

Assessment of the cod stock in Subdivision 3Pn
and divisions 4R and 4S

by

Stratis Gavaris
Research and Resource Services
Department of Fisheries and Oceans
Northwest Atlantic Fisheries Center
P. O. Box 5667
St. John's, Newfoundland
A1C 5X1

Abstract

Catch rates were standardized using a multiplicative model. Estimates of effort derived from the standardized catch rates were used with the reported catch to solve the non-equilibrium surplus production model. The results indicated that the stock was approaching equilibrium at the MSY level. The average equilibrium yield at $2/3$ effort MSY is 73,867 t.

Résumé

Les taux de capture ont été normalisés à l'aide d'un modèle multiplicateur. Les estimations de l'effort déduites des taux de capture normalisés ont été utilisées parallèlement aux captures signalées afin de résoudre le modèle de production excédentaire en condition de non-équilibre. Les résultats indiquent que le stock approche l'équilibre au niveau du RMS. Le rendement d'équilibre moyen correspondant aux $2/3$ de l'effort du RMS est de 73,867 t.

Cod directed catch and effort data from 1959-77 were obtained from ICNAF records, information for 1978 came from the STATLANT reports, and the Economics Branch provided data for Newfoundland vessels in 1979-80. A multiplicative model (Gavaris 1980) was applied in order to incorporate as much of the data as possible in determining standardized catch rates and effort. Each of the data points was weighted according to $(\text{CATCH} \times \text{EFFORT})^{0.5}$.

Results from the regression indicated that not all of the categories of country-gear types and months were distinct therefore they were combined and the regression was performed again. The model accounted for 90% of the variation in the data (Table 1). Although the data failed to satisfy the normality assumptions, as determined by using the Kolmogorov-Smirnov test, examination of the residuals showed that this may have been due to a few stray points. The standards selected were, for years, CanM OT-4 and CanN OT-5, for months January and February and for Div. 4R. The estimated catch rates for 1959-80 are presented in Fig. 1. The estimate of effort is listed in Table 2 along with the catch and estimated catch rate.

The catch and standardized effort were subsequently used to obtain estimates for the parameters of the generalized stock production model (Fletcher 1978; Rivard and Bledsoe 1978). As can be seen from Fig. 2 the residuals are not independent of each other. This is to be expected since the influence of each cohort extends over several years. However, Rivard and Bledsoe (1978) report that "serial correlation can be safely ignored when the ratio $(r-p)/r$ is near unity". In their example the ratio was 0.85 and here it is 0.77.

The results of the analysis suggest that in 1959 the stock was still in a relatively virgin state (Fig. 3). Considering that the otter trawl fishery only began in the late 50's (Wiles and May 1968) this does not seem unreasonable. Subsequent fishing intensity fluctuated about the MSY effort level gradually reducing the stock biomass to its MSY value (Fig. 4 and Fig. 5). It appears that in the last few years the stock may be approaching equilibrium. The MSY for this stock was estimated at 83,080 t. The average sustainable yield at 2/3 effort MSY, is 73,867 t. The non-equilibrium catch for 1981 predicted by the model, at 2/3 effort MSY is 59,766 t. As can be seen from the poor fit in 1981 (Fig. 2), this last value may be too low.

References

- Fletcher, R. I. 1978. Time-independent solutions and efficient parameters for stock production models. *Fish. Bull.* 76: 377-388.
- Gavaris, S. 1980. Assessment of the cod stock in Div. 3M. NAFO Res. Doc. 80/II/25, Ser. No. 57.
- Rivard, D. and L. J. Bledsoe. 1978. Parameter estimation for the Pella-Tomlinson stock production model under non-equilibrium conditions. *Fish. Bull.* 76: 523-534.
- Wiles, A. and A. W. May. 1968. Biology and fishery of the West Newfoundland cod stock. *ICNAF Res. Bull.* 5: 5-43.

Addendum

There were several errors discovered in the data reported for 1978. Indications are that catch rates were higher than reported here. This change would improve the fit to the model and further strengthen the argument that the stock is approaching equilibrium.

