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Estimates of Natural Mortality Coefficients of American Plaice

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Introduction

Huntsman (1918) estimated the total mortality rate for male and female plaice combined from an unexploited population in the Gulf of St. Lawrence to be 12.5% per annum using the Jackson (1939) method ($Z = 0.14$). When these data were used to fit a catch curve, however, Z was calculated at 0.21 for ages 9 to 22 and 0.18 for ages 9 to 24 (Fig. 1). Powles (1969) for the same area with samples collected at the beginning of the other trawler fishery estimated Z at 0.13 by the Jackson method. However, using a modification of this method by Robson and Chapman (1961) he obtained a value of 0.26 ± 0.092 . A line fitted to Powles' data (Fig. 1) gave a total instantaneous mortality coefficient of 0.29 for ages 10 to 19 and 0.26 for ages 9 to 19. From tagging data and using a method developed by Paloheimo (1958), Powles (1969) calculated M at 0.11 to 0.16 (sexes combined), which he used in his assessment.

Growth curves (Pitt, 1967) produce different parameters for the two sexes; also a study of catch curves seemed to indicate that the total instantaneous mortality rates were probably 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. Males mature between ages 5 and 7, whereas in females sexual maturity occurs between 12 and 14 years (Pitt, 1966). Separate estimates of natural mortality for the males and females were therefore considered necessary.

Estimates of natural mortality from age composition of unexploited populations

The relatively small population in St. Mary's Bay on the Southeast Coast of Newfoundland was unexploited at least until the mid-1960's. Tagging data indicated that this population was discrete and hence not affected by exploitation of plaice on the Grand Bank. Hamilton Inlet Bank (ICNAF 2J) also supports a small plaice population that is apparently discrete from the Grand Bank. Although there is no fishery for plaice in this area, plaice sometimes, at least, occupy the same niche as cod, and some are removed by the cod fishery. However, prior to 1960 the fishing intensity in this area was much less than in recent years, producing less than 40,000 tons annually in 1954-60 (May, 1967). Thus up to 1959 fishing mortality of plaice was probably minimal.

The catch curves from research samples from these two areas, St. Mary's Bay, 1957-60 (Fig. 2) and Hamilton Inlet Bank (2J), 1957-59 (Fig. 3) gave estimates of total instantaneous mortality as follows:

<u>St. Mary's Bay</u>	Males	=	0.27
	Females	=	0.18
<u>Hamilton Inlet Bank</u>	Males	=	0.30
	Females	=	0.22

For the latter area some fishing mortality may be included, but it was probably less than 0.05.

Estimates of M from catch and effort data (Divisions 3L and 3N)

The Beverton and Holt (1957) iterative method was applied to 14-, 15- and 16-year-old males and 17-, 18- and 19-year-old females from ICNAF Divisions 3L and 3N using the procedure described by Ricker (1958). Instantaneous natural mortality estimates of 0.27 (3L) and 0.56 (3N) for males and 0.23 (3L) and 0.16 (3N) for females were calculated (Fig. 4). The high value for 3N males (0.56) and poor correlation of the data ($r = 0.268$) was apparently caused by the unrealistically low survival rates calculated for the early years of the fishery. The only explanation that can be given for these is the possible inadequacy of the sampling during this period. By editing the data drastically as shown in Fig. 4, the value of M was reduced to 0.22 ($r = 0.756$).

In Fig. 4 the estimates of M using Paloheimo's (1961) linear formula are also shown. This method involves the plotting of Z for the age group against $\frac{1}{2}(f_n + f_{n+1})$ instead of f_n (f_n = effort in year n) as in the previous method. Values of M were similar to those calculated from the more laborious iterative method; 0.22 (3L) and 0.53 (3N) for males, and 0.23 (3L) and 0.18 (3N) for females (Fig. 3). Again elimination of the early values for the 3N males gave a lower value for M , 0.17 and an improvement in the correlation coefficient from 0.332 to 0.855.

The final method used was a plot of total instantaneous mortality coefficients obtained from catch curves of a number of year classes (Fig. 5 and 6) against the mean effective effort calculated by method of Paloheimo (1961) as indicated above, but in this case a mean value for the span of years used was calculated, i.e.

$$r^1 = \frac{\sum_{n=1}^r \frac{1}{2}(f_n + f_{n+1})}{r-1}$$

where r^1 = mean effective effort and r = number of age groups included.

Values for M were (males) 0.24 and 0.39, (females) 0.23 and 0.21 for 3L and 3M respectively. Since basically the same data were used as in the previous methods the value for 3M males was again relatively high. The various estimates are summarized in Table 1.

