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Trends in the Population of 3M Cod and Biological Reference Points: an Approach Using Survey Data

by

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Abstract

In the present work fluctuations in the recruitment and biomass survey indices of the 3M cod stock are followed from 1978 to 1990, using standardized data collected during three different series of campaigns held in Flemish Cap. All the stock components have been declining during the time period of this study, and were at a depressed level in 1990.

Biological reference points of F_{low}, F_{med} and F_{high} were estimated to be at 0.1, 0.5 and 0.9 respectively. The critical size of the spawning stock biomass should be between 24,500 tons and 30,700 tons, although its present value, given by the July 1990 EEC survey, is of 21,662 tons.

Introduction

During the last decade, namely after a moratorium was approved in 1987 to the 3M cod fishery, the Fisheries Commission has asked several time for the Scientific Council to comment on the appropriateness of establishing a minimum target biomass for the Flemish Cap cod stock, above which the reopening of this fishery could be reconsidered. In 1990 the Scientific Council redefined this question stating that "establishing a minimum level for the exploitable biomass was not an appropriate target to judge the status of a stock, while spawning biomass is the relevant variable to take into account" (NAFO Sci. Coun. Rep.,1990).

In the 1990 June Meeting of the Scientific Council two working papers were presented, with the purpose of gathering the available data related to the assessment of this stock and doing a preliminary analysis of its contents (Serchuk, 1990; Cardenás and Ávila de Melo, 1990).

Those data came from three distinct sources: research surveys (1978-1990), a Faroese longline CPUE series (Reinert, 1990) and the VPA's results (Wells, 1980; Wells, Borges and Vázquez, 1984).

Cardenás and Ávila de Melo (1991) suggested that, for this cod stock, no mixing should be made between the analysis of data taken from the commercial catches and data from surveys and/or sampling data directed collected on board, since the first type of data seemed to be strongly biased, due to a lack of reliability in the basic information, mainly the catch levels declared.

In the present work an attempt is made to detect the trends of the components of the Flemish Cap cod stock along the eighties up to 1990, based on survey data, as well as to contribute to answer the Fisheries Commission question, as it was redefined by the Scientific Council.

Materials and Methods

Three series of surveys occurred in the Flemish Cap since 1977: a Canadian bottom trawl series from 1977 to 1985; a Soviet bottom trawl/acoustic series since 1983 and an EEC bottom trawl series starting in 1988 and also still on the run.

Trawlable abundances and mean lengths at age have been made available for the three series of surveys (Kuzmin, 1990; Vazquez, 1989, 1990 and 1991; Wells, 1983 and 1986; Wells and Baird, 1985). Age compositions and mean lengths at age for the Soviet surveys have been kindly provided by Dr. Rikhter. The Hodder (1964) length weight equation was then used to get the mean weights at age, and abundances were transformed in biomass at age.

For each year and series, total, exploited and spawning biomass were finally estimated assuming a mean age of maturity for both sexes of 5 years old (Kuzmin, 1990) (Tables 1, 2 and 3).

With these parameters and the annual recruitment (abundance of age 3), the Canadian and EEC series of data were standardized to Soviet "units", using a conversion factor between the indices of the Canadian and Soviet surveys and another one between the European and Soviet indices:

$$\text{Factor} = \frac{\sum Vi}{\sum Si}$$

where

i - overlapping year between the two series
Si - total Soviet biomass
Vi - total biomass of the series to be transformed

To all computations total biomass indices were used, since some discrepancy was detected between the series when data by age classes were compared, probably due to different criteria in otolith readings.

From the three series standardized this way to Soviet units an unique series was obtained, by averaging the indices in the overlapping years. This last series was then normalized to be graphically represented (Table 4).

To get a better picture of what is going on with this stock since the late seventies, the total (1+), exploitable (3+) and spawning stock biomass (SSB) indices were put in the same figure together with the CPUE longline Faroese values, to check if they followed similar trends (Fig. 1); on the other hand recruitments were plotted with SSB's along the studied period (Fig. 2).

The slopes corresponding to the biological points of reference were estimated by plotting the SSB indices against recruitments, given by the abundances of the age class 3, three years later (Fig. 3).

