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Flemish Cap Redfish Assessment

by

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INTRODUCTION

The status of the Flemish Cap redfish stock has been evaluated in previous years using the general production model as modified by Gulland (1961) (McKone, 1978; McKone and Parsons, 1977). This paper re-evaluates the stock using the same model but a different method of standardizing fishing effort.

MATERIALS AND METHODS

Catch and effort data were obtained from the ICNAF Statistical Bulletins for the years 1956 to 1977. As in the past, redfish directed catches were taken to be those in which 50% or more of the catch was redfish.

Recent years have seen the advent of Canadian participation in the fishery along with the increasing importance of mid-water trawls. Mid-water trawls accounted for 37% of the total redfish catch in Div. 3M in 1974, 18% in 1975 and 70% in 1976 and 1977.

To take account of these changes a different method of standardizing fishing effort was used. Almost all the available effort data was incorporated into a model of the form

$$CPE = BPMY$$

where CPE is catch per effort, B is basic catch rate, P is fishing vessel type denoted by country, tonnage class and gear, M is month and Y is year of fishing. Similar multiplicative models have been used previously in fisheries (Gulland, 1956; Robson, 1966). The above model postulates that CPE is the product of a basic catch rate modified by the power of the fishing vessel type, monthly changes in fish concentration (or fishing conditions) and yearly changes in recruitment (or technological improvements).

For computational purposes, the model used is

$$CPE = B \times P_i^{ai} \times M_j^{bj} \, Y_k^{ck} \, E_{ijk}$$

where a, b, and c are dummy variables which assume the values below

$$a_i = \begin{cases} 1 \text{ if fishing vessel type } i \text{ is used} \\ 0 \text{ otherwise} \end{cases}$$

$$b_j = \begin{cases} 1 \text{ if month } j \text{ is involved} \\ 0 \text{ otherwise} \end{cases}$$

$$c_k = \begin{cases} 1 \text{ if year } k \text{ is involved} \\ 0 \text{ otherwise} \end{cases}$$

P_i, M_j and Y_k are the parameters to be estimated and E_{ijk} is the error term associated with an observation.

This model may be converted into a linear form by taking the log of both sides, giving

$$\log CPE = \log B + a_i \log P_i + b_j \log M_j + C_k \log Y_k + \log E_{ijk}$$

Note that for significance tests to be performed on this model, the assumption that $\log E \sim N(0, I\,\sigma^2)$ is made. This may be checked by examining the residuals of the fitted equation.

To obtain relative powers of fishing vessel type, month and year, one of each of these classes is arbitrarily chosen as a standard and set equal to one. This implies

$$P_o = 1 \text{ or } \log P_o = 0$$
$$M_o = 1 \text{ or } \log M_o = 0$$
$$Y_o = 1 \text{ or } \log Y_o = 0$$

Once the parameters, $\log P_i$, $\log M_j$ and $\log Y_k$, are estimated by standard multilinear regression procedures, they may be used to standardize effort. Since we are interested in standardizing the CPE's and not log CPE's, the antilogs of $\log P_i$, $\log M_j$ and $\log Y_k$ must be taken.

For example, for a given catch c and considering the power of the vessel type only,

let CPE of the standard vessel type o be c/f_o and
CPE of the vessel type 1 be c/f_1

then $\log c/f_o = \log B + \log P_o = \log B$ and
$\log c/f_1 = \log B + \log P_1$.

Taking the antilog of both sides

$$c/f_o = B$$
$$c/f_1 = B \times P_1$$
$$= c/f_o \times P_1 \quad (1)$$

As we are interested in standardizing effort, (1) may be rewritten as

$$f_o = f_1 \, P_1$$

Thus the antilog of the parameters estimated by the multilinear regression equation may be used to convert effort to the standard effort. Similarly, differences between months may be adjusted to the standard month by using the appropriate coefficient M_j. Finally

$$f_o = f_i\ P_i\ M_j$$

Stepwise regression was used to isolate those factors which influenced the variation in the dependent variable, log CPUE, to the greatest extent.

