Northwest Atlantic Fisheries Organization

Serial No. N1234

NAFO SCR Doc. 86/107

SCIENTIFIC COUNCIL MEETING - SEPTEMBER 1986

An Estimate of Redfish Availability to Cod on the Flemish Cap in the Period 1978-85

by

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INTRODUCTION

Cod and redfish have been taken in commercial quantities on the Flemish Cap for many years. On this bank, and in other areas as well, redfish constitute a common food item in the stomachs of cod. The predator-prey relationship between these two species is constrained by their relative sizes and the practice of cod to take whole specimens. Abundance estimates and length compositions for each species are available for the period 1978-85 from research vessel observations. If the overall supply of food to cod in this area is limiting to their growth and well-being, large fluctuations in the availability of a major food item may well be of importance. An attempt has been made here to estimate the amount of redfish available to cod of different sizes for the 8-year period.

MATERIALS AND METHODS

Intensive random-stratified surveys for groundfish were carried out with the Canadian research vessel GADUS ATLANTICA in January-February, 1978-85. Cod and redfish from each successful fishing set are routinely measured. Since the otter trawl used contains a 1 1/8 inch liner in the codend, estimates of both species include specimens smaller than those retained in the commercial fishery. Detailed biological sampling of specimens is done at sea and samples are also preserved for further observations at the laboratory.

In 1983 and 1984, 250 morphometric observations taken at sea on the Flemish Cap included the gape of cod, that is, the opening of the mouth measured in the dorso-ventral aspect.

From the years 1956 and 1958, 156 observations of redfish greatest body depth were made at the laboratory from previously frozen specimens taken from the Flemish Cap. An additional 75 observations were made at sea on fresh specimens in 1984. Greatest body depth was measured from a position just anterior to the first dorsal spine to a point on the ventral surface opposite this and at right angles to the main longitudinal axis of the fish. This was usually on the flat section between the bases of the pelvic fins. Measurements were made using calipers.

Abundance estimates of each species were made by means of the areal expansion method.

RESULTS

Length compositions

Cod taken on the Flemish Cap in the period 1978-85 were generally within the length range 20-60 cm (Fig. 1). While in 1978-82, the population exhibited two or more modes, in 1983-85 the length frequencies were dominated by one mode in each year.

The presence of two strong modes was evident in the redfish length frequencies over the whole period 1978-85 (Fig. 2). There was, however, a clear tendency for these two modes to coalesce by 1983. In 1981, but especially in 1982 and 1983, small redfish (less than 15 cm) were very much in evidence. In 1982 and 1983, these small redfish, clearly composed of two peaks, dominated in abundance the redfish population. In 1984 and 1985 the abundance of these groups had diminished relative to the population and were no longer dominant.

Body depth of beaked redfish

The relationship of maximum body depth to fork length is significantly described (r^2 = .96) by maximum body depth (cm) = .2915 fork length (cm) - .4977 (Fig. 3). There was no significant difference in measurements made at sea to those made from previously frozen specimens.

Whole weight of beaked redfish

From unpublished data available at the Northwest Atlantic Fisheries Centre, the relationship of whole (ungutted) weight of beaked redfish to fork length was significantly described (r^2>.99) by log whole weight = 2.988 log fork length - 1.822 (Fig. 4).

Mouth size of cod

From observations of the extended mouth of cod, it was concluded that the shape was spherical and therefore that a single measurement was sufficient to describe it. A significant relation (r^2>.99) was found between the gape (mouth diameter) and fork length of cod:

gape (cm) = .109 fork length (cm) - .111 (Fig. 5).

Minimum size of cod required to consume redfish of a particular length

It was assumed that a cod would be able to capture and consume redfish of body depth up to and including that equivalent to the gape of the cod's mouth. Where gape of cod = maximum body depth of redfish, .109 cod length - .111 = .291 redfish length - .498. That is, cod length = 2.67 redfish length - 3.55.

Redfish biomass available to cod at each length group

The whole weight to fork length relationship of beaked redfish was applied to the numbers of redfish at each 1 cm length group in each year. The sum of these redfish biomasses at length was usually within 5% (range 93-103%) of the biomass estimated directly from the survey using catch weight per standard tow. The biomasses at length calculated using the length-weight relationship were adjusted to correspond with the biomasses estimated from the survey weights per tow.

Each redfish biomass at length x was distributed over the range of cod with mouths at or above the minimum size necessary to consume redfish of length x. It was assumed that any cod at or above this minimum length would have an equal probability of capturing redfish.

As an example, cod of length 37 cm would be able to eat redfish of length 15 cm and less. In the hypothetical example given in the Appendix, cod of 37 cm would have an estimated biomass of 6.0 t of redfish of length 15 cm available to them. Additional biomass of redfish less than 15 cm would also be available.

From Table 1, 90% of the biomass of beaked redfish was potentially available only to cod of length greater than 70 cm. The influence of the appearance of small redfish upon the potential redfish biomass available to smaller cod is clearly seen in 1982 and 1983. In 1982, of the 1550 t of redfish potentially available to cod of length 31 cm, about 1100 t was made up of 11 and 12 cm redfish. Similarly, in 1983, almost all the 1850 t potentially available to 25 cm cod was made up of 10 and 11 cm redfish, and redfish of 14-16 cm comprised 2500 of the 3300 t potentially available to cod of length 46 cm.

