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Estimation of the Stock Status and TAC for Redfish *Sebastes marinus* in Div. 3M for 1991

by

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ABSTRACT

Estimates of exploitable redfish stock abundance and biomass are presented for 1983-89 according to the trawl survey data. The VPA method was used to calculate abundance, biomass and fishing mortality coefficients by age groups for 1968-89. The TAC estimate is given for 1991 with different intensity of catch rate.

Redfish stock from the Flemish Cap Bank is estimated to be at the average level: the biomass calculated by VPA method using differentiated natural mortality coefficients made up 239.3 x 10^3 and with constant M=0.1 for all age groups - 303.4 x 10^3t.

INTRODUCTION

The analysis of data of international redfish catches taken on the Flemish Cap Bank gives evidence of increased fishery for 1986-89. The same situation was observed in 1971-75 (Fig. 1). If until 1987 the USSR was leading in redfish fishery, in 1989 the yield taken by the EEC countries constituted about 50%.

The Polar Institute carries out regular hydroacoustic surveys in the Division and uses mathematical methods for the stock estimation. The results of surveys show that redfish stock size from the Flemish Cap Bank is at the average level (Vaskov et al., 1987, 1989). In our opinion, this is due to a high biological productivity in the Division and to a decreased press of predators, cod in the first place.

The present paper is aimed at obtaining the most unbiased redfish stock and TAC estimates by mathematical methods.

MATERIAL AND METHODS

Abundance and biomass of exploitable redfish stock are estimated by VPA method according to age composition data for 1968-89. Table 1 lists data on age composition of catches for the recent 12 years. Data on international catch statistics for 1989 are borrowed from the NAFO Circular Letter 89/62. In view of revision of total international catch (Power and Atkinson, 1989) the data on age composition of catches for 1988 were recalculated. Fishing efforts per each year were given for a standard Soviet vessel of the BMRT type. On the whole, the methods of calculation are set forth in the paper by Vaskov et al. (1989).

RESULTS

Using two variants of natural mortality coefficient values for the VPA method we obtained appropriate estimates of redfish stock for 5-23-year-olds. To calculate starting coefficients F the method suggested by Saville (Pope and Shepperd, 1983) for tuning VPAs was chosen, for which correlation coefficients between the fishing mortality and effort were within 0.44-0.76 for 6-19-year-olds. Application of constant coefficients M leads to the stock overestimation (Tables 2-5) and influences the TAC value (Tables 6 and 7).

Analysis of abundance and biomass dynamics (Tables 2-5) shows a relatively stable stock size on the Flemish Cap which in recent years remains at the level of 200-240 x 10^3t. In 1989 abundance and biomass with regard for differentiated M values amounted to 1104.9 x 10^6 spec. and 239.3 x 10^3 t while with constant coefficients of natural mortality - 1417.8 x 10^6 spec. and 303.4 x 10^3 t respectively.

The catches taken by research and fishing vessels on the Flemish Cap consisted of redfish 8-45 cm long aged 1-22. Specimens 24-28 cm long prevailed in the catches (Fig. 2). A good recruitment of the stock with the 3-4-year-olds of abundant 1985-1986 year-classes was observed in 1989.

According to data of multispecies trawl survey carried out in June 1989 the portion of redfish stock available to a bottom sampling trawl on the Flemish Cap increased from 183.1 x 10^6 to 283.7 x 10^6 spec. and biomass increased from 47.0 x 10^3 to 83.3 x 10^3 t (Fig. 3). The bulk of redfish was found in June 1989 in pelagic waters which is confirmed by hydroacoustic survey data. A total abundance and biomass estimate obtained from the data of the trawl-acoustic survey in 1989 made up 2231.0 x 10^6 spec. and 365.9 x 10^3 t.

To calculate the TAC for 1991 three levels of rate of exploitation

were used: $F_{0.1}$ = 0.25, F_{MSY} = 0.40 and F = F_{1989} (Tables 6 and 7). Considering that for major age groups the catch rate in 1989 was lower than F_{MSY} (Tables 8 and 9) the F_{1989} level may be taken as regulation measure. With the use of differentiated coefficients of natural mortality the TAC value for 1991 will constitute 39 x 10^3 t. The stock size forecast is made on the assumption that recruitment of redfish aged 5 in 1989-1991 will be at the average level for 1986-1988, the biomass in 1991 being 300.0 x 10^3 t.

CONCLUSIONS

The redfish stock size from the Flemish Cap Bank remains at a stable level. In 1991 the biomass will be no less than the average value for 1986-89 and reach 300.0 x 10^3 t. The TAC value in 1991 may be at the level of 39 x 10^3 t.

REFERENCES

POPE, J.G., and I.G.SHEPPERD. 1983. Comparison of the performance of various methods for tuning VPAs using effort data. ICES C.M. 1983/:9 (mimeo).

POWER, D., and D.B.ATKINSON. MS 1989. Status of redfish in NAFO Division 3M. NAFO SCR Doc., No.56, Serial No.N1636.

VASKOV, A.A., G.B.RUDNEVA, and A.G.GALUZO. MS 1987. Estimation of the stock size and total allowable catch of beaked redfish in Div. 3LN for 1988. NAFO SCR Doc., No.20, Serial No. N1300.

