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Yield per recruit assessment of ICNAF Division 3P redfish

by

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Introduction

Nominal catches of redfish from Division 3P have been at a relatively high level in recent years, averaging approximately 31,000 m. tons during 1969-72, with the bulk of the catch being taken by the USSR and Canada. Parsons and Parsons (MS 1973) used a Schaefer yield model to provide an approximate estimate of maximum sustainable yield (23,000 m. tons) for Division 3P redfish from commercial catch/effort data and concluded that the recent level of catches was above the maximum sustainable yield. At the 1973 Annual Meeting of ICNAF a total allowable catch for 1974 of 25,000 m. tons was established for this stock.

This paper provides a further assessment of Division 3P redfish on the basis of the Beverton and Holt yield per recruit model and examines the current status of this stock.

Material and Methods

Ages of research and commercial samples of redfish collected in 1973 were determined from otoliths by the authors according to the method of Sandeman (1969). Bertalanffy growth curves were fitted separately to the pooled length-at-age for male and female redfish in the 1973 research samples by Allen's (1966) method.

In the absence of biological sampling data for USSR redfish landings from Division 3P, it has been assumed that the USSR trawler landings have the same size and age composition as those of Canadian trawlers. Age-length keys from Canadian commercial samples were used to estimate the numbers caught at age in 1973. Estimations of total mortality (Z) were made from the 1973 commercial catch curves.

In an attempt to assess recruitment prospects in relation to the level of recruitment which has supported the 3P redfish fishery since 1965, length distributions of male and female redfish taken in catches by the Canadian research vessel A. T. Cameron during survey cruises to ICNAF Division 3P in February 1965 and February 1973, the only years during which cruises adequately surveyed redfish depths, were plotted. The A. T. Cameron fished a no. 41-5 Yankee otter trawl, with the codend lined by a 29-mm mesh nylon liner. Only daylight sets were used in these comparisons. In each year four survey lines were fished across depth contours on the edges of Burgeo and St. Pierre Banks. Standard 30-minute tows were carried out at the following depths on each of these lines where applicable: 100, 125, 150, 175, 200 and 240 fathoms. The overall length distribution in each year was determined by averaging the numbers caught at each size at each depth. For 1973 data age-length keys derived from random samples taken from several depths and positions were used to estimate from the numbers caught at each length interval the numbers caught at each age per hour fished.

Commercial fishing effort in 1972 was estimated from the catch per hour fished of Canada (Newfoundland) and USSR otter trawlers of 151-500 tons, adjusted as described by Parsons and Parsons (MS 1973), and for 1973 from the catch per hour fished of Canada (Newfoundland) vessels of the standard tonnage category.

Results

Growth

The parameters for the von Bertalanffy growth curves fitted to the 1973 research data and their standard errors were as follows:

	Males	Females
K	0.11 ± 0.01	0.10 ± 0.01
t_0	0.01 ± 0.23	0.39 ± 0.16
L_∞	37.73 ± 0.72	41.24 ± 0.49

These curves are shown in Fig. 1 with Sandeman's (1969) growth curves for Hermitage Bay, Newfoundland, based upon 1953-59 data (excluding the 1953 year-class). The curves are very similar. Sandeman's lengths at age were greater than ours by less than 2 cm for the younger ages and less than ours by a maximum of about 1½ cm at ages from 30 to 50 for females and about 3 cm at those ages for males. The curves for males cross at about age 12 and those for females at about age 20.

Yield per recruit

The Beverton and Holt yield per recruit model was applied to males and females separately using the following parameters:

	Males	Females
W_∞ (asymptotic weight)	0.754 kg	1.037 kg
K (from Bertalanffy equation)	0.106	0.099
t_0 (growth correction factor)	0.011	0.391
t_ρ (age at entry to the exploited area)	6	6
$t_\rho{}^1$ (age at mean selection length)	13.9	14.2
t_λ (last age of significant contribution to fishery)	24	24

No precise estimates of the natural mortality coefficient are available for redfish. However, it has long been assumed to be low relative to faster growing species such as cod and herring for which $M = 0.2$ has been commonly used. Sandeman (1973) considers values of 0.2 and 0.01 to be extreme high and low estimates for redfish with the most likely value lying somewhere between 0.1 and 0.05. Values of M of 0.05, 0.1 and 0.15 were used here and yield per recruit values calculated up to $F = 2.5$.

