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The Long-term Effects of Decreased Fishing Mortality on the Age/size Composition and Variability of Catch of Division 4VW Haddock

by

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Abstract

Yield per recruit analyses using maximum ages from 11 to 45 show that $F_{0.1}$ for 4VW haddock is not particularly sensitive to maximum age past age 18. Simulations of the population at F = 0.2 and F = 0.3 for 119 years using a random selection of observed recruitments show that average age and size of haddock in the catch would be expected to increase by about 10% and average population biomass by about 20%. Average catch would decrease by about 8%. There was no appreciable reduction in the interannual variability of the catch weight.

Résumé

Des analyses de rendement par recrue, utilisant les âges maxima de 11 à 45, démontrent que, dans le cas de l'aiglefin des div. 4VW, $F_{0,1}$ n'est pas particulièrement sensible à un âge maximum après l'âge 18. Selon des simulations de population à F = 0,2 et F = 0,3 pendant 119 ans, avec sélection aléatoire des recrutements observés, on pourrait s'attendre que la taille et l'âge moyens de l'aiglefin dans les prises augmenteront d'environ 10 %, et la biomasse moyenne de la population d'environ 20 %. Les prises moyennes diminueraient d'environ 8 %. Il n'y aurait pas diminution appréciable de la variabilité interannuelle des prises.

Introduction

In 1983 the method of calculating $F_{0.1}$ for haddock was changed. Instead of using ages 1-12 in the calculation of Y/R, ages 1-16 were used (Mahon et al., 1983). As a consequence $F_{0.1}$ was estimated to be 0.22 rather than 0.30. The resulting differences in TACs for 1983 and 1984 were:

	TAC ('000 t) 1983	1984
F = 0.30	14.2	16.6
F = 0.22	10.7	13.2
Projected in 1982	19.0	-

The expected long term consequences of the change were stated to be:

1) the mean age and weight of fish in the catch would increase; and

2) there would be more age classes in the fishery thus reducing interannual variability in catch caused by recruitment variability.

The change from a maximum age of 11 to one of 16 was based on the observation that haddock of age 16 had been recorded from the catch in past years (Mahon and White 1983). However the occurrence of fish of age 16 in the catch would suggest that there are fish which are older yet in the population.

In this analysis I consider first the relationship between $F_{0.1}$ and the number of ages included in the yield per recruit calculation, then attempt to estimate the extent to which the proposed benefits of the change in $F_{0.1}$ are likely to be realized.

Methods

Lengths at ages 1-45 were estimated from a Von Bertalanffy relationship fitted to the 1982 lengths-at-age 1-15 (K = 0.144, $L_{infinity}$ = 83.8 cm, t_0 = -1.48). Weights-at-age were estimated using the 1982 weight-length relationship, $W = 0.01202L^{2.958}$ (Mahon et al. 1983). A series of yield per recruit analyses were run for maximum ages of 11, 14, 16, 18, 20, 25, 30, 45.

Projections using ages 1-23 were run for 144 years at F = 0.2 and F = 0.3 and the first 25 years discarded. Input data were:

1) weights-at-age estimated as above; and

2) partial recruitment as per the 1983 assessment:

Age	1	2	3	4	5	6+
PR	0.03	0.05	0.17	0.43	0.68	1

3) number of recruits at age 1 in each year selected at random from the numbers at age 1 estimated by cohort analysis (F_t = 0.4) for 1970-81, and for 1982 as equal to the largest observed prior to 1980.

Results

Figure 1 shows the relationship between maximum age and $F_{0.1}$. The rate of change of $F_{0.1}$ is greatest between maximum ages of 11 and 20. The F values of 0.2 and 0.3 for the projections were chosen on the basis of this curve.

Figure 3 shows the recruitment vector used for both projections. Figure 2 indicates that there is a positive relationship between stock size and the number of recruits at age 1 in the following year.

The means and coefficients of variation for various stock and catch parameters are in Table 1. The trends in each of the parameters over the 119 year period are shown in Figures 4 and 5. The frequency distributions of values are in Figures 6 and 7. The average age composition of the catch under each regime is in Figure 8.

Trends in the population biomass (Figure 4) suggest that 119 years may not be a long enough simulation. This will be the case if there are cycles with periods which are long relative to the length of the simulation. The fact that the average stock biomass is significantly higher in the second half of the series than in the first half (95,996 t versus 84,749) suggests that this is the case here. This problem will be most severe when absolute mean values are being considered, but since the variation in this analysis is driven by the same recruitment series at each level of F, the comparisons should still be valid (see Appendix 1).

