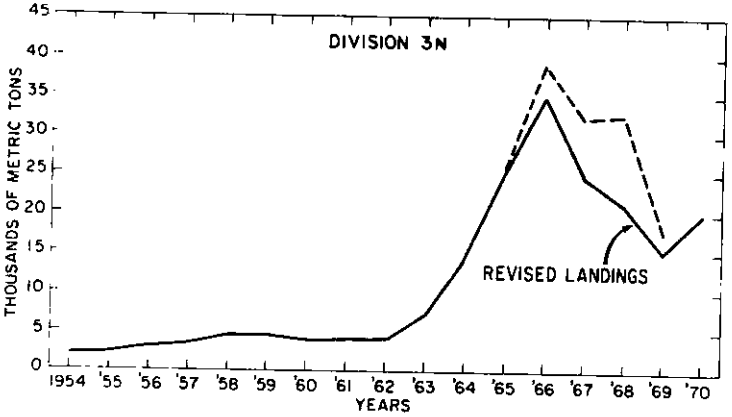

Fig. 2. Comparisons of the revised landings in 3N based on USSR 1970 breakdown. Dotted line represents landings based on Canada (N) breakdown.

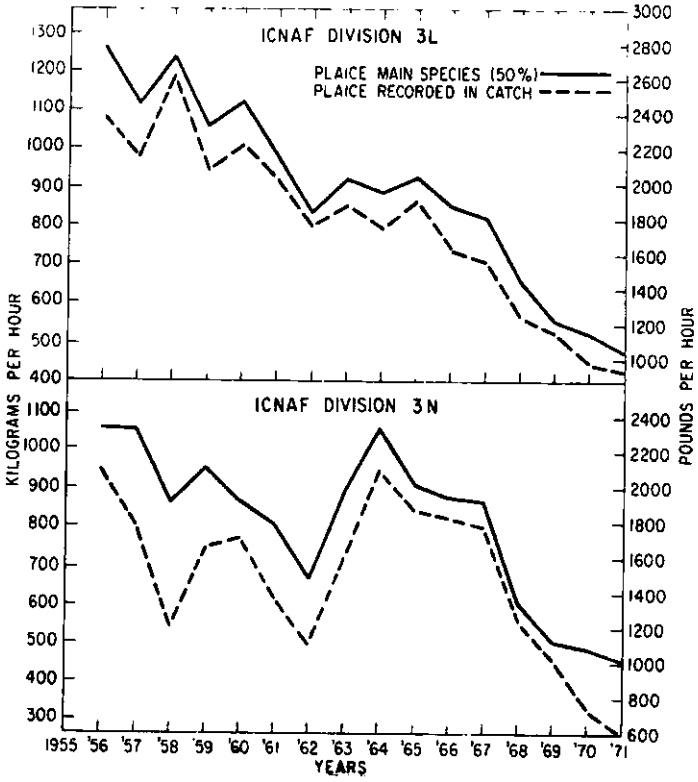

Fig. 3. Plaice landings per hour by Canada (N) fleet in Canada (N) stern trawler units.

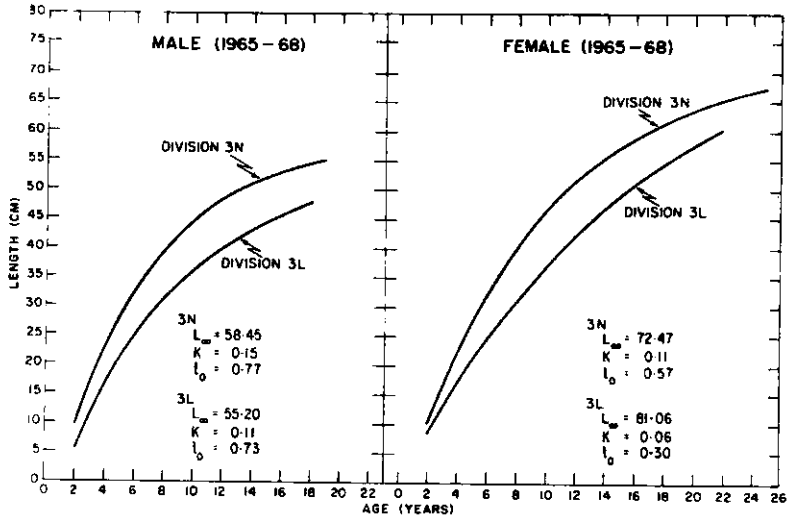

Fig. 4. A. Growth curves of male American plaice from ICNAF Divisions 3L and 3N. B. Growth curves of female American plaice from ICNAF Divisions 3L and 3N.