Discussion

Except for the high values for 3M males estimates of natural mortality for male plaice tend to be about 0.24. For females a lower value of 0.20 would appear to be reasonable. However, it should be pointed out that for all the methods where Z is plotted against effort the standard errors of the estimate of M are relatively high. The high values calculated for 3M males do not seem to be realistic so that for purposes of stock assessment values of 0.25 for males and 0.20 for females for both ICRAF divisions are appropriate.

References

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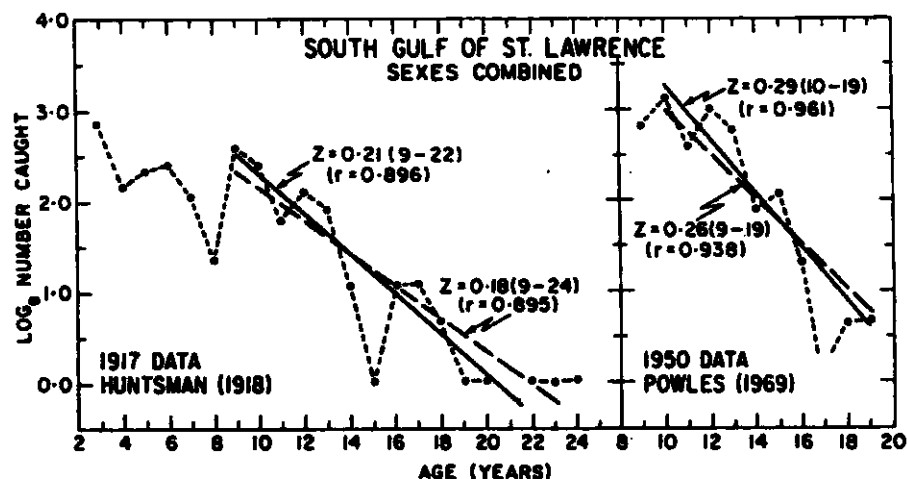


Fig. 1. Total mortality estimates from unexploited stocks for the Gulf of St. Lawrence (Huntsman, 1918 and Powles, 1969).

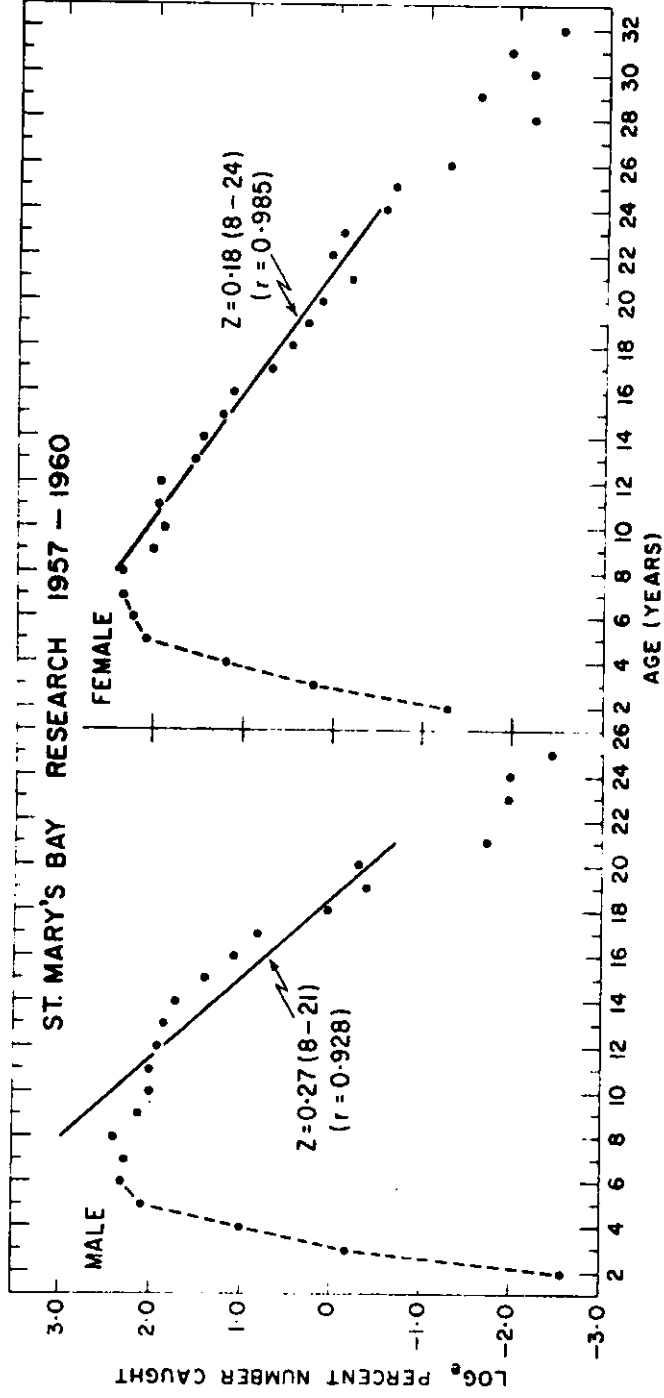


Fig. 2. Catch curves of unexploited stock, St. Mary's Bay, Newfoundland with estimates of total mortality.