The yield curves (Fig. 2) were basically flat-topped with F_{max} occurring at 0.50 for males and 0.55 for females with M = 0.05. For other values of M no maximum values were obtained up to F = 2.5. However, beyond fishing mortality values of 0.4 the increments in yield per recruit were exceedingly small. Estimated levels of F_{opt} ($F_{0.1}$) (Gulland and Boerema, 1973) for the males were 0.22, 0.28 and 0.38 and for the females 0.21, 0.28 and 0.40 with M = 0.05, 0.10 and 0.15 respectively.

Estimates of total mortality (Z) from the 1973 commercial catch curves were 0.46 for both males and females (Fig. 3). These values indicate a level of fishing mortality beyond $F_{0.1}$ with M = 0.05 and 0.1 and close to $F_{0.1}$ for M = 0.15. These estimates probably represent the average level of total mortality during 1964-73 when catches averaged approximately 24,000 m. tons annually.

Size and age of commercial and research catches

An estimated 33.6 million redfish were caught in Division 3P in 1973 and approximately 73 per cent of these were 14- to 17-year-old fish of the 1956 to 1959 year-classes (Fig. 4).

An examination of the length distributions of redfish taken in the 1973 research survey (Fig. 5) reveals that a very high proportion of the fish caught were relatively small with modal lengths of 21 cm for males and 21-22 cm for females. These were primarily 7, 8 and 9 year old fish (Fig. 6) with 8-year-olds of the 1965 year-class dominant. Although the presence of these young fish in the research catches indicates that prospects are for further significant recruitment to the fishery over the next several years, a comparison of the numbers caught at each length per hour fished in the 1965 and 1973 research surveys (Fig. 5) suggests that fish less than 30 cm in length were only about fifty per cent as abundant in 1973 as in 1965. 9- to 13-year-old fish were dominant in the 1965 research catches.

Catch per unit effort and effort

Standard commercial catch per hour fished was 0.679 tons in 1972 and 0.612 tons in 1973 compared with 0.707 and 0.619 tons in 1970 and 1971 respectively. Total catch was slightly less in 1972 than in 1971 (26,037 versus 27,500 m. tons) but according to preliminary catch statistics declined to 17,155 m. tons in 1973. Fishing effort declined from 44,426 standard hours fished in 1971 to 38,346 hours in 1972 and 28,031 hours in 1973. From the general production curve for Division 3P (from Parsons and Parsons, MS 1973) fishing effort equivalent to 40,000 standard hours fished will produce the maximum sustainable yield under equilibrium conditions (Fig. 7). The 1972 catch was above the equilibrium curve and the 1973 catch below it.

Discussion

From the yield-per-recruit analyses it would appear that the average level of fishing mortality during 1964-73, when catches averaged approximately 24,000 m. tons annually was beyond $F_{0.1}$ for M = 0.05 and 0.1 and close to $F_{0.1}$ for M = 0.15, which suggests a sustainable yield at the $F_{0.1}$ level of less than 24,000 m. tons at the recruitment levels prevailing during this period. This agrees very well with the maximum sustainable yield estimate of approximately 23,000 m. tons derived previously from a Schaefer-type general production study of this stock (Parsons and Parsons, MS 1973).

Standardized commercial catch per unit effort values for 3P redfish (Parsons and Parsons, MS 1973) point to an increase in redfish abundance in that area during the mid- and late-60's, presumably as a result of the entry to the fishery of the 22-30 cm redfish (modal lengths of 26 cm for males and 27 cm for females) which were caught in large numbers in the 1965 research survey. Recruitment to the redfish stock in Division 3P was higher during 1965-71 than during the 1959-64 period. From a gross comparison of the numbers caught per hour fished in the 1965 and 1973 research surveys, it appears that long-term prospects for the period when the 7- to 9-year-old fish dominant in the 1973 research catches will enter the fishery are for a recruitment level substantially lower than that which supported the 3P fishery during 1965-73. Since the maximum sustainable yield estimate for this stock of 23,000 m. tons was derived from commercial catch effort data for 1965-71, a period of apparently high recruitment, it seems likely that the sustainable yield from this stock will be substantially less once the fishery becomes dependent upon fish of the 1964-66 year-classes.

