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COMPARISON OF HADDOCK FROM GEORGES AND BROWNS BANKS

By HOWARD A. SCHUCK and EDGAR L. ARNOLD, JR.

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By HOWARD A. SCHUCK and EDGAR L. ARNOLD, JR., *Fishery Research Biologists*

Two large areas in the Northwest Atlantic Ocean are of utmost importance to the United States haddock fishery. These are the Georges Bank area and the chain of Nova Scotian banks. From these two areas comes over 95 percent of the United States production of haddock. In the years 1931 to 1949, the Georges Bank area produced about 2,092,000,000 pounds (round weight) of haddock and the Nova Scotian banks better than 910,000,000 pounds.

These two areas are close geographically but are separated by the relatively deep Fundian Channel. The question of the effectiveness of this channel as a barrier to the passage of haddock (*Melanogrammus aeglefinus*) between the Georges Bank area and the group of Nova Scotian banks is economically and scientifically important. Its answer, among other things, determines whether the haddock stocks in the two areas can be expected to fluctuate simultaneously or whether they must be considered separately in interpreting observed fluctuations in abundance.

It is possible that some intermingling of the egg or fry stages may occur between the two banks. Walford (1938), however, concluded that during 1931 and 1932 (the only years in which the drift of young has been studied) Georges Bank, at least, had received no recruits from other areas.

Regarding the bottom-dwelling stages of haddock, various investigators (Needler 1930, Herrington 1944) expressed the opinion that intermigration between the two areas is negligible, and that the populations inhabiting the two areas are largely independent. At present, direct evidence from the movement of marked fish is limited. Returns from haddock tagged in shallow inshore waters have been obtained (Needler 1930, Schroeder 1942, Rounsefell 1942, United States Fish and Wildlife Service unpublished records), but early tagging of large groups of haddock located off shore was unsuccessful. The extremely delicate haddock require special methods of collecting and handling, particularly in deep water, if returns are to be obtained. Recent attempts at offshore tagging from the *Albatross III* are proving successful, but it will be some time before enough returns are available to determine how much migration occurs across the Fundian Channel.

As for indirect lines of evidence, Vladykov (1935) has shown small differences in the average numbers of vertebrae in haddock from Georges Bank and the Nova Scotian banks. The significance of the differences is not known, as no measures of variation of these averages were given. Other data by Needler (1930) indicate differences in the size composition and the growth rate between Nova Scotian and Georges Bank haddock. But again only averages were given and the samples were taken by commercial gear which excluded the younger ages and possibly exercised selection for the larger sizes of certain ages.

Recent data collected on a cruise of the *Albatross III*, research vessel of the United States Fish and Wildlife Service, make possible a critical comparison between the haddock from Georges Bank and those from Browns Bank, the Nova Scotian bank lying closest to Georges. By such a comparison, it is the purpose of this report to consider further the effectiveness of the Fundian Channel as a barrier to bottom-dwelling stages of haddock. In effect, this study supplements Needler (1930) by including younger fish and by providing stringent statistical comparison of data from the two banks.

In collecting the original data for this study John B. Colton, Jr., Frank A. Dreyer, Freeman A. Pluff, Louis D. Stringer, and Roland L. Wigley assisted. Sterling L. Cogswell and Richard E. Sayles prepared the scales for study, and Manuel Vieira prepared the illustrations. Robert Kirkpatrick summarized the 1950 Browns Bank data, and John C. Marr, Chief, South Pacific Fishery Investigations, reviewed the manuscript.