In the computation of the yield per recruit and SSB per recruit curves (Fig. 4), the partial recruitment vector was obtained by comparing the age composition of the July 1989 commercial stern trawl catches of 3M cod with the one from the EEC survey, done in the same month and year (Table 5). For the same purpose, mean lengths at age were obtained through the results of the EEC surveys from 1988 to 1989 (Vazquez, 1989 and 1990), and converted to mean weights at age using the Hodder (1964) length/weight equation.

Results and Discussion

From Fig. 1 it can be observed that the 1+, 3+ and SSB indices suffered a drop from 1978 to the 1979/81 period, followed by a second (smaller) decline to the 1982/86 period. The 1987 and 1988 years recorded the lowest values of the series. A downward trend can also be seen in the Faroese longline CPUE series, although the values prior to 1976 seemed to fluctuate within the same range of the period 1980/85.

Recruitment fluctuates rather freely from the size of the parental spawning biomass (Fig. 2), with two of the three years recording the largest values of biomass of spawners in the series producing the lowest number of recruits (1978 and 1979).

In Fig. 3 are presented the recruitment/SSB lines for the biological levels of reference. If we draw a parallel to the x axis which would leave the two highest recruitments of the series above it, this parallel would intercept the F_{high} line in a point corresponding to biomass of spawners between 8,000 tons and 10,000 tons (Soviet units). From that point to the left, the probability of having a good recruitment (above the mentioned parallel) with a SSB below the 8,000 tons/10,000 tons (Soviet units) level, is no greater than 10%. The biomass of spawners has been increasing since 1988, where its minimum value was recorded, representing in 1990 about 46% of the total biomass and with an estimated standardized value, from the EEC survey, of 7,048 tons. The main reason for this increase was the partial entry of the 1985 year-class (the second largest year-class for the 1988-1990 period) in the spawning component of the stock in 1990 (Ávila de Melo and Alpoim, 1991). The increase of the SSB is expected to continue during 1991 with fish from the strong 1986 year-class attaining maturity. The magnitude of this increase will depend on the level of depletion of the 1986 and 1985 year-class in 1991.

In EEC survey values, that, for reasons explained next, are closer to the real population size, the critical spawning stock biomass level is somewhere between 24,500 tons and 30,700 tons, while its size in July 1990 was of 21,662 tons.

The biological levels of reference are F_{low} - 0.1, F_{med} - 0.5 and F_{high} - 0.9 (Table 6). From July 1989 to July 1990 the mean value of F, derived from the abundances at age (since age 3) found by the EEC surveys, was about 1.3. Using these survey estimates of the abundances and F's at age to get the predicted catches at age for that period, a total level of catches of 60,000 tons is reached (Vazquez, pers. comm.). Although an overestimation of this figure can be accepted due to a change in the catchability induced by the use of different research vessels in each year, its value is in the same order of magnitude of the 40,000 tons estimated by the Scientific Council as the level of the 3M cod catches for 1989 (NAFO Sci. Coun. Rep., 1990).

Being so, a fishing mortality higher than F_{high} has most probably been applied to the 3M cod stock during 1990, while the biomass of spawners was reaching the lower limit of its critical size range.

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C A N A D A

Abundance(000's)

Age	78	79	80	81	82	83	84	85
1	0	0	0	32	628	293	43	56
2	95	4675	1030	0	1781	71001	1526	974
3	4757	1067	19475	5172	21	7824	15833	6485
4	15531	5610	2377	15479	1663	319	1897	18981
5	45688	5437	2990	975	978	2357	73	974
6	12135	6712	2737	2108	32	958	645	56
7	476	1706	3912	1041	150	45	426	111
8	181	108	160	2069	137	84	12	83
9	65	55	23	102	219	68	44	0
10	154	20	6	23	11	237	63	28
10+	169	224	35	17	11	11	98	83

Mean lengths at age(cm)