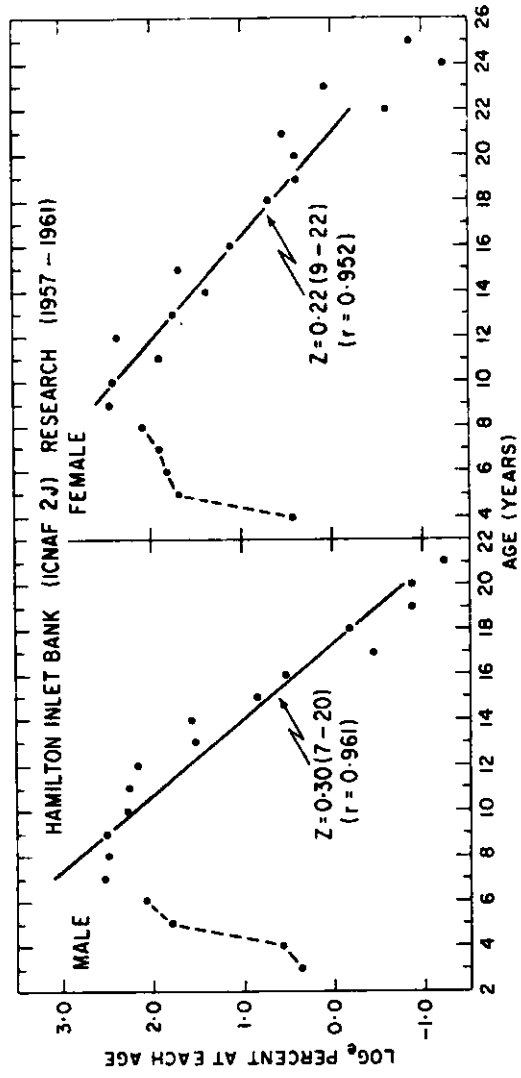


Fig. 3. Catch curves from research vessel samples, ICNAF 2J, and estimates of total mortality.

