Northwest Atlantic Fisheries Organization

Serial No. N1300

NAFO SCR Doc. 87/20

SCIENTIFIC COUNCIL MEETING - JUNE 1987

Estimation of Stock Size and Total Allowable Catch of Beaked Redfish in Div. 3LN and 3M for 1988

by

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ABSTRACT

Abundance and biomass of the commercial stock of beaked redfish in Divs. 3LN and 3M for 1975-1986 have been estimated by VPA. Calculations are based on international catch and biological statistics. Fishing and natural mortality rates in different age groups have been estimated. A TAC estimate for 1988 is given.

INTRODUCTION

Redfish is an important object of fishing in the Northwest Atlantic. Similarly to other commercial fish stocks redfish are assessed in trawl surveys, mathematical models and methods established in fisheries research in the USSR and abroad are applied. As noted previously (Tretyak, 1983), the majority of models do not take account of variations in fishing and natural mortality rates with age. The present paper considers the 1988 estimates of the abundance, biomass and TAC of beaked redfish in Divs. 3M and 3LN with respect to variations in fishing and natural mortality rates with age and to year class strength dynamics.

MATERIAL AND METHODS

The abundance and biomass of commercial stocks of beaked redfish for 1975-1986 were estimated by VPA. To realize the method natural mortality rates in different age groups of fish, assumed constant during one year of their life, were

calculated together with initial instantaneous fishing mortality rates (F_{st}). The number of fish in the catch by age groups contained in the commercial stock was estimated following the method suggested by N.A.Maslov (1957) (Tables 1,2).

Redfish from both areas were assumed to recruit the commercial stock at age 5, and the oldest fish in the commercial stock were assumed to be 23 years of age. The fishing effort in each year was standardized to Soviet large refrigerator trawler effort and the 1975-1985 average was used for 1986. Natural mortality rates were estimated following the method described by V.L.Tretyak (Tretyak, 1983; Efimov, Savateeva, Tretyak, 1986).

Initial instantaneous fishing mortality rates for fish from Divs.3LN were calculated as follows: after averaging catches for a considered time interval a so-called "averaged" year class was formed in each age group. For each age group in this "averaged" year class, from $\tau_1 = 5$ to $\tau_n = 23$, reliable maximum estimates of initial fishing mortality rate $F_{\tau\,st}$ were derived following the method described by Nikolskaya T.L., Savateeva A.N., Tretyak V.L.(1985). For age groups 24-27 catch values were recovered from

$$\lg \frac{C_\tau}{N_{o\tau}} = A_\tau + B$$

where

C_τ - catch composed of age group τ ;

$N_{o\tau}$ - initial abundance of age group τ .

$F_{\tau\,st}$ for age groups $\tau = 5, 6 \ldots 23$ were calculated once again in view of recovered catch values. Thus revised $F_{\tau\,st}$ estimates were used in a preliminary VPA run, which provided fishing mortality rate averages for all years.

$$\overline{F}_{\tau st} = \frac{\sum_{j=1}^{n-2} F_{\tau_j} \cdot N_{\tau_j}}{\sum_{j=1}^{n-2} N_{\tau_j}}$$

where

N_{τ_j} - abundance of age group τ in year j;

n - number of years used in calculations.

Thus revised $F_{\gamma st}$ estimates were used again in VPA runs. This procedure was accomplished until $F_{\gamma st}$ estimates in two successive steps were close within desired accuracy ($\delta = 0.005$).

To obtain initial fishing mortality rate estimates for beaked redfish in Div. 3M the procedure of VPA tuning was implemented using the method suggested by Saville (Pope, Shepherd, 1983) for the first time.

Tables 3 and 4 present estimates of fishing mortality rate for beaked redfish from Divs. 3 LN and 3M. Status quo estimates of TAC were obtained (Pope, 1983), implying that a projected exploitation level is equal to the 1986 exploitation level.