References

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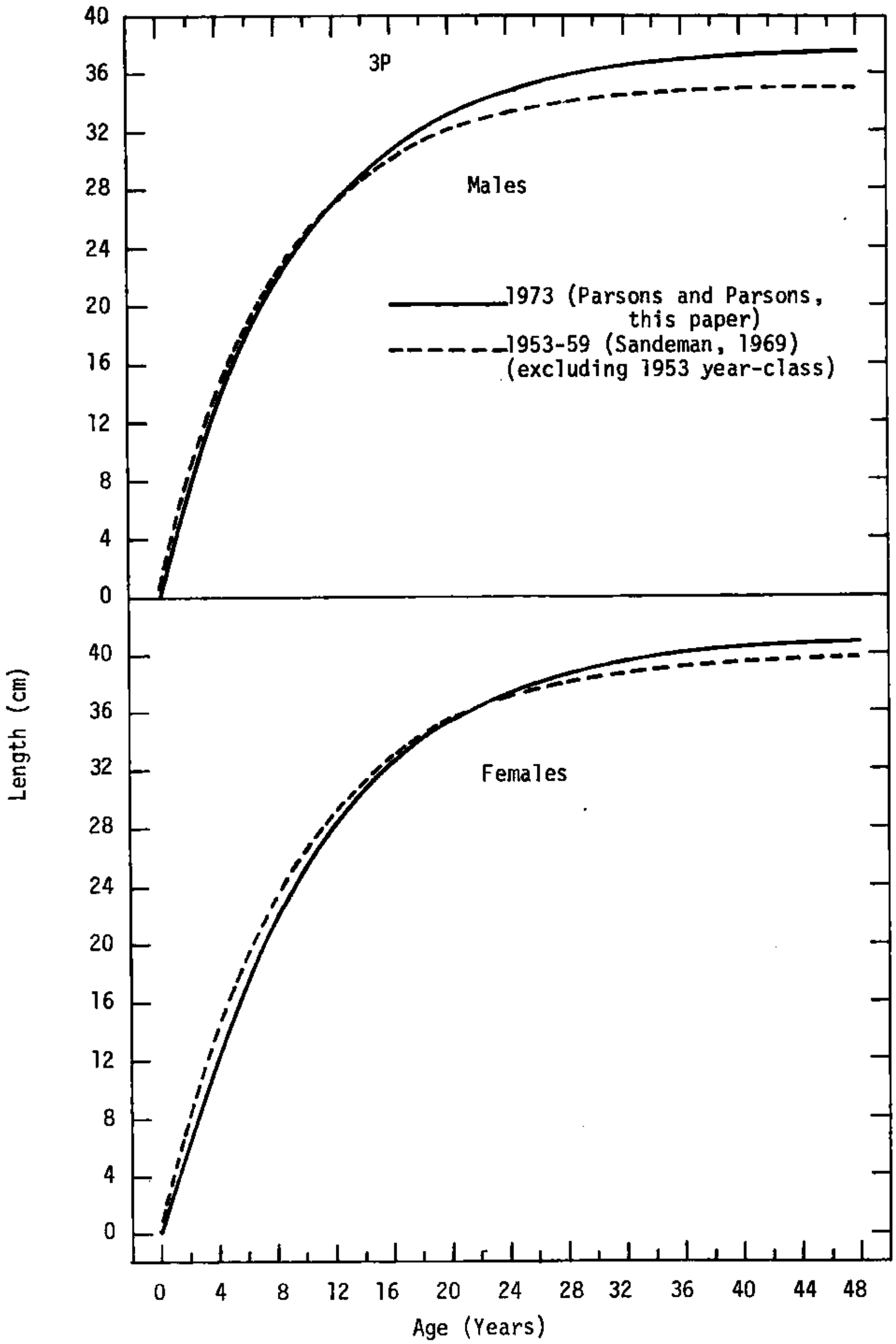

Fig. 1. Growth curves of male and female mentella redfish from ICNAF Division 3P.