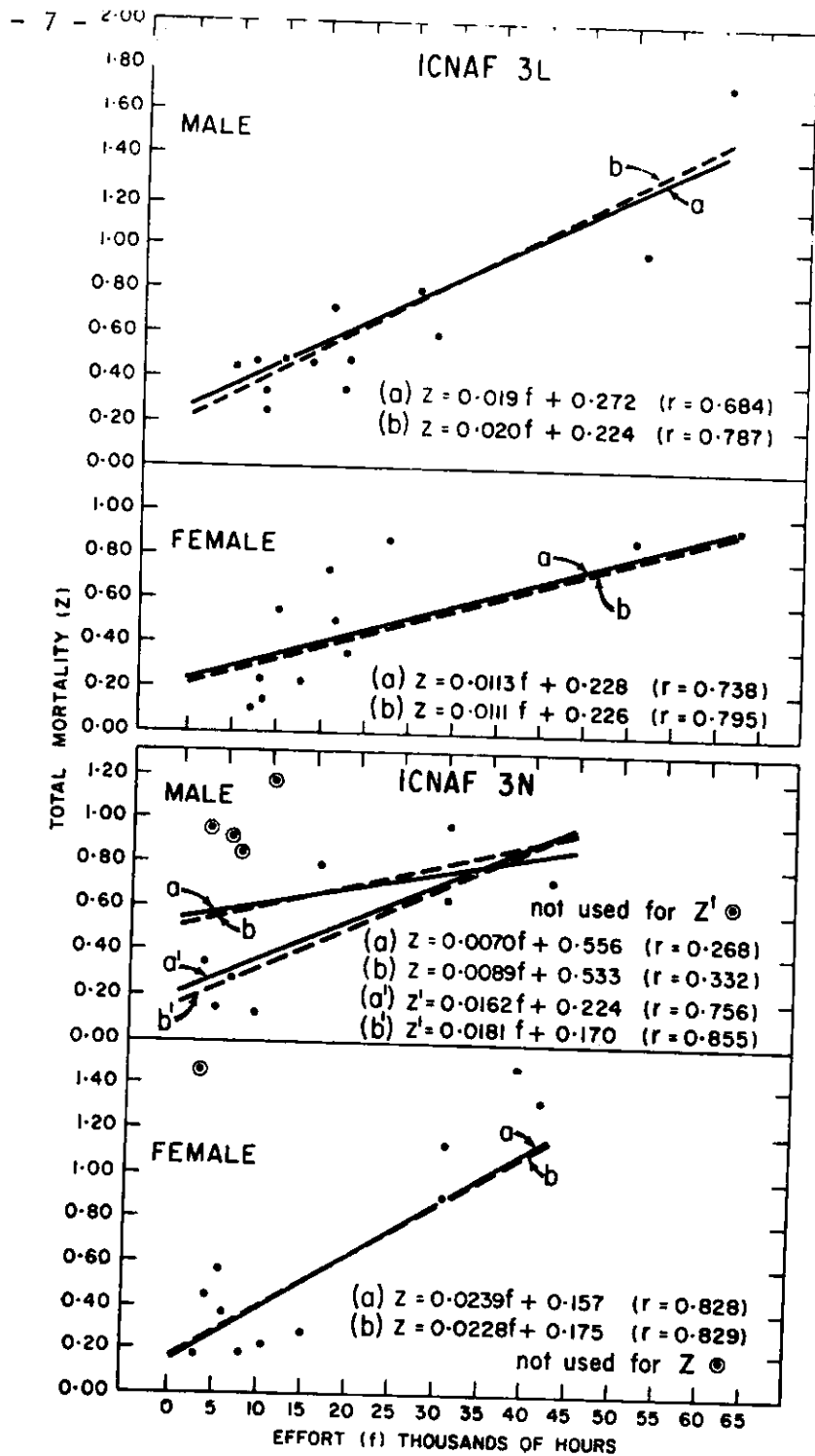


Fig. 4. Estimates of M by (a) the Beverton and Holt (1957) iterative method and (b) Paloheimo's (1961) linear formula

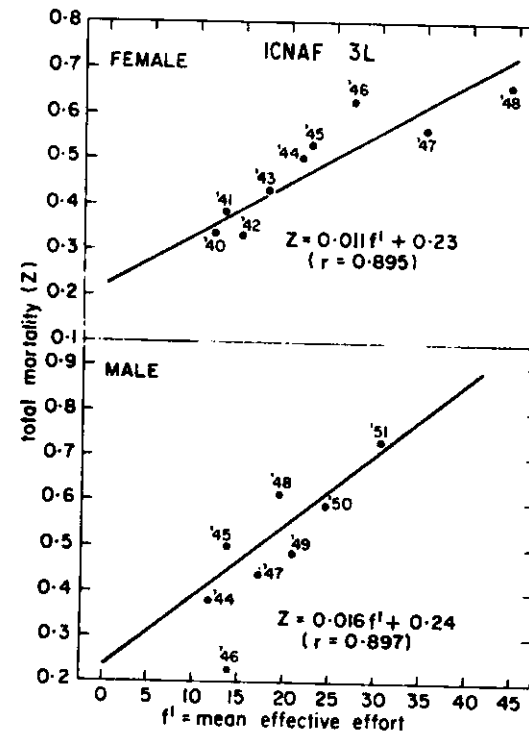


Fig. 5. Estimation of natural mortality in 3L using Z from catch curves of a series of year-classes (Fig. 7).

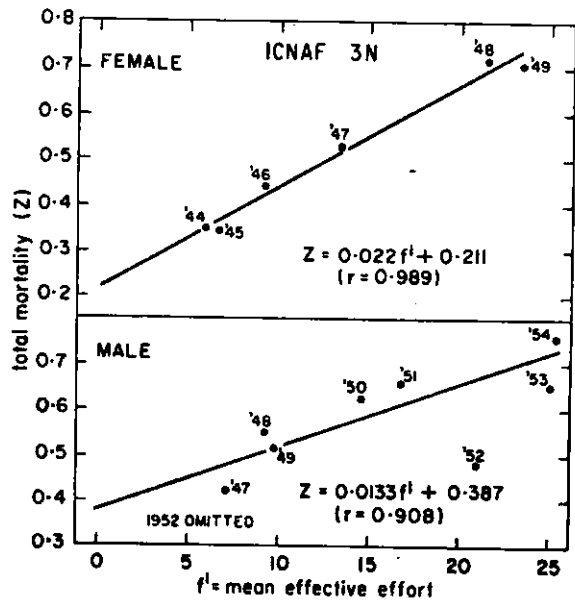


Fig. 6. Estimation of natural mortality in 3N using Z from catch curves of a series of year-classes (Fig. 8).