1	0	0	0	13	11.05	12.37	14.64	12
2	19.46	24.49	22.86	0	30.97	23.61	21.83	20.71
3	27.92	29.47	36.15	37.53	0	43.95	35.32	29.41
4	35.29	40.64	40.4	48.08	52.31	59.96	58.18	45.94
5	48.4	45.77	54.26	52.24	60.85	66.37	65.95	69.44
6	58.19	56.07	59.48	62.5	66.82	72.5	80.64	75.9
7	77.56	65.07	69.37	66.43	74.57	76.37	85.11	88.85
8	87.24	86.72	81.96	75.73	79.19	82.19	92.31	91.37
9	88.35	95.17	97.25	80.75	94.87	83.71	95.17	94
10	101.8	104.03	103	91	112	94.79	95.29	104.5
10+	113.6	103.9	121	109	111.92	125.5	103.2	109.2

Biomass at age(tons)

1	0.0	0.0	0.0	0.5	6.4	4.3	1.1	0.7
2	5.6	558.6	99.5	0.0	439.0	7577.4	127.9	69.4
3	851.6	225.7	7735.3	2306.0	0.0	5677.9	5853.9	1362.9
4	5727.2	3197.5	1330.3	14819.3	2065.1	603.5	3270.5	15790.8
5	44645.0	4471.7	4156.8	1205.8	1936.4	6100.3	185.3	2898.2
6	20932.1	10325.3	5051.5	4532.9	84.6	3256.2	3044.2	219.2
7	1992.2	4154.0	11604.4	2701.8	556.1	179.6	2374.6	706.5
8	1088.9	637.9	793.9	8044.6	611.4	420.4	85.9	575.9
9	406.6	432.7	193.4	483.4	1706.4	360.1	346.2	0.0
10	1491.5	207.1	60.2	157.6	143.0	1841.9	497.6	294.0
10+	2295.7	2310.5	577.6	203.3	142.7	203.2	990.0	998.1
1+	79436.4	26520.9	31603.0	34455.1	7691.2	26224.8	16777.1	22915.8
3+	79430.8	25962.4	31503.5	34454.6	7245.7	18643.1	16648.1	22845.7
*5+	50529.5	20303.3	20359.5	16726.5	4212.4	9311.6	7431.2	4242.9

* SSB = 50% age 5 plus 6+

Table 1.- Mean lengths at age, trawlable abundance and biomass indices from Flemish Cap surveys: Canada(1978/85).

U S S R

Abundance(000's)

Age	83	84	85	86	87	88	89
1	9856	2065	639	663	27709	50	1621
2	25606	10804	881	17557	2765	16842	915
3	15091	22267	9208	6471	3757	8418	54320
4	3566	16811	15786	5550	848	1146	13243
5	6297	5402	8643	6559	999	106	283
6	2644	1823	1547	518	628	106	67
7	1150	969	262	114	113	81	
8	592	303	81	40			
9	235	121	7	40			
10	148	61	7	7			
10+	309	61		740			

Mean lengths at age(cm)

1	15.4	16.92	13.23	16	17.08	14.5	16.42
2	23.81	26.31	20.15	27.63	27.23	25.49	21.8
3	28.26	33.8	28.01	33.92	42.41	35.03	35.3
4	40.52	38.83	41.24	42.87	53.11	47.25	46.21
5	49.06	45.42	51.42	59.69	57.08	63.8	62.6
6	53.17	56.15	60.18	73.18	69.11	71.6	75
7	64.88	63.31	73.07	87.37	88	80.75	79
8	75.07	71.56	87.08	94	94		91
9	80.12	77.95	76	99.14	116.5		100
10	82.12	81.57	114	97	116.5		
10+	98.31	93.33		108.77			

Biomass at age(tons)

1	281.5	78.9	11.4	21.3	1089.2	1.2	56.4
2	2804.8	1610.3	57.7	3043.4	458.2	2276.6	76.4
3	2804.3	7188.0	1664.8	2111.9	2442.4	3034.2	20048.5
4	2014.1	8325.5	9413.7	3730.1	1103.5	1039.8	11218.2
5	6415.8	4339.0	10179.5	12237.9	1623.8	242.9	611.5
6	3452.7	2816.7	2960.2	1812.1	1841.4	346.7	252.8
7	2775.0	2168.1	912.3	689.0	698.2	383.9	0.0
8	2240.5	989.3	484.5	302.9	0.0	0.0	0.0
9	1087.2	514.3	27.5	357.0	0.0	0.0	0.0
10	738.8	298.3	96.1	58.4	0.0	0.0	0.0
10+	2687.3	451.9	0.0	8791.2	0.0	0.0	0.0
1+	27302.0	28780.2	25807.8	33155.2	9256.8	7325.3	32263.8
3+	24215.8	27091.0	25738.7	30090.5	7709.3	5047.4	32131.0
*5+	16189.5	9408.1	9570.4	18129.7	3351.6	852.0	558.6