The general production model, as modified by Gulland (1961), was applied to the standardized effort and catch data. Six-, eight-, and ten-year running averages of effort were chosen as the most likely to describe the fishery. The least squares regressions of catch per unit effort on each of the averaged efforts was calculated.

Length frequencies, sampled by midwater and bottom trawl from both Canadian research and commercial sources have been provided (Fig. 4 and 5). The age frequencies for the 1978 Canadian research sampling are shown in Fig. 6.

RESULTS AND DISCUSSION

The stepwise regression procedure applied to the catch per effort model produced a significant regression (multiple R value of 0.83, $P<0.01$) with the assumptions of the model satisfactorily met. The resulting power coefficients for the fishing vessel types and months are listed in Table 1. Midwater trawls ranked higher than otter trawls except for the case of Japan. Among USSR fishing vessels, increasing tonnage class was associated with increasing power. Two months, May and December, were singled out as being different from the rest of the year in having lower than average catch rates. The years 1958 and 1974 were included in the regression. High catches and catch rates characterized both these years.

Trends in the nominal catch, effort and catch per unit effort are shown in Fig. 1. Under quota regulations of recent years, effort and catch per unit effort have remained fairly steady.

The regressions of catch per unit effort on the mean effort resulted in significant regression coefficients ($P<0.05$) of 0.543 and 0.606 for eight- and ten-year running averaged periods respectively (Fig. 2). The regression for the six-year period was not significant.

The yield curves based on the above regressions gave maximum sustainable yield estimates of 16,900 mt for the ten-year period and 16,300 mt for the eight-year as illustrated in Fig. 3. The sustainable yields associated with two-thirds the effort at MSY were 14,900 and 14,800 mt for the ten-year and eight-year averaging respectively. The two curves gave very similar results. Assuming the fishery to be in equilibrium as determined by the ten-year averaging parabola, catch rates for the years 1975 to 1977 were better than the catch rate at two-thirds the effort at MSY. This would indicate that the stock is in relatively good condition.

An examination of the length frequencies of the Canadian commercial catch for 1978 (Fig. 4) compared with similar data for the previous year (McKone, 1978) showed that redfish ranging in size from 27 to 42 cm made up the bulk of the fishery in both years. Smaller redfish which first appeared in the 1977 commercial catches, appeared to be more prominent in the 1978 catch. The otter trawl catch included redfish ranging down to 22 cm in length while in the previous year the minimum size was approximately 26 cm. The midwater trawl catches clearly showed a peqk of small sized redfish of 21 cm to 26 cm with a modality of about 23 cm. This peak of small redfish also appeared in the Canadian research sampling (Fig. 5). The age frequencies for the Canadian research sampling (Fig. 6) indicated that this group of small redfish would be the 1970 year-class.

CONCLUSIONS

The multilinear regression approach to the problem of effort standardization made use of almost all the available effort data for the 3M redfish fishery. The method was found to be adaptable to a changing fishery. It also pointed out trends in the fishing power of different vessels and seasonal and yearly fluctuations in catch rates.

The catch rates of recent years suggested that the stock was in relatively good condition. The age and length frequencies from Canadian sources showed young small-sized redfish have begun to be recruited to the fishery. Since the strength of this year-class at age relative to other year-classes which have contributed significantly to the fishery in the past is unknown, the importance of this newly recruited age class cannotbe gauged precisely. However, indications are that a relatively good year-class is enterinq the fishery.

The general production curves gave sustainable yield values at two-thirds the effort at MSY of 14,900 mt and 14,800 mt for the ten-year and eight-year averaging respectively.

REFERENCES

Gulland, 1956. On the fishing effort in English demersal fisheries. Fish. Invest. Lond. (1), 20(5): 41p.

1961. Fishing and the stocks at Iceland. Fish. Invest. Lond. (2), 23(4): 52p.

McKone, W.D. 1978. An update of Flemish Cap redfish assessment. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 78/48, Ser. No. 5210.