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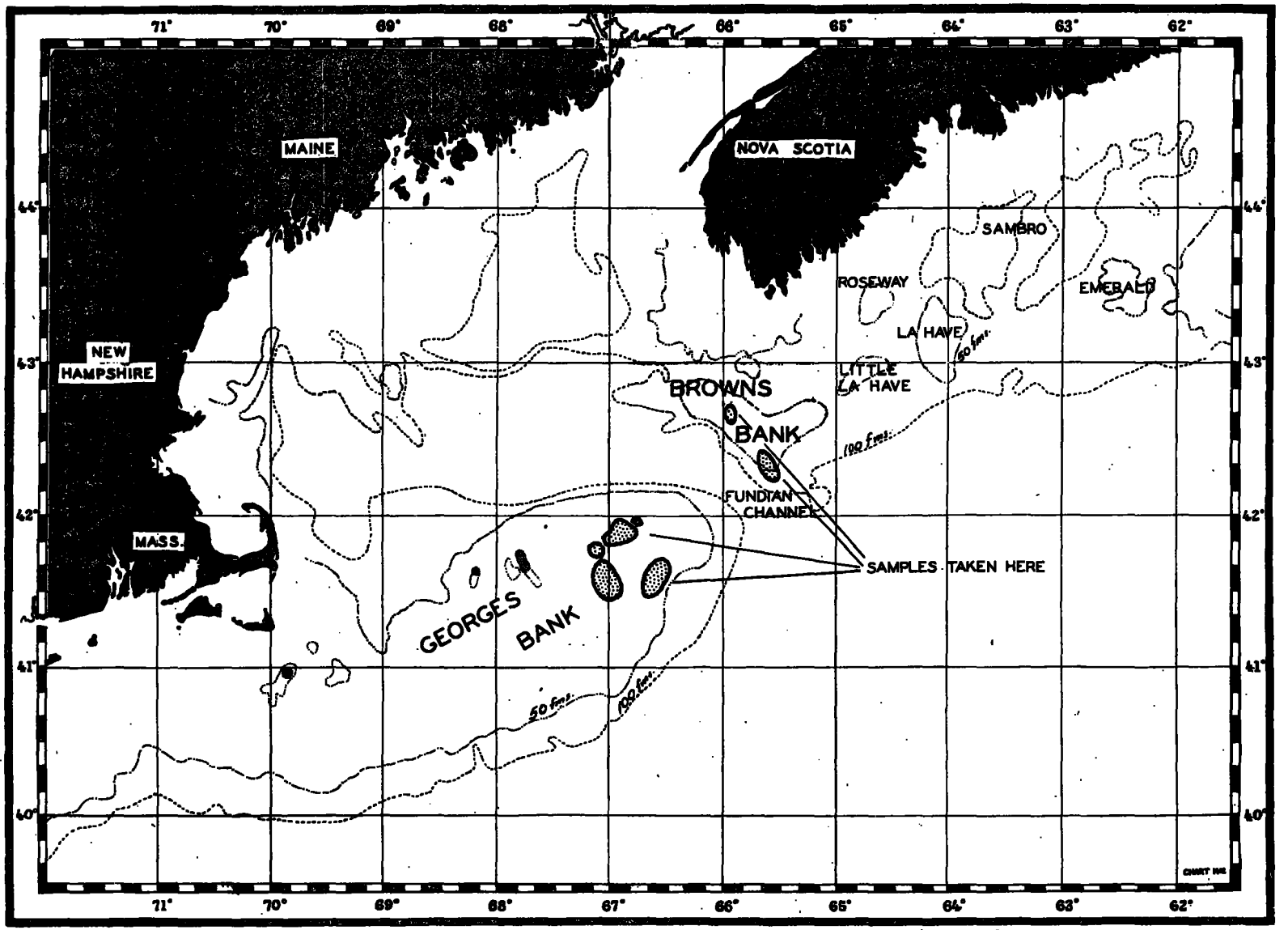

FIGURE 1.—Areas of Georges and Browns Banks from which sample haddock were taken.

COLLECTION OF DATA

Cruise 23 (June 23 to June 29, 1949) of the *Albatross III* was made primarily to tag haddock on Georges and Browns Banks. However, length measurements and scale samples were obtained concurrently from a substantial number of fish on each of the two banks, and these data form the basis for this report.

The mesh in the otter trawl used was small enough, 2-inch stretched measure, to obtain a representative sample of all sizes and ages of bottom-dwelling haddock (other than young of the year) in a given area. The samples were obtained from two locations on Browns Bank and from five locations on Georges Bank (fig. 1). These locations were not selected at random, but all fish caught on the two banks were taken in nets of the same size, fished in the same manner.

SIZE COMPOSITION

During this cruise, 10,163 haddock were caught in 61 tows, 9,321 in 45 tows on Georges Bank and 842 in 16 tows on Browns Bank. The size compositions[1] of these catches are shown in table 1. The percentage size compositions of the catches from the two banks also are shown in table 1 and are plotted in figure 2. From these data it can be seen that there is a marked difference in the size compositions of the catches from the two banks.

[1] By fork length, from tip of snout to fork of tail. All lengths were recorded by centimeters, that is, lengths from 20.0 centimeters to and including 20.9 centimeters were recorded as 20.0 centimeters, lengths from 21.0 centimeters to and including 21.9 centimeters were recorded as 21.0 centimeters, and so on. Data are arranged in 3-centimeter groups, that is, 20-, 21-, and 22-centimeter fish are grouped as 21-centimeter fish; 23-, 24-, and 25-centimeter fish are grouped as 24-centimeter fish, and so on.