Table 1. Analysis of variance for the cod stock in Subdivision 3Pn and Divisions 4R and 4S.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... 0.949
 MULTIPLE R SQUARED..... 0.901

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
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TYPE 1	7	2.18290E2	3.11843E1	218.987
TYPE 2	9	6.69524E1	7.43915E0	52.240
TYPE 3	2	6.18872E0	3.09436E0	21.729
TYPE 4	21	7.55997E1	3.59998E0	25.280
REGRESSION	39	1.82870E3	4.68899E1	329.277
RESIDUALS	1396	1.98793E2	1.42402E-1	
TOTAL	1435	2.02750E3		

Table 2. Historical catch and estimated catch rate and effort using the specified standards.

YEAR	CATCH	CATCH RATE		EFFORT
		MEAN	STD ER	
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1959	58060	1.513	0.234	38374
1960	94350	1.317	0.091	71640
1961	100010	1.744	0.096	57345
1962	91682	1.576	0.107	58173
1963	76151	2.037	0.159	37383
1964	84234	1.950	0.141	43196
1965	68929	1.726	0.126	39935
1966	65085	1.614	0.109	40325
1967	79312	1.315	0.082	60313
1968	89671	1.621	0.099	55318
1969	71140	1.447	0.087	49163
1970	106736	1.417	0.073	75325
1971	84310	1.078	0.057	78209
1972	57062	1.194	0.072	47790
1973	66489	0.911	0.054	72984
1974	66428	1.016	0.057	65381
1975	60215	0.863	0.053	69693
1976	76981	0.946	0.054	81375
1977	73566	1.023	0.051	71912
1978*	70089	0.632	0.042	110900
1979*	89697	1.276	0.080	70295
1980*	75000	1.490	0.123	50335