McKone, W.D. and D.G. Parsons. 1977. An update of the assessment of redfish from Subarea 2 + Div. 3K, Div. 3M, Div. 3LN and Div. 3Ø. Intern. Comm. Northw. Atlant. Fish. Res. Doc. 77/18, Ser. No. 5038.

Robson, D.S. 1966. Estimation of the relative fishing power of individual ships. Res. Bull. Intern. Comm. Northw. Atlant. Fish., No. 3, pp. 5-14.

Table 1. Power coefficients of fishing vessel types and months. Symbols are as those used in the ICNAF Statistical Bulletin

	Parameter		Relative Power
a) Country	Tonnage Class	Gear	
Japan	7	OT	2.518
Can N	5	MT	1.770
USSR	7	MT	1.377
Can MQ	5	OT	1
USSR	7	OT	1
USSR	6	OT	0.714
Can N	5	OT	0.545
Poland	7	OT	0.375
USSR	5	OT	0.331
USSR	4	OT	0.298
b) Months			
May			0.710
December			0.490
All Others			1

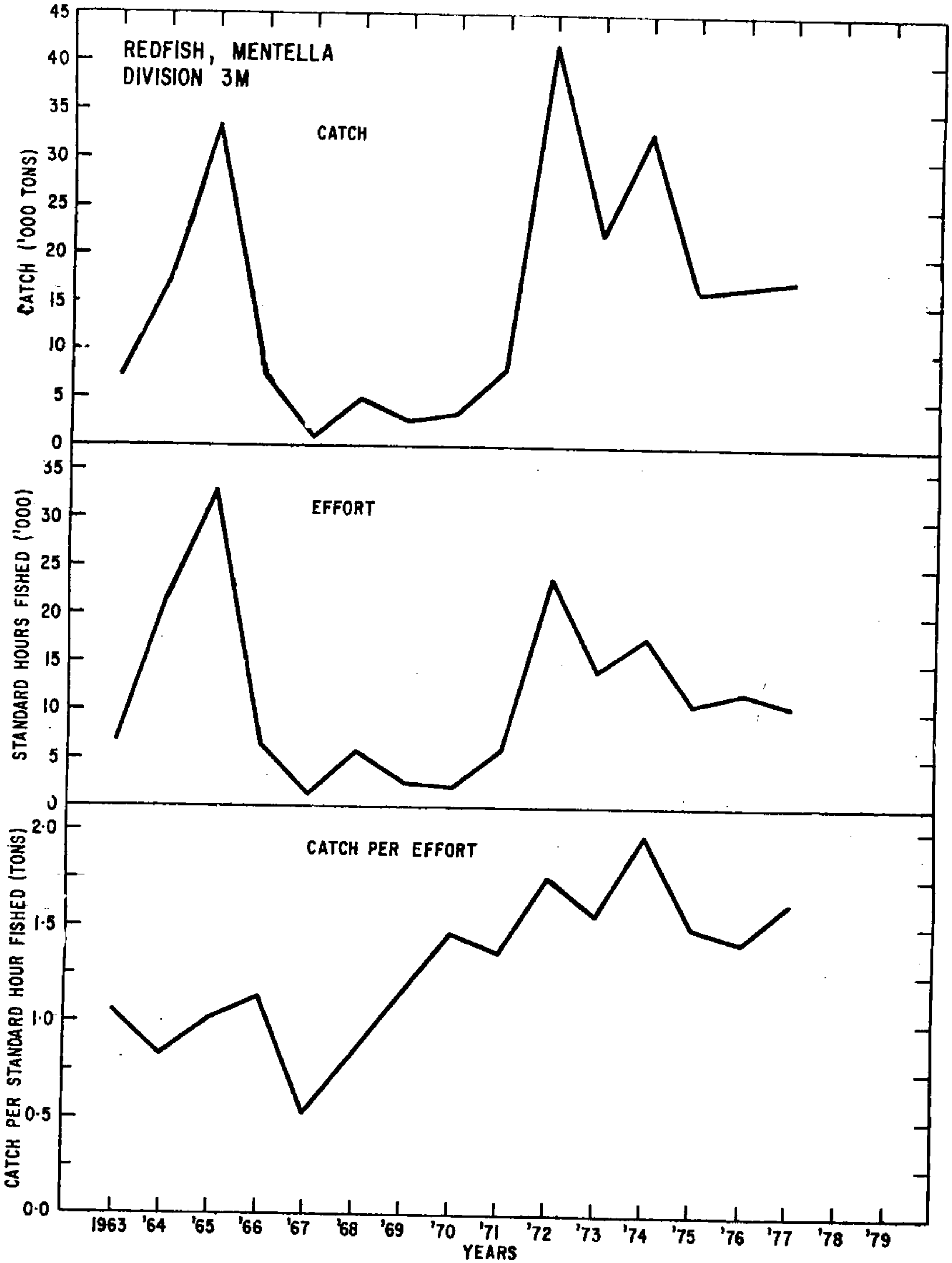

Fig. 1. Trends in nominal catch, effort and catch per unit effort in standardized units as described in the text.