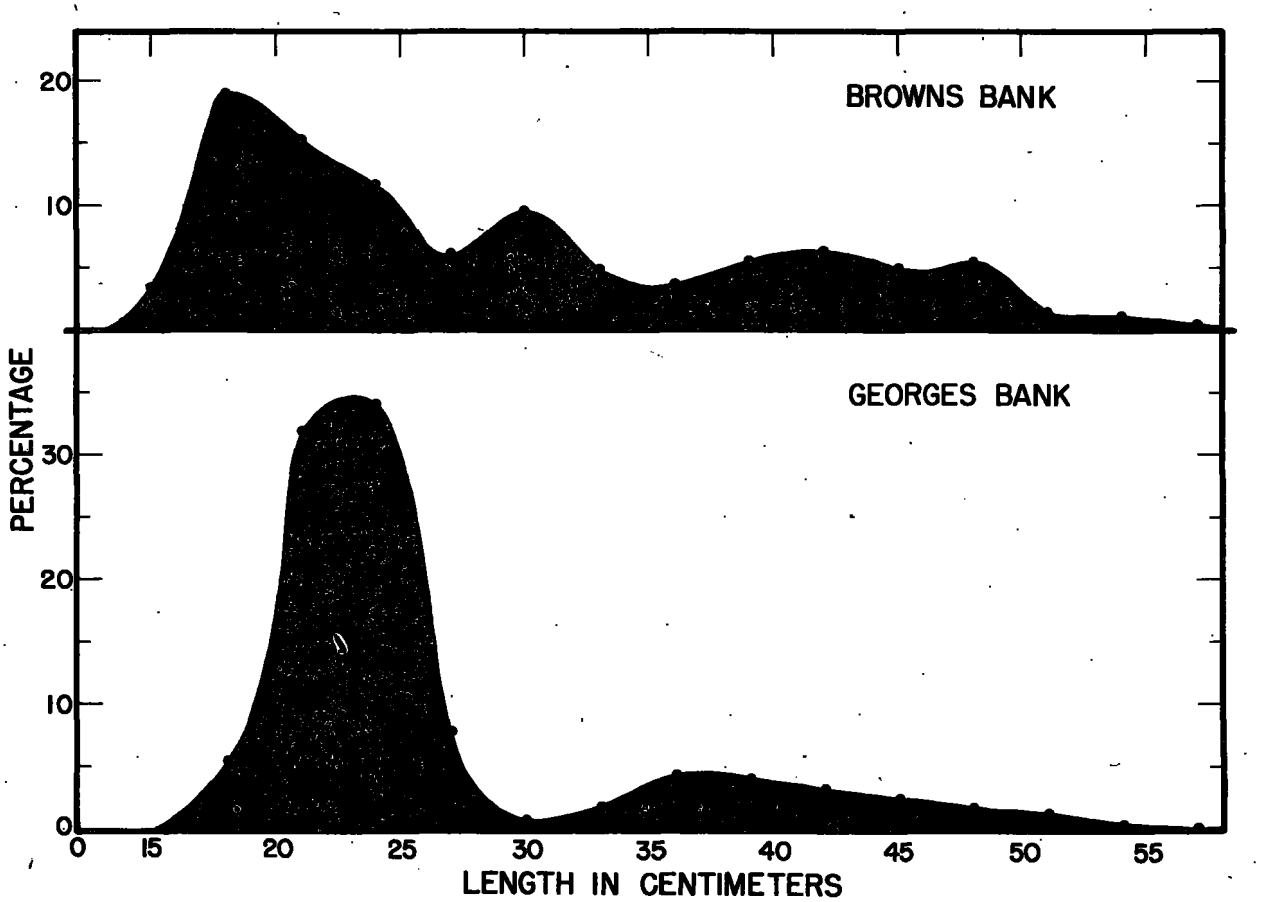

FIGURE 2.—Percentage size compositions of haddock catches from Georges and Browns Banks.

TABLE 1.—*Size compositions of haddock catches from Georges and Browns Banks*

Length in 3-centimeter groups [1]	Georges Bank		Browns Bank	
	Number	Percent	Number	Percent
15 centimeters			29	3.44
18 centimeters	511	5.48	160	19.00
21 centimeters	2,973	31.90	129	15.32
24 centimeters	3,180	34.12	99	11.76
27 centimeters	734	7.87	52	6.18
30 centimeters	75	.81	81	9.62
33 centimeters	182	1.95	41	4.87
36 centimeters	410	4.40	32	3.80
39 centimeters	376	4.03	47	5.58
42 centimeters	298	3.20	53	6.29
45 centimeters	239	2.56	42	4.99
48 centimeters	159	1.71	46	5.46
51 centimeters	117	1.26	12	1.42
54 centimeters	40	.43	10	1.19
57 centimeters	18	.19	4	.48
60 centimeters	3	.03	4	.48
63 centimeters	3	.03	1	.12
66 centimeters	1	.01		
69 centimeters				
72 centimeters	2	.02		
Total	9,321	100.00	842	100.00

[1] See text footnote 1.