*Preliminary

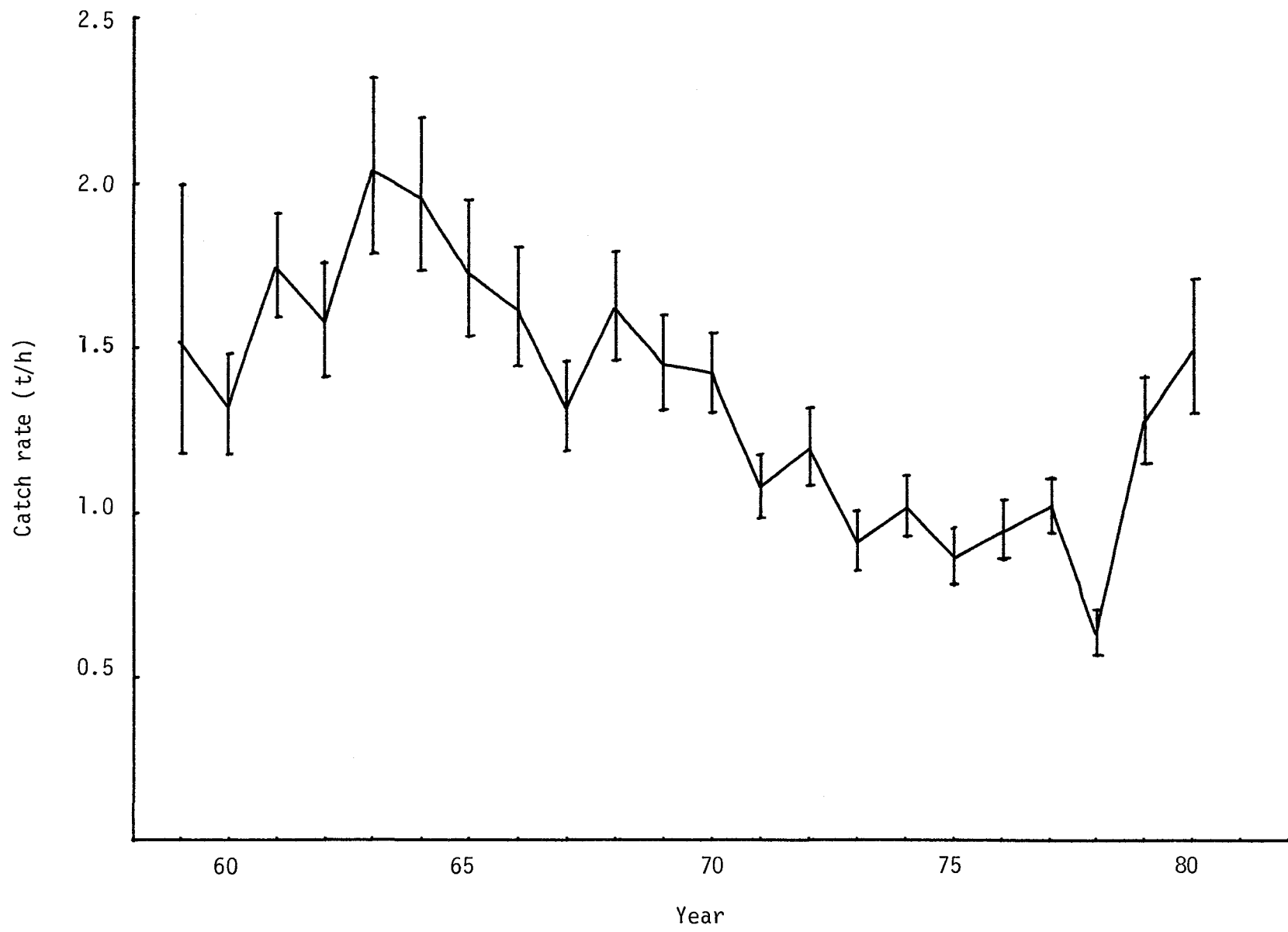


Fig. 1. Standardized catch rate and approximate 90% confidence intervals for the mean. The standards used were CanN OT-5 and CanM OT-4 during January and February in Division 4R.