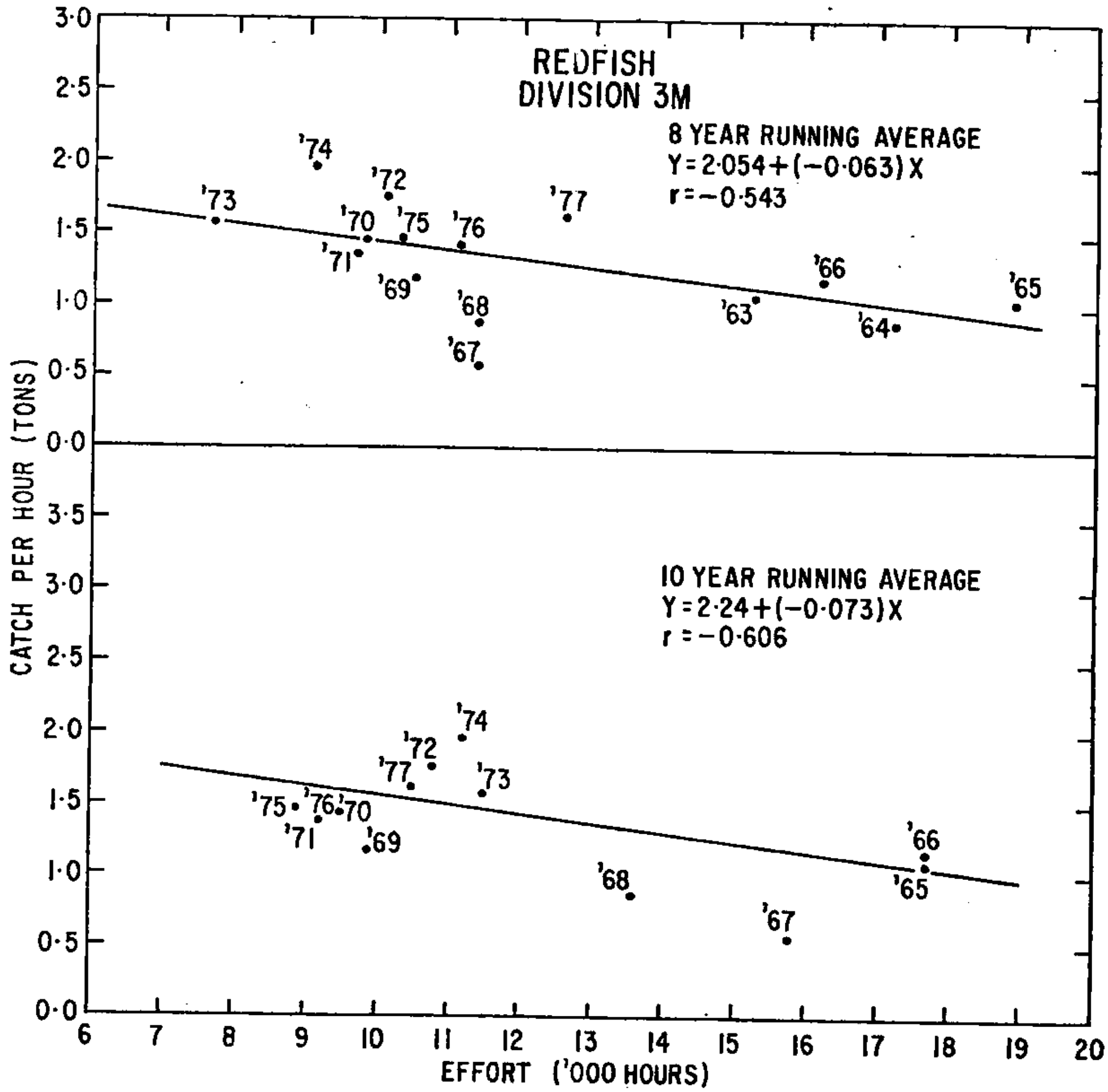

Fig. 2. Least squares regression of catch per standard hour fished against 8-year and 10-year running averages of standard hours fished.