RESULTS

Beaked redfish from Divs. 3LN. Abundance estimates by the beginning of each year of fishery are given in Table 5. VPA results indicate that the commercial stock of redfish in the Grand Bank is at a high level. This is confirmed by Soviet and Canadian investigations (Nikolskaya et al., 1985; Atkinson, Power, 1986).

Data from research and commercial vessels show that the 1986 catches are dominated by 19-27 cm long fish from strong 1973-1981 year classes (Fig.1), with the abundance estimated at 508 mill. fish. 1979-1981 year classes are the strongest. The 1988 catches will be composed of fish 21-29 cm in length aged 7-15 years from 1973-1981 year classes.

According to VPA the 1975-1986 average biomass of the commercial stock was 170 thou.t and it was estimated at 243 thou.t in 1986 (Table 6).

Biomass and abundance of the commercial stock are found to increase since 1985 due to recruitment from strong 1979-1981 year classes.

Assuming mature fish in each age group older 11 years constitute 100%, the 1988 biomass of the spawning stock increases to 110 thou.t.

Due to the fact that in 1988 the commercial stock will contain 9 strong year classes, its total abundance and biomass will be 999 mill.fish and 300 thou.t, respectively. At F=0.15 the TAC is estimated to be 40 thou.t.

Beaked redfish from Div. 3M. Data from research and commercial vessels show that the catches were dominated by small fish 20-23 cm in length aged 5-7 years from strong 1979-1981 year classes and by large fish 30-37 cm long aged 10-15 years from 1972-1976 year classes (Fig.2).

Table 7 gives abundance estimates by the beginning of each year of fishery.

The average biomass of the commercial stock in 1975-1986 was estimated at 120 thou.t and the 1986 biomass was estimated by VPA at 157 thou.t.

In 1988 catches will contain considerable quantities of small fish 22-25 cm long aged 7-9 years from 1979-1981 year classes and large fish 32-39 cm long aged 12-16 years from 1971-1975 year classes.

Assuming mature fish in each age older 12 years constitute 100%, the 1988 biomass of the spawning stock will be 52 thou.t. The total abundance and biomass of the commercial stock in 1988 will be 649 mill.fish and 176 thou.t, respectively. Due to the fact that in 1988 the commercial stock will be composed chiefly of small fish, a precautionary exploitation level is preferable. At $F_{0.1}$= 0.14 the TAC will constitute 20 thou.t.

CONCLUSIONS

The VPA results for 1975-1986 indicate an increasing trend in the abundance and biomass of beaked redfish in Divs. 3LN. This increase is due to recruitment of strong year classes in the fishery. Bearing in mind a high level of redfish stock in these areas a TAC may be set at 40 thou.t.

Data for 1975-1986 suggest evidence of a slight increase in the abundance and biomass of redfish in the Flemish Cap, which is due to the recruitment of strong 1979-1981 year classes in the fishery. Current stock status and size-age structure of beaked redfish in this area allow to set a TAC at 20 thou.t.

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Table 1. Total number of beaked redfish (thou.fish) captured in Divs. 3 LN (according to NAFO Circular Letter 87/13)

Age, years	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
5	7716	217	26	2243	4786	2773	7618	9346	5213	2731	6597	7967
6	7591	533	109	2939	4294	2803	8771	13616	10933	4570	6875	7631
7	5191	953	241	2442	3633	2486	6911	11328	10743	4812	5535	4646
8	6519	1672	449	3159	5397	3572	8252	11949	11646	6021	7225	8385
9	5545	2434	749	2609	4014	3430	7972	10964	9411	5222	5273	5505
10	3972	6223	2095	2674	3441	4297	7531	9042	9270	5913	4393	4460
11	1900	7711	3255	1617	2238	3019	4123	3159	3593	3147	1664	1823
12	1498	7912	3872	1867	1998	3539	4086	2175	2493	2515	1304	1777
13	1322	5295	3198	1518	1396	2924	2639	1016	1102	1255	686	1856
14	1223	2982	2467	1193	908	1915	1493	534	587	662	445	1103
15	873	1810	2481	1120	796	1453	1305	385	344	461	463	430
16	850	972	1409	613	614	783	797	227	213	262	323	279
17	526	497	788	264	421	462	517	94	86	129	222	197
18	476	558	1208	342	535	496	548	102	58	141	240	186
19	299	642	908	324	395	370	495	48	15	68	167	128
20	1498	165	1682	1255	962	1144	1406	79	28	95	250	105
21	207	484	719	300	214	217	310	16	20	15	74	58
22	495	332	344	386	247	323	417	25	20	3	19	46
23	500	194	164	184	127	153	220	25	20	3	9	23