Discussion

The relationship between $F_{0.1}$ and maximum age used in the estimation of $F_{0.1}$ (Figure 1) shows that for 4VW haddock after age 18, $F_{0.1}$ is not particularly sensitive to the maximum age. Consequently, the inability to accurately estimate maximum age is not necessarily a problem in the estimation of $F_{0.1}$.

The decrease in variability in any of the parameters listed in Table 1 on decreasing fishing mortality from 0.3 to 0.2 was minor. Average age and weight in the catch did increase by about 10%. Average population biomass increased by about 20%. However, there was a decrease in catch of about 8%.

A further consideration is the possible compensatory effect of density-dependent reduction in growth rate as population biomass increases. Data presented by Mahon and White (1983) show substantial variation in size-at-age which may be related to population size. Pending further analysis of these data it is impossible to predict the consequences of increased population size on fish size-at-age.

One noteable feature displayed by the haddock population under the conditions of this simulation is its extreme variability. Catch biomass fluctuated widely between extremes of about 5,000 and 25,000 t. This is a consequence of the recruitment variability. Figure 2 suggests that "recruitment overfishing" of 4VW haddock had occurred in the mid 1970's when the stock was at its lowest. As the stock recovers, the average level of recruitment may increase leading to higher average catch and population size. However, since low recruitment appears to result from low stock size, recovery of the stock will generally be slower than in this simulation where a random high value of recruitment comes along every few years to "rescue" the stock, regardless of stock size.

References Cited

Mahon, R. and G.N. White 3rd. 1983 MS. The effects of temporal trends in size-at-age on $F_{0.1}$ for 4W haddock. CAFSAC Res. Doc. 83/48. 21 p.

Mahon, R., P. Simpson, and D.E. Waldron. 1983 MS. Eastern Scotian Shelf haddock: stock status in 1982 and projections to 1984. CAFSAC Res. Doc. 83/47. 41 p.

Appendix 1

G. White (MFD, BIO, pers. comm.) has found a strong cyclical component with a period of about 50 years in a similar simulation of 4X haddock. This suggests that a simulation for about 1000 years would be necessary to provide an adequate record for detailed analysis. Specialized software for this type of analysis is being prepared by G. White. A trial run with this software gave coefficients of variation of 0.28 and 0.30 at F = 0.2 and 0.3 respectively for population biomass over a period of 1000 years using 16 ages. These are similar to the values found in this study, which indicates that the 119 years record was sufficient for these preliminary analysis.

Table 1. Mean and coefficient of variation in various parameters over 119 year projections at F = 0.2 and F = 0.3.

	F = 0.20	F = 0.30
Catch biomass	12419 (.296)	13506 (.317)
Population biomass	109723 (.278)	90582 (.295)
Average age in catch	6.19 (.082)	5.61 (.081)
Average weight in catch	1.76 (.101)	1.57 (.103)

