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Estimates of Natural Mortality for ICNAF Division 2J Cod

by

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In view of the importance of reliable estimates of natural mortality (M) in virtual population analyses, estimates of M have been derived for Division 2J cod for which a virtual population assessment was presented at the 1971 ICNAF Annual Meeting (Res. Doc. 71/10). At that time M = 0.2 was assumed as the level of natural mortality in this stock.

The basic data used were catch and effort figures for 1959-70. The catch figures were those reported in Res. Doc. 71/10 as number of cod caught per age-group updated to 1970. The effort figures were derived by standardizing the effort for various gears for each year to standard Spanish otter trawler units using the method developed by Hodder (1965) and used by Wiles and May (1968) and Pinhorn (1969, 1970). This consists of obtaining conversion factors from slopes of regressions of catch/hour fished of each country and/or gear on catch/hour fished of the standard gear. These conversion factors are then used to convert the effort of each country/gear to that of the standard gear. Where necessary numbers per standard hour for each age-group were then calculated.

Five methods of arriving at estimates of M were used, although it is realized that these are not independent but are only essentially five treatments of the same basic data. However, the different approaches should serve to indicate the range within which M likely lies and should produce an $\overline{M}$ close to the true M.

The various estimates of M are shown in Table 1.

Catch curves from period of low fishing effort

The average catch curve for 1960-61 produced a Z of 0.24 which would represent the upper limit of M assuming no fishing mortality (F) (Fig. 1). The actual Z measured from this curve reflects the total mortality during some earlier period, in this case approximately 1954-59 (Ricker, 1958). The average effort in

Table 1. Estimates of M by various methods, 2J cod

	Method	M
1)	Catch curves of low effort period	0.20
2)	Silliman	0.15
3)	F of VPA versus fishing effort	0.16
4)	Z of year-class catch curves versus fishing effort	0.20
5)	Z of year-class from VPA versus fishing effort	0.21
6)	Least squares estimation	0.18
	$\overline{M}$	0.18

this period was about 22000 standard hours. In 1959 an effort of 35000 hours resulted in an average F of 0.07 for the fully recruited age-groups. Therefore, assuming an F of 0.04 for the 1954-59 period results in an estimate of 0.21 for M.

Silliman Method

The rapid increase in fishing effort in 1960 and 1961 from a level of approximately 22000 hours in 1954-59 to 133000 hours in 1961-66 allows an estimate of M by the Silliman Method (Fig. 1).

The level of Z during the 1954-59 period as determined from the average catch curve for 1960-61 was 0.24 with an effort level of 22000 hours. During the 1961-66 period the Z as determined from the average catch curve of 1966-67 was 0.64 and the level of effort 133000 hours. Solving the equation of the method with these variables results in an estimate of 0.15 for M.

Regression of $\overline{F}$ from VPA on fishing effort (f)

In conducting the VPA on 2J cod, an estimate of M = 0.2 was used. If this coincided with the true value of M, then the regression of $\overline{F}$ on f should pass through the origin. Any intercept, therefore, gives some measure of the deviation of the assumed M from the true M. The regression from the VPA data produced an intercept of -0.04, indicating a value of M = 0.16 (Fig. 2).

Regression of Z from year-class catch curves on fishing effort (f)

From numbers caught at each age in each year and the effective fishing effort in each year, numbers caught per hour's fishing were calculated for each age. These were plotted as catch curves for the year-classes 1950-59 (Fig. 3). Total mortality estimates (Z) were then determined from slopes of lines fitted to the $\log_e$ of these values. It must be stressed that these are the author's interpretation of the slopes for age 8 onwards for the 1950-53 year-classes and age 7 onwards for the 1954-59 year-classes. For example, because of the inadequacy of samples in 1959, the slope for the 1950 year-class is fitted from age 10 onwards. Similarly for the 1954, 1955 and 1956 year-classes the points representing the 1965 catch are not included in fitting the line because of doubt as to their validity. For the same reason, points representing the 1969 catch were not included for the 1956-59 year-classes. These values of Z are then plotted against the average effective effort for each year-class by the method of Paloheimo and the regressions (Fig. 4) yielded an estimate of 0.20 for M.

Regression of $\bar{Z}$ for each year-class from VPA estimates of $\bar{S}$ on fishing effort (f)

VPA produce preliminary estimates of survival rates (S) and hence Z for each age by year-class. The regression of $\bar{Z}$ for fully recruited age-groups for each year-class on average effective fishing effort for that year-class produces an intercept which is an estimate of M. From the 2J VPA data (Fig. 5), an estimate of $M = 0.21$ was obtained in this way. In obtaining $\bar{Z}$ by year-class the same range of ages was used for each year-class as in the previous section.

Least squares estimation from catch data

A method described by Agger et al., (1971) to estimate M by least squares estimation from numbers caught at each age for each year-class produced a value of 0.18. This method is significant in that it produces an estimate of M which is derived completely independently of fishing effort and is thus a confirmation of the $\bar{M}$ produced by the other methods.

Probable value of M

Estimates of M obtained in this study ranged from 0.15 to 0.21 with $\bar{M} = 0.18$. Thus, the value of M is not likely to be less than 0.15 or greater than 0.21. Even assuming M as low as 0.15, the assumed value of 0.20 used in the 2J VPA would result in $\bar{F}$ being underestimated by approximately 10%. If the value of M is close to the $\bar{M} = 0.18$ then the F-values estimated in the 2J VPA would be little changed.