VASKOV, A.A., G.B.RUDNEVA, and I.A.OGANIN. MS 1989. Estimation of the stock status and TAC for redfish in Divs. 3M and 3LN for 1990. NAFO SCR Doc., No.6, Serial No.N1570.

Table 1. Age composition of redfish catches in Div. 3M, spec. x 10^{-3}

Age, years	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
5	1.16	0.62	0.12	0.32	0.01	0.01	1.29	11.94	5.33	7.27	0.00	6.12
6	1.10	2.12	0.82	1.19	0.23	0.15	1.11	5.64	13.18	23.77	0.51	1.88
7	1.23	3.57	2.71	2.92	1.14	0.84	1.94	0.99	8.24	59.25	4.63	9.44
8	1.14	3.66	3.67	4.53	3.05	3.32	3.31	0.50	2.81	44.40	6.54	25.32
9	1.72	3.15	4.40	5.88	5.12	6.03	4.87	1.90	2.42	17.20	3.91	16.42
10	3.69	3.02	3.85	6.41	7.33	9.79	7.63	3.69	4.71	6.79	3.14	9.09
11	4.91	3.36	2.83	4.85	6.39	9.09	7.84	3.82	5.64	8.49	5.12	2.94
12	4.47	3.63	2.28	2.70	3.57	5.29	5.47	5.00	7.87	5.67	4.63	5.33
13	4.55	4.49	2.84	2.22	2.35	3.64	4.56	5.89	7.26	6.78	6.44	4.98
14	3.61	3.98	2.74	1.67	1.60	2.52	3.28	4.74	5.94	5.11	5.14	2.14
15	2.61	3.32	2.41	1.23	1.19	1.78	2.27	2.48	3.37	3.02	3.41	1.71
16	1.80	2.51	1.87	0.85	0.96	1.28	1.56	2.43	2.87	2.73	3.14	1.08
17	0.94	1.36	1.13	0.45	0.61	0.68	0.72	0.81	1.00	0.95	1.54	0.42
18	0.62	0.99	0.85	0.31	0.45	0.46	0.44	0.69	0.88	0.54	0.99	0.27
19	0.44	0.79	0.66	0.24	0.38	0.36	0.32	0.28	0.48	0.31	0.60	0.05
20	0.26	0.56	0.47	0.16	0.26	0.23	0.20	0.41	0.58	0.25	0.33	0.05
21	0.16	0.38	0.32	0.11	0.17	0.15	0.12	0.29	0.35	0.15	0.25	0.02
22	0.06	0.14	0.13	0.04	0.05	0.00	0.03	0.10	0.12	0.06	0.10	0.01
23	0.05	0.07	0.04	0.01	0.01	0.00	0.00	0.05	0.06	0.01	0.03	0.01
	34.5	41.7	34.1	36.1	34.9	45.7	47.0	51.7	73.1	192.8	50.5	87.3

Table 2. Redfish abundance estimated by VPA method with differentiated coefficients M by age groups, spec. x 10^{-6}

Age years	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
5	89.36	79.75	62.63	70.75	69.41	61.81	180.85	319.85	464.61	232.40	96.11	258.78
6	76.55	76.61	68.75	54.34	61.21	60.33	53.72	156.02	266.94	398.95	195.27	83.40
7	56.99	67.53	66.62	60.82	47.55	54.61	53.90	47.08	134.43	226.68	334.92	174.52
8	36.52	51.42	58.91	58.90	53.33	42.80	49.61	47.89	42.51	116.18	152.46	304.86
9	25.41	33.28	44.88	51.92	51.07	47.27	37.09	43.51	44.62	37.31	66.44	137.22
10	21.07	22.73	28.90	38.81	44.12	44.06	39.51	30.86	39.94	40.50	19.02	59.99
11	20.19	17.00	19.29	24.51	31.69	35.99	33.49	31.17	26.59	34.49	32.98	15.53
12	18.79	15.10	13.49	16.28	19.44	25.02	26.59	25.36	27.05	20.72	25.70	27.55
13	16.73	14.16	11.33	11.08	13.43	15.69	19.51	20.88	20.14	18.95	14.87	20.84
14	13.26	12.04	9.55	8.40	8.76	10.96	11.91	14.78	14.81	12.72	12.02	8.32
15	9.95	9.31	7.76	6.57	6.51	6.93	8.16	8.33	9.67	8.53	7.32	6.61
16	7.12	7.01	5.70	5.10	5.10	5.09	4.91	5.61	5.57	6.00	5.24	5.69
17	4.15	4.91	4.12	3.52	3.94	3.83	3.51	3.08	2.89	2.44	2.96	1.87
18	3.16	2.83	3.11	2.62	2.72	2.95	2.79	2.47	1.99	1.65	1.29	1.21
19	2.18	2.12	1.51	1.87	1.95	1.90	2.09	1.97	1.46	0.89	0.91	0.21
20	1.42	1.34	0.98	0.62	1.27	1.21	1.20	1.38	1.32	0.74	0.43	0.21
21	0.66	0.81	0.51	0.32	0.31	0.70	0.68	0.70	0.66	0.47	0.33	0.04
22	0.37	0.30	0.24	0.09	0.13	0.07	0.34	0.35	0.23	0.16	0.19	0.03
23	0.28	0.17	0.07	0.04	0.02	0.04	0.04	0.17	0.13	0.04	0.05	0.03
	404.1	418.4	408.3	416.5	422.0	421.3	529.9	761.4	1105.6	1159.8	968.5	1104.9