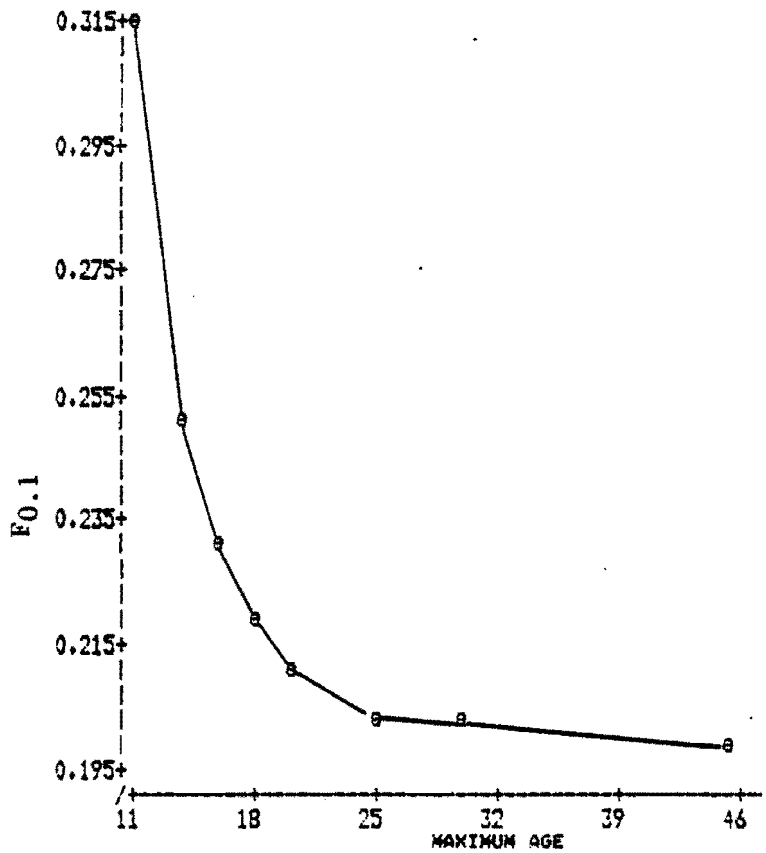


Figure 1. The relationship between $F_{0.1}$ and the maximum age used in the calculations.

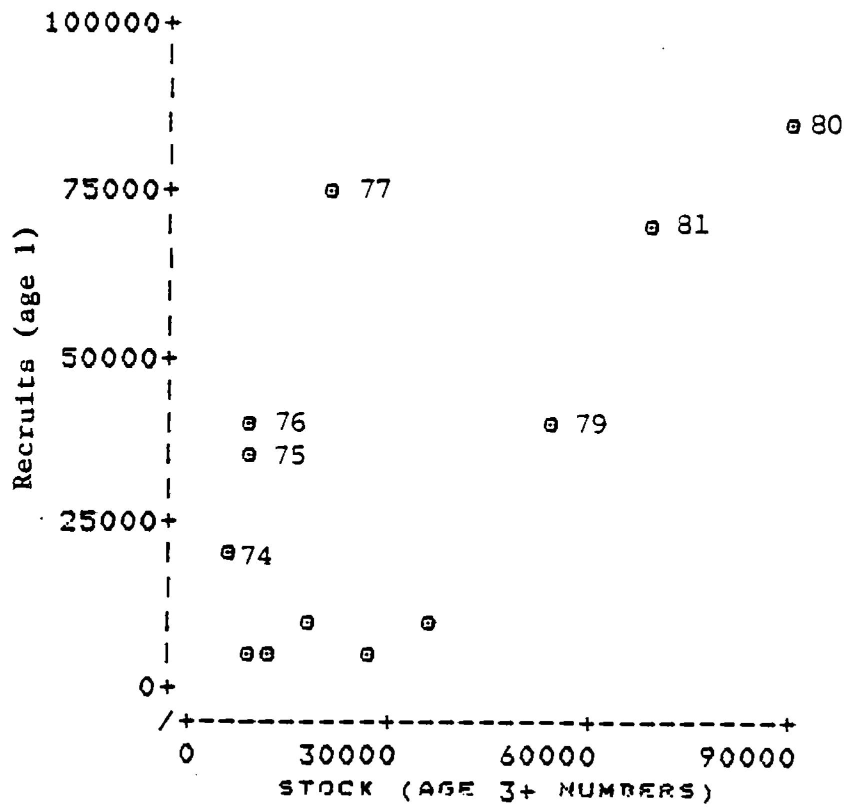


Figure 2. The relationship between adult stock and number of recruits the following year