D 5

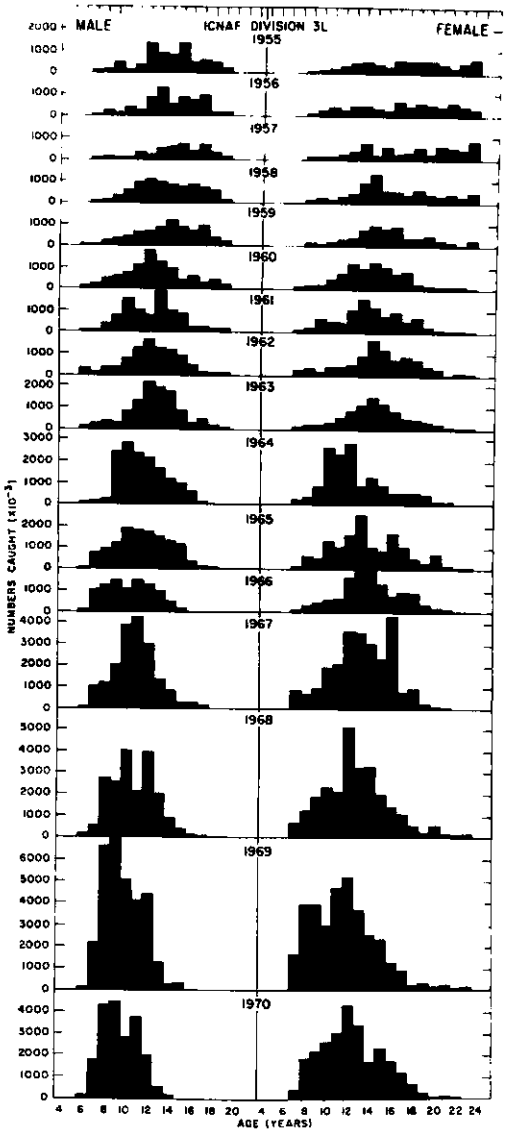

Fig. 5. Numbers of male and female plaice caught in ICNAF Division 3L.

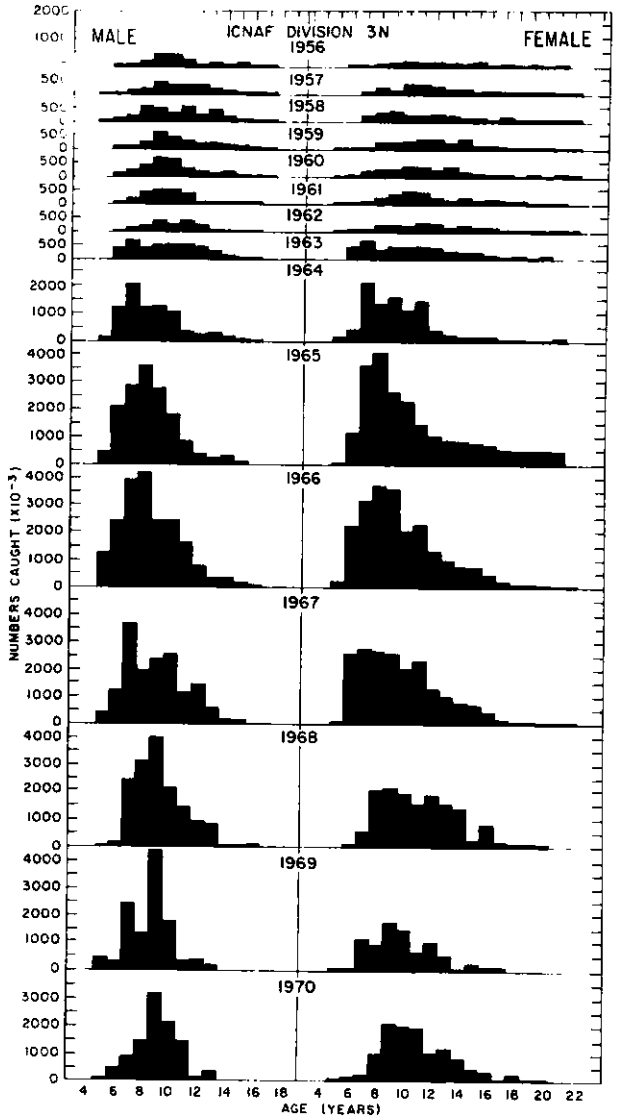

Fig. 6. Numbers of male and female plaice caught in ICNAF Division 3N.