* SSB 50% age 5 plus 6+

Table 2.- Mean lengths at age, trawlable abundance and biomass indices from Flemish Cap surveys: USSR(1983/89).

EEC

Abundance(000's)

Age	88	89	90
1	4580	20850	2370
2	71960	11000	11790
3	40370	84220	4670
4	10850	49220	15880
5	1280	18580	14530
6	220	1270	3940
7	280	150	320
8	110	120	130
9			80
10		10	3
10+			

Mean lengths at age(cm)

1	15.2	15.67	16.3
2	22.36	22.03	26.4
3	35.11	32.7	33.2
4	40.34	44.53	44.7
5	58.86	51.46	54.4
6	70.51	60.69	63.7
7	82.65	75.88	75.2
8	89	89.28	83.8
9		92	91.7
10		115	100.3
10+			

Biomass at age(tons)

1	125.6	628.3	80.7
2	6493.3	948.1	1775.9
3	14653.8	24549.1	1426.5
4	6044.4	37193.1	12141.6
5	2287.3	21935.7	20361.3
6	686.3	2494.2	8984.2
7	1425.8	586.8	1217.5
8	703.8	775.3	690.8
9	0.0	0.0	561.3
10	0.0	141.1	27.8
10+	0.0	0.0	0.0
1+	32420.3	89251.5	47267.5
3+	25801.4	87675.2	45411.0
*5+	3959.5	14965.2	21662.2

* SSB = 50% age 5 plus 6+

Table 3.- Mean lengths at age, trawlable abundance and biomass indices from Flemish Cap surveys: EEC(1988-1990).

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	CANADA	5910	1326	24194	6425	26	9720	19669	8056					
R	USSR						15091	22267	9208	6471	3757	8418	54320	
	CEE											13135	27403	1520
	MEAN	5910	1326	24194	6425	26	12405	20968	8632	6471	3757	10777	40862	1520
	MEAN norm.	0.14	0.03	0.59	0.16	0.00	0.30	0.51	0.21	0.16	0.09	0.26	1.00	0.04
	CANADA	98684	32947	39261	42804	9555	32579	20842	28468					
SB	USSR						27302	28780	25808	33155	9257	7325	32264	
	CEE											10549	29040	15380
	MEAN	98684	32947	39261	42804	9555	29941	24811	27138	33155	9257	8937	30652	15380
	MEAN norm.	1.00	0.33	0.40	0.43	0.10	0.30	0.25	0.27	0.34	0.09	0.09	0.31	0.16
	CANADA	98677	32253	39137	42803	9001	23160	20682	28381					
EB	USSR						24216	27091	25739	30091	7709	5047	32131	
	CEE											8395	28527	14776
	MEAN	98677	32253	39137	42803	9001	23688	23887	27060	30091	7709	6721	30329	14776
	MEAN norm.	1.00	0.33	0.40	0.43	0.09	0.24	0.24	0.27	0.30	0.08	0.07	0.31	0.15
	CANADA	62773	25223	25293	20779	5233	11568	9232	5271					
SBB	USSR						16189	9408	9570	18130	3352	852	559	
	CEE											1288	4869	7048
	MEAN	62773	25223	25293	20779	5233	13879	9320	7421	18130	3352	1070	2714	7048
	MEAN norm.	1.00	0.40	0.40	0.33	0.08	0.22	0.15	0.12	0.29	0.05	0.02	0.04	0.11

R - Recruitment age 3
SB - Stock Biomass (1+)
EB - Explotaible Biomass
SSB - Spawning Stock Biomass

Convertions Factors

Canada/USSR = 0.805
EEC/USSR = 3.070

Table 4.- Recruitment and biomass indices from the Canadian and EEC survey series converted to USSR indices. Mean values for the time period 1978-1990 are also presented normalised.