Biomass of redfish available per cod at length

Biomass values of Table 1 were divided by the numbers of cod at each 3 cm length to arrive at the biomass (kg) of redfish available per cod at each cod length. The influence of the influx of small redfish in 1982 and 1983 upon the redfish biomass potentially available as food to cod of about 55 cm or less is clear (Table 2). On average over the 8-year period, less than 10 kg of redfish per cod was available to cod less than 60 cm in length while between 10-100 kg per cod was available to cod between 60 and 70 cm (Fig. 6). Beyond 70 cm, the redfish biomass potentially available as food rose quite sharply to a level in excess of 1000 kg for cod greater than 90 cm.

Biomass of redfish per biomass of cod at length

From Wells (this meeting), the parameters of the logarithmic fork length - gutted weight relationships of cod in January-February, 1978-85 were:

	Slope	Intercept
1978	3.106	-5.286
1979	3.083	-5.258
1980	3.138	-5.361
1981	3.101	-5.274
1982	3.110	-5.294
1983	3.145	-5.354
1984	3.180	-5.423
1985	3.172	-5.421

These relationships were applied to derive estimates of the average gutted weight of cod at length in each year. The biomasses per cod (Table 2) at length were divided by these average weights to provide redfish biomass per cod biomass at each cod length. For the period 1978-81, redfish alone could hardly have provided an adequate food source for cod less than about 50 cm (Table 3) if a minimum yearly ration of 2-3 times a fish's own weight is required. In 1982 and 1983, more than adequate redfish prey was potentially available for all cod. In 1984 and 1985 potential redfish biomass was inadequate in itself as a food supply for cod less than about 46 cm. For cod greater in length than about 55 cm, potential redfish prey of suitable size was almost never limiting.

DISCUSSION AND CONCLUSIONS

Redfish taken on the Flemish Cap by research trawl in the period 1978-85 ranged in length up to about 50 cm but were generally less than 40 cm. The size of the cod mouth compared to the greatest body depth of redfish implied that cod could eat redfish up to about 1/3 of their own length. Cod were present in the research vessel catches up to about 130 cm and thus most redfish would be vulnerable to predation.

In the period 1978-85, the redfish biomass available to cod of lengths of 70 cm and greater was quite large. For cod less than about 50 cm, available redfish biomass was rather low in 1978-81 but increased strongly in 1982 and 1983 when there was an influx of young redfish into the population.

It is concluded that effects, if any, of changes in redfish abundance in the period 1978-85 on growth and other vital functions of cod would be most apparent in cod of about 50 cm or less.

Table 1. Biomass of beaked redfish (tons) available per cod length group. The biomass was calculated for each redfish length group and partitioned amongst cod length groups able to consume it by using cod numbers as a weighting factor.

Cod forklength (cm)	1978	1979	1980	1981	1982	1983	1984	1985
13					.1			
16				.1		.1		
19						8.9	1.0	
22		1.0			7.5	490.6	2.8	.1
25		5.0			53.4	1849.5	6.6	.5
28	.2	2.1		.2	517.1	912.2	14.7	1.1
31	1.6	.8	.9	2.1	1550.5	242.5	39.1	2.7
34	5.6	1.4	5.0	16.2	799.1	178.0	121.0	8.2
37	9.1	6.4	10.8	33.0	28.9	661.4	255.6	23.0
40	10.3	28.4	7.2	25.7	77.4	1106.7	327.6	76.8
43	34.1	48.8	3.0	30.0	48.5	2309.3	466.9	238.1
46	452.0	103.3	13.6	80.9	177.6	3270.2	669.9	1172.8
49	1497.7	168.1	44.7	116.0	668.5	2875.2	311.5	2061.0
52	2822.6	253.6	140.6	132.4	1016.1	1333.2	307.1	2457.9
55	3197.0	835.9	628.0	126.1	1138.6	162.1	366.8	2017.3
58	2477.2	1570.1	2011.5	215.8	655.9	223.2	668.1	1461.4
61	1708.7	2283.4	5179.5	811.6	603.1	513.6	865.3	730.1
64	1360.0	1888.6	10682.0	2834.9	1038.7	1139.1	959.3	374.9
67	933.4	2047.6	13436.5	5163.8	630.4	2371.4	546.3	226.2
70	1211.9	1676.7	10412.1	14152.0	1383.4	5228.2	568.3	559.7
73	1465.3	1253.4	11091.5	10027.4	1486.2	5172.3	724.2	2239.0
76	1933.5	1868.3	7869.8	7919.5	2965.6	5219.2	3147.2	4771.8
79	2426.0	2610.0	10635.0	7603.2	5806.0	6593.9	6541.1	5349.8
82	4538.7	4656.6	13357.8	10761.4	3238.3	8618.5	14298.9	3379.1
85	8946.8	3094.0	14043.8	12510.2	5254.7	8115.9	14886.9	4292.6
88	16704.6	4747.6	16439.1	13858.7	2903.3	5661.0	13509.3	7991.4
91	15417.8	1665.3	21733.2	16885.4	2025.0	4140.2	9651.8	11329.4
94	13547.4	8632.7	14951.2	32028.4	2672.1	11254.9	16302.9	11600.3
97	14097.0	5297.8	11597.2	14313.6	13388.7	12474.6	7201.1	11365.8
100	23528.7	12301.4		21060.6	12328.7	9497.9	10979.1	6592.6
103	45170.0	20579.0	18424.8	9110.3	7548.1	11610.7	6778.0	
106	15905.6	7410.7	10357.9	18002.3	14177.6	21802.4	7845.2	3895.3
109	21749.7	3909.4	11138.2	8268.5	6705.9	14360.0	8787.9	12136.0
112	32926.0	12160.1	23329.4		4349.2	5330.0	3288.4	20712.9
115	9988.2	4171.6		13239.2	5132.4	5672.5	7046.1	4285.7
118	5501.1	4253.7	24628.7			6015.7	3736.6	
121	5522.2	12780.1	12734.2					9003.2
124	16715.0	8549.4						
127								
130		8557.1					4188.3	
133						6996.7		
Total available	271805.0	139419.4	264907.2	219329.5	100376.6	173414.9	145410.9	130356.5