Table 3. Redfish biomass estimated by VPA method with differentiated coefficients M by age groups, t x 10^3

Age years	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
5	10.28	8.37	8.14	7.07	9.16	6.18	18.45	32.30	57.61	21.85	8.94	13.20
6	14.16	14.17	13.27	11.03	12.24	12.13	10.74	28.08	52.32	49.87	26.36	10.51
7	12.99	16.41	15.59	14.11	10.13	12.78	11.86	9.98	30.65	34.00	57.61	34.21
8	8.58	13.11	15.02	14.31	12.00	10.61	11.91	11.45	10.54	21.26	31.10	75.30
9	7.49	8.89	14.27	14.02	12.46	12.48	9.49	12.84	12.49	8.80	16.94	40.48
10	6.91	6.77	9.36	13.00	15.00	14.45	13.31	10.49	13.14	13.08	6.30	20.64
11	7.55	5.88	7.93	9.56	11.88	13.97	13.06	12.72	10.21	13.21	13.19	6.04
12	13.94	7.59	6.41	7.55	8.07	10.51	12.42	11.39	12.44	8.93	11.46	12.23
13	8.97	7.19	5.95	5.74	6.49	7.92	10.77	11.09	10.79	9.68	7.79	10.86
14	8.14	7.47	5.42	4.81	5.21	6.69	7.66	8.82	9.06	7.45	6.95	5.29
15	7.04	6.15	5.10	4.00	4.54	4.85	5.85	5.79	6.69	5.60	4.86	4.60
16	5.23	5.30	4.03	3.75	3.74	3.79	3.61	3.98	4.13	4.31	3.80	2.77
17	3.32	3.88	3.12	2.73	3.09	3.00	2.69	2.40	2.27	1.87	2.29	1.51
18	2.72	2.45	2.43	2.05	2.30	2.48	2.31	2.17	1.69	1.41	1.11	1.08
19	2.01	1.99	1.31	1.69	1.77	1.78	1.95	1.80	1.38	0.84	0.79	0.22
20	1.33	1.48	0.92	0.62	1.25	1.18	1.19	1.43	1.33	0.73	0.43	0.22
21	0.68	0.90	0.52	0.34	0.35	0.75	0.73	0.78	0.72	0.49	0.35	0.05
22	0.43	0.35	0.28	0.10	0.14	0.08	0.41	0.40	0.27	0.19	0.22	0.04
23	0.36	0.22	0.09	0.05	0.02	0.05	0.05	0.21	0.16	0.06	0.06	0.05
	122.1	118.6	119,2	116.5	119.8	125.7	138.5	168.1	237.9	203.6	200.5	239.3

Table 4. Redfish abundance estimated by VPA method with constant coefficient M for age groups, spec. $\times 10^{-6}$

Age, years	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
5	113.57	102.46	80.52	94.85	93.99	73.90	214.91	380.27	584.41	292.33		318.79
6	103.31	101.66	92.12	72.74	85.52	85.03	66.85	193.22	332.73	523.73	122.44	110.79
7	79.98	92.43	89.97	82.58	64.68	77.16	76.79	59.43	169.47	288.54	257.39	232.41
8	52.36	71.20	80.24	78.84	71.94	57.45	69.02	67.64	52.84	145.51	451.21	403.87
9	36.02	46.29	60.24	69.11	67.03	62.19	48.83	59.31	60.73	45.14	204.80	179.09
10	27.99	30.96	38.90	50.96	56.95	55.78	50.55	39.55	51.86	52.65	89.59	77.35
11	24.76	21.82	25.15	31.53	40.03	44.57	41.18	38.49	32.28	42.45	24.56	19.24
12	21.35	17.74	16.55	20.07	23.92	30.15	31.70	29.82	31.19	23.85	41.19	32.40
13	17.94	15.08	12.60	12.81	15.60	18.26	22.26	23.49	22.24	20.75	30.35	23.07
14	13.31	11.92	9.38	8.71	9.48	11.88	13.06	15.81	15.67	13.25	16.20	8.57
15	9.14	8.62	7.01	5.89	6.30	7.06	8.36	8.71	9.81	8.55	12.36	6.31
16	5.82	5.80	4.66	4.06	4.16	4.57	4.70	5.41	5.52	5.69	7.15	3.24
17	3.49	3.56	2.87	2.45	2.87	2.85	2.92	2.77	2.59	2.29	4.87	1.45
18	2.42	2.27	1.93	1.52	1.79	2.01	1.93	1.96	1.74	1.40	2.57	0.87
19	1.58	1.60	1.12	0.94	1.08	1.19	1.39	1.33	1.12	0.74	1.17	0.14
20	0.90	1.02	0.70	0.40	0.62	0.62	0.74	0.95	0.94	0.56	0.76	0.12
21	0.39	0.57	0.39	0.19	0.20	0.32	0.34	0.48	0.48	0.30	0.37	0.03
22	0.18	0.20	0.16	0.05	0.07	0.02	0.14	0.19	0.16	0.10	0.27	0.01
23	0.14	0.11	0.05	0.02	0.01	0.01	0.02	0.10	0.08	0.03	0.12	0.02
	514.7	535.3	525.3	537.7	546.2	535.0	655.7	928.9	1375.8	1467.8	1267.4	1417.8