Table 2. Total number of beaked redfish (thou.fish) captured in Div. 3M (according to NAFO Circular Letter 87/13)

Age, years	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
5	2658	16	39	1160	618	123	321	14	13	1027	8200	2571
6	2735	135	99	1104	2118	818	1194	233	155	875	3870	6350
7	3667	462	308	1228	3571	2708	2925	1137	837	1536	670	3973
8	3937	1342	706	1140	3665	3672	4533	3050	3320	2621	350	1353
9	4537	2827	1581	1718	3146	4399	5877	5119	6031	3857	1310	1163
10	6449	5794	3445	3690	3020	3855	6412	7334	9792	6044	2520	2272
11	5967	7025	4736	4913	3364	2827	4855	6387	9095	6204	2630	2718
12	3811	5323	4238	4467	3632	2280	2699	3569	5291	4335	3440	3793
13	2558	4533	4662	4550	4492	2838	2223	2350	3643	3612	4050	3495
14	1623	3093	4014	3611	3985	2740	1666	1600	2523	2599	3300	2861
15	1062	2016	3483	2609	3316	2409	1235	1187	1783	1799	1700	1622
16	789	1410	2929	1799	2508	1867	850	963	1281	1233	1670	1383
17	482	703	1671	936	1364	1134	454	615	684	573	570	482
18	371	449	1263	623	986	853	311	454	457	351	460	426
19	370	333	982	437	795	658	237	383	356	250	180	231
20	258	211	705	259	558	471	164	264	229	158	280	281
21	241	136	491	165	376	324	108	170	154	99	210	171
22	176	61	210	57	143	133	41	50	48	25	70	60
23	145	17	61	49	68	37	14	7	5	4	40	28

Table 3. Natural (M_{ζ}) and fishing mortality rates for beaked redfish from Divs.3 LN during one year of life

Age, years	M_{ζ}	Fishing mortality rate by years of fishing										
		1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
5	0,100	0,219	0,006	0,000	0,033	0,064	0,023	0,049	0,074	0,068	0,021	0,020	0,070
6	0,080	0,275	0,019	0,003	0,066	0,073	0,044	0,085	0,104	0,104	0,071	0,060	0,026
7	0,060	0,233	0,044	0,009	0,077	0,094	0,048	0,126	0,131	0,097	0,053	0,100	0,046
8	0,040	0,306	0,093	0,022	0,133	0,205	0,108	0,189	0,281	0,164	0,062	0,090	0,183
9	0,030	0,238	0,149	0,047	0,145	0,208	0,163	0,306	0,338	0,307	0,086	0,060	0,077
10	0,020	0,155	0,369	0,153	0,192	0,237	0,292	0,506	0,539	0,429	0,264	0,081	0,055
11	0,010	0,098	0,402	0,271	0,138	0,198	0,272	0,400	0,330	0,339	0,204	0,090	0,036
12	0,020	0,100	0,569	0,290	0,200	0,205	0,432	0,561	0,306	0,375	0,339	0,100	0,108
13	0,030	0,109	0,481	0,383	0,145	0,186	0,418	0,534	0,213	0,205	0,268	0,120	0,167
14	0,040	0,114	0,316	0,353	0,199	0,102	0,342	0,320	0,160	0,153	0,153	0,120	0,238
15	0,070	0,070	0,208	0,394	0,227	0,168	0,201	0,348	0,109	0,126	0,147	0,130	0,139
16	0,110	0,061	0,092	0,219	0,140	0,166	0,219	0,143	0,082	0,072	0,128	0,129	0,096
17	0,150	0,011	0,043	0,093	0,054	0,125	0,168	0,203	0,021	0,038	0,053	0,130	0,101
18	0,210	0,016	0,014	0,135	0,052	0,145	0,208	0,299	0,055	0,016	0,078	0,130	0,150
19	0,280	0,016	0,029	0,030	0,051	0,082	0,148	0,347	0,040	0,011	0,024	0,130	0,099
20	0,370	0,082	0,013	0,111	0,060	0,238	0,409	1,612	0,096	0,033	0,098	0,131	0,128
21	0,490	0,021	0,044	0,089	0,033	0,016	0,098	0,236	0,076	0,040	0,028	0,130	0,051
22	0,630	0,077	0,061	0,057	0,090	0,049	0,045	0,412	0,038	0,187	0,011	0,065	0,162
23	0,800	0,065	0,065	0,065	0,065	0,065	0,065	0,065	0,065	0,065	0,065	0,065	0,178