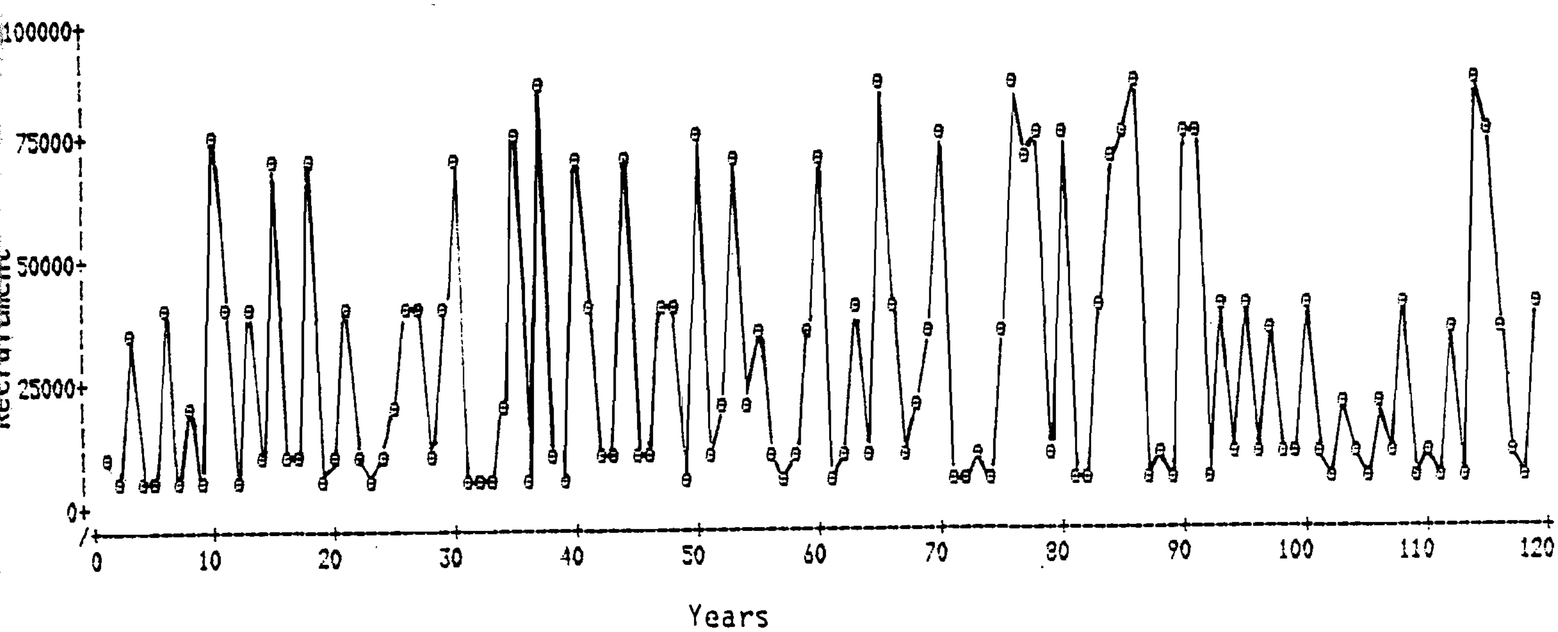


Figure 3. The vector of recruitments in random order used in