Table 2. Biomass of beaked redfish (kg) available per cod at length on Flemish Cap for the years 1978-85. Values <.05 were not included.

Cod forklength (cm)	1978	1979	1980	1981	1982	1983	1984	1985	Average
16				.1					.1
19									
22					1.9	.1			1.0
25					5.3	.4			2.9
28				.1	8.6	.7			3.1
31				.1	9.6	1.5	.1		2.8
34				.1	9.6	3.6	.1		3.4
37				.1	9.6	6.7	.3	.1	3.4
40		.1		.1	9.7	8.3	.6	.1	3.2
43		.1		.1	9.7	8.7	1.4	.3	3.4
46	.2	.3	.2	.1	9.9	8.9	4.4	1.7	3.2
49	.7	.6	.4	.1	10.0	9.0	5.5	3.2	3.7
52	1.8	1.3	.9	.2	10.2	9.2	6.3	5.1	4.4
55	3.1	3.7	2.6	.7	10.5	9.5	7.1	6.4	5.5
58	3.9	9.5	8.8	2.0	11.3	10.1	8.0	7.0	7.6
61	4.2	19.4	28.0	5.2	13.1	10.9	9.6	7.5	12.2
64	4.4	27.4	59.7	16.3	18.2	12.1	12.1	8.3	19.8
67	4.9	31.5	97.4	43.4	31.5	14.2	17.6	10.3	31.4
70	8.8	38.1	125.4	123.1	138.3	38.7	47.4	28.0	68.5
73	20.1	57.0	133.6	156.7	212.3	80.8	90.5	65.9	102.1
76	50.9	116.8	154.3	198.0	269.6	145.0	143.1	136.3	151.8
79	115.5	237.3	204.5	245.3	322.6	235.5	218.0	267.5	230.8
82	216.1	465.7	318.0	326.1	404.8	359.1	297.9	422.4	351.3
85	372.8	773.5	585.2	463.3	525.5	579.7	391.8	613.2	538.1
88	668.2	1186.9	1174.2	692.9	725.8	943.5	540.4	887.9	852.5
91	1101.3	1665.3	2173.3	993.3	1012.5	1380.1	742.4	1258.8	1290.9
94	1693.4	2158.2	3737.8	1392.5	1336.1	1875.8	1018.9	2320.1	1941.6
97	2349.5	2648.9	5798.6	2044.8	1673.6	2494.9	1440.2	2841.5	2661.5
100	2941.1	3075.4		3008.7	2054.8	3166.0	1829.9	3296.3	2767.5
103	3474.6	3429.8	9212.4	4555.2	2516.0	3870.2	2259.3		4188.2
106	3976.4	3705.4	10357.9	6000.8	2835.5	4360.5	2615.1	3895.3	4718.4
109	4349.9	3909.4	11138.2	8268.5	3353.0	4786.7	2929.3	4045.3	5347.5
112	4703.7	4053.4	11664.7		4349.2	5330.0	3288.4	4142.6	5361.7
115	4994.1	4171.6		13239.2	5132.4	5672.5	3523.1	4285.7	5859.6
118	5501.1	4253.7	12314.4			6015.7	3736.6		6364.3
121	5522.2	4260.0	12734.2					4501.6	6754.5
124	5571.7	4274.7							4923.2
127									
130		4278.6					4188.3		4233.5
133						6996.7			6996.7

Table 3. Ratio of available beaked redfish biomass to cod biomass at length. Values <.05 were not included.