Table 5. Redfish biomass estimated by VPA method with constant coefficient M for age groups, $t \times 10^3$

Age, years	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
5	13.06	10.76	10.47	9.49	12.41	7.39	21.92	38.40	72.45	27.46	11.39	16.26
6	19.11	18.81	17.78	14.77	17.10	17.09	13.37	34.78	65.20	65.45	34.75	13.96
7	18.24	22.46	21.05	19.16	13.78	18.06	16.89	12.60	38.64	43.27	77.61	45.55
8	12.30	18.16	20.46	19.16	16.19	14.25	16.57	16.17	13.10	26.63	41.78	99.76
9	10.63	12.36	19.38	18.66	16.35	16.42	12.50	17.50	17.00	10.65	22.65	52.83
10	9.18	9.23	12.60	17.07	19.36	18.30	17.03	13.45	17.06	17.01	8.13	26.61
11	9.26	7.55	10.34	12.30	15.01	17.29	16.06	15.70	12.40	16.26	16.48	7.48
12	15.84	8.92	7.86	9.31	9.93	12.66	14.80	13.39	14.35	10.28	13.54	14.39
13	9.62	7.66	6.62	6.64	7.53	9.22	12.29	12.47	11.92	10.61	8.49	12.02
14	8.17	7.39	5.32	4.99	5.64	7.25	8.40	9.44	9.59	7.76	7.14	5.45
15	6.47	5.69	4.61	3.58	4.40	4.94	5.99	6.05	6.79	5.61	4.75	4.39
16	4.27	4.39	3.30	2.99	3.05	3.41	3.45	3.84	4.09	4.09	3.54	2.44
17	2.79	2.81	2.17	1.90	2.25	2.23	2.24	2.16	2.04	1.76	1.98	1.17
18	2.08	1.97	1.51	1.19	1.51	1.69	1.60	1.72	1.48	1.20	1.01	1.77
19	1.46	1.51	0.97	0.85	0.98	1.11	1.29	1.21	1.05	0.70	0.66	0.14
20	0.85	1.12	0.66	0.39	0.62	0.61	0.73	0.99	0.95	0.55	0.38	0.13
21	0.41	0.64	0.40	0.20	0.22	0.34	0.37	0.53	0.52	0.31	0.29	0.03
22	0.21	0.23	0.19	0.06	0.08	0.03	0.17	0.22	0.18	0.12	0.14	0.02
23	0.18	0.14	0.06	0.03	0.01	0.02	0.02	0.12	0.10	0.03	0.04	0.02
	144.1	141.8	145,7	142.7	146.4	152.3	165.7	200.7	288.9	249.7	254.9	303.4

Table 6. Prediction of redfish stock status and TAC
(with differentiated coefficient M)

T	M	F	1989 N spec. x 10^{-6}	1990 N spec. x 10^{-6}	1990 B t x 10^3	1991 Biomass, t x 10^3 $F_{0.1}$	$F=F_{1989}$	F_{MSY}	1991 TAC, t x 10^3 $F_{0.1}$	$F=F_{1989}$	F_{MSY}
5	0.140	0.0104	258.78	258.78	13.20	13.20	13.20	13.20	0.07	0.13	0.11
6	0.110	0.0241	83.40	222.64	28.05	28.18	28.05	28.08	0.37	0.63	0.58
7	0.080	0.0579	174.52	72.93	14.29	38.54	38.16	38.24	1.88	2.06	2.88
8	0.060	0.0894	304.86	152.04	37.55	15.79	15.69	15.33	1.18	1.30	1.76
9	0.040	0.1301	137.22	262.55	77.45	38.99	38.63	37.26	3.60	4.62	5.26
10	0.020	0.1660	59.99	115.76	39.82	78.60	76.19	74.29	3.54	11.54	5.19
11	0.010	0.2112	15.53	49.81	19.38	42.13	37.39	41.03	2.83	7.08	4.24
12	0.010	0.2160	27.55	12.45	5.53	20.41	17.73	19.62	1.68	3.43	2.47
13	0.010	0.2744	20.84	21.98	11.45	5.89	5.17	5.61	0.72	1.24	1.04
14	0.030	0.3019	8.32	15.68	9.97	12.14	10.52	11.27	1.65	2.70	2.31
15	0.040	0.3071	6.61	5.97	4.15	9.13	7.83	8.39	1.12	2.03	1.56
16	0.070	0.3601	3.69	4.67	3.51	3.77	3.17	3.49	0.67	0.93	0.92
17	0.110	0.2674	1.87	2.40	1.94	2.86	2.45	2.55	0.39	0.55	0.52
18	0.160	0.2822	1.21	1.28	1.14	1.65	1.47	1.51	0.28	0.34	0.38
19	0.230	0.3059	0.21	0.77	0.81	0.93	0.86	0.83	0.13	0.20	0.18
20	0.320	0.3552	0.21	0.12	0.13	0.56	0.49	0.51	0.10	0.13	0.13
21	0.420	0.5802	0.04	0.10	0.12	0.08	0.07	0.07	0.01	0.03	0.02
22	0.560	0.5430	0.03	0.02	0.02	0.07	0.05	0.06	0.01	0.02	0.01
23	0.720	0.5001	0.03	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
			1104.9	1200.0	268.5	312.9	297.1	301.3	20.2	39.0	29.5

