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Age Structure of *Macrourus Berglax* L. in the Northwest Atlantic in 1985

by

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ABSTRACT

Keys for converting of length distribution into age one have been made using Macrourus berglax age samples, collected by a bottom trawl at 610-1240 m depths in Divs.3K, 0B, 2G and 2H in 1985. Age structure of catches from the Divisions mentioned occurred to be similar. Macrourus berglax were aged by scale using polarized transmitted light. Linear growth is expressed by exponential function and von Bertalanffy formula and weight - by exponential function and Gomperts formula. Length-weight relationship is satisfactorily described by exponential function . The materials confirm the relatively slow growth and multiaged structure of Macrourus berglax populations.

INTRODUCTION

It is more difficult to age deepwater fishes, specifically Macruridae, than those from the upper ocean layers, since the rings are hardly visible on their registrating structures (scales, otoliths, gill covers). According to opinion of most investigators the reason for this is poor pronouncing of seasonal phenomena at large depths. However, when using special methods (polarized light, chemical influence upon registrating structures) the rings are elucidative (Savvatimsky et al., 1977). French investigators manifested that the rings also exist on otoliths of fish caught at 4700 m depth (Rannou, 1975). Otolith structure of bathypelagic macrourus Coryphaenoides guntheri , studied by electronic microscope, turned to be similar to the otolith structure of fish from upper layers; the rings showing rhythmical variations in growth and corresponding to seasonal cycles, are visible.

The rings on Macrourus scales, which are regarded as yearly ones, are distinguishable when using polarized transmitted light. According to opinion of the investigators, having applied different methods for age determination, Macrourus berglax has a prolonged life cycle and multiaged populational structure, which are typical for deepwater fishes (Hureau et al., 1979). However, information on

Macrourus berglax age and growth is fragmentary and does not give clear idea of age populational structure.

K.P.Yanulov (1962) reports that a female of this species (70.5 cm long), caught at the northern coast of Norway, was at age 16. The Norwegian investigators regard the Macrourus berglax to reach the age of 25 (Eliassen, 1983) and 30 (Bakken et al., 1975). According to our data fish 48-70 cm long, caught by a bottom trawl in December 1982 in the Lofoten Isls area , were at age 8-17 (Savvatimsky, 1986).

Females of this species, 67-89 cm long and 1950-4700 g in weight, from Iceland area, were at age 17-25 (Savvatimsky, 1971).

Fish 41-86 cm long at age 8-18, with the specimens 62-75 cm long at age 12-15 predominant, were found in catches, taken on the Dohrn Bank, not far from the eastern coast of Greenland (Kosswig, 1979).

Few information on age and growth rate of Macrourus berglax, inhabiting the Northwest Atlantic, are available in scientific literature. Such information is based on minor material, besides, the scientists applied different methods for growth estimation, which , in our opinion, determine some discrepancies in the results obtained. According to the data of scientists from Poland (Chrzan, 1969), analysis of 203 otoliths of Macrourus berglax, caught in the area of the Funk Island (Div. 3K) and Belle Isle (Div. 2J) Banks in May-June 1968, indicated the fish 31-85 cm long to be, supposedly, at age 2-17. According to our data Macrourus berglax caught in March 1959 by a bottom trawl in the northeastern slope of the Grand Bank (3L) at age 3-16, was 26-66 cm long, however, in total 28 males and 63 females have been analysed (Savvatimsky, 1971). A specimen of macrourus, caught by a long-line on the Grand Bank (Divs. 3L, 30) in summer 1982, was much larger. Its length made up 40-87 cm and age - 6-23 (Savvatimsky, 1984).

In the paper given an attempt has been undertaken to add the information available on age, to elucidate the growth patterns, to obtain an idea of Macrourus berglax age structure, inhabiting the Northwest Atlantic.

MATERIAL AND METHODS

Macrourus berglax age samples have been collected by RV "Nikolai Kononov" (MB-0422) in October-December 1985 when conducting the bottom trawl survey for stock assessment of bottom fishes in the areas of the Baffin Land, Labrador and Notre Dame Bay (Table 1, Fig.1).

Fish were weighed accurate to 10 g. Scales were taken between fish dorsal fins, somewhat higher above lateral line. Age was determined by scales, keeping them between two polarized filters. Alternating dark and light rings were considered as yearly rings since their number coincided with a number of those found by another methods not only in Macrouridae, but also in other fishes (Savvatimsky, 1971). The rings were counted on lateral sides of scales free of small thorns and combs (Fig. 2).

It should be noted that a preliminary soaking of scales in $AgNO_3$ solution promotes to elucidate rings (Fig.3) and more precise age reading.

Macrourus berglax were measured from tip of snout to the end of tail accurate to 1 cm. For convenience of statistical processing of materials the undamaged specimens of fish with unbroken tails were taken from catches. Fish were pooled by length into classes of 3 cm (21-23, 24-26 etc.), by which mean values for weight were found in age samples. Mean length (cm) and weight (g) from each age class were also measured. Linear growth has been estimated by von Bertalanffy formula and exponential relationship and that of linear - by the exponential relationship and Gomperts formula (Ricker, 1979); length and weight/relationship - by the exponential relationship (formulae are given in tables and figures). Yearly length and weight increments have been obtained as a difference between length and weight calculated for two adjacent year classes.

Age composition of catches for Macrourus berglax from Divs.0B, 2GH and 3K has been estimated by summarized length frequencies for 1969-1989, using the length-age keys (Tables 2, 3 and 4). The keys have been made by age samples for 1985.

Designation of the areas surveyed in the text, tables and figures corresponds to NAFO Divisions.

RESULTS AND DISCUSSION

The difficulties, arising when reading Macrouridae age by otoliths and scales, have been already mentioned earlier (Savvatimsky,1971; Savvatimsky, 1984; Savvatimsky et al., 1977). It is not difficult to count rings by otoliths and scales in small fish, however, age reading in average and large fish is more complicated since a lot of rings are available and they are close to each other. Besides, the rings in the central part of scales may constitute 1-2 years when reading age especially in large fish.

Age of small number of fish caught in different areas at Canadian coast has been determined (Table 1, Fig.1). Having compared the

growth rate (age curves), separately females and males of Macrourus by different areas, no reliable differences have been found, therefore, all age samples have been pooled into one, including 459 males and 745 females. Using this single sample the keys were made (Tables 2-4) for subsequent converting of length distribution (Table 5) into age one and for analysing of age structure of Macrourus catches in Divs. OB, 2GH and 3K (Table 6). Age structure occurred to be similar. Mean age for males in these Divs. make up 7.7, 8.6 and 8.5, for females - 10.9, 10.4 and 10.7, respectively. A difference is that age composition of catches (both males and females) from Div. OB has a single-topped frequencies, and two-topped - for that from Divs.2GH and 3K. The reasons are not known.

It is necessary to note that the length-age keys and size composition of catches should be taken from the same stock and in the same year, since the growth rate may change. Here the length composition of catches has been used for a prolonged period (1969-1989), therefore, only general idea of age populational structure is possible to have, moreover, fish trawl selectivity is not considered. Plot of linear growth, i.e. the relationship between fish length and age is usually a curve in a shape of S and in order to describe this relationship von Bertalanffy formula is used. If a relatively short age frequency is taken (as in this case), then a simpler exponential function is applied and similar results are obtained (Tables 7-10, Fig.4).

Fish weight growth is frequently expressed by the exponential function by scientists, especially when analysing a short age frequency, consisting of fish mean by age. In case of complete age frequency, including all or nearly all age classes in a population , the formulae of von Bertalanffy or Gomperts are necessary to be applied, since growth is allometric. Age frequencies for Macrourus studied are described by both the exponential function and Gomperts formula (Tables 11-14, Fig.5), probably because the sample includes rather short age frequencies.

The relationship between fish length and weight is assumed to be expressed by the exponential function. Some differences by this sign are noted in Macrourus males and females ; the weight is somewhat larger specifically in small males at similar length compared to females (Tables 15 and 16; Fig.6). But these differences are not reliable, since the length frequency for males is very short.