SIZES AT VARIOUS AGES

Without some method of age determination, we could only speculate about the ages of the fish represented by the modes in these size distributions. Fortunately the age of haddock, at least for the ages represented here, can be assessed accurately by microscopic examination of impressions of their scales. Figure 3 shows impressions of scales of 1-, 2-, 3-, and 4-year-old haddock collected on this cruise.

Scale samples were taken from 1,285 haddock, 823 from Georges Bank and 462 from Browns Bank. Tables 2 and 3 show the distribution of these fish by size, and the number and percentage of fish from each size group that were assigned to each age on the basis of scale examination. From the percentages thus obtained, it was possible to estimate how many fish in the total catch were of each age.

It was necessary to determine the number of each age in the entire catch, rather than to use only the age samples of tables 2 and 3, because scales were taken from more large fish than from small, in proportion to their abundance. This was done because of the relative scarcity of larger sizes and because of the greater number of ages that make up the size groups of larger fish.

The age composition of the total catch was obtained by allotting the total catch of each size group (table 1) to the various ages on the basis of the percentages shown in tables 2 and 3. For example, the Georges Bank age analysis showed that, of all 18-centimeter fish for which age readings were made, 100 percent were 1-year olds. Accordingly, the total catch (511) of 18-centimeter haddock taken on Georges Bank were considered to be 1-year-old fish. Likewise, of all 36-centimeter fish for which the ages were read, 92.1 percent were 2-year-olds and 7.9 percent were 3-year-olds. Thus, of the 410 fish of 36

TABLE 2.—*Age composition of 823 Georges Bank haddock, by scale analysis*

[In parentheses is the percentage that each age contributed to the total for each size]

Length in 3-centimeter groups [1]	Number and percent in age group—									Total number, all ages
	1	2	3	4	5	6	7	8	9 and over	
18 centimeters	3 (100.0)									3
21 centimeters	39 (100.0)									39
24 centimeters	39 (100.0)									39
27 centimeters	18 (100.0)									18
30 centimeters	6 (46.2)	7 (53.8)								13
33 centimeters		65 (100.0)								65
36 centimeters		139 (92.1)	12 (7.9)							151
39 centimeters		105 (67.7)	50 (32.3)							155
42 centimeters		34 (30.6)	75 (67.6)	2 (1.8)						111
45 centimeters		2 (2.2)	69 (77.6)	18 (20.2)						89
48 centimeters			35 (56.4)	23 (37.1)	4 (6.5)					62
51 centimeters			10 (20.4)	35 (71.4)	4 (8.2)					49
54 centimeters				11 (78.6)	2 (14.3)	1 (7.1)				14
57 centimeters				3 (37.5)	3 (37.5)	1 (12.5)		1 (12.5)		8
60 centimeters					1 (50.0)	1 (50.0)				2
63 centimeters						2 (100.0)				2
66 centimeters						1 (100.0)				1
69 centimeters										0
72 centimeters								1 (50.0)	1 (50.0)	2
All sizes	105	352	251	92	14	6		2	1	823

[1] See text footnote 1.

TABLE 3.—*Age composition of 462 Browns Bank haddock, by scale analysis*

[In parentheses is the percentage that each age contributed to the total for each size]

Length in 3-centimeter groups [1]	Number and percent in age group—									Total number, all ages
	1	2	3	4	5	6	7	8	9 and over	
15 centimeters	13 (100.0)									13
18 centimeters	62 (89.9)	7 (10.1)								69
21 centimeters	13 (16.0)	68 (84.0)								81
24 centimeters		50 (96.2)	2 (3.8)							52
27 centimeters		11 (31.4)	24 (68.6)							35
30 centimeters			49 (100.0)							49
33 centimeters			32 (97.0)	1 (3.0)						33
36 centimeters			12 (63.2)	7 (36.8)						19
39 centimeters				19 (90.5)	2 (9.5)					21
42 centimeters				20 (87.0)	3 (13.0)					23
45 centimeters				10 (40.0)	15 (60.0)					25
48 centimeters				4 (17.4)	16 (69.6)	2 (8.7)	1 (4.3)			23
51 centimeters					5 (83.3)	0 (0.0)	1 (16.7)			6
54 centimeters					1 (12.5)	5 (62.5)	2 (25.0)			8
57 centimeters							1 (50.0)	1 (50.0)		2
60 centimeters								1 (100.0)		1
63 centimeters									2 (100.0)	2
All sizes	88	136	119	61	42	7	5	2	2	462

[1] See text footnote 1.

centimeters caught on Georges Bank, 378 (92.1 percent) were estimated to be 2-year-olds and 32 (7.9 percent) to be 3-year-olds.

The total numbers of haddock caught of each size and age, shown in tables 4 and 5, were transformed into percentages and plotted in figure 4. In effect, this amounted to converting the percentage size compositions shown in figure 2 into percentage age compositions. From figure 4, it can be seen that, as already suspected from figure 2, the modes are composed largely of fish of different ages.

