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The Use of Fishing Effort as a Basis for Estimating Fishing Mortality in Div. 2J+3KL Cod

by

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INTRODUCTION

In the early days of stock assessments within ICNAF, relationships between annual estimates of standardized fishing effort and average fishing mortality (usually weighted or unweighted averages of fully recruited fishing mortalities) were widely used as a basis for estimating input fishing mortality in the final year of the cohort analyses (eg. ICNAF, 1978). In fact this method was used as late as 1980 for some stocks (NAFO, 1980). However, in many cases only a small portion of the effort used was actually measured but rather the total effort was calculated by dividing the catch by the catch per unit of effort of some standard country-tonnage class-gear category (Pinhorn, 1969). More recently, the standardized effort has been derived using a multiplicative model (Gavaris, 1980) but in this case also a small amount of measured effort of some standard country-gear-tonnage class category is sometimes used to estimate the total effort from the catch. Since total effort derived from the multiplicative model and fishing mortality derived from cohort analyses both involve catch, it was realized by assessment biologists that spurious correlations between fishing effort and fishing mortality could arise under certain circumstances. This was demonstrated by D. Rivard (unpublished data) in a series of examples presented to a special CAFSAC assessment meeting in 1981. I use these examples here to investigate the implications for 2J3KL cod. The data used were for redfish in Div. 4RST, 1972-77 where the effort index was based on Canadian otter trawlers of 151-500 tons, mackerel in Subareas 3-6, 1970-78, where the effort index was based on Canadian research vessel survey catch per tow, and mackerel in Subareas 3-6, 1968-75, where the effort index was based on U.S.A. research vessel survey catch per tow. The procedure was to generate at random a series of CPUE values within the observed range of CPUE values and use these to derive total effort values by dividing catch by CPUE. These total effort values were then regressed against F, the fishing mortalities estimated from cohort analyses. The resulting regression lines were compared with those obtained when using the actual CPUE index of a research survey (mackerel) or of a chosen tonnage class (redfish). The results of these examples are summarized below:

Species	R^2	
	F versus effort from observed CPUE	F versus effort from random CPUE
4RST redfish	0.87	0.71
Mackerel-Canadian R/V	0.95	0.96
Mackerel-USA R/V	0.98	0.02

Figure 1 shows the CPUE trends for these examples. For the case of mackerel using the Canadian R/V CPUE, there is no trend in CPUE. For redfish there is a moderate trend and for mackerel using the U.S. R/V CPUE there is a marked trend.

The conclusion I draw from these examples and Fig. 1 is that the probability of a spurious correlation between F and effort is extremely high when there is no trend in CPUE (Mackerel, SA3-6, Canadian surveys), is extremely low when there is a sharp trend in CPUE (Mackerel, SA3-6, U.S. Surveys) and is moderate when there is a moderate trend in CPUE (Redfish, 4RST).

The case for 2J3KL cod

Fig. 2 shows the regression between fishing effort as derived from the multiplicative model and weighted fishing mortality for 2J3KL cod (Baird and Bishop, 1985). The fishing mortality was derived according to the formula:

$$F_t = \ln \left[\sum_{i=n}^{m-1} N_{i,t} \Big/ \sum_{i=n}^{m-1} N_{i+1,\ t+1} \right] - M$$

where n = first age group to be included in the summation.
m = oldest age group.
i = age group.
t = year.
M = instantaneous natural mortality.
N = number of fish in the population.

Fig. 1 also shows the CPUE FOR 2J3KL cod for the 1962-84 period. From the examples above one would not expect the regression in Fig. 2 between F and fishing effort for 2J3KL cod with such a high R^2 (0.81) to be spurious with such a marked trend in CPUE. To further test this and following Rivard's procedure, CPUE values were selected at random within the range of the observed CPUE index values for 2J3KL cod (0.684-2.651) and these were used to calculate fishing effort by dividing catch by CPUE. This was repeated 50 times. No R^2 were significant at the 1% level and only 6 of 50 at the 5%, with 4 of these being barely significant (P = 0.047, 0.045, 0.047, and 0.047 respectively). Thus I conclude that the significant regression between F and effort (R^2 = 0.81) for 2J3KL cod is not spurious but represents a real relationship between fishing effort and weighted fishing mortality.