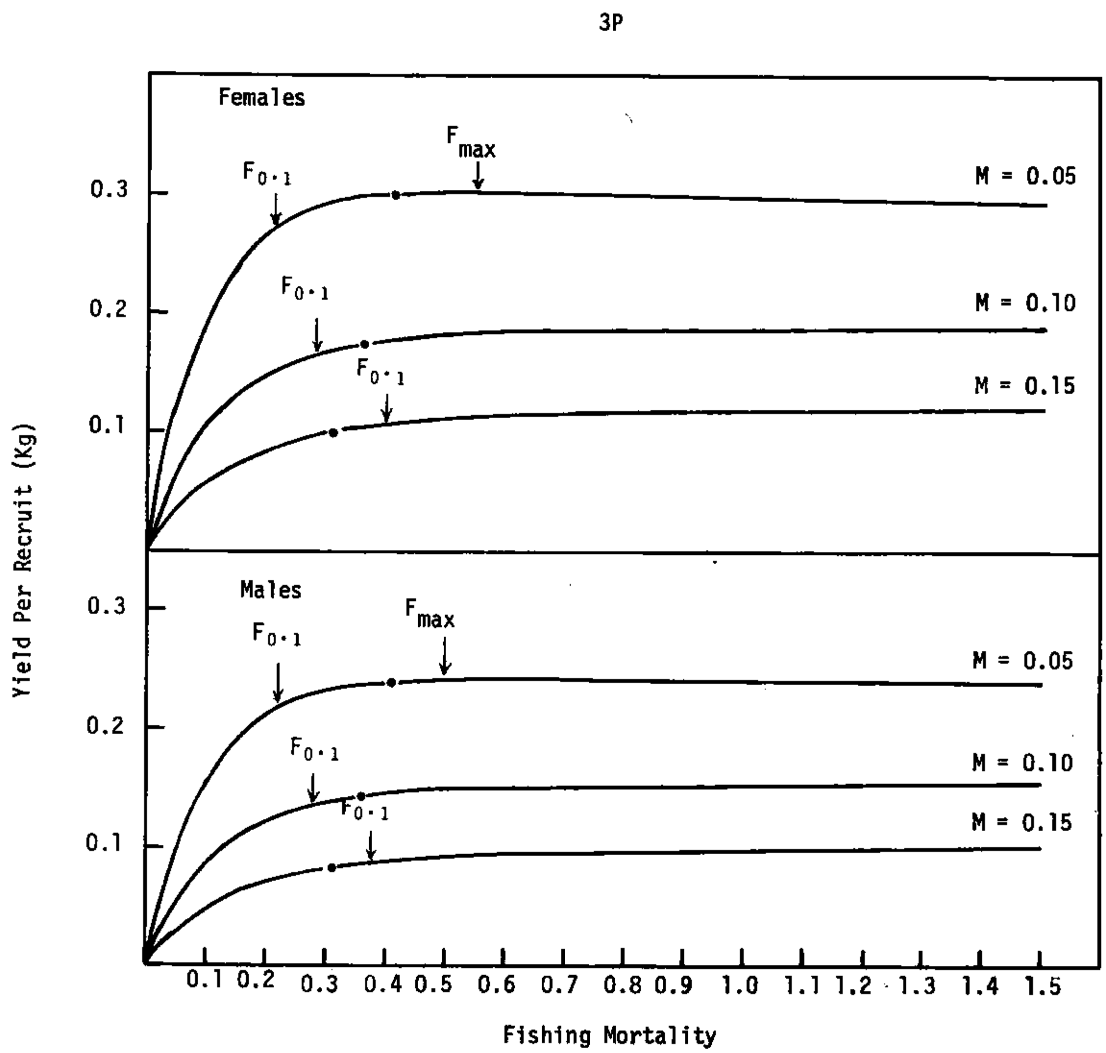

Fig. 2. Yield per recruit curves for male and female mentella redfish from Division 3P. Points on curves indicate fishing mortality estimates from 1973 commercial data.