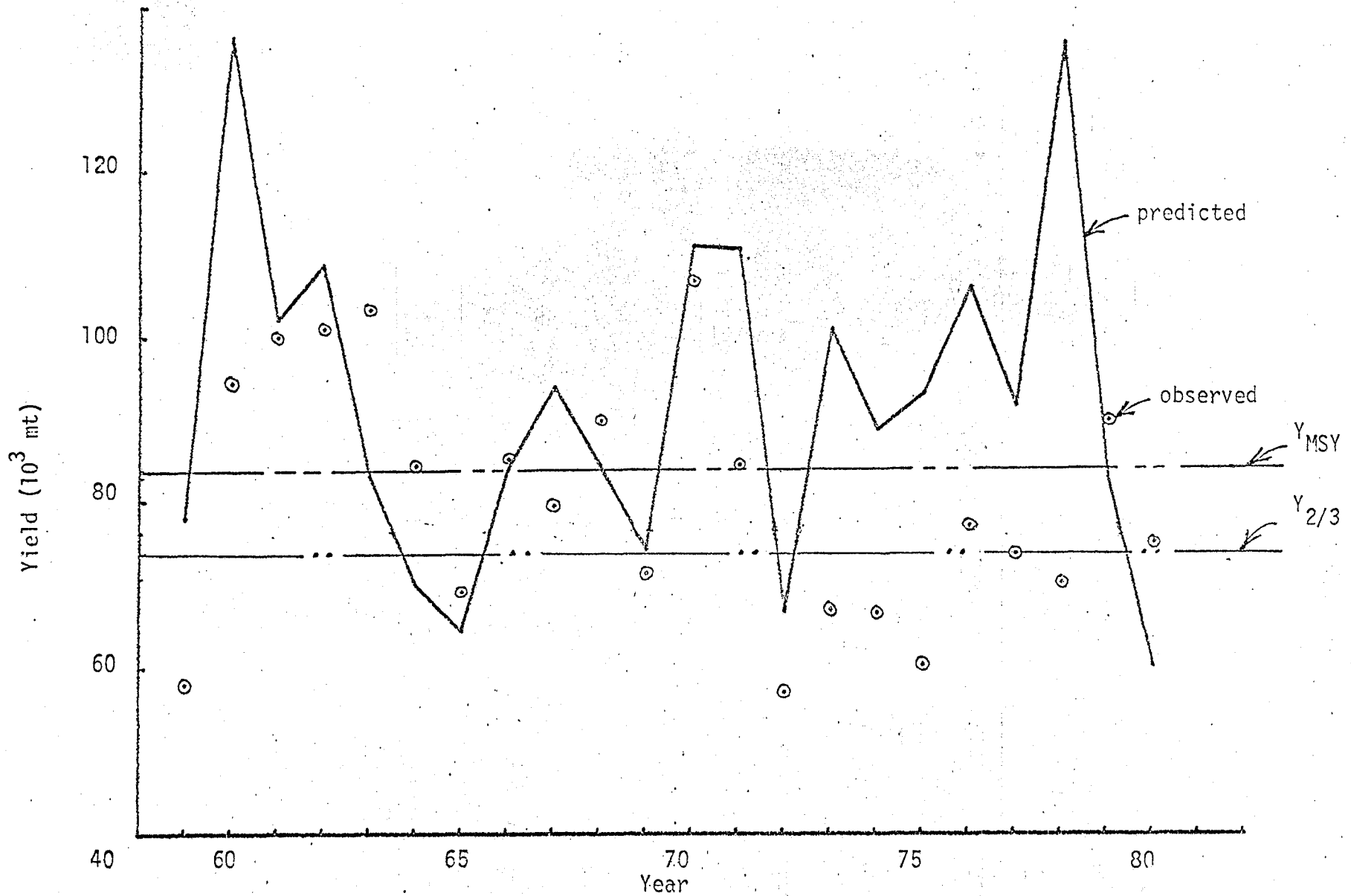


Fig. 2. Observed and predicted values of the dependent variable, yield. The yield at MSY and at 2/3 effort MSY are indicated.