It can be seen from figure 3 and also from table 6 that for each age the fish caught on Georges Bank were considerably larger than those caught on Browns Bank. One-year-olds from Georges averaged 22.7 centimeters as compared with only 17.9 centimeters from Browns; 2-year-olds from Georges were 36.6 centimeters as compared with 22.4 from Browns; 3-year-olds were 43.2 centimeters as compared with 30.6; 4-year-olds were 49.4 centimeters as compared with 41.1 centimeters. Also shown in table 6 are the ranges of the means, expressed as the mean + 2 times its standard

TABLE 4.—*Estimated age distribution of haddock catch from Georges Bank*

Length in 3-centimeter groups [1]	Number in age group—									Total, all ages
	1	2	3	4	5	6	7	8	9 and over	
18 centimeters	511									511
21 centimeters	2,973									2,973
24 centimeters	3,180									3,180
27 centimeters	734									734
30 centimeters	35	40								75
33 centimeters		182								182
36 centimeters		378	32							410
39 centimeters		255	121							376
42 centimeters		91	202	5						298
45 centimeters		5	186	48						239
48 centimeters			90	59	10					159
51 centimeters			24	83	10					117
54 centimeters				31	6	3				40
57 centimeters				7	7	2		2		18
60 centimeters					2	1				3
63 centimeters						3				3
66 centimeters						1				1
69 centimeters										0
72 centimeters								1	1	2
All sizes	7,433	951	655	233	35	10	0	3	1	9,321

[1] See text footnote 1.

TABLE 5.—*Estimated age distribution of haddock catch from Browns Bank*

Length in 3-centimeter groups [1]	Number in age group—									Total, all ages
	1	2	3	4	5	6	7	8	9 and over	
15 centimeters	29									29
18 centimeters	144	16								160
21 centimeters	21	108								129
24 centimeters		95	4							99
27 centimeters		16	36							52
30 centimeters			81							81
33 centimeters			40	1						41
36 centimeters			20	12						32
39 centimeters				42	5					47
42 centimeters				46	7					53
45 centimeters				17	25					42
48 centimeters				8	32	4	2			46
51 centimeters					10	0	2			12
54 centimeters					1	6	3			10
57 centimeters							2	2		4
60 centimeters								4		4
63 centimeters									1	1
All sizes	194	235	181	126	80	10	9	6	1	842

[1] See text footnote 1.