To judge by the samples available the growth of Macrourus corresponds to general regularities for fish growth. Decrease in increments of length and increase in those of weight are noted with age both in males and females.

In order to elucidate the differences available in males and females growth, the length and weight of fish of similar age classes at age 3-13 have been compared. Males occurred to grow slower than females, as it has been noted earlier (Savvatimsky, 1984). For example, according to calculated data, in males at age 9-10 increments in length make up 2.7 - 2.9 cm and those in weight - 113-114 g; in females - 3.5-3.7 cm and 128-152 g (Table 17).

The impression is that the length and weight of Macrourus males, compared to females, are larger at early age (3-5 years), as it was registered in Greenland halibut (Reinhardtius hippoglossoides) from the Northeast Atlantic (Nizovtsev, 1991). However, the amount of younger fish is miserable in the sample obtained and this hypothesis should be tested using more representative material.

The materials presented here confirm a relatively slow growth of Macrourus berglax and multiaged structure of its populations.

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Table 1. Areas, terms and depth of collecting the age samples of Macrourus berglax in 1985 (only the fish with age determined are mentioned)

Div.	Month	Depth, m	No.of males, spec.	No.of females, spec.
3K	October	930-1100	174	125
0B	November	640-850	100	283
2G	December	610-1150	80	170
2H	December	705-1240	105	167
Total	Oct - Dec	610-1240	459	745

Table 2 Combined length-age key of males Macrourus berglax from Div. 0B+2G+2H+3K, 1985

	Age, years												
L,cm	3	4	5	6	7	8	9	10	11	12	13	NN	W.av. g
24-26	1	0	0	0	0	0	0	0	0	0	0	1	60
27	3	6	2	1	0	0	0	0	0	0	0	12	79
30	0	2	17	1	0	0	0	0	0	0	0	20	114
33	0	0	25	10	0	0	0	0	0	0	0	35	138
36	0	0	5	49	18	0	0	0	0	0	0	72	179
39	0	0	1	16	33	0	0	0	0	0	0	50	237
42	0	0	0	1	39	12	0	0	0	0	0	52	303
45	0	0	0	0	3	60	7	2	0	0	0	72	379
48	0	0	0	0	0	22	38	15	6	0	0	81	477
51	0	0	0	0	0	0	6	14	22	6	0	48	604
54	0	0	0	0	0	0	0	0	4	7	0	11	733
57	0	0	0	0	0	0	0	0	1	1	2	4	883
60	0	0	0	0	0	0	0	0	0	0	0	0	1055
63-65	0	0	0	0	0	0	0	0	0	0	1	1	1256
NN	4	8	50	78	93	94	51	31	33	14	3	459	
W.av. g	114	124	171	241	326	484	585	630	703	783	1162		
L.av. cm	26.3	27.8	32.2	36.1	39.9	45.3	47.9	49.2	51.0	52.9	59.0		

Table 3 Combined length-age key of females Macrourus berglax from Div. 0B+2G+2H+3K, 1985

	Age, years																				
L,cm	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	NN W.av
21-23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 60
24	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2 69
27	1	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9 109
30	0	2	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12 137
33	0	0	30	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45 179
36	0	0	12	41	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70 240
39	0	0	0	18	40	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	61 303
42	0	0	0	5	33	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51 383
45	0	0	0	0	1	54	5	5	0	0	0	0	0	0	0	0	0	0	0	0	65 487
48	0	0	0	0	0	16	19	13	4	0	0	0	0	0	0	0	0	0	0	0	52 628
51	0	0	0	0	0	0	4	24	19	7	0	0	0	0	0	0	0	0	0	0	54 764
54	0	0	0	0	0	0	0	1	43	23	2	1	0	0	0	0	0	0	0	0	70 894
57	0	0	0	0	0	0	0	0	13	33	11	4	0	0	0	0	0	0	0	0	61 1056
60	0	0	0	0	0	0	0	0	4	31	20	3	0	0	0	0	0	0	0	0	58 1256
63	0	0	0	0	0	0	0	0	0	7	26	7	6	0	0	0	0	0	0	0	46 1463
66	0	0	0	0	0	0	0	0	0	2	6	6	6	3	0	0	0	0	0	0	23 1758
69	0	0	0	0	0	0	0	0	0	1	1	8	3	9	2	0	0	0	0	0	24 2029
72	0	0	0	0	0	0	0	0	0	0	0	0	3	4	3	0	0	0	0	0	10 2237
75	0	0	0	0	0	0	0	0	0	0	0	0	1	6	6	4	0	0	0	0	17 2665
78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	1	0	0	5 2764
81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	3 3225
84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1 4930
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	1	4 4317
93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0
99-101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1 7160
NN	3	9	53	80	91	86	28	43	83	104	66	29	19	22	12	8	2	5	0	2	745
W.av. g	79	111	183	251	322	491	622	694	894	1111	1351	1583	1831	2203	2460	2772	3771	3911	0	5739	
L.av. cm	24.0	27.3	32.9	36.4	39.6	44.9	47.9	49.5	53.8	57.5	61.2	63.8	66.9	70.8	73.5	76.9	85.5	85.2	0.0	93.0	

Table 4 Combined length-age key of males and females Macrourus berglax from Div. 0B+2G+2H+3K, 1985

	Age, years																				
L.cm	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	NN	W.av. g
21-23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	60
24	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	79
27	4	12	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	114
30	0	4	26	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	138
33	0	0	55	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	179
36	0	0	17	90	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	142	237
39	0	0	1	34	73	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	111	303
42	0	0	0	6	72	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	103	379
45	0	0	0	0	4	114	12	7	0	0	0	0	0	0	0	0	0	0	0	0	137	477
48	0	0	0	0	0	38	57	28	10	0	0	0	0	0	0	0	0	0	0	0	133	604
51	0	0	0	0	0	0	10	38	41	13	0	0	0	0	0	0	0	0	0	0	102	733
54	0	0	0	0	0	0	0	1	47	30	2	1	0	0	0	0	0	0	0	0	81	883
57	0	0	0	0	0	0	0	0	14	34	13	4	0	0	0	0	0	0	0	0	65	1055
60	0	0	0	0	0	0	0	0	4	31	20	3	0	0	0	0	0	0	0	0	58	1256
63	0	0	0	0	0	0	0	0	0	7	27	7	6	0	0	0	0	0	0	0	47	1462
66	0	0	0	0	0	0	0	0	0	2	6	6	6	3	0	0	0	0	0	0	23	1758
69	0	0	0	0	0	0	0	0	0	1	1	8	3	9	2	0	0	0	0	0	24	2029
72	0	0	0	0	0	0	0	0	0	0	0	0	3	4	3	0	0	0	0	0	10	2237
75	0	0	0	0	0	0	0	0	0	0	0	0	1	6	6	4	0	0	0	0	17	2664
78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	1	0	0	5	2763
81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	3	3224
84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	4930
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	1	4	4317
93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99-101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	7160
NN	7	17	103	158	184	180	79	74	116	118	69	29	19	22	12	8	2	5	0	2	1204	
W.av. g	97	118	177	246	324	487	601	662	840	1073	1343	1582	1831	2204	2460	2771	3771	3910	0	5739		
L.av. cm	25.3	27.5	32.6	36.3	39.7	45.1	47.9	49.3	53.0	57.0	61.1	63.8	66.9	70.8	73.5	76.9	85.5	85.2	0.0	93.0		

Length composition (%) of Macrourus berglax in the catches by bottom trawl in Divs. 0B, 2GH, 3K, 1969-1989