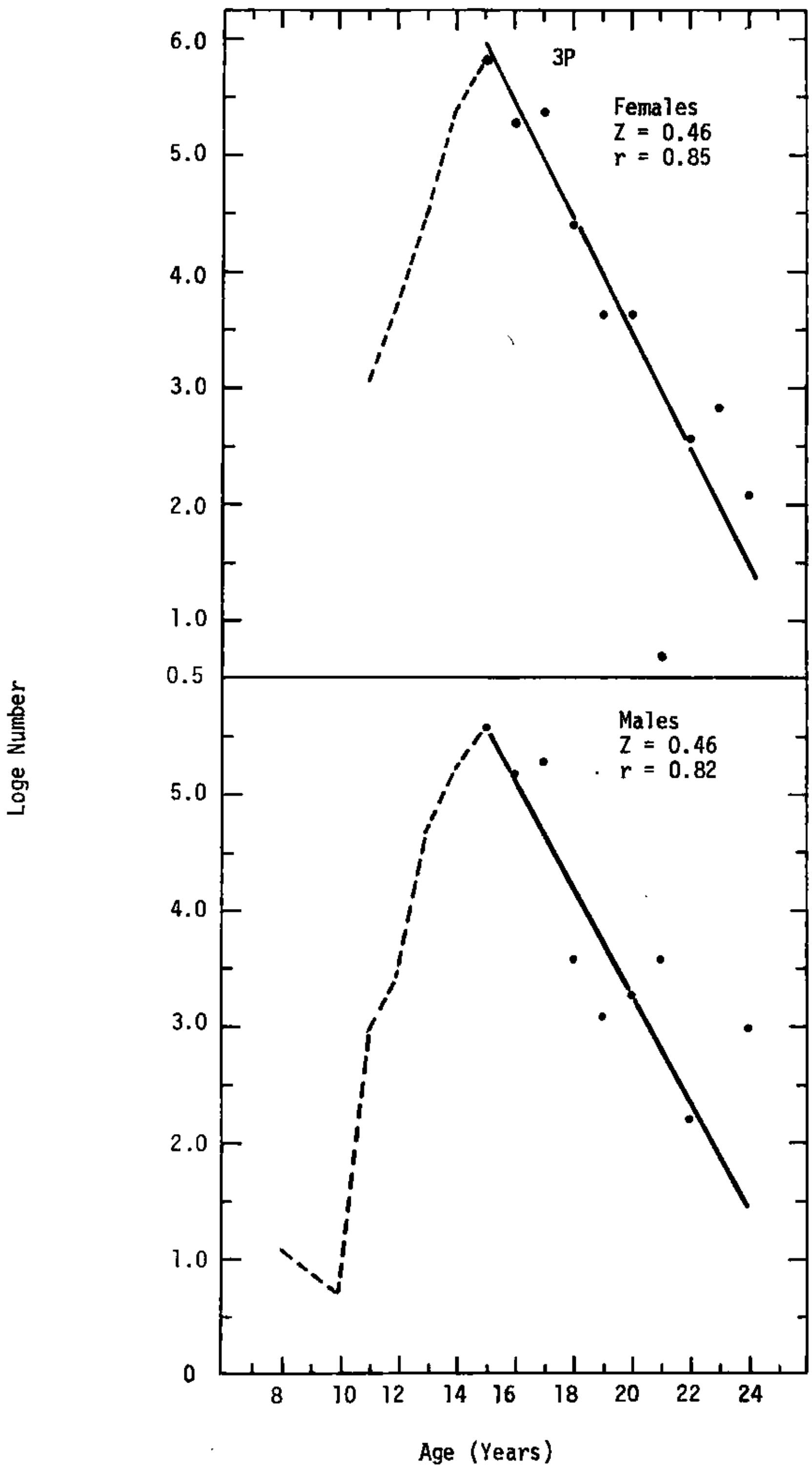

Fig. 3. Catch curves of Division 3P male and female redfish from 1973 commercial data.