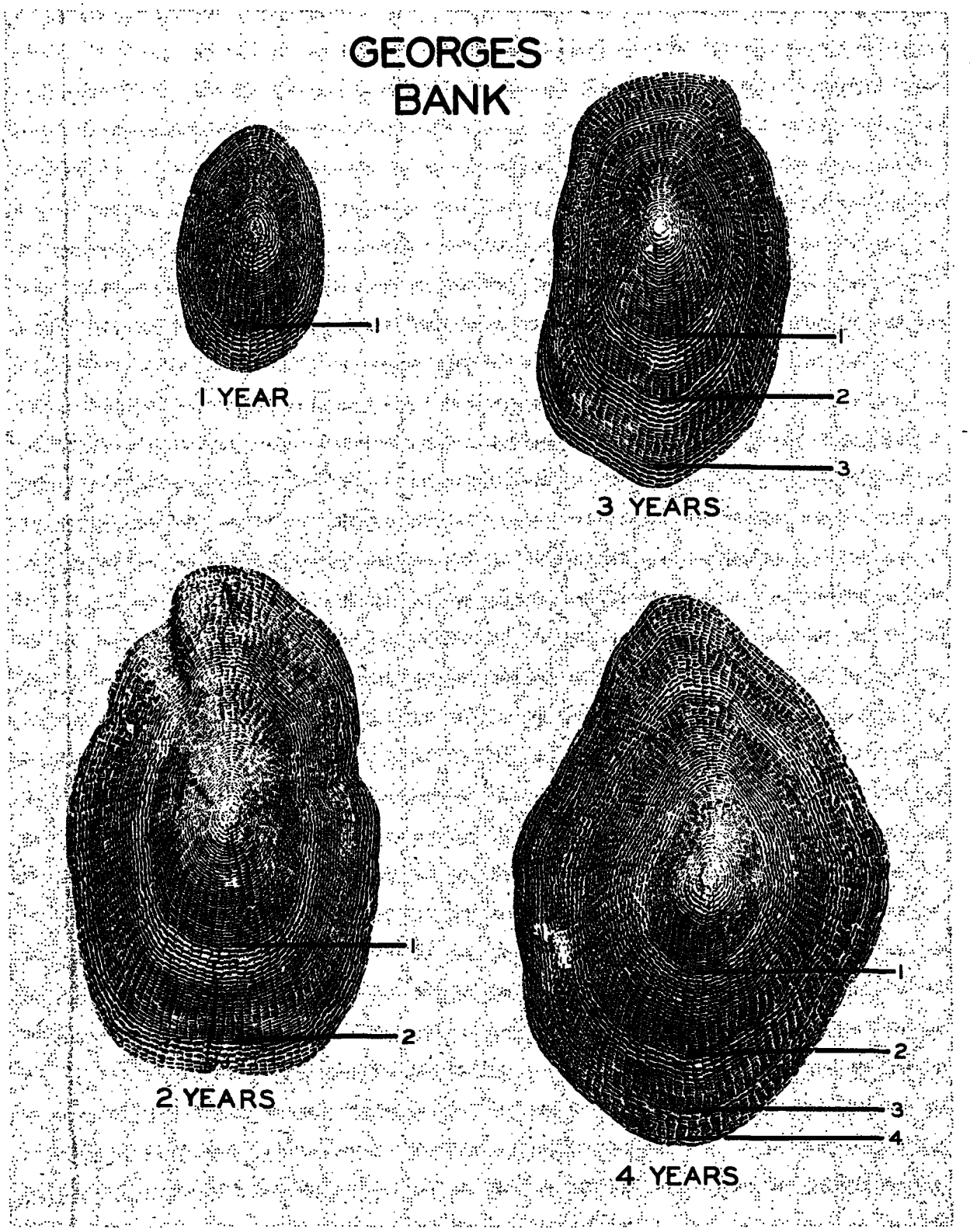

FIGURE 3a.—Impressions of scales of 1-, 2-, 3-, and 4-year old haddock from Georges Bank.