The regression line fitted in Fig. 2 omits the 1974-76 points as being obviously anomalous. These same points have been omitted consistently in recent assessments (Baird and Bishop, 1985) but no good explanation for the anomaly has been forthcoming to date.

Implications to recent assessments of using the fishing mortality-fishing effort relationships

The regressions in Fig. 2 are fitted to the 1962-80 data points (excluding 1974-76) and therefore can be used to predict the weighted fishing mortality values for 1981-84. The insert in Fig. 1A shows the weighted age 4+ fishing mortality as estimated from the regression and the fishing effort for each of the years 1981-84. The agreement with the recent cohort (Bishop et al. 1985), which estimated a fully recruited F of 0.23 in 1984 is striking. If anything the regression would have estimated a slightly lower terminal F in 1984.

The regression in Fig. 2B is between fishing effort and weighted age 6+ (fully recruited) fishing mortality. The regression is still very significant but the R^2 (0.68) is lower than with the weighted age 4+ fishing mortality. This is not surprising since the latter regression would have accounted for shifts in effort to recruiting ages over the years. Nevertheless, the weighted age 6+ F values from the regression are still for the most part only 10-12% above those from the recent cohort; this regression would have estimated terminal F in 1984 to have been 0.26 rather than 0.23.

CONCLUSION

From the above I conclude that there is some merit in re-examining the relationship between F and effort in 2J3KL cod as an estimator of terminal F. Compared to relationships between CPUE and exploitable biomass, it does not suffer from the variablity due to the introduction of partial recruitment and average weights.

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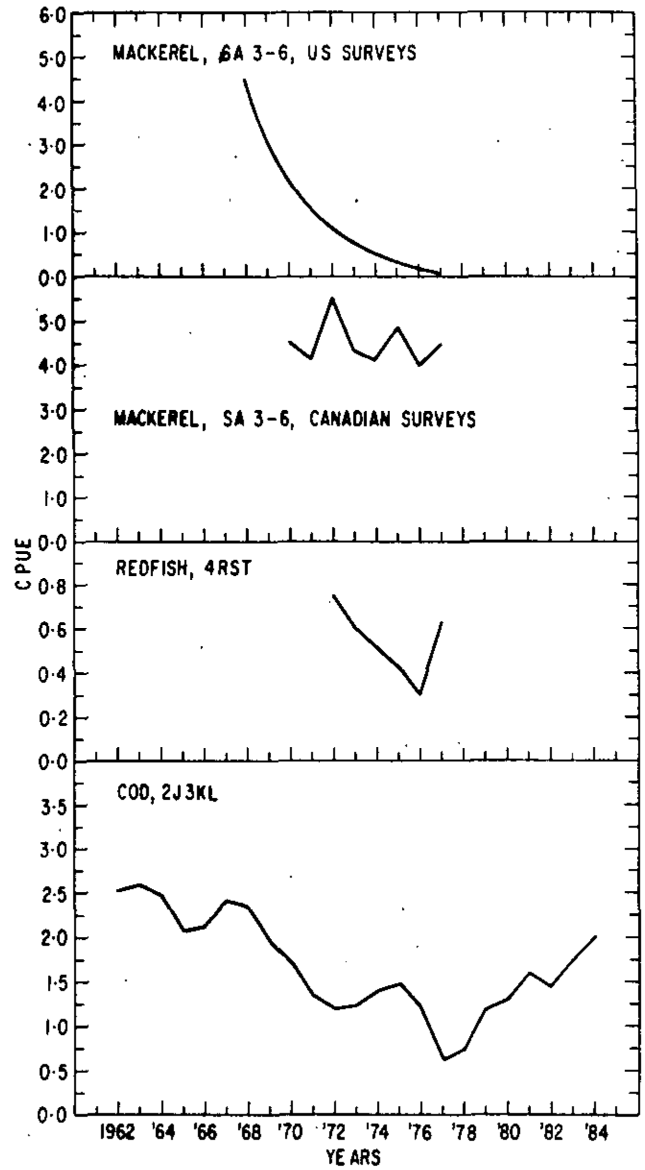