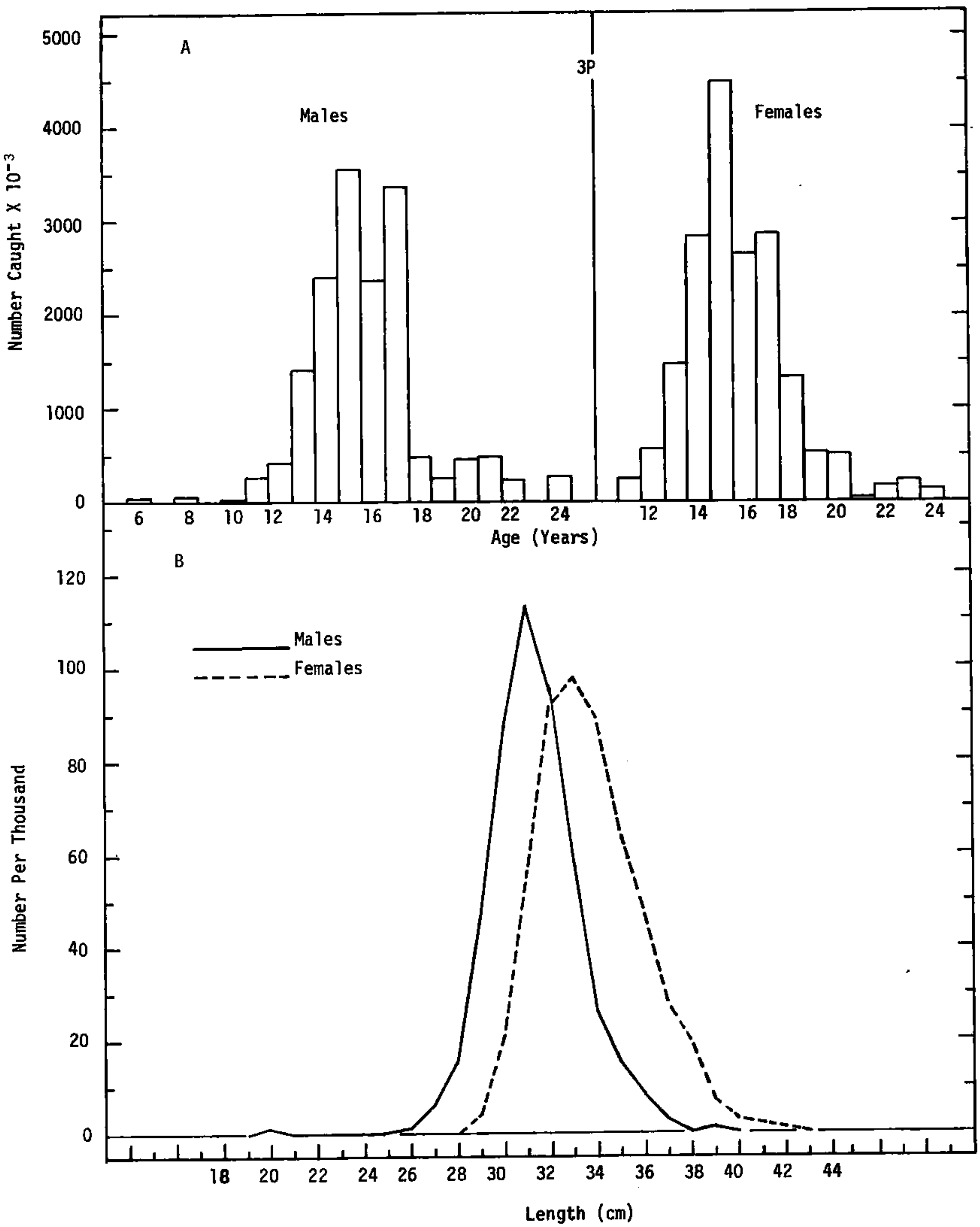

Fig. 4. Length and age distributions of the 1973 commercial catch from Division 3P.