Age	Mean(1) lengths	Mean(2) weights	PR 89(3)
3	33.91	0.324	0.39
4	42.44	0.647	1
5	55.16	1.452	1
6	65.6	2.48	1
7	79.27	4.446	0.5
8	89.1	6.376	0.5
9	91.3	6.875	0.5
10	102.37	9.785	0.5
11	110.4	12.353	0.5
12	113	13.272	0.5

Table 5.- Input parameters of the Y/R curve.

(1) Average mean lengths from the 88/89 EEC surveys.
(2) Hodder(1964) length/weight equation.
(3) From age composition of commercial and EEC survey catches in July 89.

	F(5-12)	Y/R	SSB/R	R/SSB	
	0	0.00	15362.56	0.07	
F low -->	0.1	240.19	9995.08	0.10	<--
	0.2	396.16	6596.08	0.15	
	0.3	500.88	4419.06	0.23	
	0.4	573.69	3007.66	0.33	
F med -->	0.5	626.12	2080.75	0.48	<--
	0.6	665.20	1463.68	0.68	
	0.7	695.27	1047.00	0.96	
	0.8	719.09	761.46	1.31	
F high ->	0.9	738.46	562.82	1.78	<--
	1	754.57	422.50	2.37	
	1.1	768.23	321.85	3.11	
	1.2	779.99	248.57	4.02	
	1.3	790.28	194.41	5.14	
	1.4	799.38	153.82	6.50	
	1.5	807.51	122.99	8.13	
	1.6	814.83	99.26	10.07	
	1.7	821.49	80.78	12.38	
	1.8	827.58	66.24	15.10	
	1.9	833.18	54.67	18.29	
	2	838.35	45.39	22.03	

Table 6.- Y/R, SSB/R and R/SSB values for a range of F's between 0 and 2. Biological reference points are indicated in the table.