Length, cm	Div. 0B			Div. 2G+2H			Div. 3K		
	males	females	total	males	females	total	males	females	total
21 - 23	+	0.6	0.7	+	0.3	0.3	+	0.4	0.4
24	1.4	0.5	0.7	0.8	0.2	0.4	0.9	0.7	0.7
27	5.1	1.0	2.0	1.8	0.8	1.2	1.8	1.0	1.3
30	2.9	1.6	2.0	2.2	1.8	1.9	2.6	1.8	2.1
33	6.8	2.9	4.0	4.8	2.7	3.5	4.3	2.3	3.0
36	10.4	5.4	6.6	6.3	4.1	4.9	5.9	4.1	4.7
39	12.1	5.0	6.8	8.7	5.2	6.4	8.6	5.1	6.2
42	13.9	5.5	7.8	10.1	6.8	7.9	12.0	6.1	8.1
45	16.6	6.3	8.9	15.4	9.7	11.7	15.9	8.4	11.0
48	13.2	7.6	9.0	19.7	10.9	14.0	20.0	9.2	12.9
51	8.5	8.7	8.6	14.8	9.3	11.1	14.8	9.1	11.0
54	5.3	7.3	6.7	8.8	9.5	9.1	7.8	8.3	8.0
57	2.8	9.3	7.5	4.4	10.6	8.1	4.1	9.6	7.5
60	-	9.8	7.7	+	7.7	5.5	-	8.9	6.1
63	0.8	7.6	5.7	2.1	7.1	5.1	1.3	7.4	5.1
66	-	7.7	5.7	-	4.9	3.5	-	6.8	4.7
69	-	5.6	4.1	-	3.3	2.2	-	4.6	3.1
72	-	3.5	2.5	-	2.2	1.5	-	3.6	2.2
75	-	2.5	1.8	-	1.5	1.0	-	1.4	1.0
78	-	0.9	0.7	-	0.8	0.5	-	0.9	0.5
81	-	0.5	0.4	-	0.4	0.2	-	0.3	0.2
84	-	-	-	-	-	-	-	-	-
87	-	0.1	0.1	-	0.1	0.1	-	0.1	0.1
90	-	-	-	-	+	+	-	0.1	0.1
93	-	-	-	-	-	-	-	-	-
96 - 98	-	-	-	-	-	-	-	+	+
21 - 98	99.8	99.9	100.0	99.9	99.9	100.0	100.0	100.0	100.0
Average length, cm	43.3 ± 0.27	54.6 ± 0.26	51.6 ± 0.22	46.4 ± 0.20	53.0 ± 0.23	50.7 ± 0.17	46.1 ± 0.11	53.9 ± 0.13	51.3 ± 0.10
Number of fishes	848	2275	3159	1450	2365	3883	4329	7521	12048

Table 6 Age composition (%) of Macrourus berglax in the catches by bottom trawl in Divs. 0B, 2GH, 3K

Age, years	Div. 0B			Div. 2G+2H			Div. 3K		
	males	females	total	males	females	total	males	females	total
3	2.7	1.0	1.6	1.3	0.4	0.8	1.3	0.8	1.1
4	2.8	1.2	1.7	1.1	0.9	1.0	1.2	1.3	1.2
5	9.1	4.3	5.5	6.2	4.1	4.8	6.1	3.8	4.6
6	13.8	6.2	8.2	9.0	5.7	6.8	8.5	5.4	6.5
7	21.8	8.3	11.8	15.5	9.0	11.3	16.8	8.4	11.3
8	20.5	9.2	12.1	20.6	13.4	15.8	21.5	11.6	15.0
9	9.0	3.9	5.5	12.6	5.4	8.1	12.8	4.7	7.6
10	5.4	6.3	5.6	8.3	7.7	7.8	8.5	7.1	7.5
11	7.4	10.8	10.2	12.6	12.8	13.0	12.1	11.7	12.1
12	5.2	15.9	13.1	8.6	15.9	13.1	7.8	15.8	12.9
13	2.2	11.8	9.2	4.3	10.2	7.7	3.3	11.2	8.1
14	-	6.2	4.7	-	4.7	3.2	-	5.7	3.9
15	-	4.9	3.6	-	3.4	2.3	-	4.4	3.0
16	-	5.4	3.9	-	3.3	2.2	-	4.4	3.0
17	-	2.6	1.9	-	1.6	1.1	-	2.1	1.4
18	-	1.3	0.9	-	0.9	0.6	-	1.0	0.6
19	-	0.2	0.1	-	0.1	0.1	-	0.1	0.1
20	-	0.4	0.3	-	0.4	0.3	-	0.5	0.3
Average age, years	7.73 ± 0.08	10.87 ± 0.07	10.03 ± 0.06	8.60 ± 0.06	10.44 ± 0.06	9.80 ± 0.05	8.51 ± 0.03	10.69 ± 0.04	9.94 ± 0.03
Average length, cm	43.32 ± 0.27	54.57 ± 0.26	51.55 ± 0.22	46.37 ± 0.20	53.04 ± 0.23	50.73 ± 0.17	46.09 ± 0.11	53.94 ± 0.13	51.25 ± 0.10
Average weight, g	436.3	1041.3	878.2	532.4	927.8	793.4	519.5	992.8	833.7
Number of fishes	848	2275	3159	1450	2365	3883	4329	7521	12048

Table 7 Linear growth of Macrourus berglax; 1985

Model: von Bertalanffy Growth Function
Formula: $L(t) = L\infty \{1 - \exp(-K[t-t0])\}$

Estimates of growth parameters Males

Param.	Estimate	std.dev	confidence limits	
L8	69.91546	1.26040	67.44506	72.38585
K	0.12348	0.00567	0.11237	0.13460
to	- 0.04233	0.11950	- 0.27657	0.19189

Observed age	Observed length	Number of observations	Calculated length	Deviation (Obs.-calc.)
3	26.3	4	21.8	4.40
4	27.8	8	27.4	0.32
5	32.2	50	32.4	- 0.20
6	36.1	78	36.7	- 0.66
7	39.9	93	40.6	- 0.71
8	45.3	94	44.0	1.28
9	47.9	51	47.0	0.87
10	49.2	31	49.6	- 0.48
11	51.0	33	52.0	- 1.03
12	52.9	14	54.1	- 1.21
13	59.0	3	55.9	3.05

Estimates of growth parameters Females

Param.	Estimate	std.dev	confidence limits	
L8	292.81839	17.57728	258.36691	327.26980
K	0.01439	0.00106	0.01230	0.01648
to	- 3.17964	0.09178	- 3.35954	- 2.99973

Observed age	Observed length	Number of observations	Calculated length	Deviation (Obs.-calc.)
3	24.0	3	24.9	- 0.92
4	27.3	9	28.7	- 1.45
5	32.9	53	32.5	0.37
6	36.4	80	36.2	0.15
7	39.6	91	39.9	- 0.31
8	44.9	86	43.5	1.36
9	47.9	28	47.0	0.80
10	49.5	43	50.6	- 1.10
11	53.8	83	54.0	- 0.26
12	57.5	104	57.4	0.01
13	61.2	66	60.8	0.35
14	63.8	29	64.1	- 0.36
15	66.9	19	67.4	- 0.53
16	70.8	22	70.6	0.14
17	73.5	12	73.8	- 0.32
18	76.9	8	76.9	- 0.05
19	85.5	2	80.0	5.45
20	85.2	5	83.0	2.11
22	93.0	2	89.0	3.96

Table 8 Linear growth of Macrourus berglax, 1985

Model: von Bertalanffy Growth Function
Formula: $L(t) = L\infty \{1 - \exp(-K[t-t0])\}$

Estimates of growth parameters Males+females

Param.	Estimate	std.dev	confidence limits	
L8	288.16040	17.95920	252.96040	323.36050
K	0.01452	0.00111	0.01233	0.01670
to	- 3.27186	0.09179	- 3.45178	- 3.09194

Observed age	Observed length	Number of observations	Calculated length	Deviation (Obs.-calc.)
3	25.3	7	25.0	0.21
4	27.5	17	28.8	- 1.37
5	32.6	103	32.6	- 0.01
6	36.3	158	36.3	- 0.00
7	39.7	184	39.9	- 0.23
8	45.1	180	43.5	1.58
9	47.9	79	47.0	0.86
10	49.3	74	50.5	- 1.21
11	53.0	116	53.9	- 0.93
12	57.0	118	57.3	- 0.31
13	61.1	69	60.6	0.45
14	63.8	29	63.9	- 0.12
15	66.9	19	67.1	- 0.25
16	70.8	22	70.3	0.45
17	73.5	12	73.4	0.01
18	76.9	8	76.5	0.32
19	85.5	2	79.6	5.87
20	85.2	5	82.6	2.56
22	93.0	2	88.5	4.48