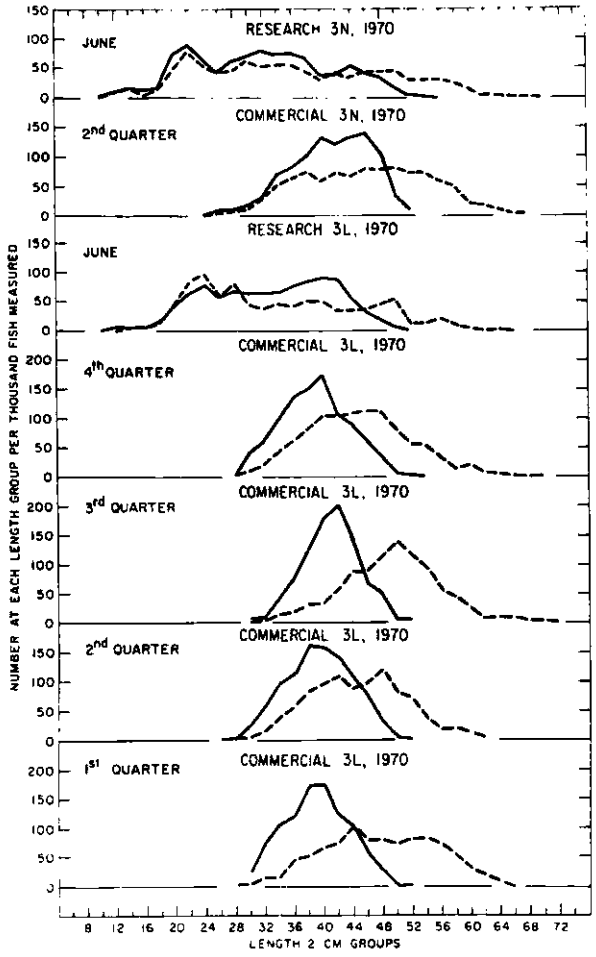

Fig. 7. Length frequencies of 1970 commercial and research plaice. 3L commercial data by quarter with 2nd quarter research data for comparison. 3N 2nd quarter commercial and research data only are available (males solid lines, females broken lines).

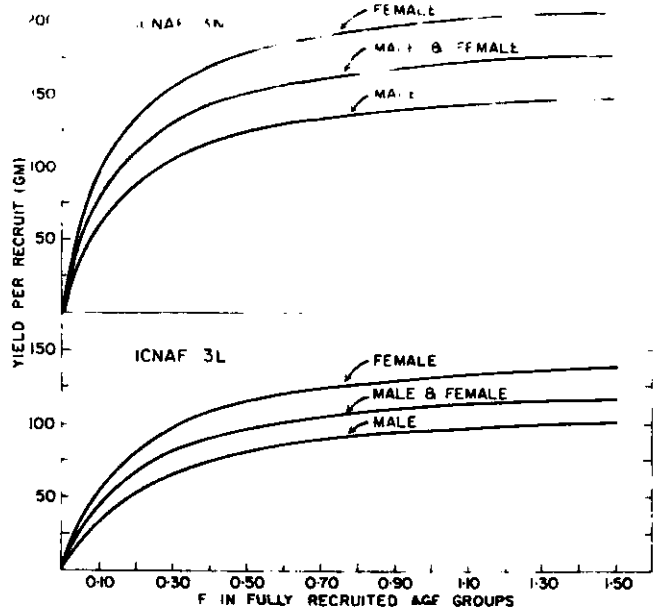

Fig. 8. Yield per recruit with partial recruitment as shown in Tables 1 to 4 from ICNAF Divisions 3L and 3N.

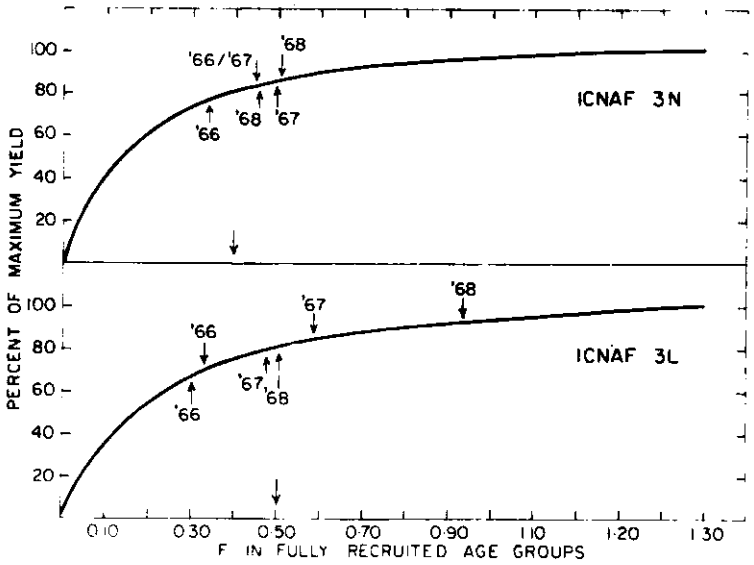

Fig. 9. Yield curves showing percentage of maximum yield for the combined male and female calculations (Fig. 8) for 3L and 3N with arrows above the curve indicating calculated F values for males and below for females. Optimal fishing level indicated at the bases.