Legend: T - age;
M - natural mortality coefficient;
F - fishing mortality coefficient;
N - abundance;
B - biomass

Table 7. Prediction of redfish stock status and TAC
(with constant coefficient M)

T	M	F	1989 N spec. x_{-6} 10^{-6}	1990 N spec. x_{-6} 10^{-6}	1990 B t $x10^3$	1991 Biomass, t $x\ 10^3$ $F_{0.1}$	$F=F_{1989}$	F_{MSY}	1991 TAC, t $x\ 10^3$ $F_{0.1}$	$F=F_{1989}$	F_{MSY}
5	0.100	0.0080	318.79	318.79	16.26	16.26	16.26	16.26	0.05	0.12	0.08
6	0.100	0.0180	110.79	286.15	36.06	36.23	36.06	36.17	0.25	0.61	0.39
7	0.100	0.0436	232.41	98.46	19.30	50.38	49.84	50.18	1.27	2.02	1.97
8	0.100	0.0681	403.87	201.32	49.73	21.42	21.07	21.10	0.83	1.32	1.27
9	0.100	0.1012	179.09	341.38	100.71	51.55	50.20	50.34	2.54	4.60	3.84
10	0.100	0.1316	77.35	146.45	50.38	100.75	96.03	97.75	2.33	11.28	3.53
11	0.100	0.1750	19.24	61.36	23.87	50.29	45.19	49.59	1.83	6.91	2.80
12	0.100	0.1893	32.40	14.61	6.49	23.71	20.69	23.19	1.12	3.40	1.70
13	0.100	0.2565	23.07	24.26	12.64	6.54	5.70	6.36	0.49	1.23	0.73
14	0.100	0.3031	8.57	16.15	10.27	12.86	10.80	12.27	1.14	2.69	1.67
15	0.100	0.3347	6.31	5.72	3.98	9.22	7.51	8.72	0.78	2.04	1.13
16	0.100	0.4291	3.24	4.09	3.07	3.54	2.78	3.36	0.47	0.93	0.67
17	0.100	0.3575	1.45	1.91	1.54	2.57	1.94	2.36	0.27	0.56	0.38
18	0.100	0.4048	0.87	0.92	0.82	1.37	1.08	1.28	0.20	0.34	0.27
19	0.100	0.4752	0.14	0.52	0.55	0.74	0.58	0.67	0.10	0.21	0.13
20	0.100	0.5968	0.12	0.08	0.08	0.44	0.32	0.40	0.08	0.14	0.11
21	0.100	0.9877	0.03	0.06	0.07	0.06	0.04	0.06	0.01	0.03	0.02
22	0.100	1.2465	0.01	0.01	0.01	0.05	0.03	0.05	0.01	0.02	0.01
23	0.100	0.9370	0.02	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00
			1417.8	1522.2	335.8	388.0	366.1	380.1	13.8	35.5	20.7

Legend: T – age;
M – natural mortality coefficient;
F – fishing mortality coefficient;
N – abundance;
B – biomass

Table 8. Fishing mortality coefficients estimated with differentiated coefficients M by age groups