Table 9 Linear growth of Macrourus berglax, 1985.
Allometry equation

$L = a A^b$

Growth parameters for length, males

R-Square: 0.98371
Adjusted R-Square: 0.97964

Parameter	Estimate	Asymptotic Std Error	CV
a	1.312E+01	7.900E-01	6.021E-02
b	5.755E-01	2.717E-02	4.721E-02

DATA MATRIX

Case	Observed age	Observed length	Calculated length	Deviation (Obs.-calc.
1	3	26.3	24.6	1.61
2	4	27.8	29.1	-1.33
3	5	32.2	33.1	-0.92
4	6	36.1	36.7	-0.68
5	7	39.9	40.2	-0.30
6	8	45.3	43.4	1.88
7	9	47.9	46.4	1.44
8	10	49.2	49.3	-0.16
9	11	51.0	52.1	-1.14
10	12	52.9	54.8	-1.92
11	13	59.0	57.4	1.59

Growth parameters for length, females

R-Square: 0.99291
Adjusted R-Square: 0.99202

Parameter	Estimate	Asymptotic Std Error	CV
a	9.819E+00	4.611E-01	4.696E-02
b	7.185E-01	1.734E-02	2.413E-02

DATA MATRIX

Case	Observed age	Observed length	Calculated length	Deviation (Obs.-calc.)
1	3	24.0	21.6	2.37
2	4	27.3	26.5	0.71
3	5	32.9	31.2	1.69
4	6	36.4	35.5	0.83
5	7	39.6	39.7	-0.14
6	8	44.9	43.7	1.15
7	9	47.9	47.6	0.29
8	10	49.5	51.3	-1.85
9	11	53.8	54.9	-1.19
10	12	57.5	58.5	-1.04
11	13	61.2	62.0	-0.80
12	14	63.8	65.3	-1.59
13	15	66.9	68.7	-1.82
14	16	70.8	71.9	-1.18
15	17	73.5	75.1	-1.68
16	18	76.9	78.3	-1.44
17	19	85.5	81.4	4.05
18	20	85.2	84.5	0.69
19	22	93.0	90.4	2.50

Table 10

Linear growth of Macrourus berglax, 1985
Allometry equation

$L = a A^b$

R-Square: 0.99117
Growth parameters for length, males+females Adjusted R-Square: 0.99007

Parameter	Estimate	Asymptotic Std Error	CV
a	9.874E+00	5.141E-01	5.207E-02
b	7.161E-01	1.923E-02	2.685E-02

DATA MATRIX

Case	Observed age	Observed length	Calculated length	Deviation (Obs.-calc.)
1	3	25.3	21.6	3.61
2	4	27.5	26.6	0.85
3	5	32.6	31.2	1.33
4	6	36.3	35.6	0.67
5	7	39.7	39.7	-0.06
6	8	45.1	43.7	1.32
7	9	47.9	47.6	0.27
8	10	49.3	51.3	-2.05
9	11	53.0	54.9	-1.98
10	12	57.0	58.5	-1.52
11	13	61.1	61.9	-0.87
12	14	63.8	65.3	-1.55
13	15	66.9	68.6	-1.76
14	16	70.8	71.9	-1.11
15	17	73.5	75.1	-1.60
16	18	76.9	78.2	-1.33
17	19	85.5	81.3	4.17
18	20	85.2	84.3	0.82
19	22	93.0	90.3	2.66

Table 11

Weight growth of Macrourus berglax, 1985
Allometry equation

$W = a A^b$

Growth parameters for weight, males

R-Square: 0.96218
Adjusted R-Square: 0.95272

Parameter	Estimate	Asymptotic Std Error	CV
a	9.601E+00	3.847E+00	4.007E-01
b	1.828E+00	1.669E-01	9.129E-02

DATA MATRIX

Case	Observed age	Observed weight	Calculated weight	Deviation (Obs.-calc.)
1	3	114.1	71.5	42.56
2	4	123.9	121.0	2.86
3	5	171.2	181.9	-10.79
4	6	240.6	253.9	-13.38
5	7	326.0	336.6	-10.66
6	8	484.4	429.7	54.65
7	9	585.4	532.9	52.40
8	10	630.4	646.2	-15.80
9	11	702.9	769.1	-66.29
10	12	782.5	901.8	-119.31
11	13	1161.7	1043.9	117.78

Growth parameters for weight, females

R-Square: 0.98920
Adjusted R-Square: 0.98785

Parameter	Estimate	Asymptotic Std Error	CV
a	1.025E+00	3.197E-01	3.119E-01
b	2.774E+00	1.055E-01	3.804E-02

DATA MATRIX

Case	Observed age	Observed weight	Calculated weight	Deviation (Obs.-calc.)
1	3	79.2	21.5	57.60
2	4	110.6	47.9	62.63
3	5	183.2	89.0	94.13
4	6	250.5	147.6	102.80
5	7	322.2	226.5	95.68
6	8	491.0	328.0	162.93
7	9	622.0	454.8	167.15
8	10	693.7	609.2	84.44
9	11	894.2	793.6	100.55
10	12	1110.5	1010.3	100.19
11	13	1350.8	1261.4	89.30
12	14	1583.1	1549.4	33.68
13	15	1831.2	1876.2	-45.04
14	16	2203.2	2244.1	-40.90
15	17	2460.1	2655.1	-195.00
16	18	2771.8	3111.3	-339.51
17	19	3770.8	3614.7	156.01
18	20	3910.5	4167.5	-257.02
19	22	5738.5	5428.8	309.68

Table 12

Weight growth of Macrourus berglax, 1985
Allometry equation

W = a A^b

Growth parameters for weight, males+females

R-Square: 0.98987
Adjusted R-Square: 0.98860

Parameter	Estimate	Asymptotic Std Error	CV
a	9.373E-01	2.865E-01	3.057E-01
b	2.804E+00	1.034E-01	3.687E-02

DATA MATRIX

Case	Observed age	Observed weight	Calculated weight	Deviation (Obs.-calc.)
1	3	96.5	20.4	76.09
2	4	117.8	45.7	72.08
3	5	177.0	85.4	91.53
4	6	245.5	142.5	102.99
5	7	324.3	219.5	104.74
6	8	487.4	319.2	168.12
7	9	601.2	444.2	156.98
8	10	662.1	596.8	65.20
9	11	839.5	779.7	59.73
10	12	1072.8	995.2	77.56
11	13	1342.7	1245.6	97.04
12	14	1582.2	1533.3	48.83
13	15	1830.6	1860.6	-30.04
14	16	2203.0	2229.7	-26.75
15	17	2459.7	2642.9	-183.22
16	18	2771.1	3102.3	-331.24
17	19	3770.5	3610.2	160.29
18	20	3910.2	4168.6	-258.45
19	22	5738.5	5445.8	292.69

Table 13

Weight growth of Macrourus berglax, 1985

Model: Gompertz Growth Function
Formula: W(t) = W0 * exp (G(1-exp(-gt)))

Growth parameters for weight, males

R-Square: 0.96409
Adjusted R-Square: 0.94871

Parameter	Estimate	Asymptotic Std Error	CV
W0	4.416E+01	3.449E+01	7.810E-01
G	6.090E+00	3.040E+00	4.992E-01
g	5.709E-02	6.033E-02	1.057E+00

DATA MATRIX

Case	Observed age	Observed weight	Calculated weight	Deviation (Obs.-calc.)
1	3	114.1	115.1	-1.07
2	4	123.9	153.1	-29.22
3	5	171.2	200.3	-29.16
4	6	240.6	258.3	-17.71
5	7	326.0	328.3	-2.35
6	8	484.4	411.8	72.53
7	9	585.4	510.1	75.24
8	10	630.4	624.4	5.94
9	11	702.9	755.8	-52.92
10	12	782.5	905.1	-122.69
11	13	1161.7	1073.2	88.40