the projections

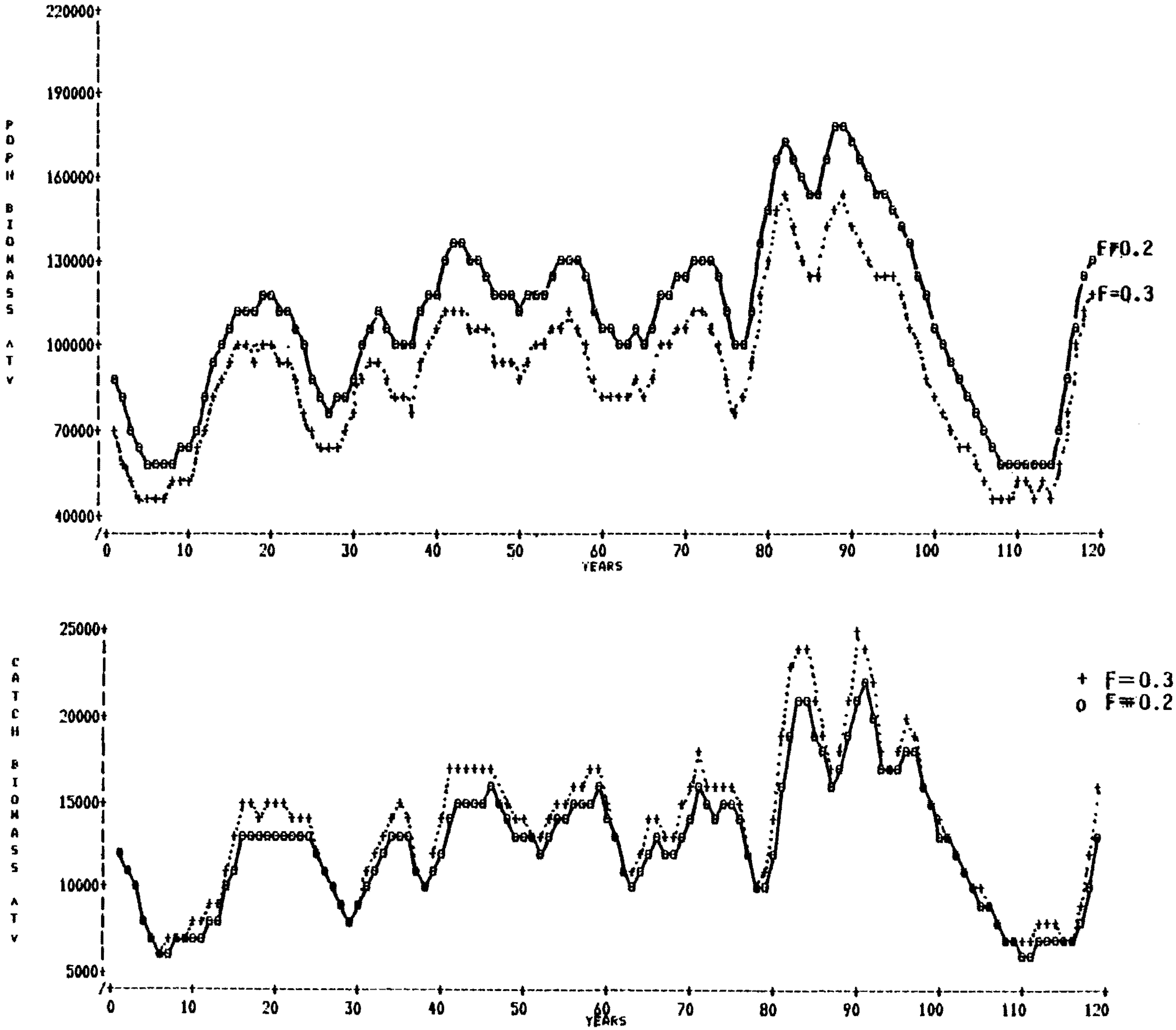


Figure 4. Trends in projected population