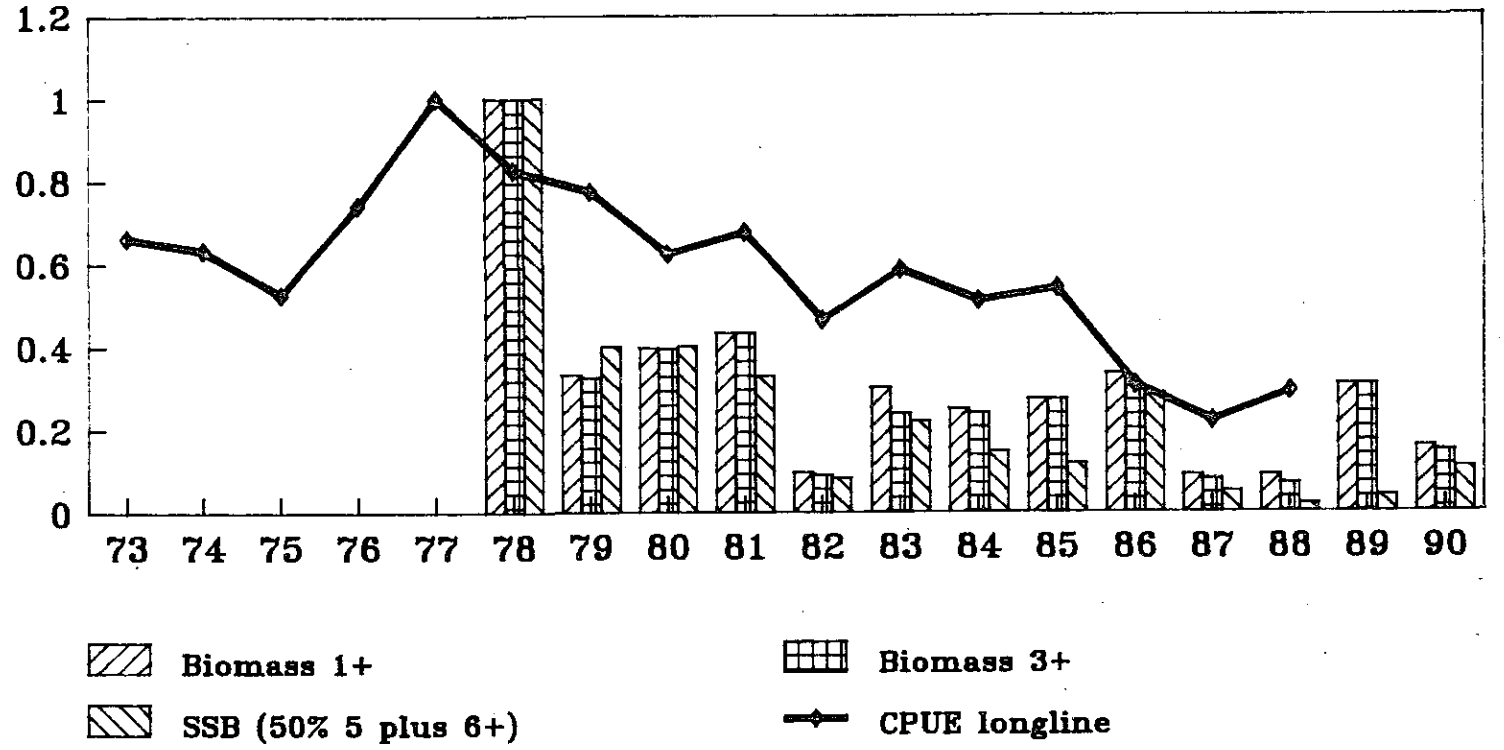

Fig.1.– Trends in the total, exploitable and spawning biomass of the 3M cod for the period 1978–1990.