Growth parameters for weight, females

R-Square: 0.99462
Adjusted R-Square: 0.99355

Parameter	Estimate	Asymptotic Std Error	CV
W0	7.896E+01	2.460E+01	3.116E-01
G	1.124E+01	3.414E+00	3.038E-01
g	2.173E-02	1.019E-02	4.688E-01

DATA MATRIX

Case	Observed age	Observed weight	Calculated weight	Deviation (Obs.-calc.)
1	3	79.2	160.4	-81.25
2	4	110.6	201.1	-90.59
3	5	183.2	251.0	-67.85
4	6	250.5	311.7	-61.28
5	7	322.2	385.4	-63.21
6	8	491.0	474.2	16.74
7	9	622.0	580.9	41.02
8	10	693.7	708.6	-14.91
9	11	894.2	860.6	33.57
10	12	1110.5	1040.8	69.61
11	13	1350.8	1253.7	97.04
12	14	1583.1	1504.1	78.95
13	15	1831.2	1797.4	33.71
14	16	2203.2	2139.8	63.38
15	17	2460.1	2537.8	-77.73
16	18	2771.8	2998.8	-227.06
17	19	3770.8	3530.9	239.84
18	20	3910.5	4142.8	-232.38
19	22	5738.5	5645.2	93.27

Table 14

Weight growth of Macrourus berglax, 1985

Model: Gompertz Growth Function
Formula: $W(t) = W0 * \exp(G(1-\exp(-gt)))$

Growth parameters for weight, males + females

R-Square: 0.99487
Adjusted R-Square: 0.99384

Parameter	Estimate	Asymptotic Std Error	CV
W0	7.331E+01	2.317E+01	3.161E-01
G	1.088E+01	2.927E+00	2.689E-01
g	2.316E-02	1.001E-02	4.322E-01

DATA MATRIX

Case	Observed age	Observed weight	Calculated weight	Deviation (Obs.-calc.)
1	3	96.5	152.1	-55.68
2	4	117.8	192.0	-74.20
3	5	177.0	240.9	-63.95
4	6	245.5	300.8	-55.32
5	7	324.3	373.6	-49.36
6	8	487.4	461.8	25.56
7	9	601.2	568.0	33.13
8	10	662.1	695.4	-33.31
9	11	839.5	847.3	-7.87
10	12	1072.8	1027.8	44.90
11	13	1342.7	1241.3	101.33
12	14	1582.2	1492.7	89.49
13	15	1830.6	1787.3	43.22
14	16	2203.0	2131.4	71.58
15	17	2459.7	2531.4	-71.74
16	18	2771.1	2994.7	-223.65
17	19	3770.5	3529.2	241.25
18	20	3910.2	4143.5	-233.32
19	22	5738.5	5649.3	89.17

Length - weight relationships of Macrourus berglax, 1985 Table 15

Model: Allometry Equation
Formula: W = a L^b

Berglax, males (by average length) R-Square: 0.99794
Adjusted R-Square: 0.99753

Parameter	Estimate	Asymptotic Std Error	CV
a	1.681E-03	3.972E-04	2.363E-01
b	3.279E+00	5.818E-02	1.774E-02

DATA MATRIX

Case	Observed length	Observed weight	Calculated weight	Deviation (Obs.-calc.)
1	25	100.0	64.3	35.60
2	28	118.7	93.3	25.32
3	31	139.3	130.3	8.94
4	34	179.2	176.4	2.73
5	37	234.0	232.8	1.15
6	40	304.3	300.6	3.64
7	43	375.9	381.1	-5.20
8	46	467.6	475.4	-7.81
9	49	589.3	584.8	4.47
10	52	697.7	710.6	-12.92
11	55	819.0	854.0	-35.08
12	58	1035.0	1016.5	18.46
13	64	1415.0	1403.7	11.25

Berglax, females (by average length R-Square: 0.98012
Adjusted R-Square: 0.97822

Parameter	Estimate	Asymptotic Std Error	CV
a	2.414E-04	1.806E-04	7.479E-01
b	3.743E+00	1.663E-01	4.444E-02

DATA MATRIX

Case	Observed length	Observed weight	Calculated weight	Deviation (Obs.-calc.)
1	22	60.0	25.5	34.47
2	25	69.0	41.1	27.81
3	28	108.6	62.9	45.66
4	31	137.0	92.1	44.88
5	34	179.2	130.1	49.03
6	37	240.3	178.6	61.68
7	40	302.6	239.1	63.46
8	43	383.0	313.4	69.53
9	46	486.9	403.4	83.43
10	49	627.6	511.0	116.51
11	52	764.2	638.3	125.81
12	55	893.7	787.4	106.20
13	58	1056.1	960.6	95.43
14	61	1256.3	1160.2	96.07
15	64	1463.1	1388.6	74.49
16	67	1758.4	1648.2	110.10
17	70	2028.7	1941.9	86.77
18	73	2237.1	2272.1	-35.06
19	76	2664.7	2641.8	22.89
20	79	2763.6	3053.7	-290.10
21	82	3224.6	3510.8	-286.21
22	88	4930.0	4572.8	357.12
23	91	4317.0	5184.1	-867.13
24	97	7160.0	6583.5	576.44

Table 16

Length - weight relationships of Macrourus berglax, 1985

Model: Allometry Equation
Formula: W = a L^b

Berglax, summary (males+females, by average length)

R-Square: 0.980035
Adjusted R-Square: 0.97847

Parameter	Estimate	Asymptotic Std Error	CV
a	2.292E-04	1.711E-04	7.463E-01
b	3.754E+00	1.660E-01	4.421E-02

DATA MATRIX

Case	Observed length	Observed weight	Calculated weight	Deviation (Obs.-calc.)
1	22	60.0	25.1	34.88
2	25	79.3	40.5	38.71
3	28	114.1	62.1	51.99
4	31	138.2	91.0	47.19
5	34	179.0	128.7	50.27
6	37	236.9	176.8	60.08
7	40	303.4	236.9	66.47
8	43	379.4	310.8	68.56
9	46	477.0	400.3	76.60
10	49	604.2	507.5	96.63
11	52	732.9	634.4	98.48
12	55	882.9	783.1	99.78
13	58	1054.7	955.9	98.79
14	61	1256.0	1155.1	100.85
15	64	1461.9	1383.2	78.61
16	67	1758.0	1642.9	115.14
17	70	2029.0	1936.4	92.51
18	73	2237.0	2266.9	-29.90
19	76	2664.0	2636.9	27.09
20	79	2763.0	3049.4	-286.40
21	82	3224.0	3507.3	-283.37
22	88	4930.0	4572.1	357.88
23	91	4317.0	5185.2	-868.28
24	97	7160.0	6589.8	570.14

Table 17

Length (cm) and weight (g) increments of Macrourus berglax from the Divs. 0B, 2GH, 3K, 1985

Age, years	Linear growth, Bertalanffy		Linear growth, L = a A^b		Weight growth, W = a A^b		Weight growth, Gompertz	
	males	females	males	females	males	females	males	females
3 - 4	5.58	3.83	4.45	4.96	49.5	26.4	37.9	40.7
4 - 5	4.93	3.77	3.99	4.62	61.0	41.1	47.3	49.9
5 - 6	4.36	3.72	3.66	4.37	72.0	58.6	57.9	60.7
6 - 7	3.85	3.67	3.41	4.17	82.7	78.8	70.0	73.6
7 - 8	3.40	3.61	3.21	4.00	93.1	101.6	83.5	88.8
8 - 9	3.01	3.56	3.04	3.86	103.2	126.6	98.3	106.7
9 - 10	2.66	3.51	2.90	3.74	113.2	152.4	114.3	127.6
10 - 11	2.35	3.46	2.78	3.64	123.0	184.4	131.4	152.0
11 - 12	2.08	3.41	2.68	3.55	132.6	216.7	149.4	180.3
12 - 13	1.84	3.36	2.58	3.47	142.1	251.2	168.1	212.9
13 - 14	-	3.32	-	3.39	-	287.9	-	250.4
14 - 15	-	3.27	-	3.32	-	326.8	-	293.3
15 - 16	-	3.22	-	3.26	-	367.9	-	342.3
16 - 17	-	3.18	-	3.20	-	411.0	-	398.0
17 - 18	-	3.13	-	3.15	-	456.2	-	461.0
18 - 19	-	3.09	-	3.10	-	503.5	-	532.1
19 - 20	-	3.04	-	3.06	-	552.7	-	611.9
20 - 21	-	2.98	-	3.02	-	610.0	-	695.0
21 - 22	-	2.97	-	2.98	-	651.3	-	807.3