D 7

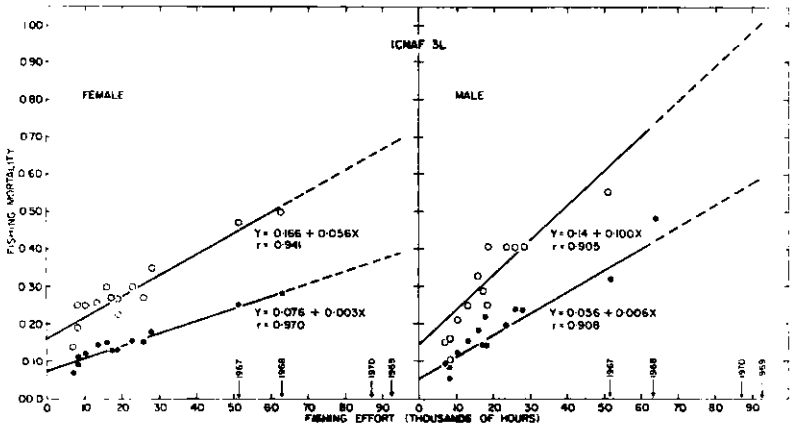

Fig. 10. Regression of mean annual fishing mortality on fishing effort for ICNAF Division 3L. Open circles are for fully recruited age groups and solid circles for all age groups. 1955-68 for females, 1955-67 for males.

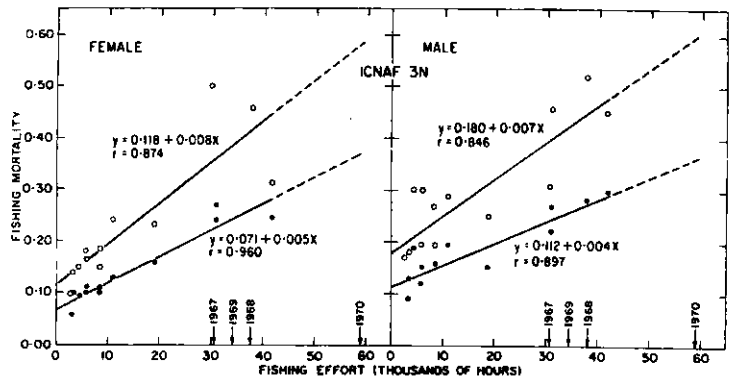

Fig. 11. Regression of mean annual fishing mortality on fishing effort for ICNAF Division 3N. Open circles are for fully recruited age groups and solid circles for all age groups. 1956-68 for females, 1956-68 for males.

D 8

Table 1. Estimates of fishing mortality of male plaice, ICNAF Division 3L.

Age \ Year	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	% from fully recruited age groups (1965-68)
7	0.001	0.001	< 0.001	0.002	0.002	0.008	0.004	0.004	0.008	0.004	0.018	0.014	0.014	0.002	2
8	0.006	0.001	0.006	0.004	0.008	0.018	0.018	0.014	0.016	0.008	0.034	0.040	0.020	0.05	8
9	0.006	0.008	0.002	0.014	0.014	0.022	0.040	0.020	0.016	0.13	0.06	0.07	0.08	0.06	14
10	0.010	0.016	0.008	0.032	0.032	0.030	0.08	0.05	0.06	0.21	0.16	0.07	0.29	0.22	38
11	0.030	0.030	0.016	0.05	0.05	0.08	0.07	0.10	0.12	0.23	0.22	0.18	0.44	0.27	55
12	0.14	0.11	0.030	0.10	0.10	0.18	0.08	0.07	0.26	0.33	0.29	0.24	0.60	0.97	100
13	0.10	0.18	0.10	0.09	0.09	0.27	0.34	0.19	0.33	0.34	0.47	0.58	0.46	1.20*	100
14	0.13	0.09	0.14	0.39	0.39	0.15	0.39	0.38	0.30	0.36	0.55	0.40	0.68	0.67*	100
15	0.24	0.20	0.04	0.43	0.43	0.25	0.20	0.74	0.52	0.65	0.38			0.86*	100
16	0.18	0.20	0.15	0.44	0.44	0.38	0.25	0.18	0.44						
Average 7-16	0.09	0.08	0.05	0.12	0.14	0.14	0.15	0.18	0.22	0.24	0.24	0.24	0.32	0.48	
Average 12-16	0.15	0.16	0.10	0.21	0.29	0.25	0.25	0.31	0.40	0.42	0.42	0.41	0.55	0.92*	

*Calculated from stock and catch.