Table 4. Natural (M_c) and fishing mortality rates for beaked redfish from Div. 3M during one year of life

Age, year	M_c	Fishing mortality rate by years of fishing											
		I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986
5	0,I40	0,055	0,000	0,000	0,0I5	0,008	0,003	0,009	0,000	0,000	0,007	0,038	0,044
6	0,II0	0,085	0,003	0,002	0,0I6	0,03I	0,0I3	0,03I	0,008	0,008	0,027	0,029	0,034
7	0,080	0,I22	0,0I6	0,008	0,025	0,057	0,045	0,053	0,033	0,030	0,084	0,024	0,034
8	0,060	0,I3I	0,052	0,027	0,032	0,082	0,068	0,086	0,063	0,III	0,I08	0,022	0,053
9	0,040	0,I37	0,II2	0,069	0,074	0,099	0,II5	0,I25	0,II2	0,I44	0,I55	0,062	0,079
I0	0,020	0,205	0,2I4	0,I6I	0,I89	0,I5I	0,I42	0,20I	0,I88	0,267	0,I75	0,I20	0,I2I
II	0,0I0	0,226	0,29I	0,220	0,29I	0,2I4	0,I68	0,2I7	0,255	0,30I	0,2I9	0,088	0,I50
I2	0,0I0	0,I82	0,260	0,230	0,268	0,29I	0,I78	0,I94	0,I99	0,279	0,I86	0,I48	0,I44
I3	0,0I0	0,I53	0,274	0,304	0,329	0,373	0,3I0	0,2I4	0,208	0,257	0,250	0,2I4	0,I78
I4	0,030	0,I48	0,227	0,335	0,329	0,427	0,330	0,246	0,I92	0,292	0,239	0,308	0,I89
I5	0,040	0,I36	0,230	0,353	0,3I2	0,463	0,406	0,202	0,230	0,280	0,288	0,202	0,203
I6	0,070	0,I33	0,228	0,504	0,262	0,464	0,43I	0,207	0,203	0,348	0,269	0,397	0,2I3
I7	0,II0	0,I02	0,I49	0,402	0,260	0,285	0,345	0,I55	0,200	0,I92	0,228	0,I70	0,I67
I8	0,I60	0,09I	0,I2I	0,400	0,238	0,442	0,269	0,I39	0,2I2	0,209	0,I33	0,268	0,I72
I9	0,230	0,098	0,I09	0,4I5	0,232	0,532	0,594	0,II0	0,252	0,254	0,I67	0,093	0,207
20	0,320	0,I27	0,080	0,384	0,I97	0,567	0,778	0,3I0	0,I86	0,254	0,I84	0,309	0,222
2I	0,420	0,I89	0,I09	0,326	0,I73	0,597	0,987	0,496	0,764	0,I89	0,I99	0,482	0,383
22	0,560	0,665	0,090	0,334	0,076	0,306	0,624	0,432	0,649	0,737	0,057	0,289	0,339
23	0,720	0,I92	0,I92	0,I92	0,I92	0,I92	0,I92	0,I92	0,I92	0,I92	0,I92	0,I92	0,289

Table 5. Number of beaked redfish (thou.fish) by age in different years of fishing in Divs. 3LN.