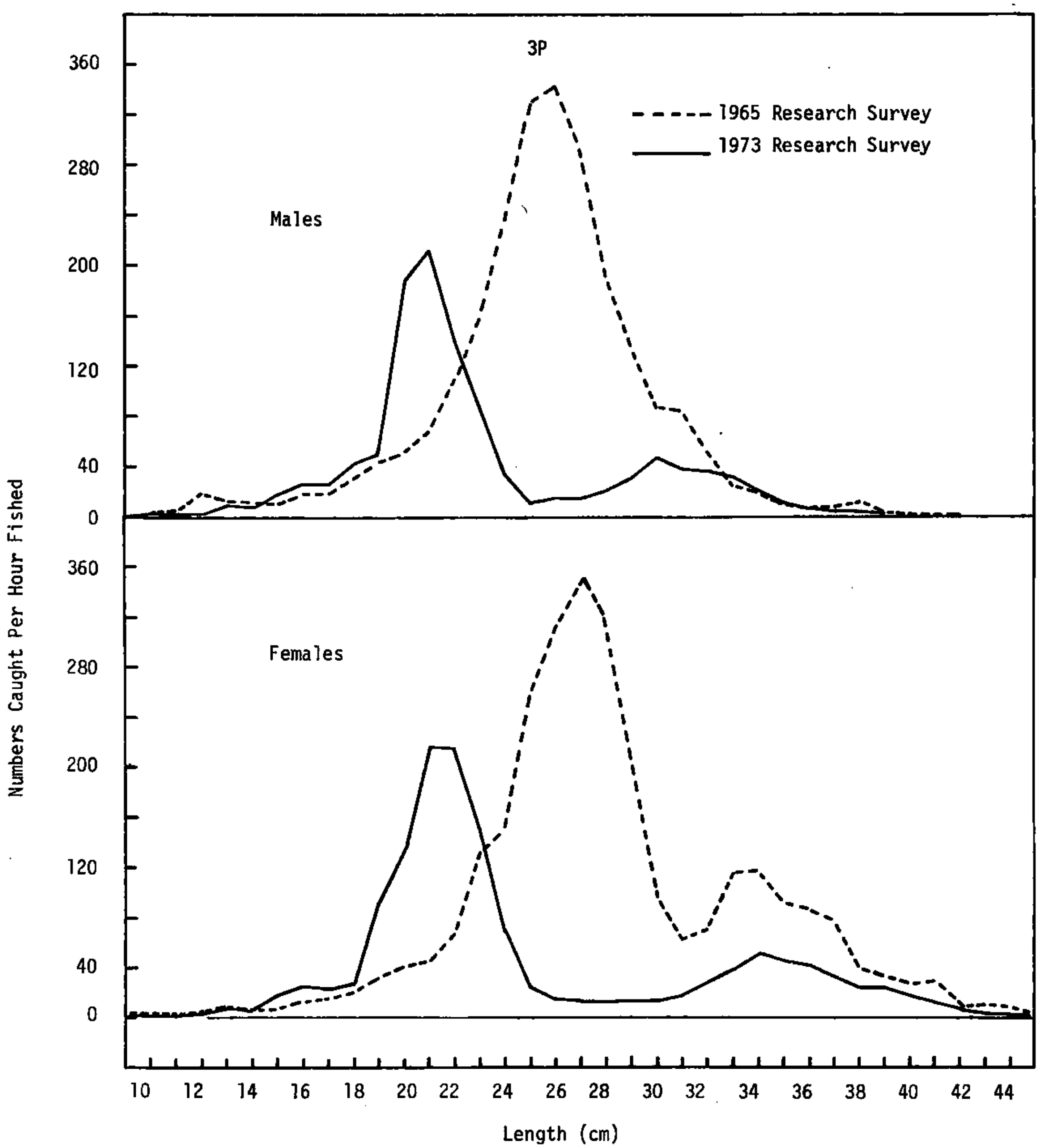

Fig. 5. Length distributions of mentella redfish taken in 1965 and 1973 research surveys of Division 3P by the A. T. Cameron.

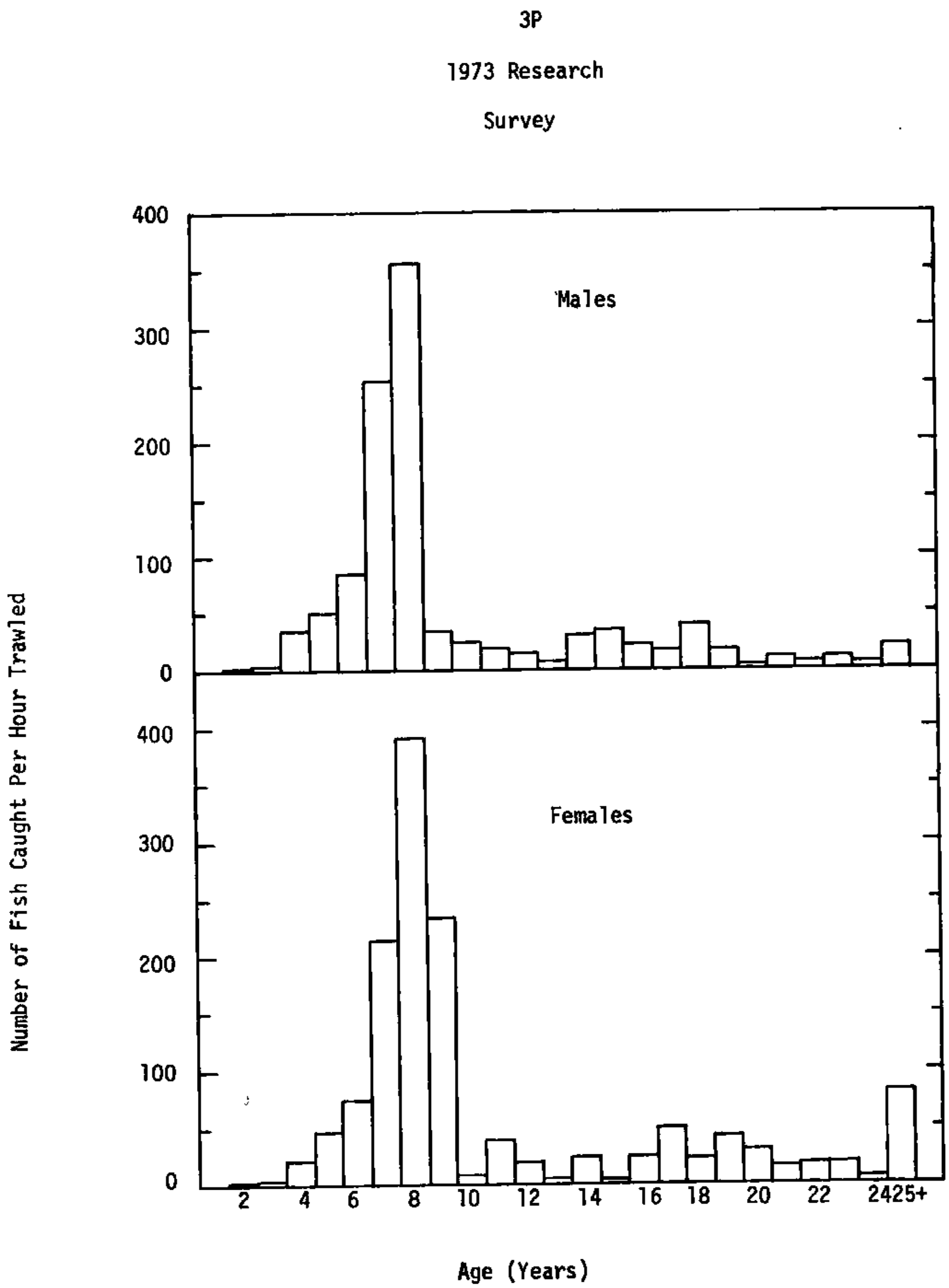

Fig. 6. Age distribution of mentella redfish taken in the 1973 research survey of Division 3P by the A. T. Cameron.