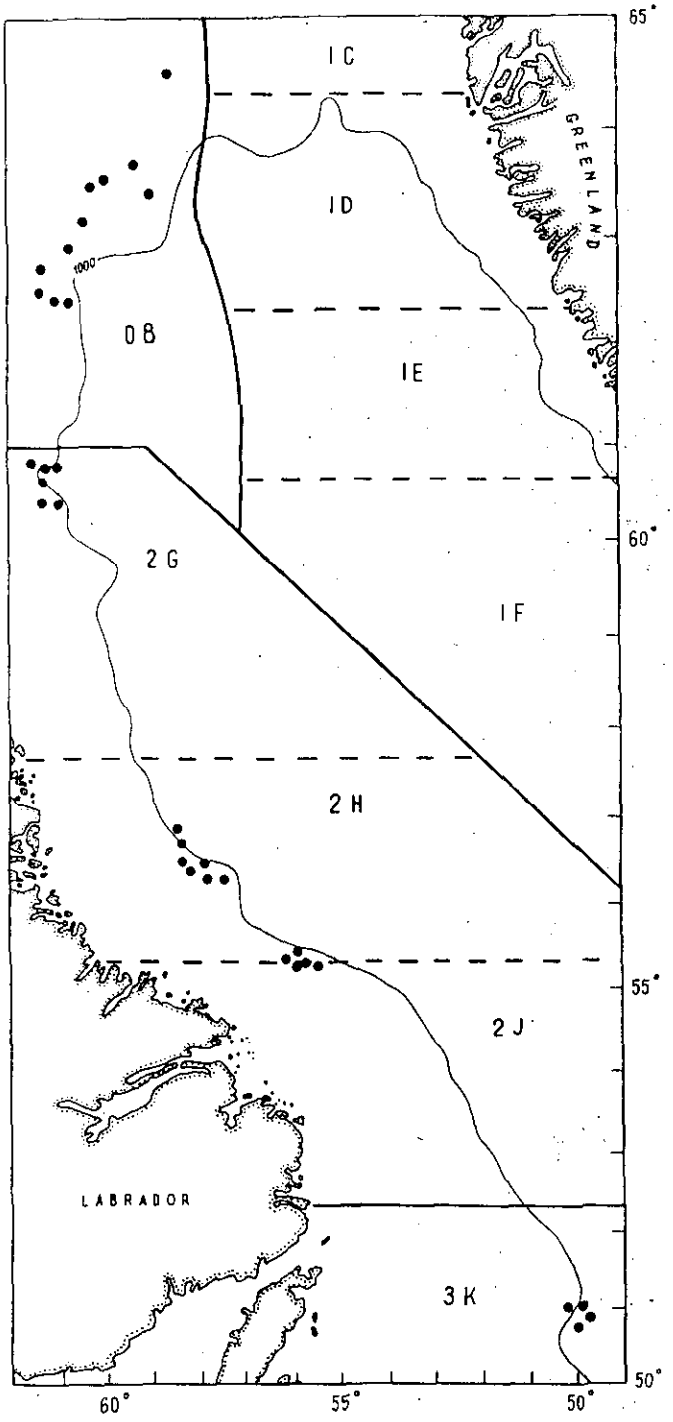

Fig. 1. Localities of Macrourus berglax age Sampling in 1985

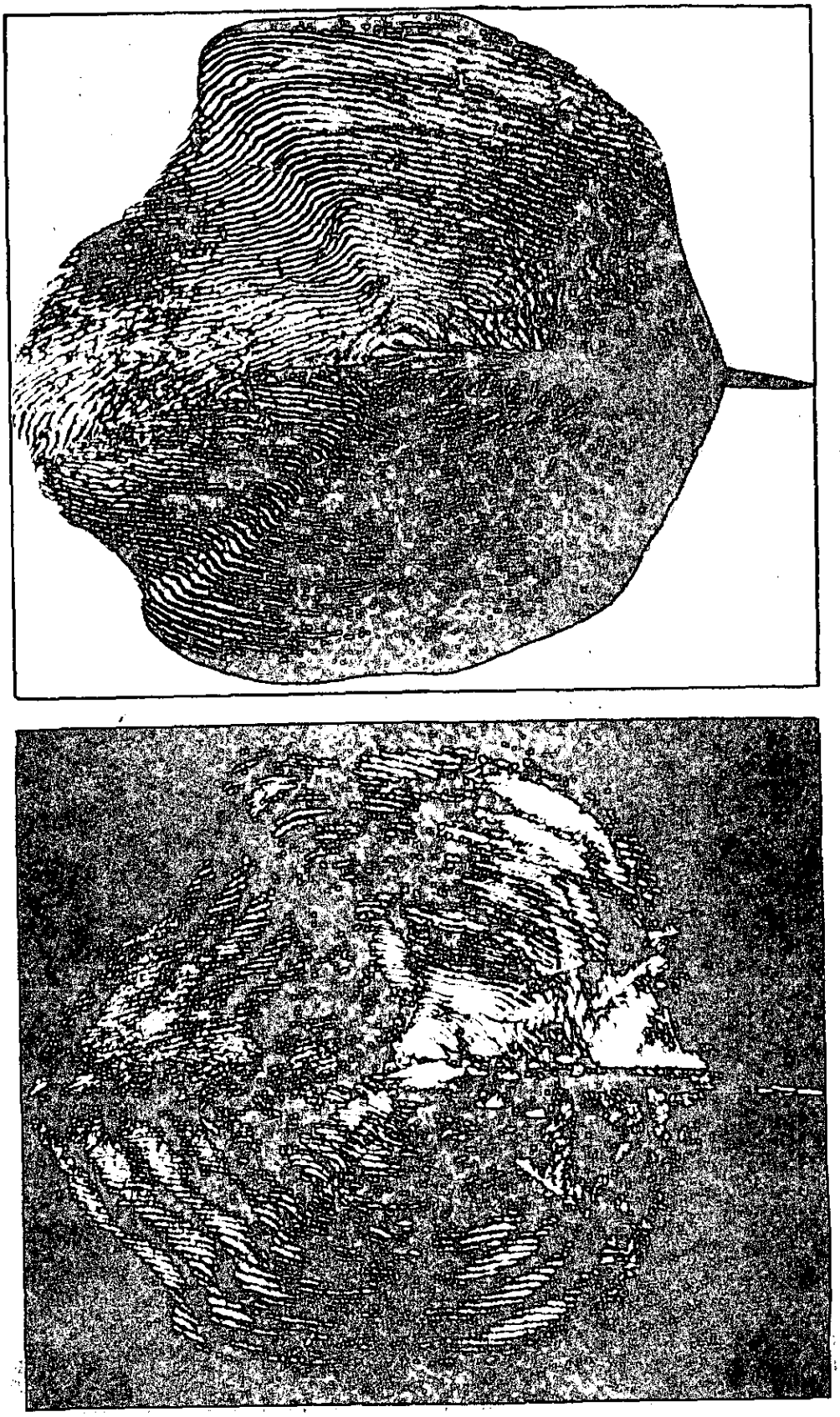

Fig.2 Scale of Macrourus berglax in normal (upper) and polarised (lower) transmitted light.