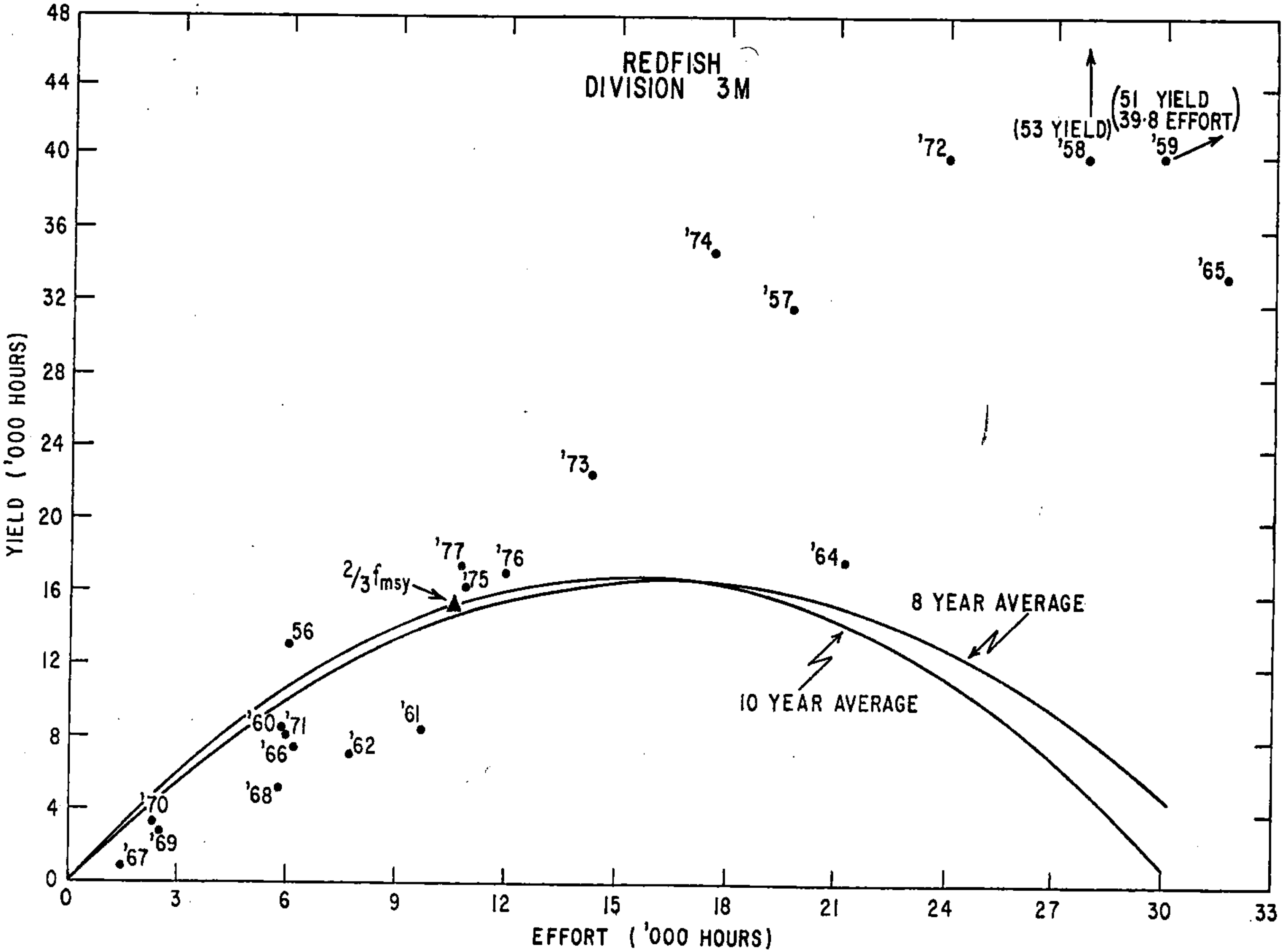

Fig. 3. Yield curves derived from the regressions of catch per standard hour versus 8-year and 10-year running averages of standard hours fished.