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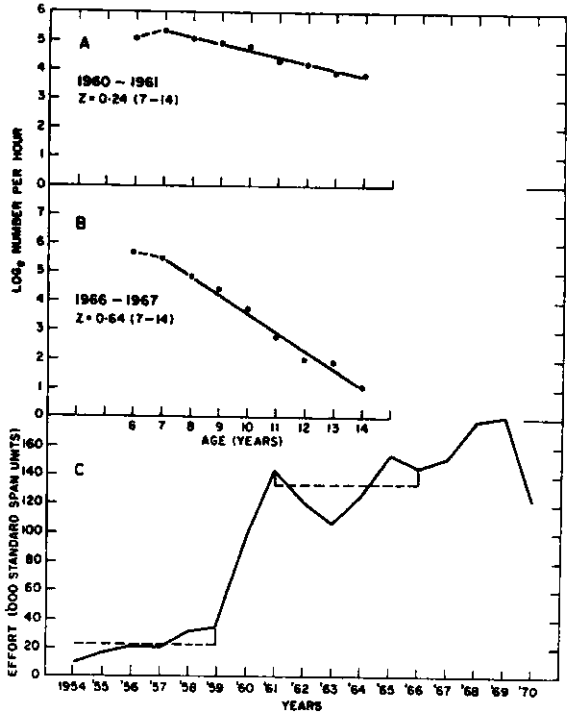

Fig. 1. A and B. Average catch curves for 2J cod, 1960-61 and 1966-67.
C. Trends in standard effort, 2J, 1954-70.

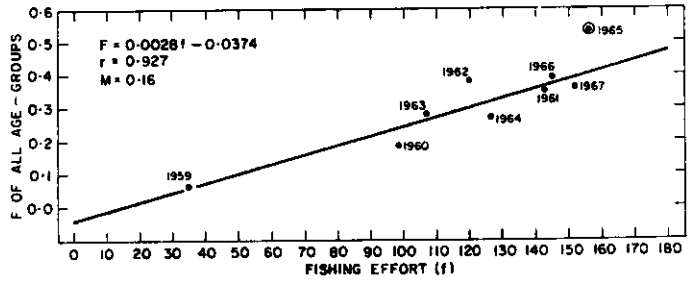

Fig. 2. Regression of $\bar{F}$ of all age-groups from VPA on effective fishing effort (f), 2J cod.

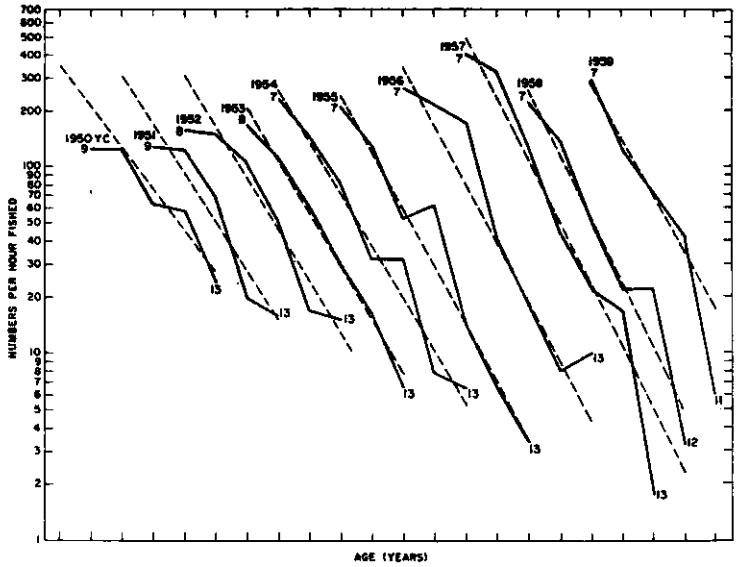

Fig. 3. Catch curves for 1950-59 year-classes (Dashed lines are author's interpretation of slopes from age 8 onwards for 1950-53 year-classes and age 7 onwards from 1954-59 year-classes).

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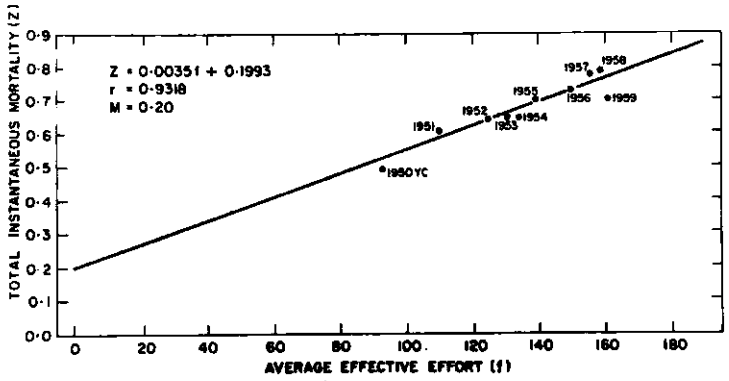

Fig. 4. Regression of $\bar{Z}$ of fully recruited age-groups from year-class catch curves on average effective fishing effort (f).

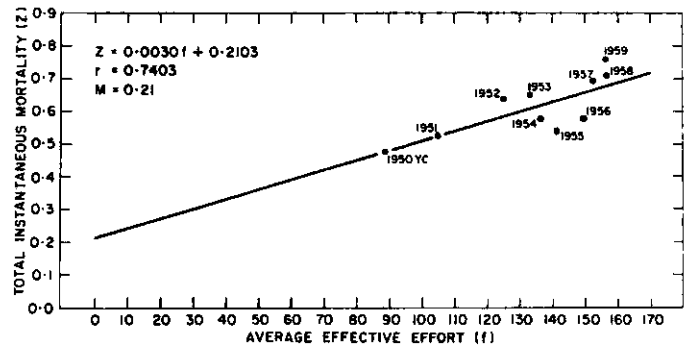

Fig. 5. Regression of $\bar{Z}$ of fully recruited age-groups from VPA on average effective fishing effort (f).