Cod forklength (cm)	1978	1979	1980	1981	1982	1983	1984	1985
16				3.5				
19								
22					25.0	1.4		
25					46.8	3.6		
28				.6	53.4	4.4		
31				.4	43.5	6.9	.5	
34				.3	32.6	12.4	.4	
37				.3	25.1	17.7	.8	.3
40		.2		.2	19.9	17.2	1.3	.2
43		.2		.2	15.9	14.3	2.4	.5
46	.3	.4	.3	.1	13.1	11.9	6.0	2.4
49	.8	.7	.5	.1	10.9	9.8	6.1	3.7
52	1.6	1.2	.9	.2	9.2	8.3	5.8	4.8
55	2.4	2.9	2.1	.5	8.0	7.2	5.5	5.1
58	2.5	6.3	5.9	1.3	7.3	6.5	5.2	4.7
61	2.3	11.0	16.1	2.8	7.2	6.0	5.3	4.3
64	2.1	13.4	29.5	7.7	8.6	5.7	5.8	4.1
67	2.0	13.4	41.6	17.7	13.0	5.8	7.3	4.4
70	3.2	14.1	46.7	43.9	49.7	13.8	17.0	10.4
73	6.3	18.6	43.6	49.1	67.0	25.2	28.5	21.4
76	14.2	33.6	44.4	54.7	75.1	39.8	39.6	38.9
79	28.5	60.7	52.1	60.1	79.6	57.3	53.3	67.5
82	47.5	106.1	72.1	71.2	89.0	77.7	64.7	94.6
85	73.2	157.8	118.5	90.5	103.3	112.0	75.9	122.6
88	117.9	217.6	213.3	121.6	128.1	163.0	93.8	159.0
91	175.0	275.3	355.3	157.1	161.0	215.1	115.8	202.7
94	243.3	322.8	552.0	199.1	192.0	264.1	143.4	337.1
97	306.2	359.6	775.9	265.3	218.2	318.2	183.4	373.7
100	348.7	380.1		355.1	243.7	366.9	211.6	393.6
103	376.9	387.0	1021.2	490.6	272.1	408.7	237.8	
106	393.5	382.7	1049.2	591.2	280.5	420.7	251.2	386.6
109	394.7	370.4	1033.6	747.1	304.1	423.0	257.5	367.5
112	392.3	353.2	994.1		362.5	432.5	265.1	345.3
115	383.6	335.1		1013.1	394.0	428.5	261.2	328.5
118	390.1	315.6	890.9			414.2	255.2	
121	362.2	292.5	851.5					293.6
124	338.7	272.2						
127								
130		235.5					210.2	
133						330.7		