Age, years	Years of fishing											
	I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986
5	42I49	4III7	52975	72272	79878	I27322	I66424	I37473	82539	I38234	348772	I23762
6	33044	30648	36973	479I6	6325I	67790	II2578	I43322	II5478	6974I	I22495	309289
7	25586	23I69	27768	340I8	4I425	54285	59909	95493	II9278	96I05	59986	I06447
8	25I22	I9082	20889	259I3	29655	35509	48729	49724	789I0	I0I943	85828	5III8
9	26870	I7778	I6699	I9627	2I798	2320I	30623	38742	36075	64368	92068	75386
I0	27853	20559	I4864	I5469	I648I	I7I87	I9I29	2I888	268I4	25748	573I5	84I69
II	20532	23383	I3937	I2506	I2520	I2747	I2582	II299	I25I9	I7II7	I938I	5I8I2
I2	I5866	I8434	I549I	I0526	I0785	I0I67	96I4	8348	8043	8826	I3820	I7529
I3	I3339	I4072	I0224	II357	845I	8608	6467	5379	6027	54I6	6I66	I2257
I4	II450	II602	8443	6767	9530	68I2	5500	368I	42I9	4762	402I	5308
I5	I3523	98I7	8I27	5697	5329	8267	4647	3836	30I3	3480	3927	3428
I6	I5244	II757	7432	5I07	423I	4200	6304	306I	3208	2478	280I	32I5
I7	50842	I2846	9607	5346	3977	32II	3023	4894	2525	2673	I953	2205
I8	32305	43266	I0593	7537	4360	302I	2336	2I25	4I25	2093	2I82	I476
I9	2III6	25758	34573	750I	5802	3058	I989	I404	I63I	3292	I569	I553
20	22529	I5698	I89I2	25348	5388	404I	I994	I063	I0I9	I220	2429	I04I
2I	I254I	I4330	I0705	II69I	I6482	2932	I854	274	666	68I	764	I472
22	9038	7524	8405	6000	6932	9932	I629	897	I56	392	405	4II
23	II493	4459	3769	4229	29I9	35I6	5056	574	459	69	206	202

Table 6. Biomass of beaked redfish (thou.t) by age in different years of fishing in Divs. 3LM.

Age, years	Years of fishing											
	I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986
5	5I42	73I8	7522	9395	I6454	I59I5	36946	30519	I7085	I6588	43596	20297
6	7567	7263	7025	I0877	I3852	I47I0	27244	34684	25635	I2553	2266I	6897I
7	6I9I	5885	6775	8436	9776	I3245	I4677	23395	2779I	20I82	I4396	26292
8	6I04	6068	5765	7877	9845	90I9	I4034	I6I60	250I4	23956	23I73	I5335
9	6825	5049	58II	6634	7476	7609	I0350	I3792	I2770	I7636	2900I	24952
I0	9275	6990	5737	6033	6724	5998	8244	87II	II047	8754	2367I	3I984
II	7I86	I0008	5979	6028	542I	5430	5687	4994	5408	6333	8566	22538
I2	6949	9752	8272	55I6	5I98	5257	5095	4399	3780	4722	6979	8852
I3	7043	7585	646I	7I44	4462	4855	3957	3292	32I2	3423	35I4	7060
I4	7I22	7I47	6028	460I	6052	43I8	364I	245I	2637	3262	2630	3450
I5	9790	7I96	6022	4204	3869	5985	3569	30I5	2I60	25I9	2867	2502
I6	II036	9523	6I83	4208	3360	309I	5283	2430	253I	I809	2297	2572
I7	4I640	I0662	84I6	4897	34I2	2665	266I	4248	2090	2206	I709	I892
I8	289I3	4I882	I0476	7I00	3898	25I9	2067	I985	3630	I892	I946	I349
I9	I9596	24006	36095	7973	572I	3I84	2II5	I428	I8I5	308I	I553	I548
20	2I853	I5949	2I503	28694	5549	4I74	22I5	I093	II42	I232	2502	I096
2I	I3444	I5534	I2653	I3737	I8525	3272	2I60	323	757	765	8I9	I658
22	I0I77	9270	I0245	7206	8236	II084	I984	I068	I85	482	452	49I
23	I3033	5493	4599	5I55	3263	4237	6300	687	549	82	252	247
	238886	2I2580	I8I567	I557I5	I4I093	I25577	I58229	I58674	I49239	I3I477	I92584	243086