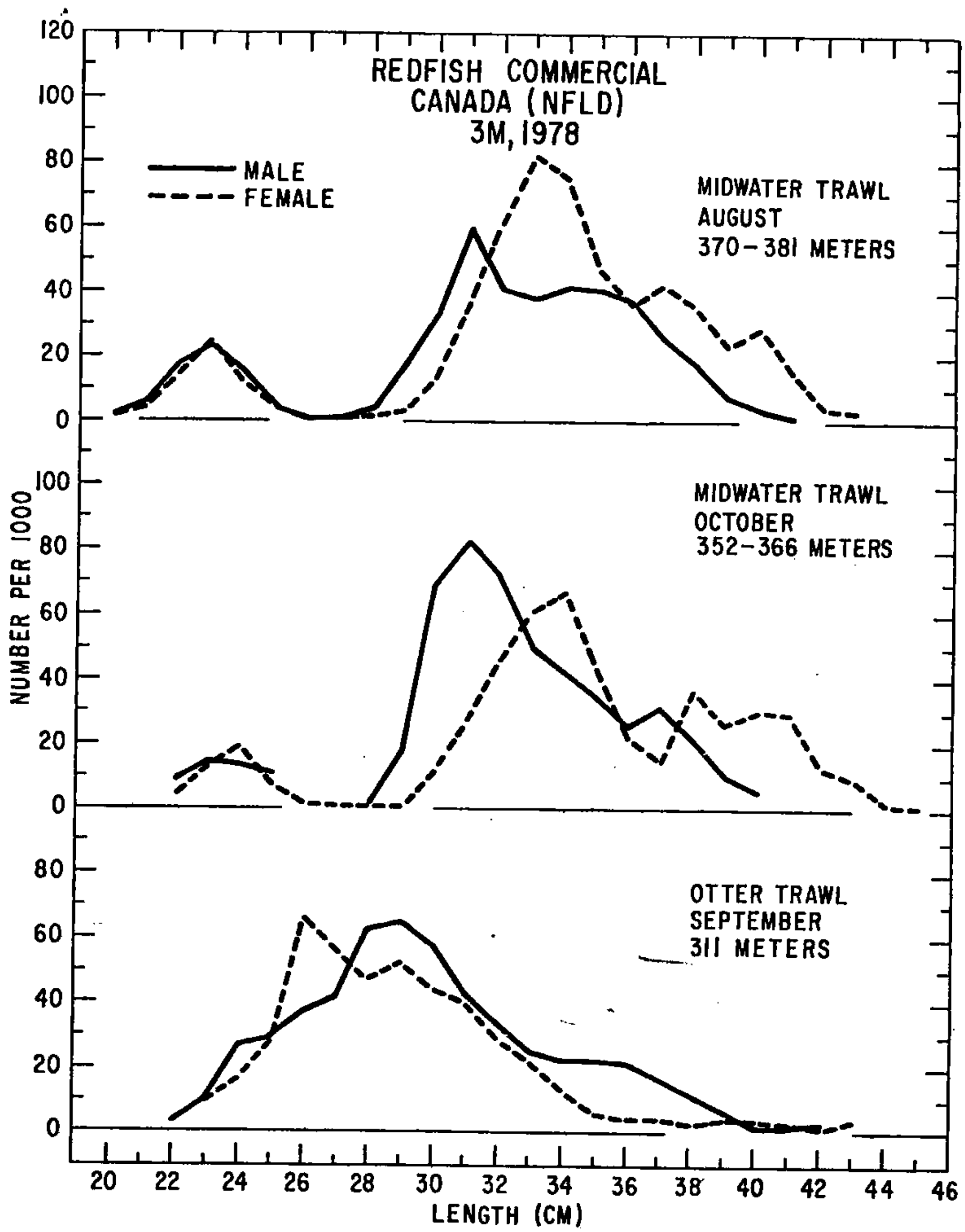

Fig. 4. Length frequencies of Canadian commercial catch for both midwater and otter trawl in 1978.