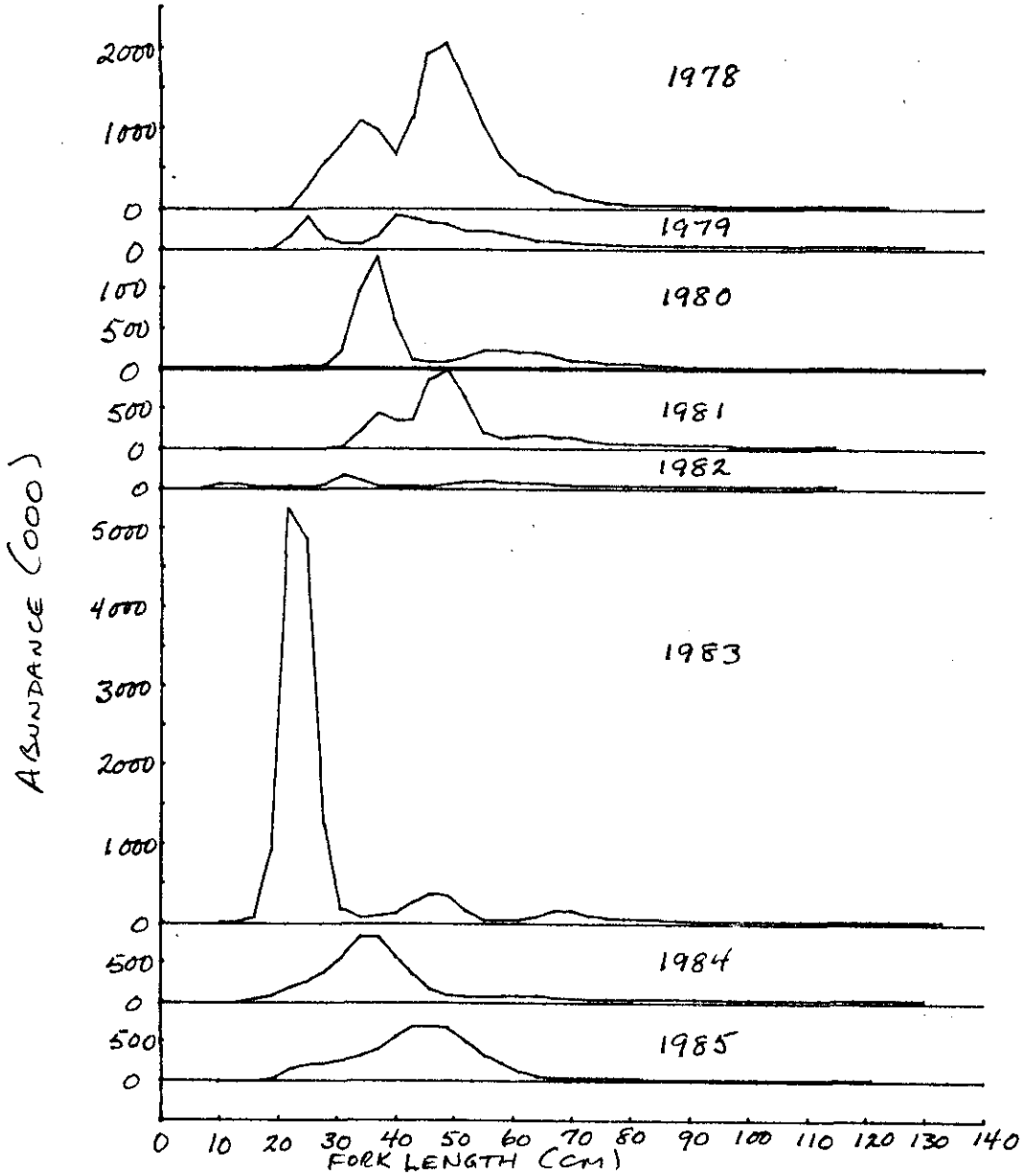

Fig. 1. Length compositions of cod taken on the Flemish Cap by Canadian research vessels in January-February, 1978-85.

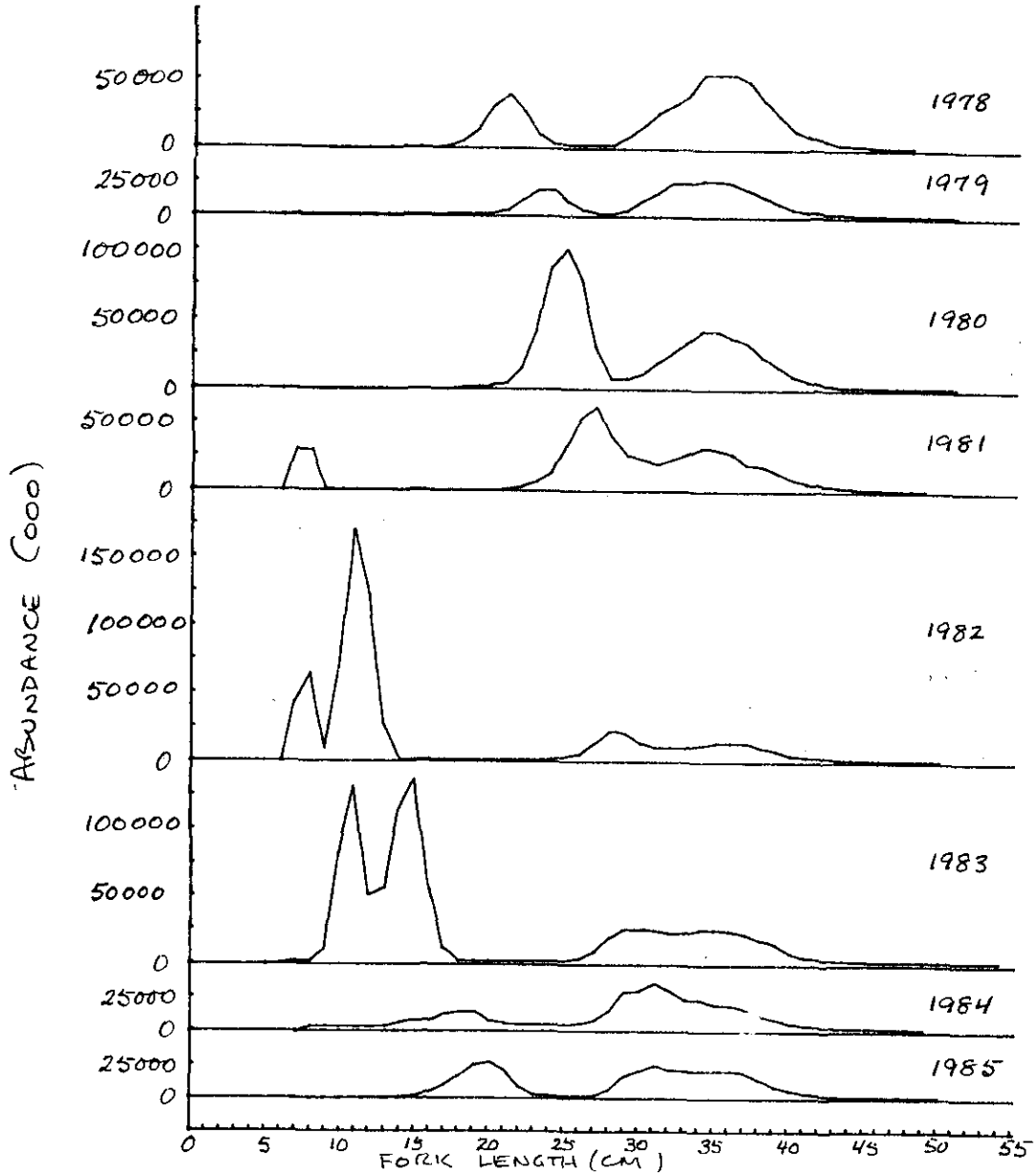

Fig. 2. Length compositions of beaked redfish taken on the Flemish Cap by Canadian research vessels in January-February, 1978-85.