Table 7. Number of beaked redfish (thou.fish) by age in different years of fishing in Div. 3M.

Age, years	Years of fishing											
	I975	I976	I977	I978	I979	I980	I98I	I982	I983	I984	I985	I986
5	55237	683I2	86493	86783	77550	48355	38453	25835	39543	I64557	239536	63972
6	357I3	45437	59366	75I66	7432I	66853	4I930	33I25	22452	34364	I42067	200534
7	33063	29398	40570	53085	66284	64539	59I27	364II	29447	I9959	28950	I23640
8	32962	270I7	26694	37I64	478I6	57769	56953	5I758	325I0	26369	I6942	26997
9	36I74	27238	24I45	24458	33902	4I469	5084I	492I3	45785	2740I	2229I	I56I4
I0	35205	303I8	23404	2I647	2I8I5	29496	35528	43II3	42255	38093	22549	20I3I
II	29794	28099	24004	I9534	I7559	I8395	2509I	28482	35022	3I7I4	3I354	I9608
I2	2293I	23532	20792	I907I	I4454	I403I	I5394	I9992	2I846	2565I	252I4	28420
I3	I8079	I8925	I7970	I6350	I4446	I0696	II623	I2557	I6224	I6368	2I092	2I538
I4	II952	I5364	I4242	I3I33	II646	9848	7765	9295	I0094	I2426	I26I9	I6855
I5	8522	I0000	II877	9886	9I69	737I	687I	5894	7442	73I6	9494	9000
I6	6548	7I48	763I	8020	6955	5543	47I8	5395	450I	5403	5269	7455
I7	5254	5346	5305	4297	5765	4077	3358	3577	4I05	2962	3849	3304
I8	46I2	4249	4I26	3I78	2967	3876	2586	2577	2623	3034	2II2	29I0
I9	4450	3588	3208	2356	2I35	I625	2523	I9I8	I776	I8I3	2264	I377
20	2524	3206	2555	I683	I484	996	7I2	I795	II85	I095	I2I8	I639
2I	I705	I6I4	2I48	I263	I004	6II	332	379	I082	667	66I	649
22	459	927	95I	I0I9	698	363	I49	I32	II6	588	359	268
23	II5I	I35	484	389	539	293	III	55	39	3I	3I7	I53