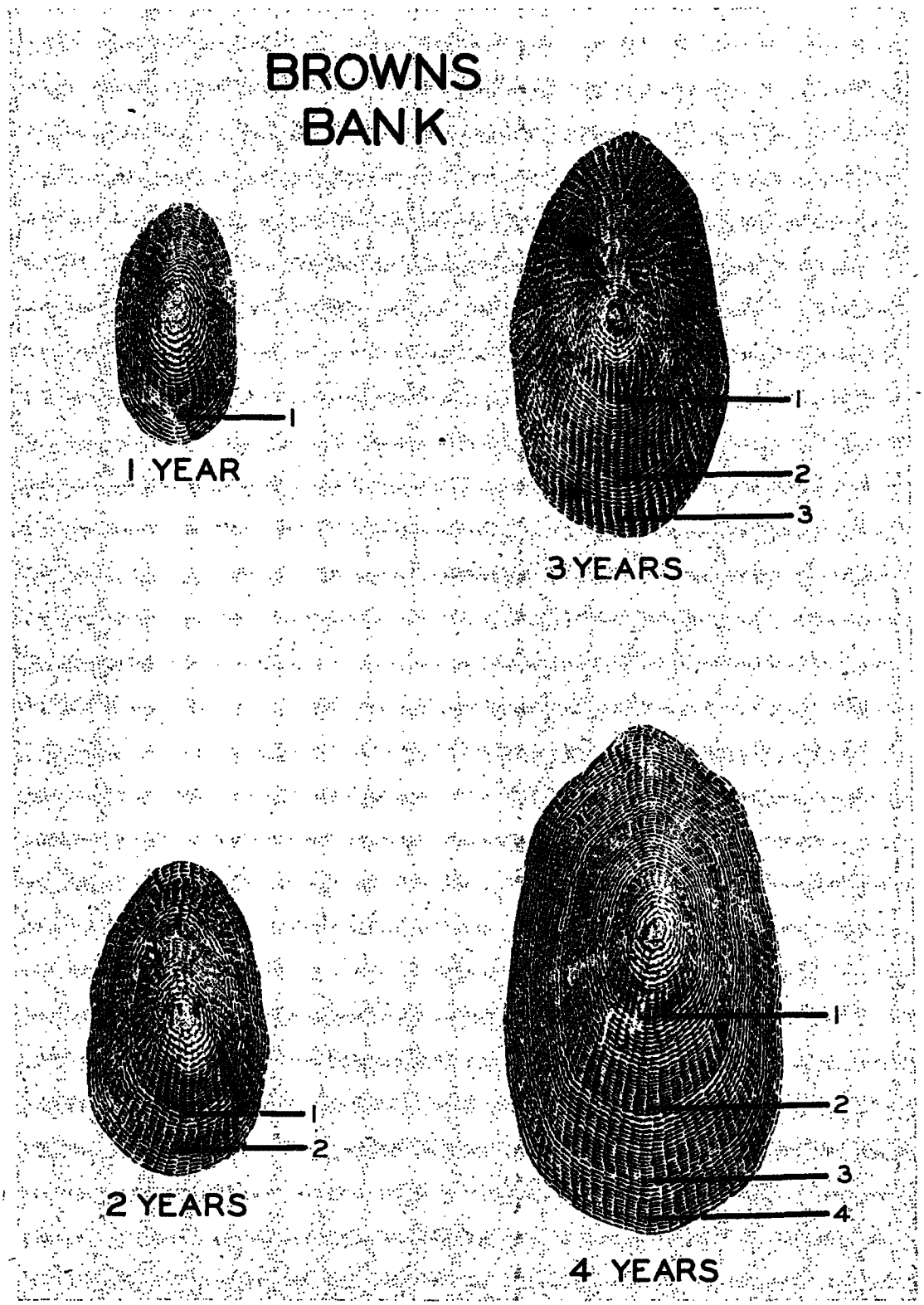

FIGURE 3b.—Impressions of scales of 1-, 2-, 3-, and 4-year-old haddock from Browns Bank.

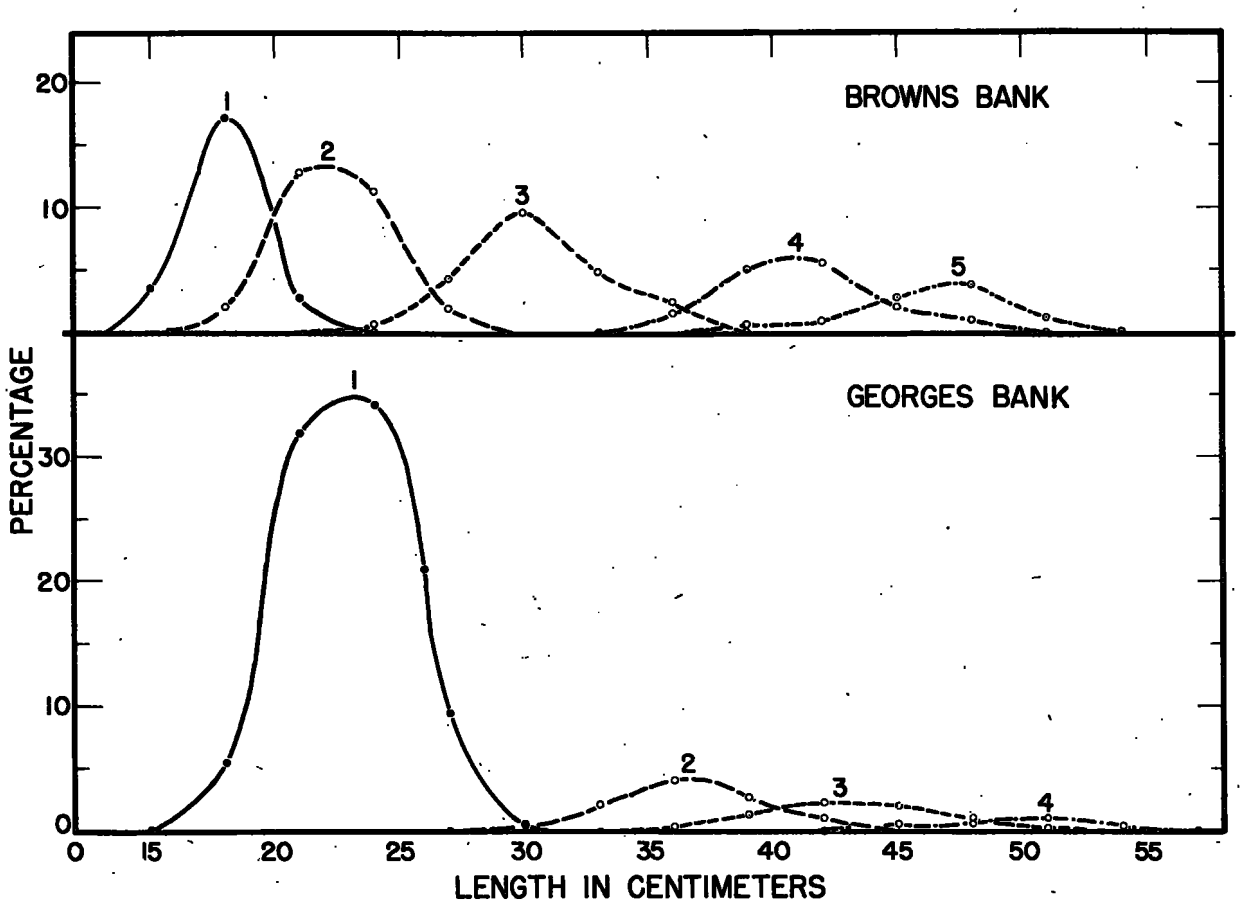

FIGURE 4.—Percentage age compositions of haddock catches from Georges and Browns Banks.

error. The variation within the age groups was such that if sampling continued, about 95 percent of the mean lengths obtained might be expected to fall within the limits indicated.