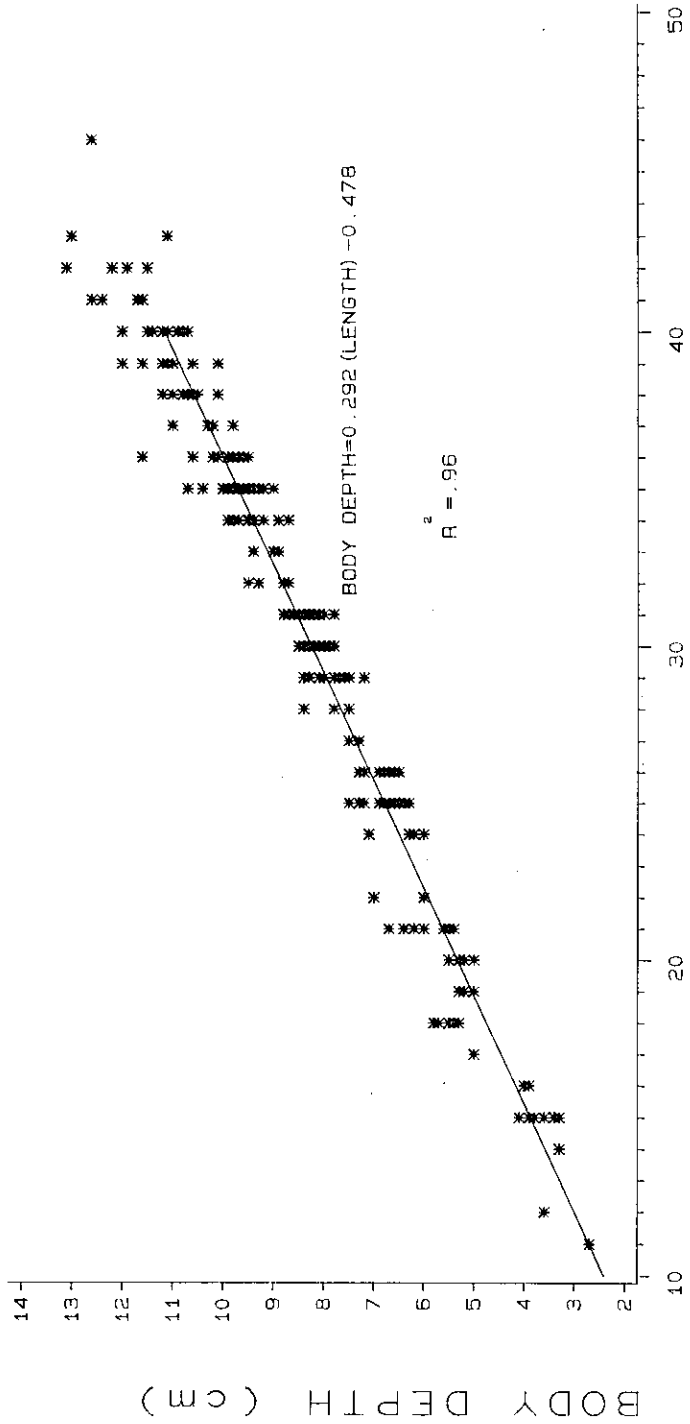

Fig. 3 Relationship of redfish body depth (cm) to fork length (cm)