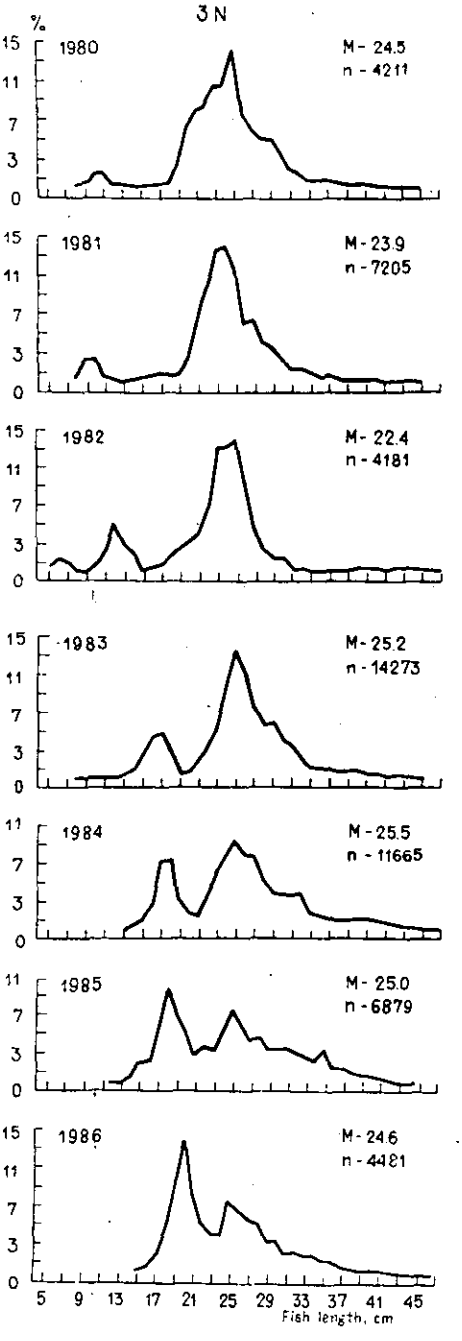
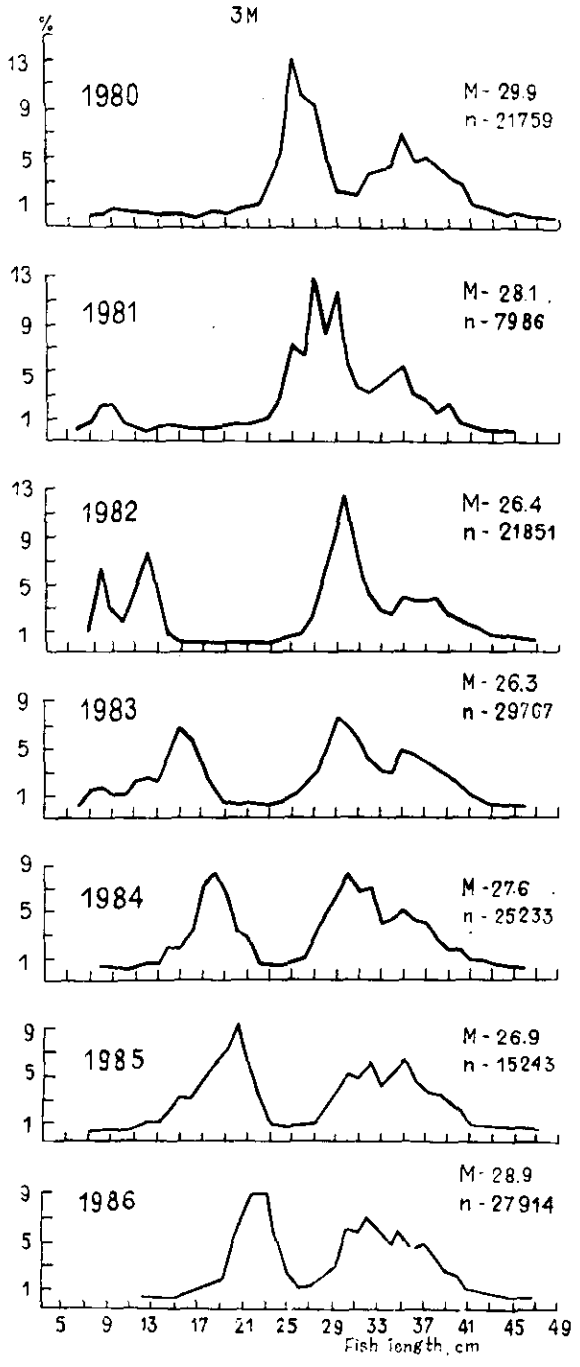


Fig. 1. Size composition of beaked redfish in fine-meshed trawl catches from South Newfoundland area in 1980-1986.



Fig,2. Size composition of beaked redfish in fine-meshed trawl catches from the Flemish Cap Bank in 1980-1986.