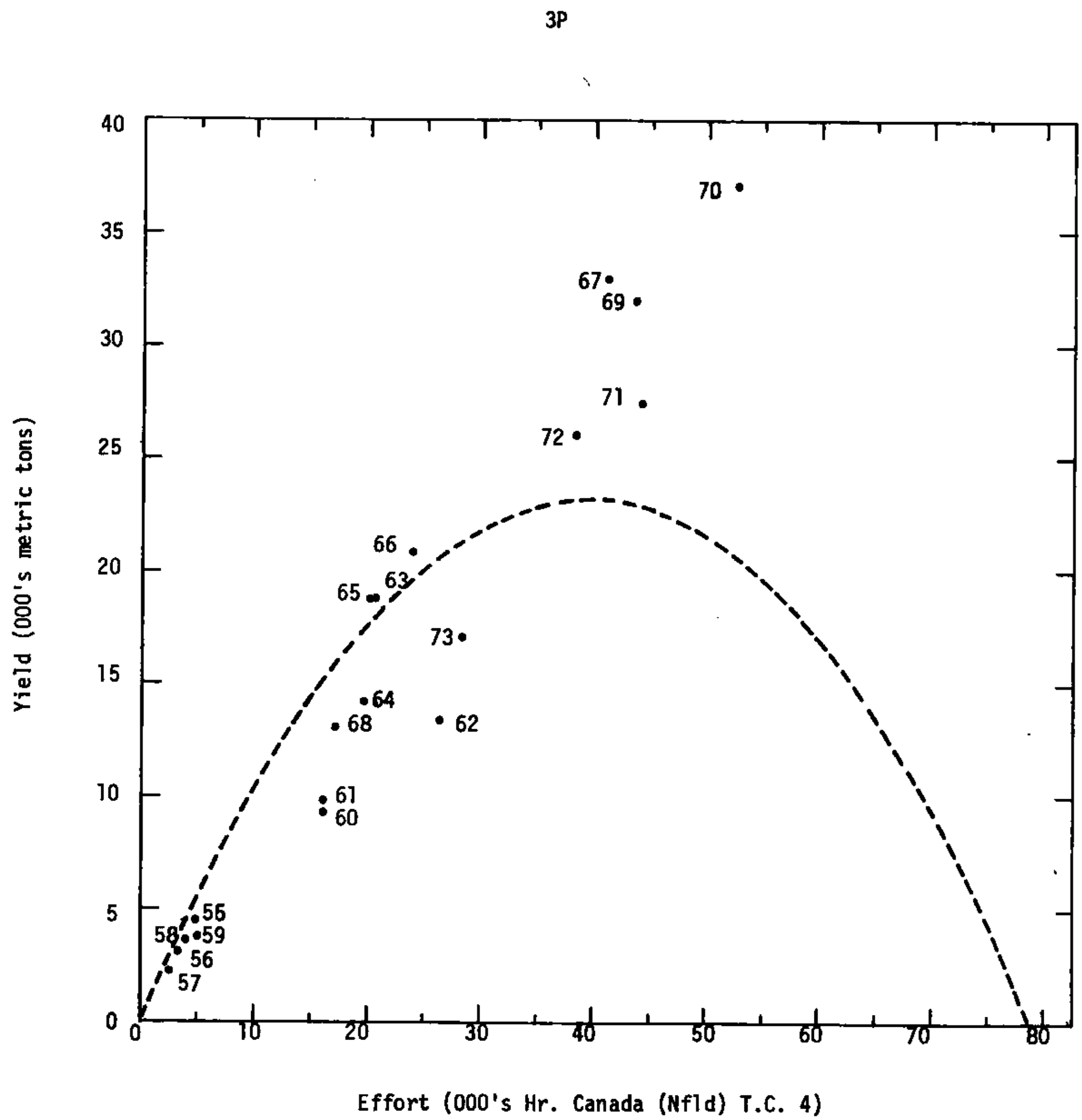

Fig. 7. General production yield curve for Division 3P redfish (from Parsons and Parsons, MS 1973, with 1972 and 1973 added).