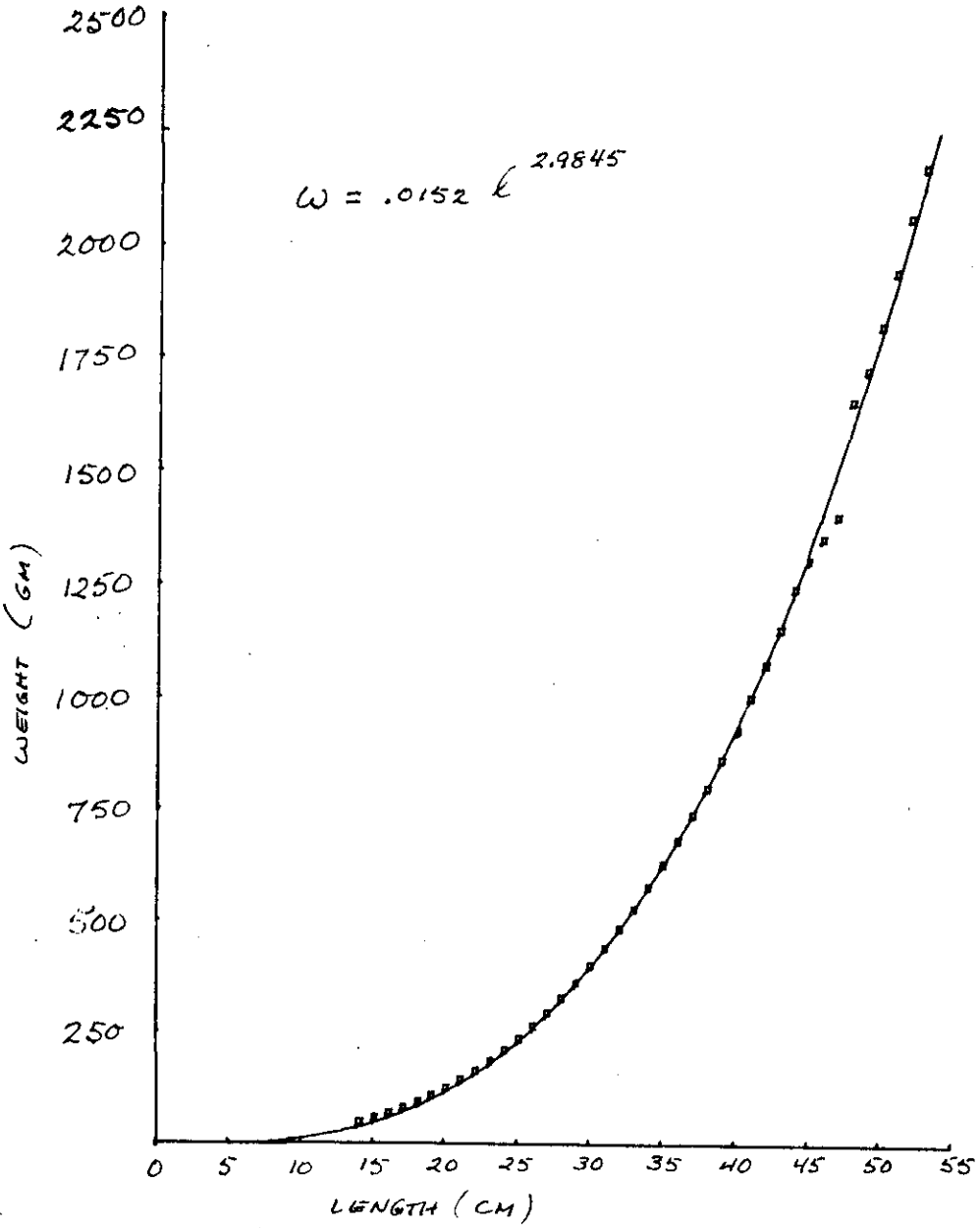

Fig. 4. Length-weight relationship of beaked redfish. Male and female data were combined (unpublished data of Northwest Atlantic Fisheries Centre, St. John's, Newfoundland).

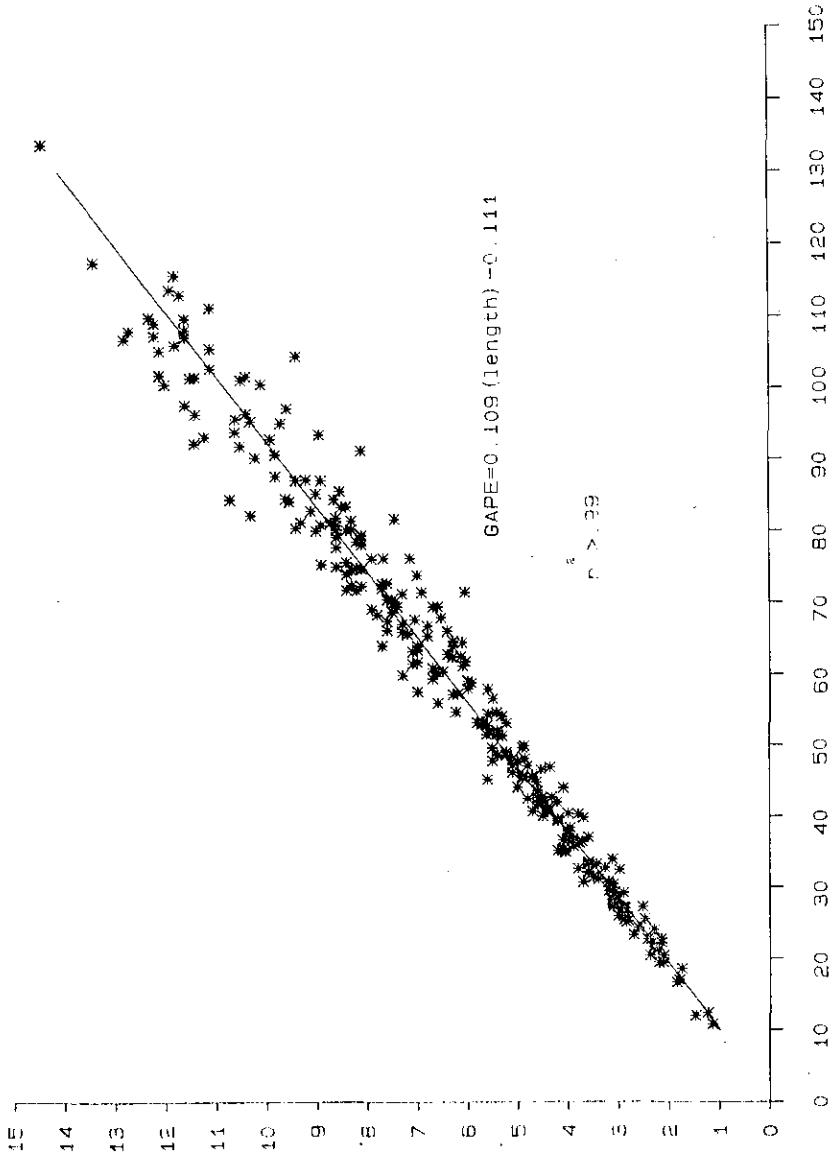

Fig. 5 Relationship of cod gape (cm) to Fork length (cm)