The differences in average length between the Georges and Browns Banks fish for each age were found to be highly significant.[2] The F-test (produced by the analysis of variance of the lengths in tables 2 and 3) showed values far in excess of the 1 percent level. The probability is much less than 1 in 100 that such a large difference in the average length at each age would be due to chance sampling of a homogeneous population of fish. If average lengths are plotted against age for the Browns Bank data, it is seen that the curve is not as smooth as that for the Georges Bank data and that two points (2- and 3-year-olds) seem particularly at variance with (below) what we might expect in a "normal" growth curve. We believe this is due to the fact that, in general, there is variability in growth rate between different year classes and one cannot expect to obtain a smooth or "normal" growth curve from a single year's collection of data. Specifically, we contend that the 1946 and 1947 year classes on Browns Bank were subnormal in attained size.

TABLE 6.—*Mean length and length range of various ages of haddock from Georges and Browns Banks*

[Averages computed from tables 4 and 5; standard errors from tables 2 and 3. Figures in parentheses show number of fish for which ages were read.]

Age	Georges Bank		Browns Bank	
	Mean length	Length range [1]	Mean length	Length range [1]
1 year	22.7 (105)	22.2 to 23.2	17.9 (88)	17.6 to 18.2
2 years	36.6 (352)	36.3 to 36.9	22.4 (136)	22.0 to 22.8
3 years	43.2 (251)	42.7 to 43.7	30.6 (119)	30.1 to 31.1
4 years	49.4 (92)	48.7 to 50.1	41.1 (61)	40.2 to 42.0
5 years	52.4 (14)	50.2 to 54.6	46.4 (42)	45.4 to 47.4
6 years	59.1 (6)		51.6 (7)	
7 years	(0)		52.7 (5)	
8 years	62.0 (2)		59.0 (2)	
9 years and over	72.0 (1)		63.0 (2)	

[2] Ages 1 to 5 only. No tests of significance were computed for older ages.

[1] Mean±2 times its standard error.

After this report was begun, the *Albatross III* completed its 1950 summer census on Browns Bank and there became available a means of testing this hypothesis: If true, the 3- and 4-year-olds taken in 1950, rather than the 2- and 3-year-olds in 1949, might be found to be smaller than expected. To investigate this, we computed the average size at each age of all haddock from which scales were taken on Browns Bank in 1950. These average lengths in centimeters are as follows:

	Average length	*Number included*
1-year-olds	19. 3	43
2-year-olds	26. 3	141
3-year-olds	31. 5	122
4-year-olds	38. 5	164
5-year-olds	48. 0	180
6-year-olds	51. 4	162
7-year-olds	55. 1	117

If these values are plotted it can be seen that the points for 3- and 4-year-olds do fall below the general trend. Thus it appears that the 1946 and 1947 year classes actually had smaller attained sizes, and this appears to be a reasonable explanation for not obtaining a smooth growth curve from the 1949 collection of data on Browns Bank.

A completely chance sampling of a homogeneous population in nature is difficult to obtain, but we believe that our sampling was sufficiently representative to confirm the differences described here. First, the haddock were caught over several hundred square miles of Georges Bank and over about 100 square miles of Browns Bank. Such large areas were not covered thoroughly, of course, but the net was set at random within them. Second, the same otter-trawl net was used on the two banks and it should have sampled similarly the same-size fish on the two banks and unquestionably should have made no selection of different ages at the same size. Third, from extensive (unpublished) studies of the catch of the commercial fleet on Georges Bank we know that haddock from different parts of Georges Bank grow at rather similar rates. The other possible objection to the tests of significance concerns the "normality" of the size distributions for various ages. Inspection of figure 4 indicates that all curves are close to normal except the flat-topped one for 2-year-old haddock from Browns Bank; even this one instance of kurtosis should have little effect on the tests of significance.

SUMMARY

The haddock on Georges and Browns Banks grow at different rates. One-year-old haddock averaged 22.7 centimeters on Georges Bank as compared with 17.9 centimeters on Browns; 2-year-olds averaged 36.6 on Georges, 22.4 on Browns; 3-year-olds were 43.2 on Georges, 30.6 on Browns; 4-year-olds were 49.4, and 41.1; and 5-year-olds were 52.4, and 46.4. This difference indicates that hereditary or ecological conditions governing growth are different in the two areas and that important intermigrations of the bottom-dwelling stages of haddock do not occur. As a consequence, we need not expect the stocks to fluctuate simultaneously and we should continue to collect and to analyze separately for the two areas the statistics of landings, age, growth, abundance, and other biological data.

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