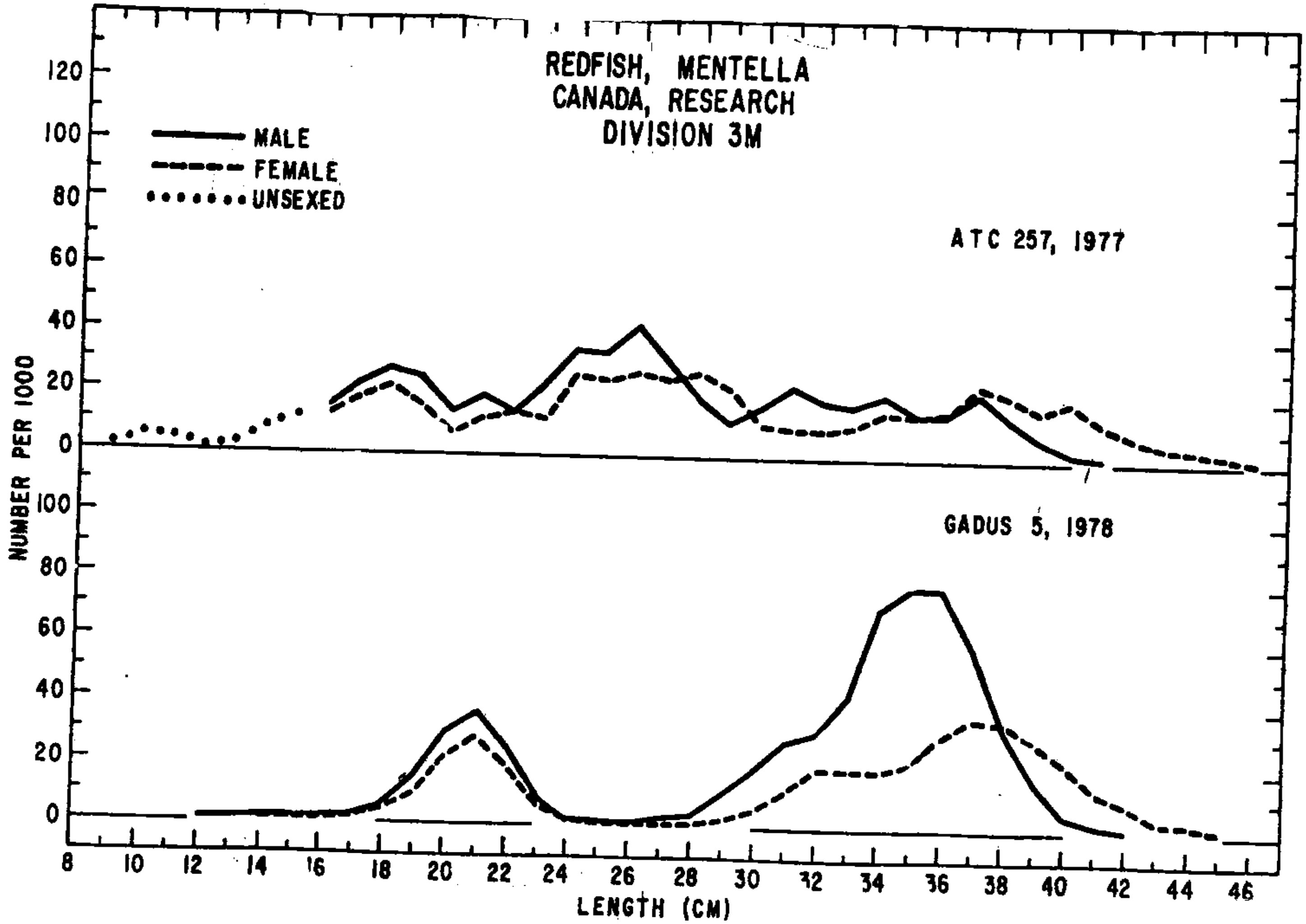

Fig. 5. Length frequencies of Canadian research sampling in 1977 and 1978.