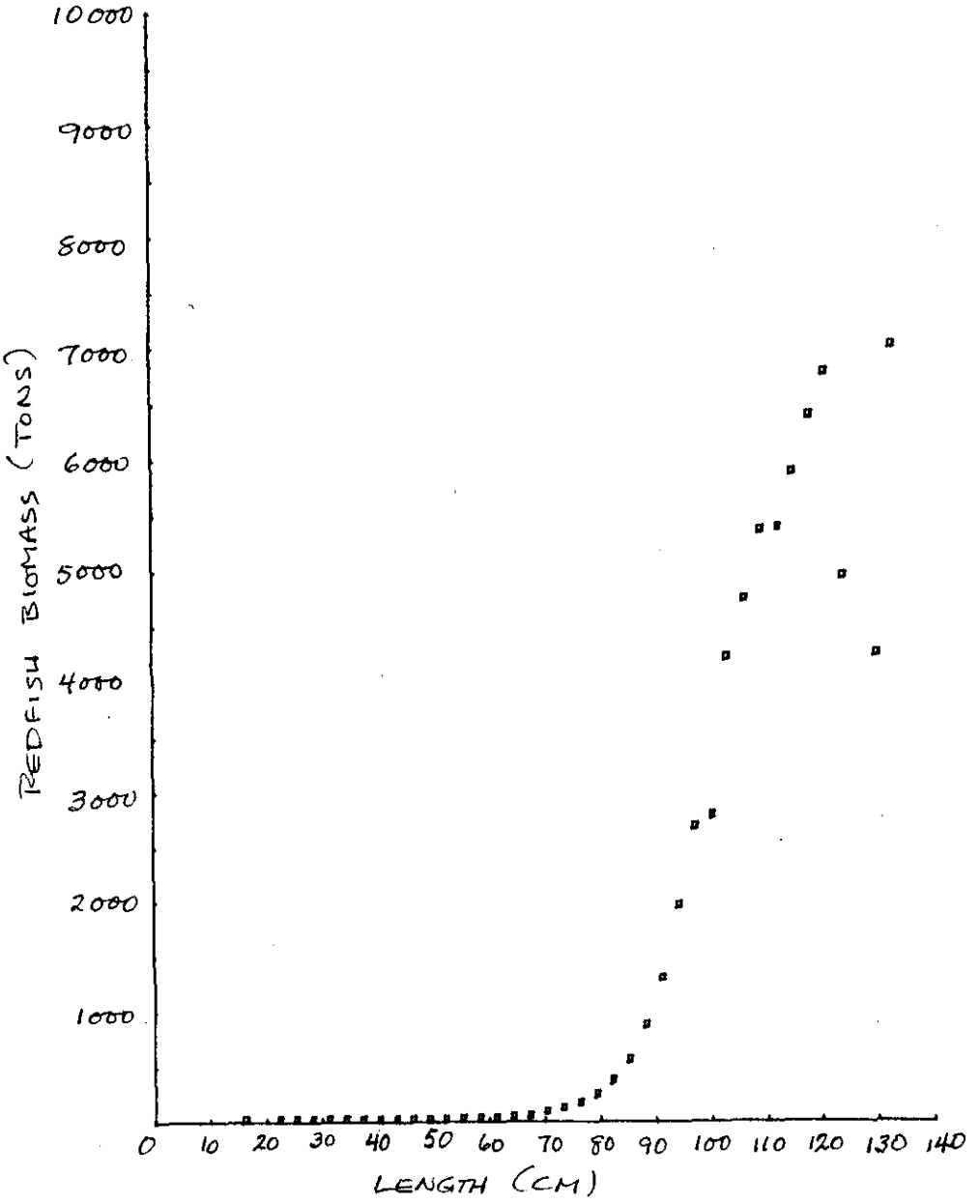

Fig. 6. Average beaked redfish biomass (tons) potentially available to cod on the Flemish Cap over the period 1978-85.

Appendix

Example of calculation of redfish biomass available at each 3 cm length group of cod:

redfish length = 15 cm
average weight = 49.2 gm
number of redfish @ 15 cm = 2000
biomass of redfish @ 15 cm = 98.4 tons

Cod length	Abundance (000)	Biomass available (t) from redfish of length 15 cm
28	5	-
31	15	-
34	72	-
37	51	6.0
40	28	3.3
43	5	.6
46	17	2.0
49	140	16.5
52	372	43.7
55	127	14.9
58	60	7.1
61	22	2.6
64	15	1.8
Total	929	98.5

Minimum size of cod necessary to consume redfish

of 15 cm = 2.67 redfish length - 3.55
= 37 cm

Number of cod of minimum size or greater = 837