and catch biomass

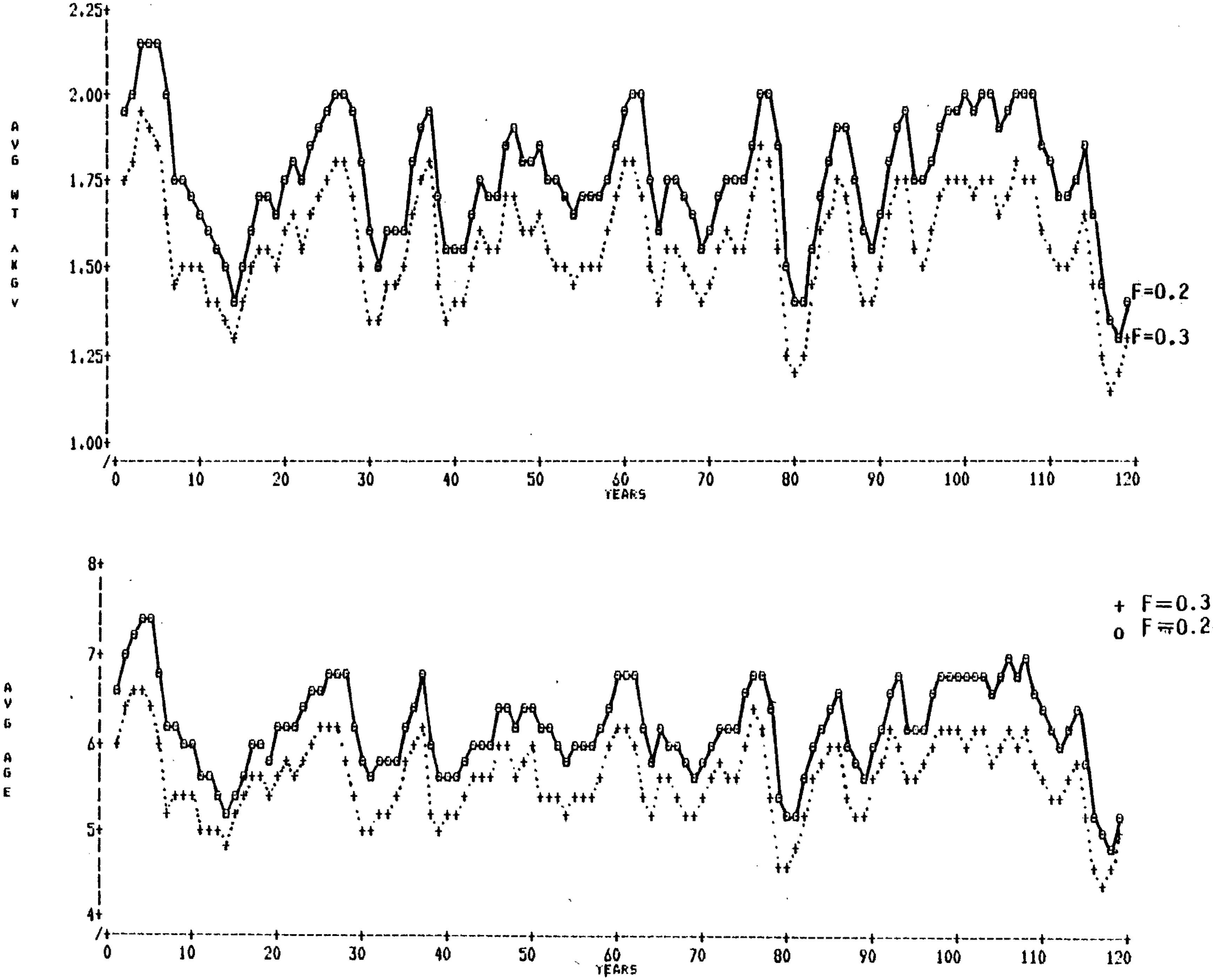
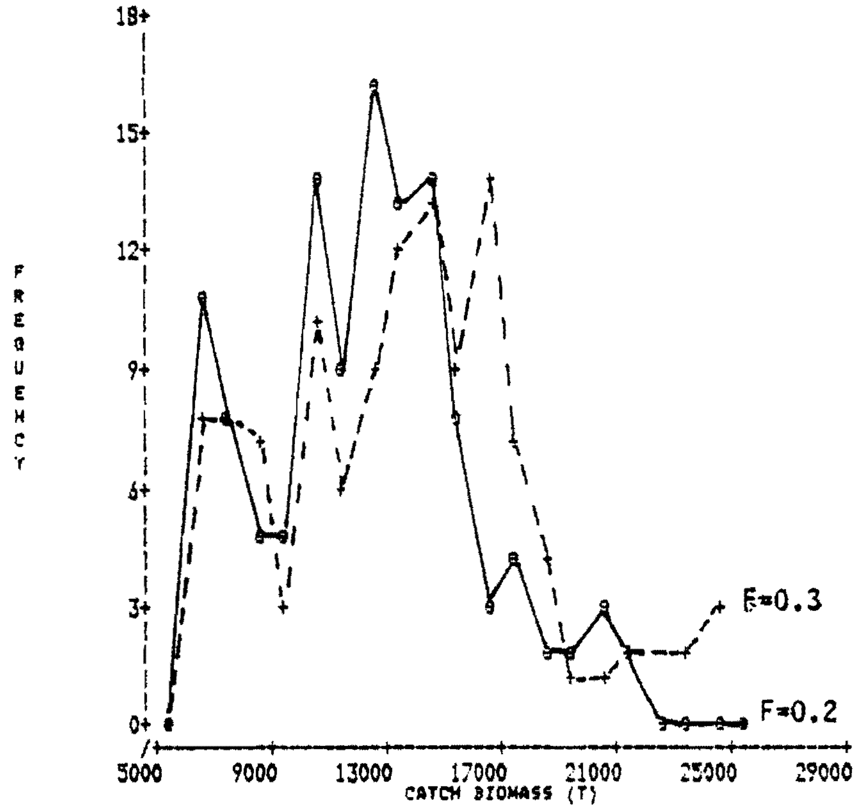