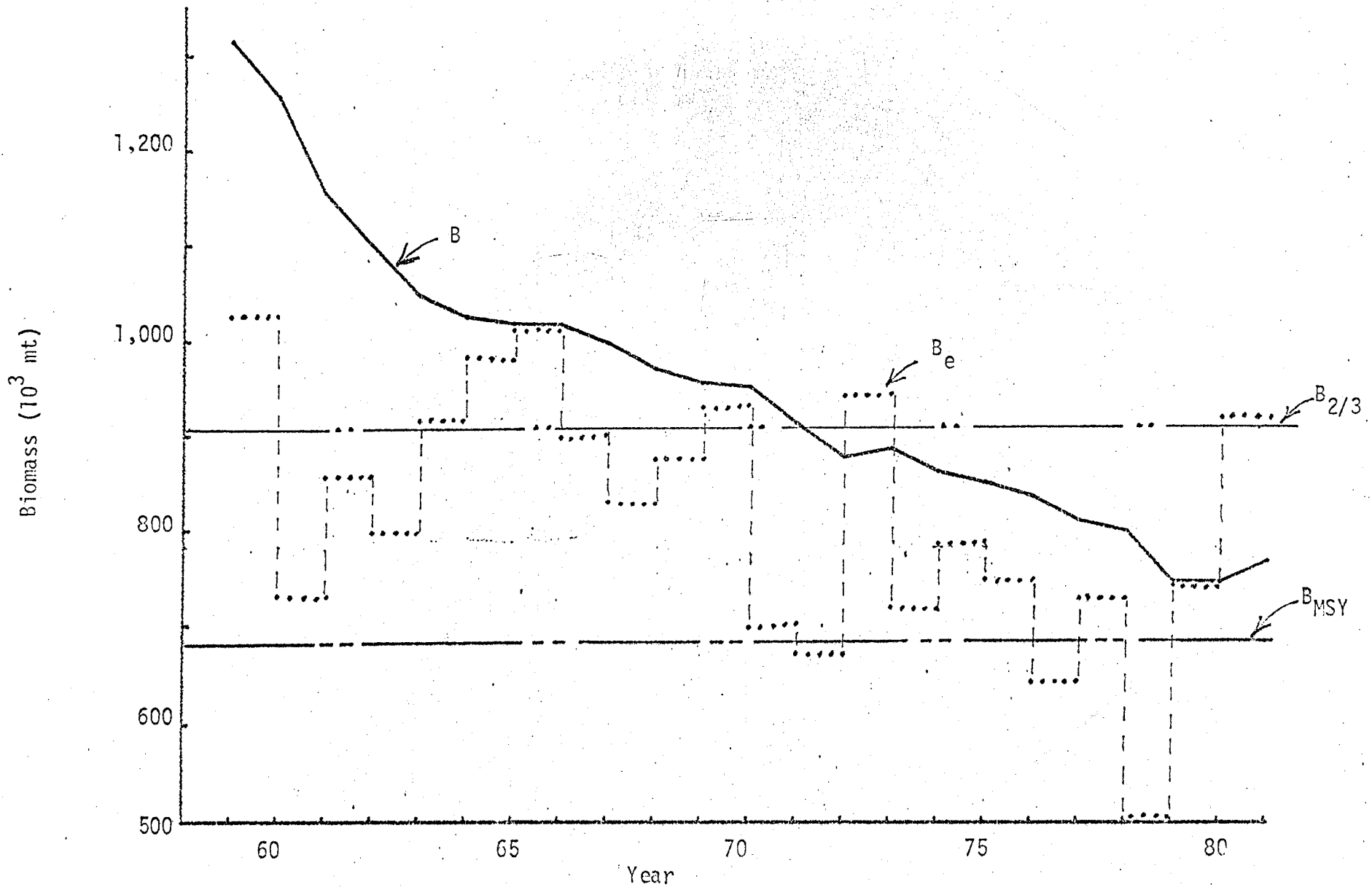


Fig. 3. The biomass at the beginning of each year, B , and the equilibrium biomass, B_e , for the level of fishing mortality occurring are shown along with the equilibrium biomasses at MSY and at 2/3 effort MSY.

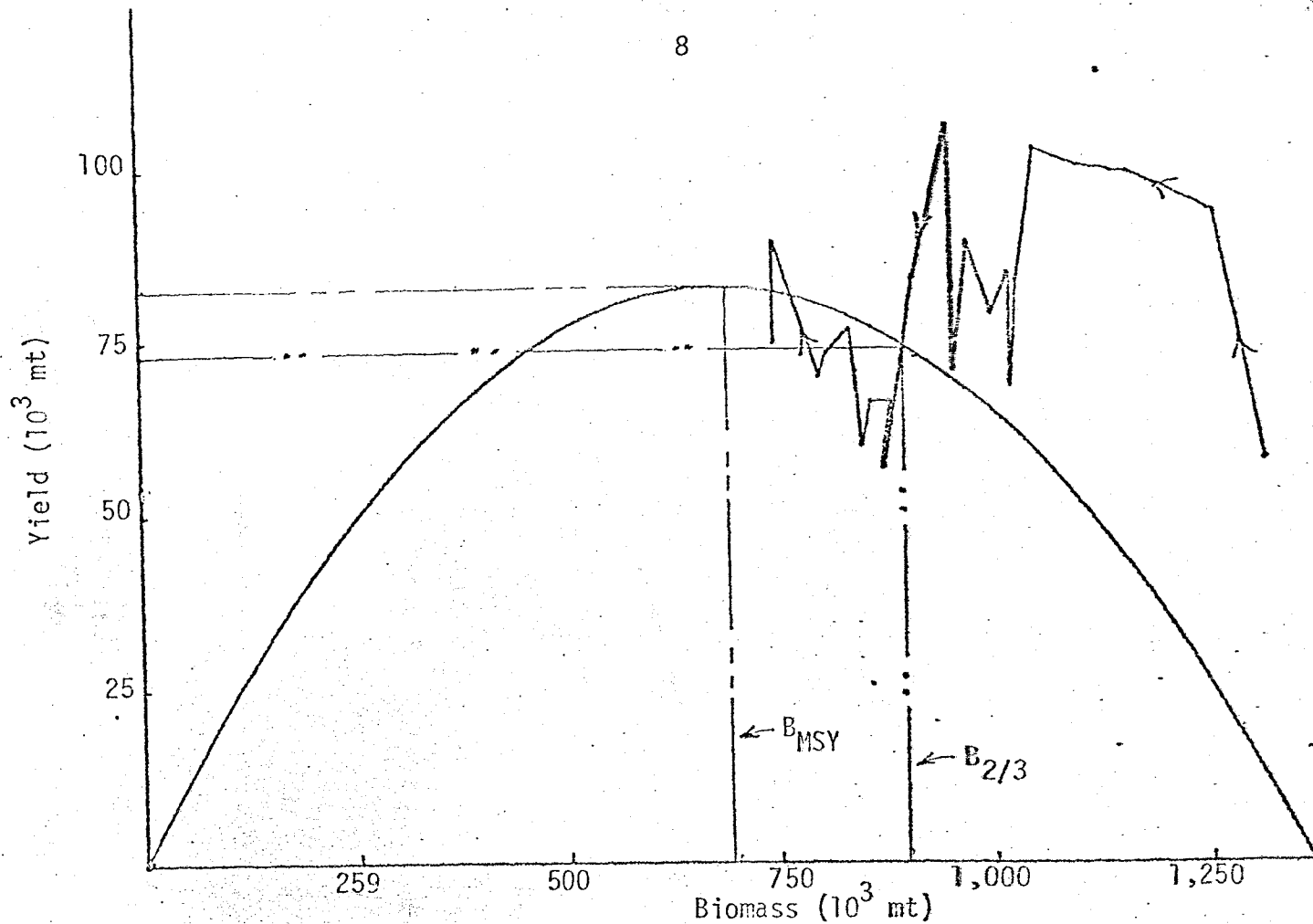


Fig. 4. Equilibrium yield vs biomass.