Div. 3K, female, total length - 37 cm, weight - 220 g, age - 6 years

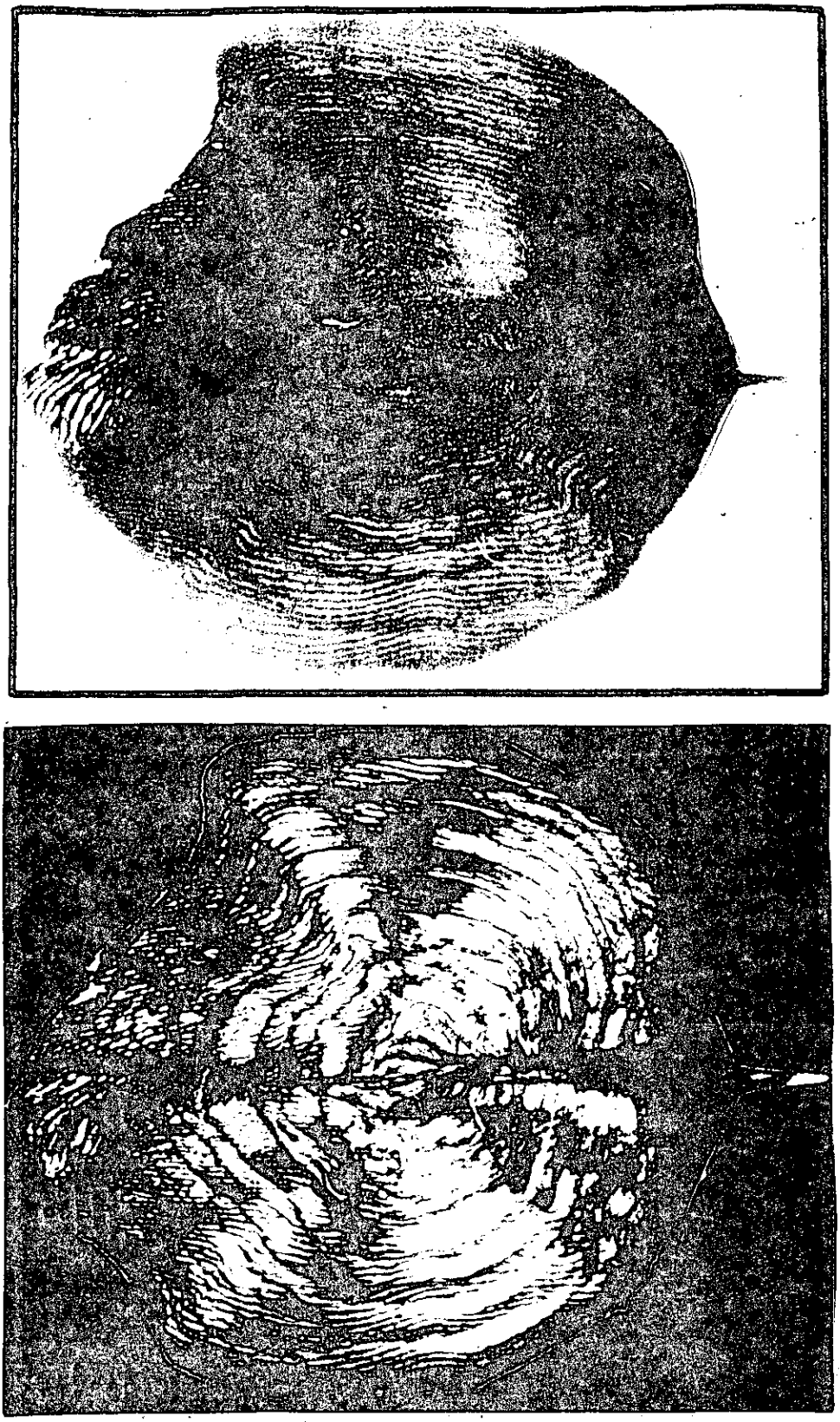

Fig. 3. Scale of Macrourus berglax, soaked for 2 hours in a 1%-solution of $AgNO_3$ in normal (upper) and polarised (lower) transmitted light.

Div. 3K, female, total length - 37 cm, weight - 220 g, age - 6 years

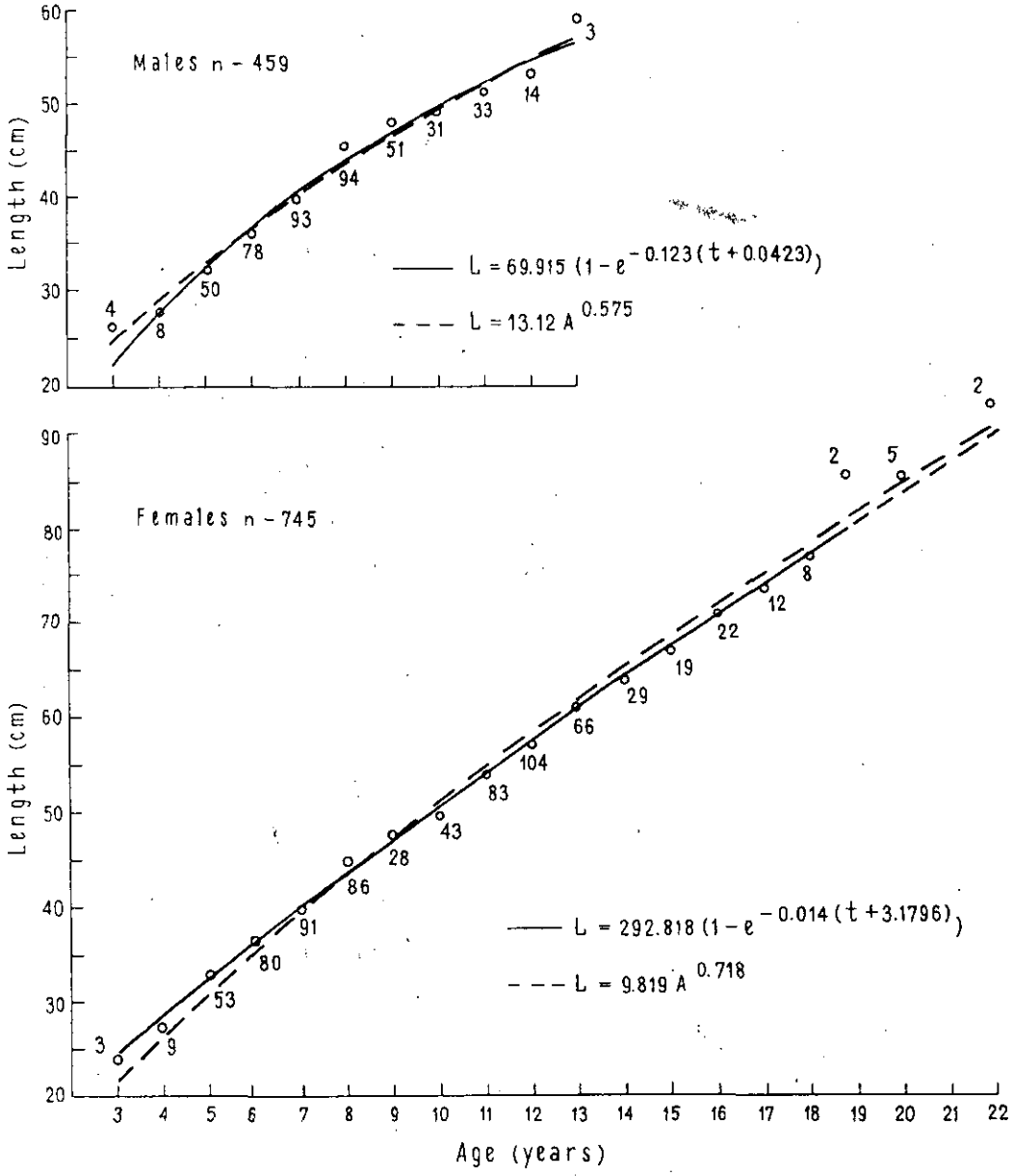

Fig. 4. Linear growth of Macrourus berglax from the Div. 0B, 2G, 2H, 3K, 1985. Figures on the curves mean a number of fish analised