Figure 5. Trends in projected average weight and age of fish in the catch



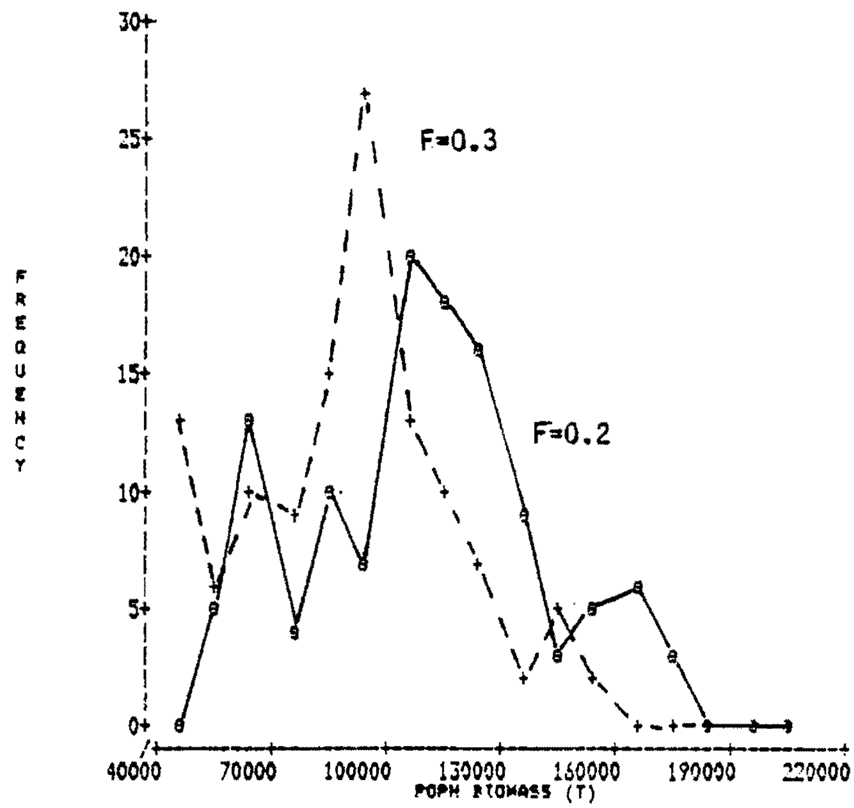


Figure 6. Frequency of occurrence of catch and population biomasses in the projections

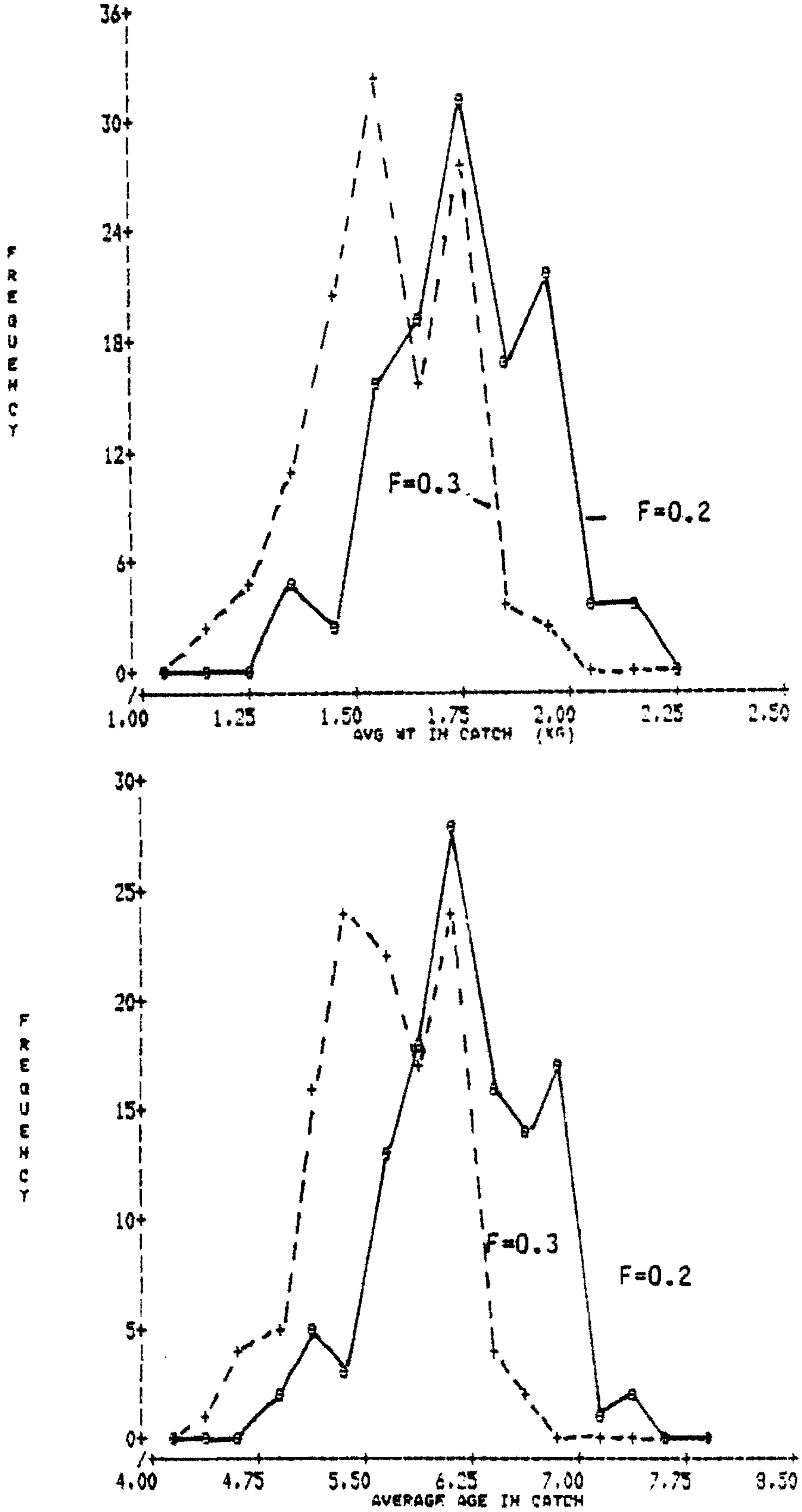


Figure 7. Frequency of occurrence of average weights and average ages in the projected catch