Fig. 1. Indices of CPUE for various stocks of fish in NAFO Area.

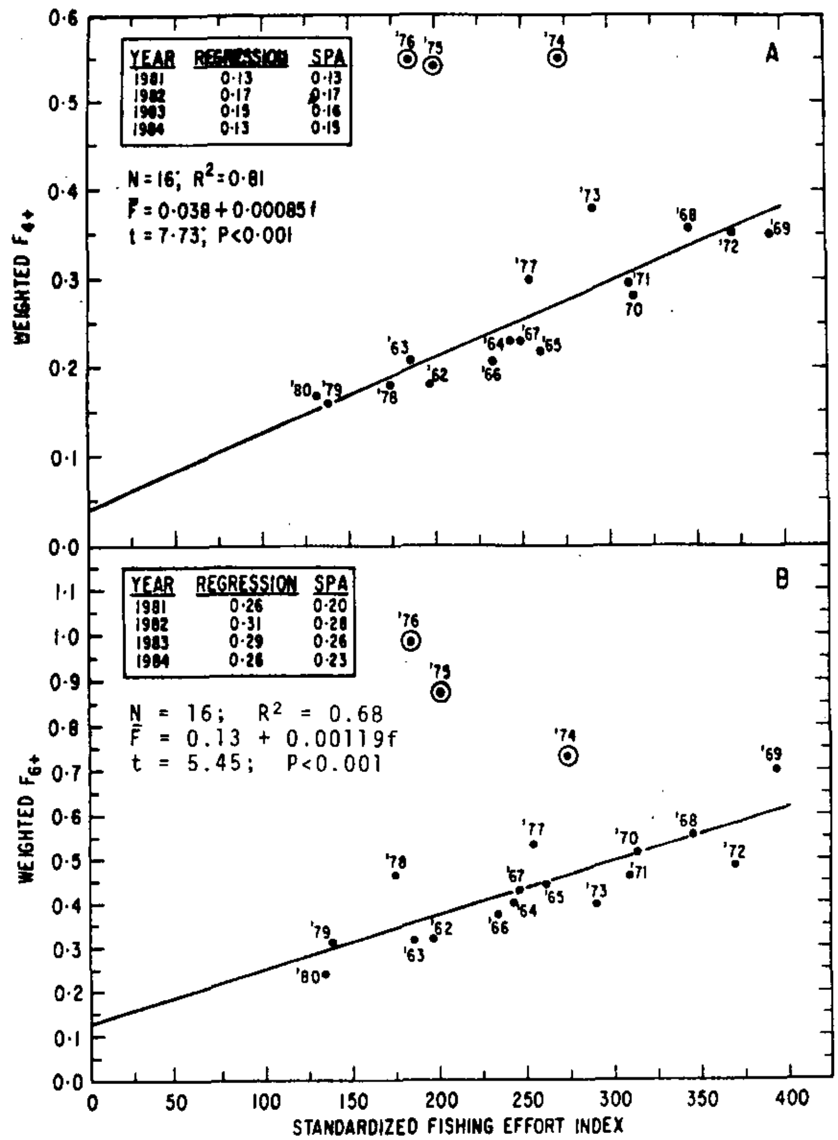

Fig. 2. Regressions of Age 4+ weighted fishing mortality (A) and Age 6+ weighted fishing mortality (B) on standardized fishing effort for 2J3KL cod, 1962-80.