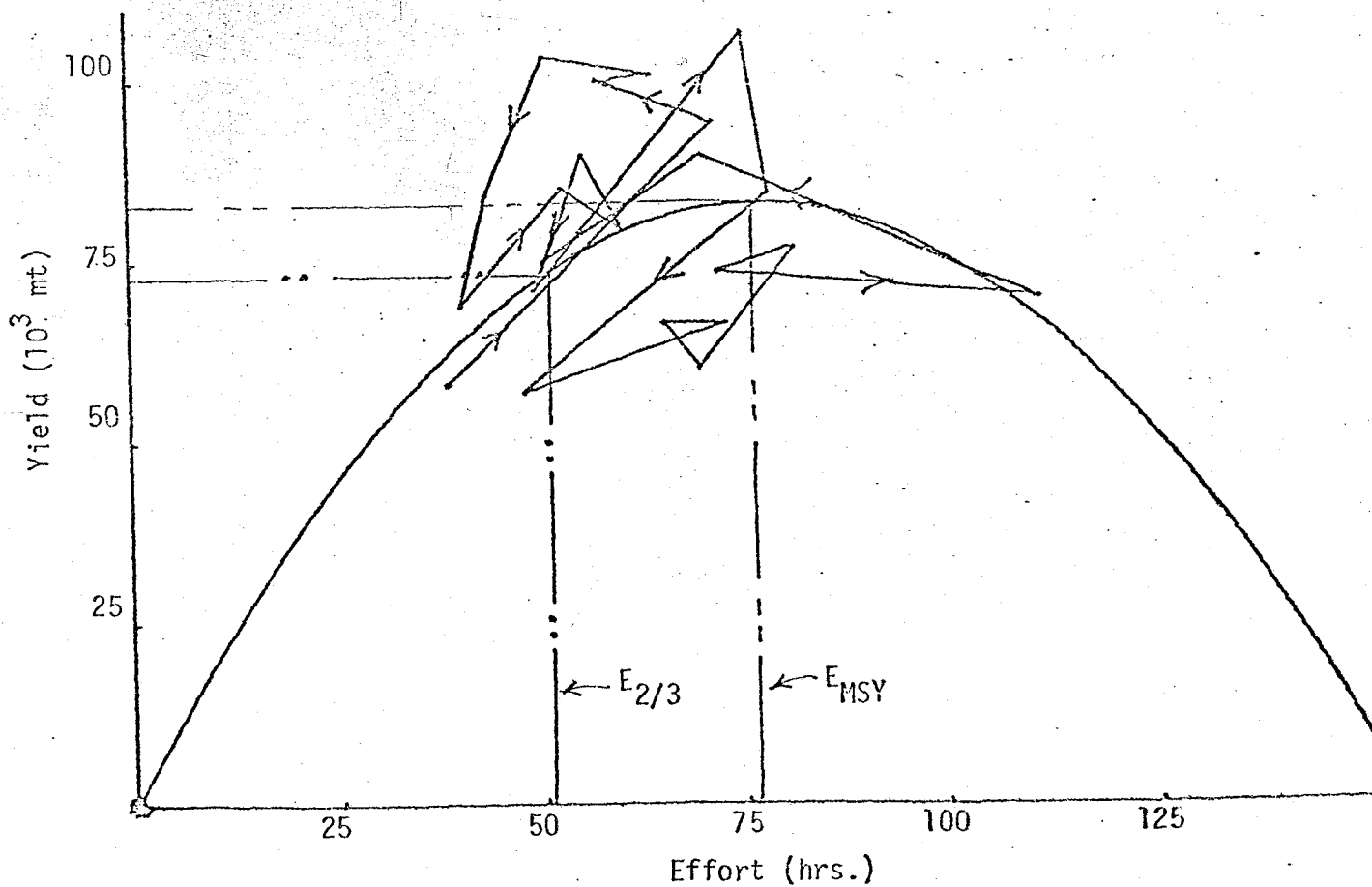


Fig. 5. Equilibrium yield vs effort.