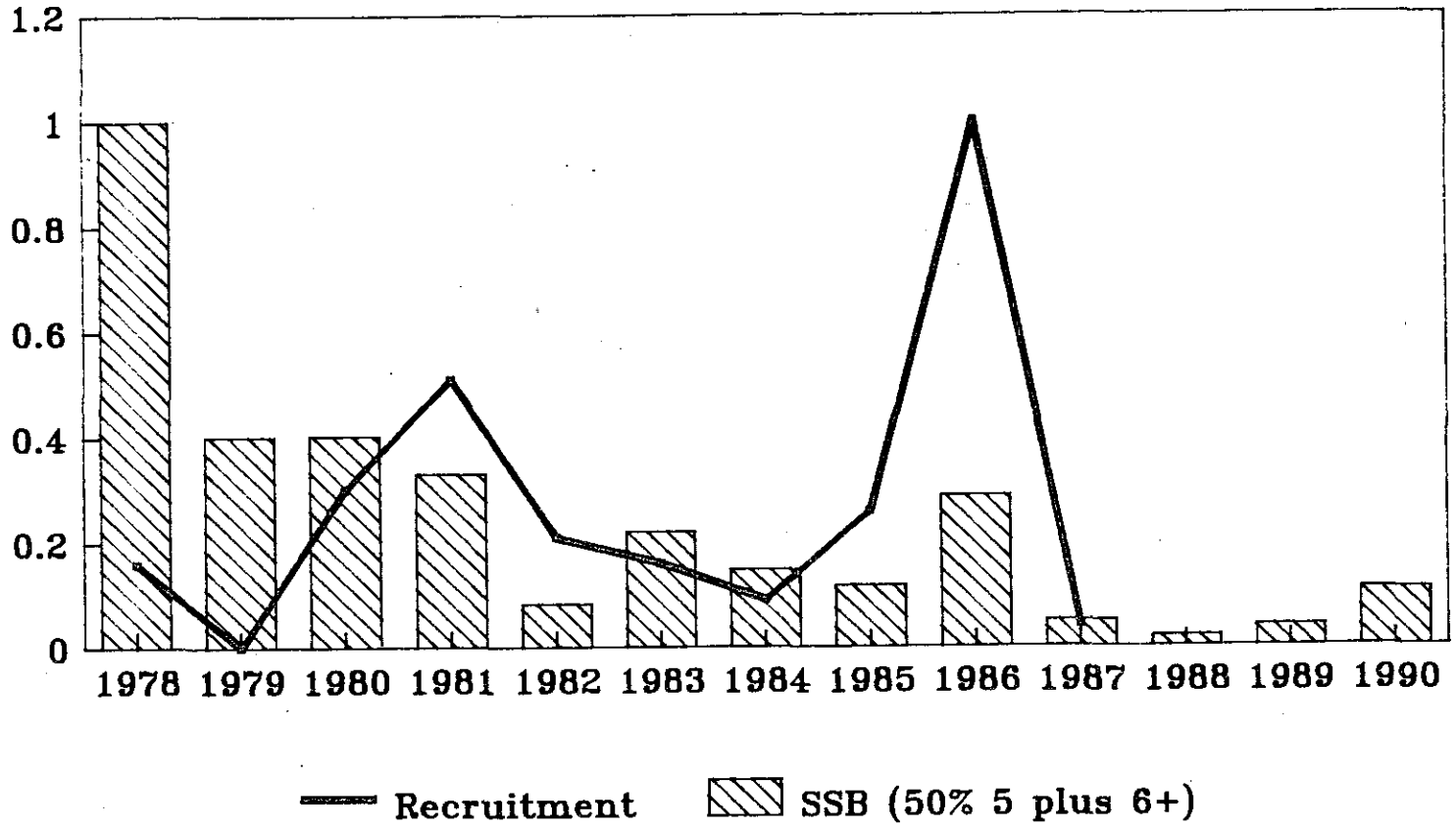

Fig. 2.- SSB/Recruitment (age 3 year +3) for the period 1978-1990.