Age, years	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
5	0.0140	0.0083	0.0021	0.0049	0.0002	0.0002	0.0077	0.0408	0.0124	0.0341	0.0000	0.0104
6	0.0153	0.0296	0.0126	0.0235	0.0040	0.0027	0.0221	0.0389	0.0535	0.0649	0.0028	0.0241
7	0.0227	0.0566	0.0432	0.0513	0.0252	0.0161	0.0382	0.0221	0.0659	0.3166	0.0145	0.0579
8	0.0327	0.0762	0.0664	0.0826	0.0607	0.0833	0.0712	0.0108	0.0704	0.4989	0.0452	0.0894
9	0.0715	0.1014	0.1053	0.1227	0.1078	0.1394	0.1439	0.0455	0.0569	0.6337	0.0618	0.1301
10	0.1946	0.1441	0.1447	0.1825	0.1857	0.2541	0.2171	0.1286	0.1269	0.1855	0.1827	0.1660
11	0.2804	0.2217	0.1593	0.2219	0.2263	0.2929	0.2680	0.1316	0.2398	0.2841	0.1698	0.2112
12	0.2729	0.2767	0.1862	0.1822	0.2040	0.2389	0.2317	0.2208	0.3459	0.3218	0.1998	0.2160
13	0.3191	0.3838	0.2898	0.2251	0.1933	0.2656	0.2678	0.3332	0.4495	0.4451	0.5708	0.2744
14	0.3233	0.4089	0.3439	0.2247	0.2049	0.2658	0.3276	0.3940	0.5219	0.5226	0.5687	0.3019
15	0.3109	0.4506	0.3800	0.2127	0.2056	0.3042	0.3339	0.3620	0.4380	0.4481	0.6438	0.3071
16	0.3025	0.4615	0.4130	0.1892	0.2170	0.3011	0.3972	0.5924	0.7570	0.6343	0.9607	0.3601
17	0.2714	0.3461	0.3424	0.1463	0.1800	0.2085	0.2440	0.3264	0.4518	0.5249	0.7897	0.2674
18	0.2393	0.4690	0.3501	0.1373	0.1985	0.1833	0.1883	0.3618	0.6489	0.4301	1.6713	0.2822
19	0.2537	0.5378	0.6573	0.1527	0.2476	0.2340	0.1854	0.1717	0.4502	0.5013	1.2642	0.3059
20	0.2389	0.6492	0.7952	0.3642	0.2750	0.2488	0.2161	0.4158	0.7113	0.4852	1.9595	0.3552
21	0.3581	0.8062	1.3641	0.5163	1.0246	0.3086	0.2489	0.6784	1.0052	0.4985	1.9686	0.5802
22	0.2253	0.8892	1.1833	0.9178	0.6948	0.0882	0.1307	0.4435	1.0975	0.6662	1.1281	0.5430
23	0.2763	0.7919	1.1401	0.6001	0.6619	0.2136	0.1975	0.5117	0.9437	0.5578	1.7201	0.5001
6-17	0.1186	0.1332	0.1044	0.1128	0.1068	0.1430	0.1476	0.0999	0.1197	0.2461	0.0667	0.1048

Table 9. Fishing mortality coefficients estimated with constant coefficient M for age groups

Age, years	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
5	0.0108	0.0064	0.0016	0.0036	0,0002	0.0002	0.0063	0.0336	0.0096	0.0265	0.0000	0.0080
6	0.0113	0.0221	0.0094	0.0174	0,0029	0.0019	0.0176	0.0312	0.0425	0.0489	0.0021	0.0180
7	0.0163	0.0414	0.0321	0.0379	0,0186	0.0115	0.0269	0.0177	0.0524	0.2426	0.0108	0.0436
8	0.0231	0.0556	0.0493	0.0623	0,0456	0.0626	0.0517	0.0078	0.0574	0.3851	0.0341	0.0681
9	0.0514	0.0740	0.0788	0.0935	0,0836	0.1074	0.1107	0.0342	0.0427	0.5083	0.0469	0.1012
10	0.1489	0.1080	0.1099	0.1416	0,1452	0.2035	0.1726	0.1030	0.1003	0.1455	0.1443	0.1316
11	0.2334	0.1765	0.1256	0.1762	0,1832	0.2408	0.2226	0.1102	0.2026	0.2354	0.1399	0.1750
12	0.2477	0.2417	0.1562	0.1522	0,1703	0.2034	0.1998	0.1935	0.3073	0.2868	0.1745	0.1893
13	0.3089	0.3741	0.2693	0.2010	0,1721	0.2348	0.2420	0.3049	0.4181	0.4184	0.5372	0.2565
14	0.3344	0.4308	0.3651	0.2239	0,1949	0.2519	0.3056	0.3774	0.5056	0.5164	0.5715	0.3031
15	0.3554	0.5149	0.4459	0.2481	0,2202	0.3075	0.3354	0.3549	0.4452	0.4625	0.6905	0.3347
16	0.3913	0.6024	0.5430	0.2477	0,2779	0.3473	0.4267	0.6350	0.7817	0.6961	1.1118	0.4291
17	0.3298	0.5124	0.5331	0.2161	0,2546	0.2896	0.2994	0.3673	0.5169	0.5674	0.9870	0.3575
18	0.3142	0.6047	0.6202	0.2408	0,3097	0.2719	0.2751	0.4634	0.7585	0.5124	2.0582	0.4048
19	0.3414	0.7317	0.9441	0.3072	0,4618	0.3775	0.2739	0.2480	0.5935	0.5926	1.7163	0.4752
20	0.3575	0.8484	1.2160	0.5690	0,5830	0.4905	0.3353	0.5884	1.0477	0.6211	2.5297	0.5968
21	0.5748	1.1553	1.9005	0.9235	2,0278	0.7127	0.4764	0.9958	1.4555	0.7704	2.8225	0.9877
22	0.4139	1.3451	1.8696	1.5966	1,4847	0.2341	0.2739	0.7588	1.6843	0.9892	1.8831	1.2465
23	0.4484	1.1153	1.6599	1.0278	1,3625	0.4785	0.3615	0.7803	1.3938	0.7918	2.3952	0.9370
6-17	0.0947	0.1065	0.0830	0.0890	0,0843	0.1125	0.1181	0.0816	0.0981	0.1909	0.0524	0.0820