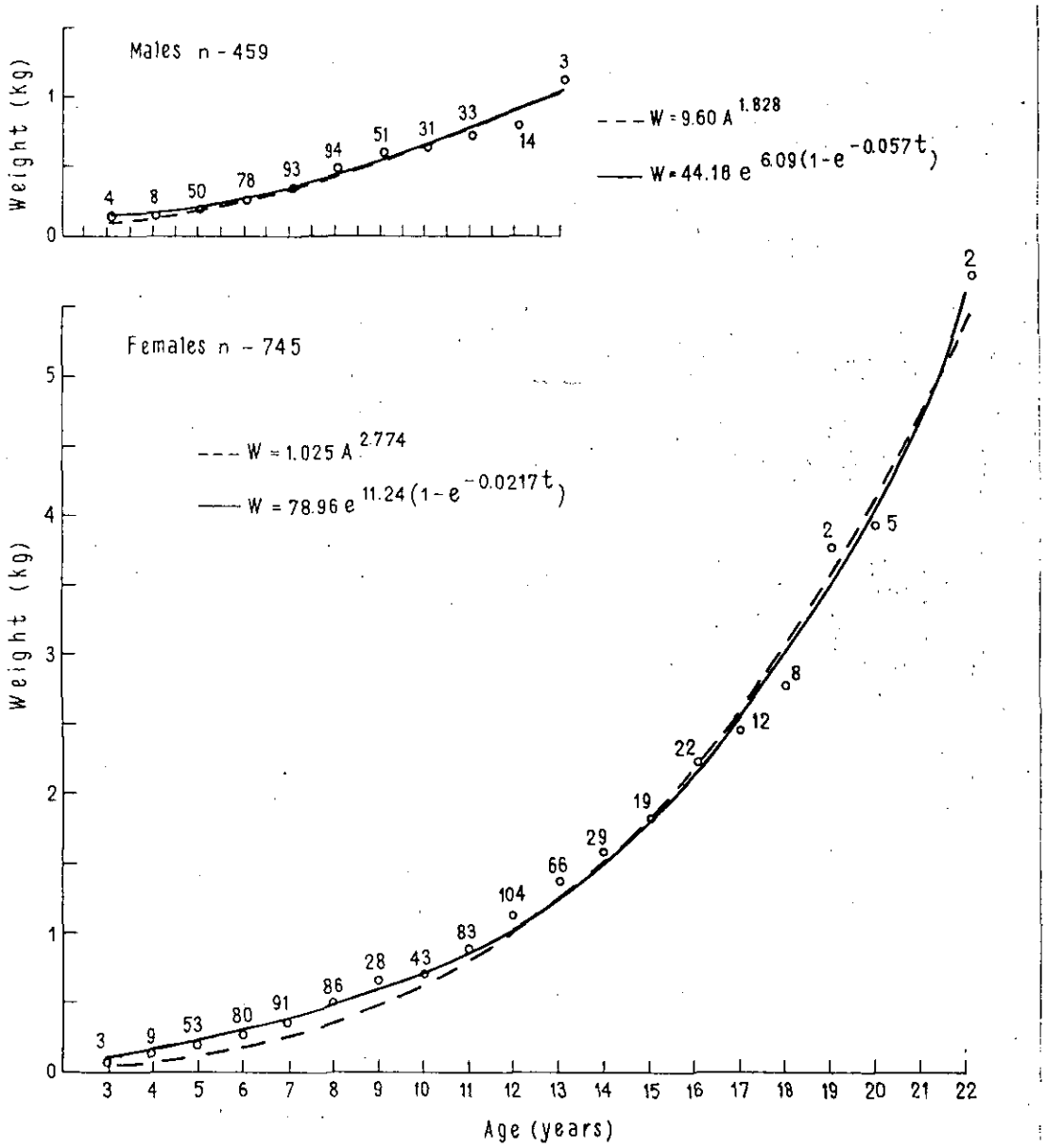

Fig. 5. Growth in weight of Macrourus berglax from the Div. 0B, 2G, 2H, 3K, 1985. Figures on the curves mean a number of fish analised

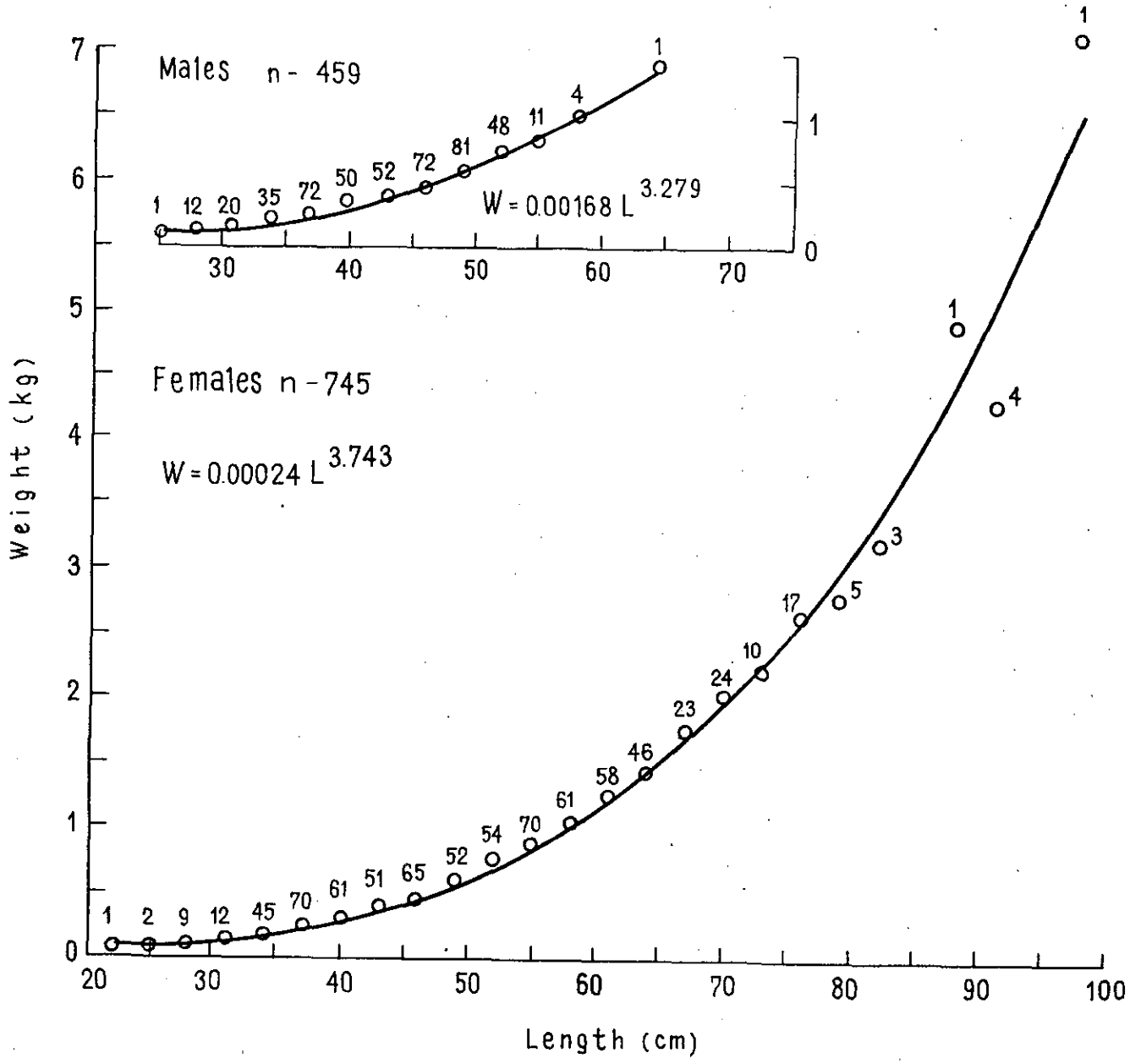

Fig. 6. Length-weight relationships of Macrourus berglax from the Div. 0B, 2G, 2H, 3K, 1985. Figures on the curves mean a number of fish analised