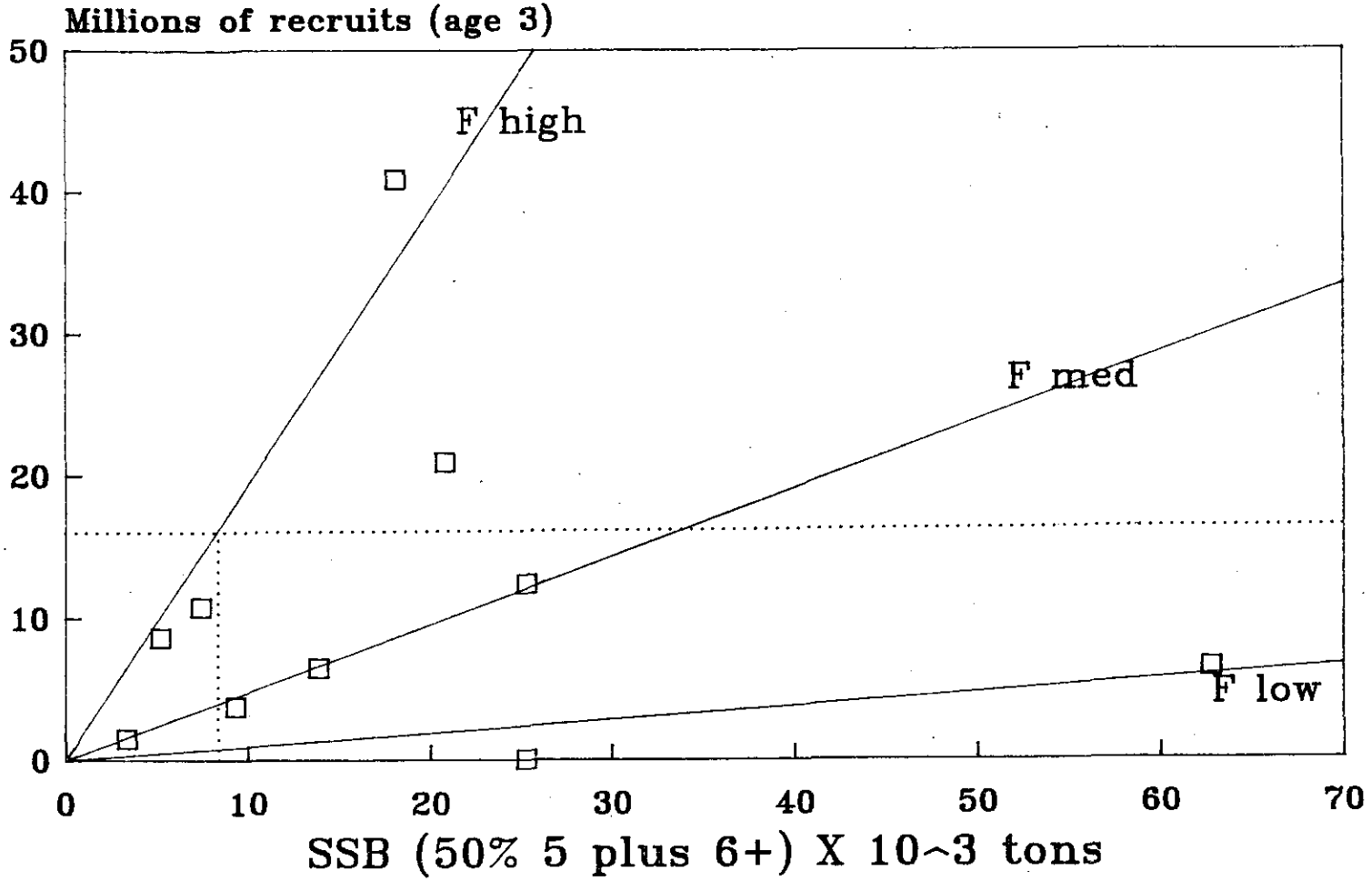

Fig. 3.– SSB/Recruitment scatterplot

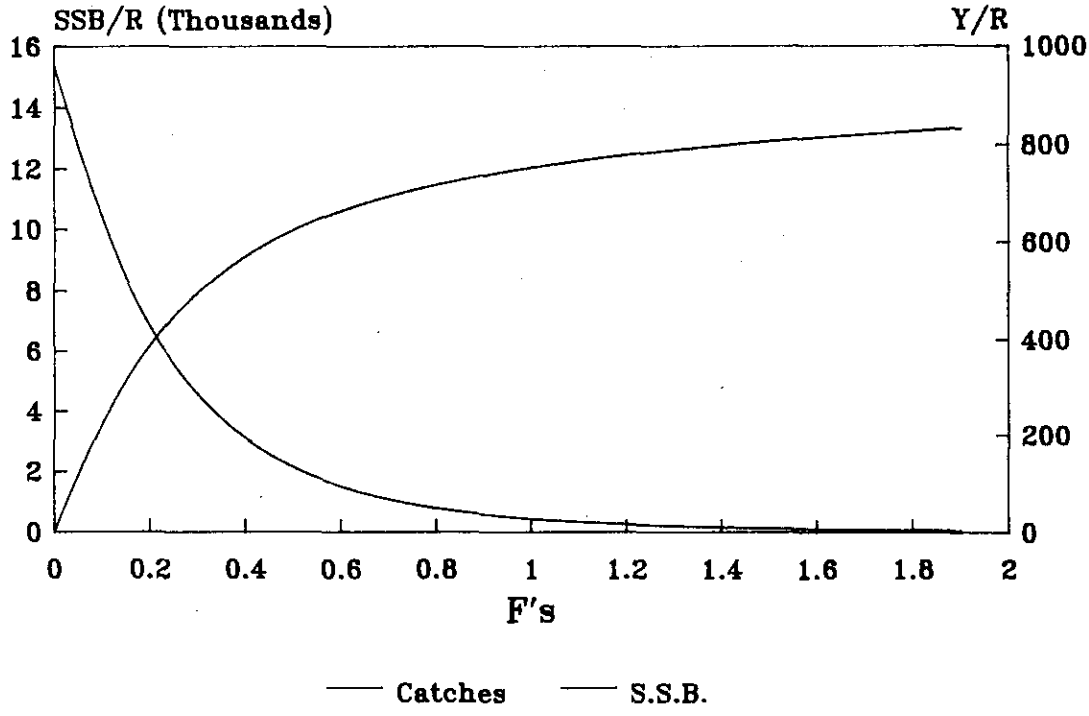

Fig. 4.- Y/R and SSB/R curves.