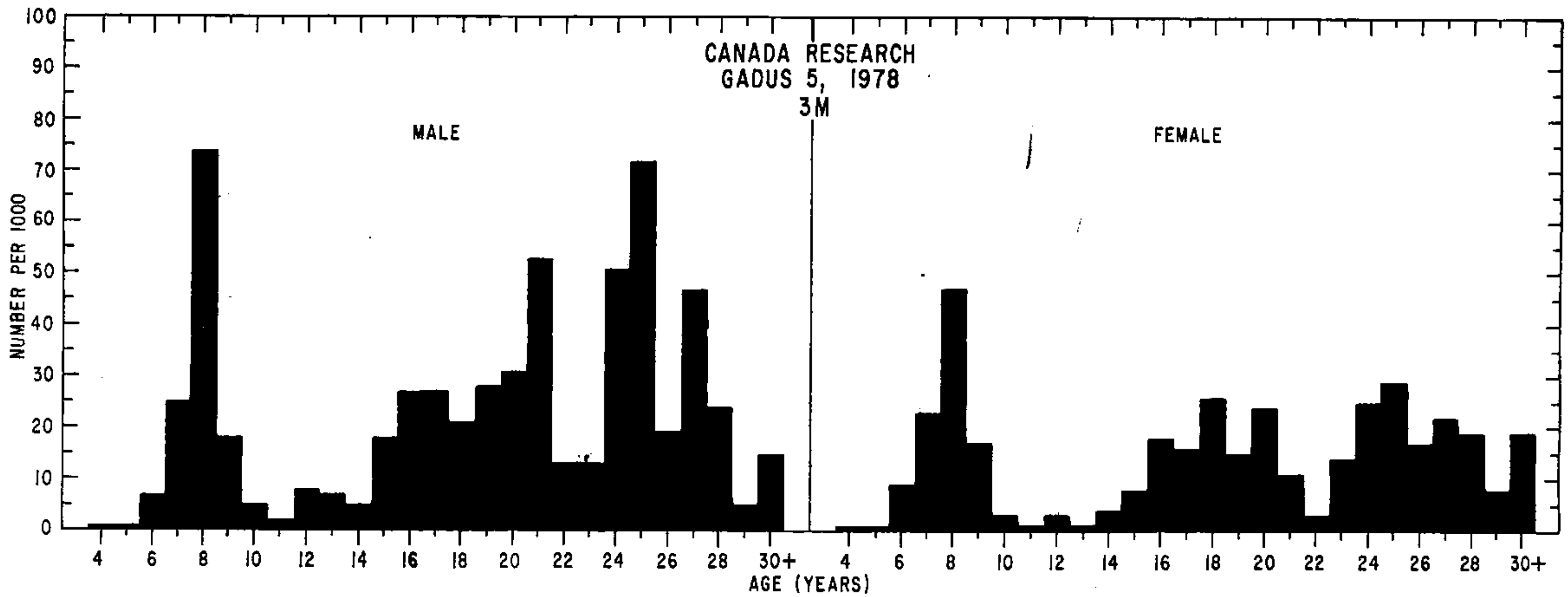

Fig. 6. Age frequencies of the 1978 Canadian research sampling.