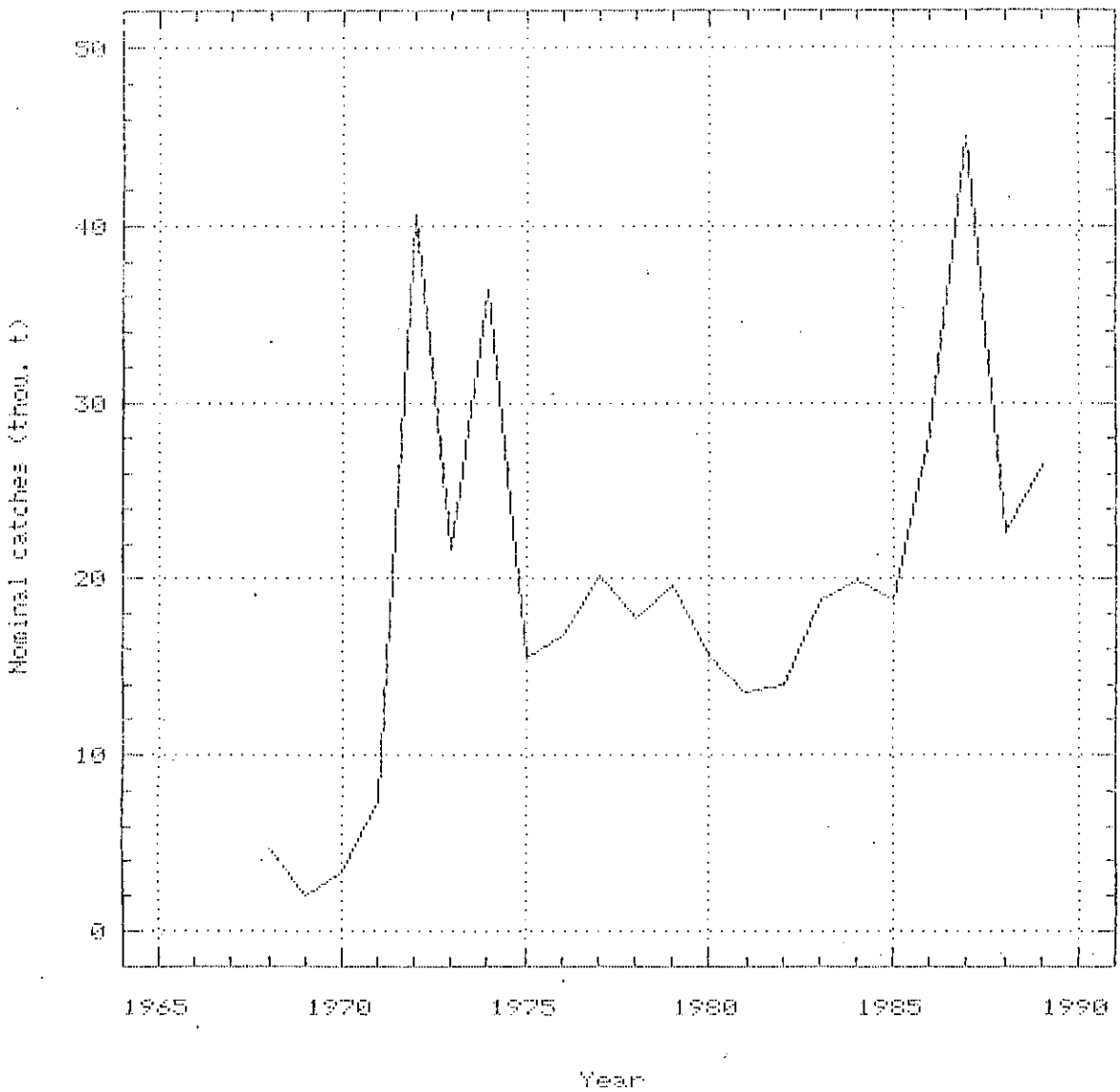

Fig. 1. Nominal catches of redfish in div.3M(1986-89 are provisional)