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

Age \ Year	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	% from fully recruited age groups (1965-68)
8	0.001	0.001	0.002	0.002	0.002	0.002	0.001	0.006	0.002	0.006	0.004	0.002	0.006	0.001	2
9	0.002	0.004	0.001	0.005	0.004	0.004	0.016	0.002	0.004	0.016	0.010	0.004	0.006	0.018	5
10	0.004	0.018	0.004	0.002	0.006	0.022	0.016	0.012	0.006	0.06	0.032	0.014	0.020	0.016	10
11	0.014	0.016	0.012	0.022	0.010	0.032	0.026	0.016	0.018	0.07	0.030	0.020	0.07	0.04	28
12	0.04	0.032	0.018	0.028	0.08	0.05	0.06	0.036	0.05	0.12	0.07	0.05	0.10	0.21	34
13	0.05	0.05	0.06	0.06	0.06	0.13	0.08	0.06	0.11	0.06	0.15	0.10	0.15	0.12	50
14	0.08	0.04	0.018	0.16	0.08	0.13	0.14	0.12	0.15	0.12	0.16	0.17	0.23	0.20	68
15	0.05	0.08	0.09	0.08	0.13	0.12	0.11	0.20	0.12	0.12	0.20	0.24	0.33	0.25	100
16	0.13	0.16	0.12	0.12	0.17	0.19	0.16	0.15	0.18	0.18	0.35	0.28	0.30	0.30	100
17	0.11	0.15	0.11	0.22	0.14	0.26	0.19	0.21	0.28	0.28	0.20	0.35	0.51	0.49	100
18	0.12	0.24	0.27	0.25	0.31	0.13	0.35	0.43	0.20	0.20	0.32	0.30	0.69	0.69	100
19	0.19	0.16	0.42	0.32	0.34	0.29	0.21	0.37	0.27	0.27	0.18	0.37	0.47	0.34	100
20	0.13	0.24	0.31	0.33	0.38	0.26	0.41	0.39	0.35	0.35	0.76	0.20	0.38	0.72	100
Average 8-20	0.07	0.09	0.11	0.12	0.13	0.13	0.14	0.15	0.14	0.15	0.18	0.16	0.25	0.28	
Average 15-20	0.14	0.19	0.25	0.25	0.27	0.23	0.26	0.30	0.27	0.27	0.35	0.30	0.47	0.50	
Fishing effort	7.3	8.4	8.6	10.2	17.5	18.4	13.8	16.2	18.0	26.0	28.0	23.5	51.6	63.2	

Thousands of hours

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

M = 0.25

Age \ Year	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	% from fully recruited age groups (1965-68)
5														
6	0.006	0.002	0.006	0.010	0.006	0.002	0.002	0.004	0.05	0.038	0.034	0.018	0.002	5
7	0.020	0.014	0.022	0.012	0.032	0.010	0.007	0.032	0.09	0.16	0.10	0.07	0.05	26
8	0.06	0.06	0.07	0.040	0.05	0.07	0.016	0.022	0.08	0.23	0.37	0.17	0.08	53
9	0.10	0.18	0.19	0.13	0.13	0.07	0.08	0.04	0.09	0.23	0.26	0.39	0.29	74
10	0.12	0.13	0.21	0.28	0.20	0.14	0.06	0.17	0.24	0.18	0.33	0.48	0.60	100
11	0.07	0.16	0.34	0.33	0.30	0.18	0.14	0.17	0.17	0.34	0.26	0.21	0.58	100
12	0.06	0.16	0.19	0.30	0.37	0.17	0.16	0.28	0.14	0.31	0.59	0.41	0.37	100
13	0.15	0.17	0.31	0.23	0.31	0.29	0.22	0.32	0.33	0.21	0.59	1.50*		100
14	0.19	0.30	0.29	0.39	0.36	0.17	0.36	0.54	0.36	0.52	0.50	0.75		100
Average 6-14	0.09	0.13	0.16	0.15	0.19	0.12	0.11	0.19	0.15	0.22	0.30	0.27	0.28	
Average 10-14	0.12	0.18	0.27	0.30	0.30	0.19	0.19	0.29	0.25	0.31	0.45	0.46	0.52	

* Not used in averages.