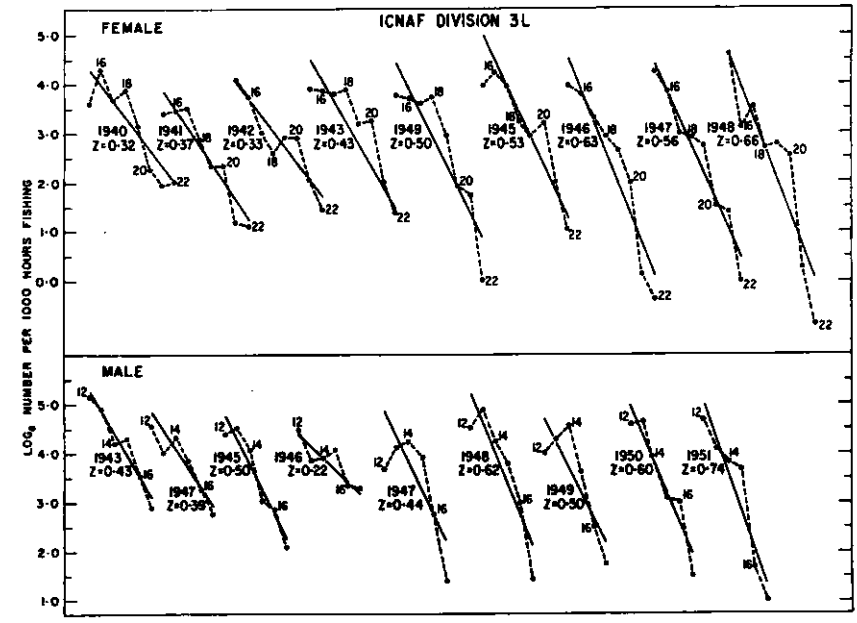


Fig. 7. Catch curves of American plaice from 3L, 1940-48 year-class for females and 1943-51 for males. Solid lines indicate interpretation of the slopes fitted from ages 15 to 22 (females) and 12 to 17 (males).

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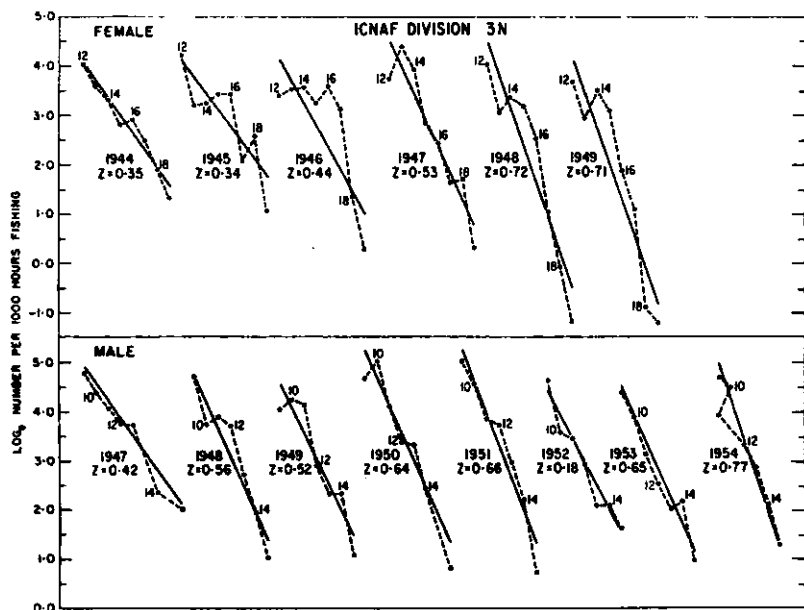


Fig. 8. Catch curves of American plaice from 3N, 1944-49 year-class for females and 1947-54 for males. Solid lines represent interpretation of slopes fitted from ages 12 to 19 (females) and 9 to 15 (males).

Table 1. Summary of estimates of natural mortality of American plaice.

Method	Division 3L		Division 3N	
	Male	Female	Male	Female
Beverton and Holt	0.27	0.23	0.22	0.16
Paloheimo linear formula	0.22	0.23	0.17	0.18
Z from year-classes	0.25	0.23	0.39	0.21
Average	0.25	0.23	0.26	0.18

Total instantaneous mortality from catch curves of unexploited stocks

<u>St. Mary's Bay</u>	Males	=	0.27
	Females	=	0.18
<u>Hamilton Inlet Bank</u>	Males	=	0.30
	Females	=	0.22