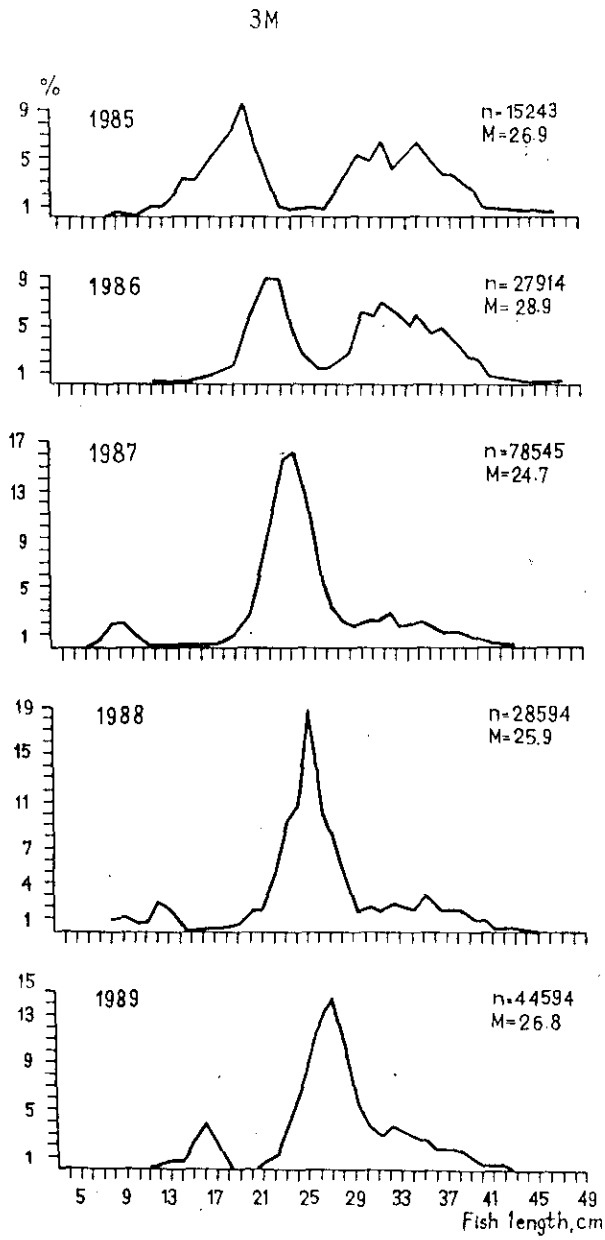

Fig. 2 Redfish length composition from catches taken with a small-meshed trawl on the Flemish Cap Bank in 1985-1989

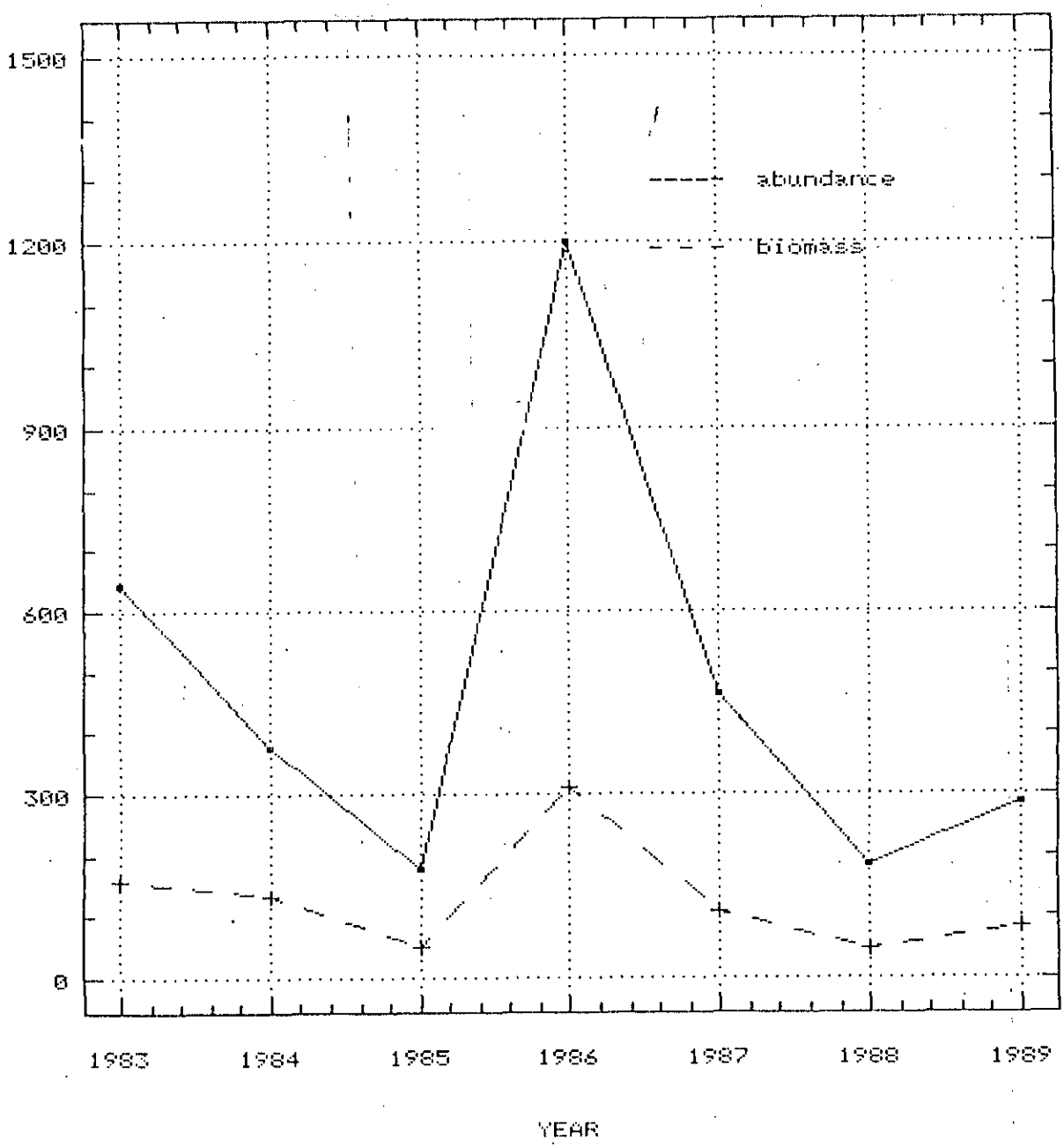

Fig.3 Abundance(mill.spec.) & biomass(thou.t) of redfish in Div.3M based on trawl data