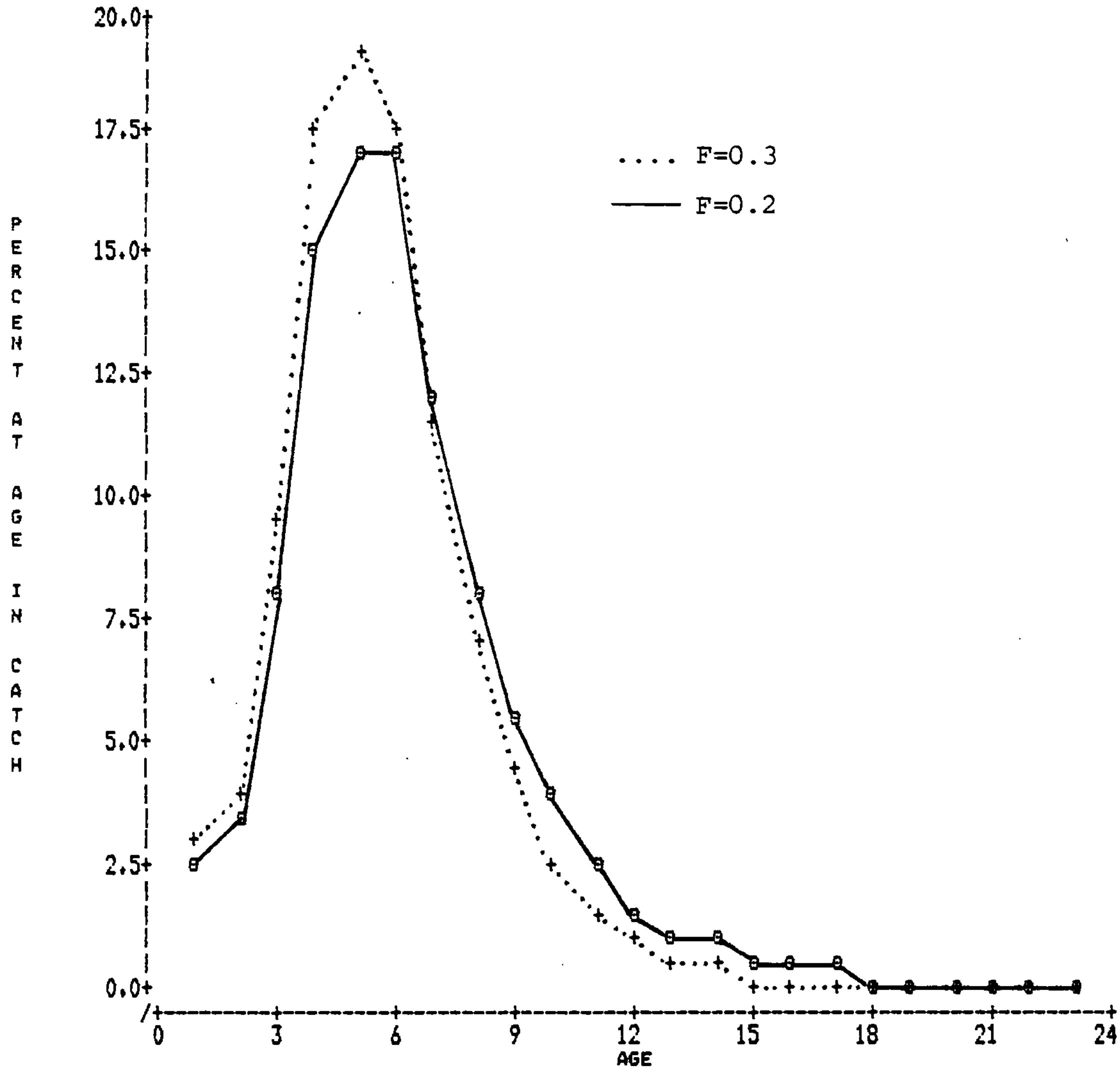


Figure 8. Average age structure of the projected catch