

UNITED STATES DEPARTMENT OF THE INTERIOR, J. A. KRUG, Secretary
FISH AND WILDLIFE SERVICE, ALBERT M. DAY, Director

AGE AND GROWTH OF IMMATURE ROSEFISH (*SEBASTES MARINUS*) IN THE GULF OF MAINE AND OFF WESTERN NOVA SCOTIA

BY ALFRED PERLMUTTER AND GEORGE M. CLARKE



Fishery Bulletin 45

From Fishery Bulletin of the Fish and Wildlife Service

VOLUME 51

UNITED STATES GOVERNMENT PRINTING OFFICE • WASHINGTON : 1949

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents

CONTENTS

	Page
Preparation and study of materials.....	207
Structures examined.....	207
Area of fish from which scale samples were taken.....	208
Collection of scale data.....	208
Preparation and method of examining scale samples.....	209
Examination of scale material.....	209
Procedure for determining age and growth from scales.....	213
Significance of circulus bands on rosefish scales.....	213
Age of rosefish at the time of scale formation.....	214
Methods of analysis.....	217
Variations in the fish length-scale radius relationship.....	218
Results.....	221
Calculated length at each annulus.....	221
Comparison of the actual and calculated average length at annulus 1.....	222
Growth between annuli.....	223
Conclusions.....	227
Literature cited.....	228

AGE AND GROWTH OF IMMATURE ROSEFISH (*SEBASTES MARINUS*) IN THE GULF OF MAINE AND OFF WESTERN NOVA SCOTIA

The rosefish (*Sebastes marinus*)¹ is abundant on the fishing banks of the Gulf of Maine and Nova Scotia in depths ranging from 50 to 120 fathoms. Until 1935, rosefish were marketable only in limited quantities, and the yearly landings were well under 7,000,000 pounds. Technological advances in handling fish, particularly filleting, quick-freezing, and the perfection of an automatic scaling machine, in addition to the development of markets in Midwestern States, stimulated a rapid increase in the rosefish fishery to an average yearly catch of more than 100,000,000 pounds. The catch reached a peak in 1946 of 178,000,000 pounds. As a result of the growing importance of the fishery, the Fish and Wildlife Service began a study of the rosefish in the fall of 1942. This report summarizes one phase of the investigation; namely, the age and growth of immature rosefish in the Gulf of Maine and off the Browns Bank area of western Nova Scotia.

PREPARATION AND STUDY OF MATERIALS

STRUCTURES EXAMINED

From a preliminary examination of the bony structure of the rosefish it was found that the opercular bones, otoliths, and scales showed series of sculpturings, which, on the basis of previous age studies on other species of fish, were suggestive of year marks. Both the opercular bone and the otolith proved difficult to use in age analysis. In the opercular bone, the markings on some specimens were indistinct or were marred by a cavernous development near the base of the bone (fig. 1). The otoliths appeared more promising for determining the age of the rosefish. Freshly recovered otoliths or dried specimens cleared slightly in oil of cloves, oil of wintergreen, or glycerine, showed dark and light bands, as did cross sections of dry otoliths (figs. 2 and 3). Otoliths from the larger fish had a greater

¹ *Sebastes marinus* in American waters does not grow so large as its counterpart in European waters. The largest fish we have recorded in the Gulf of Maine was 48 cm. from the tip of the snout to the fork of the tail. Preliminary taxonomic comparison of recently collected data on the American fish with published data on the European fish indicates extensive variations of the genus throughout its range and the need for a complete taxonomic study.

number of bands, but the individual rings were close together and less distinct. Because of the difficulty in collecting and preparing otoliths, and in distinguishing bands in the larger fish, together with the fact that only age data and no growth data could be obtained from otoliths, the study of them was discontinued. Attention was focused on the scales as a method of determining age and growth in rosefish.

Rosefish scales are oblong and strongly ctenoid on their outer edge, the number of rows of cteni being

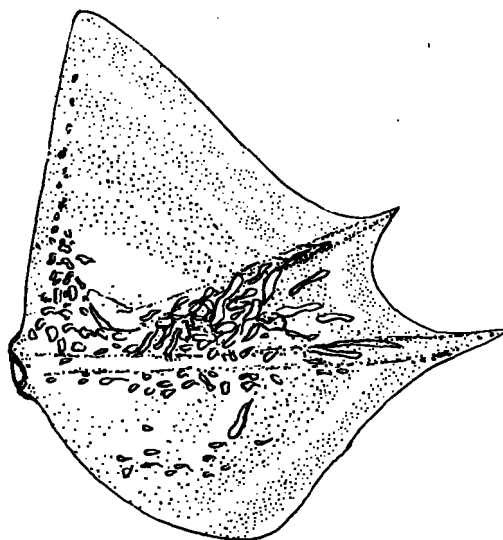


FIGURE 1.—Opercular bone showing growth bands. From a female rosefish 160 mm. long taken in the Gulf of Maine, January 1945. Enlarged 4 times.

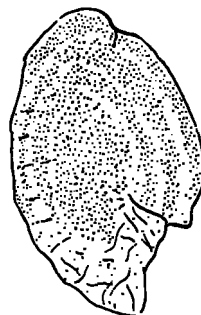


FIGURE 2.—Otolith showing growth bands. From a male rosefish 144 mm. long taken in the Gulf of Maine, November 1942. Enlarged 6 times.

greater on the scales of larger fish. Radii extend from the focus to the anterior margin of the scale and are more numerous in the larger than in the smaller fish. The circuli are distributed in bands of different spacings, and a band of wide-spaced circuli is generally followed by a band of narrow-spaced circuli.

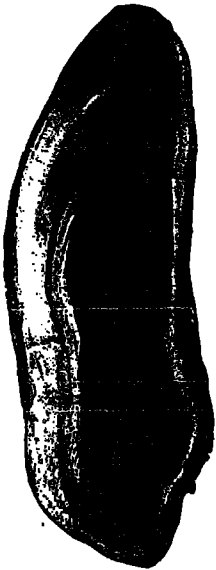


FIGURE 3.—Cross section of an otolith showing growth bands. From a female rosefish 70 mm. long taken in the Gulf of Maine, August 1943. Enlarged 30 times.

AREA OF FISH FROM WHICH SCALE SAMPLES WERE TAKEN

To determine the region on the body of the rosefish from which scales should be collected, the body was arbitrarily divided into 16 areas (fig. 4). Scales were taken from the midpoint of each of these areas and compared as to relative size, regularity, and circulus count. Four fish were examined in this manner. It was found that areas 11 and 13, the region covered by the tip of the pectoral fin and immediately posterior to it and adjacent to the lateral line, had the largest and most uniformly shaped scales with the highest circulus count (table 1). The relatively larger and more uniformly shaped scales from the "pectoral patch" were easier to mount and measure than scales from other parts of the body. Also, since scales from the "pectoral patch" area have the highest circulus count, it is most likely that they show maximum growth from the beginning of scale formation. All scale samples in the present study were taken from the "pectoral patch."

COLLECTION OF SCALE DATA

Scale collections were obtained from random lots of fish taken from individual trips of rosefish druggers. In each case, the boat captain was interviewed and

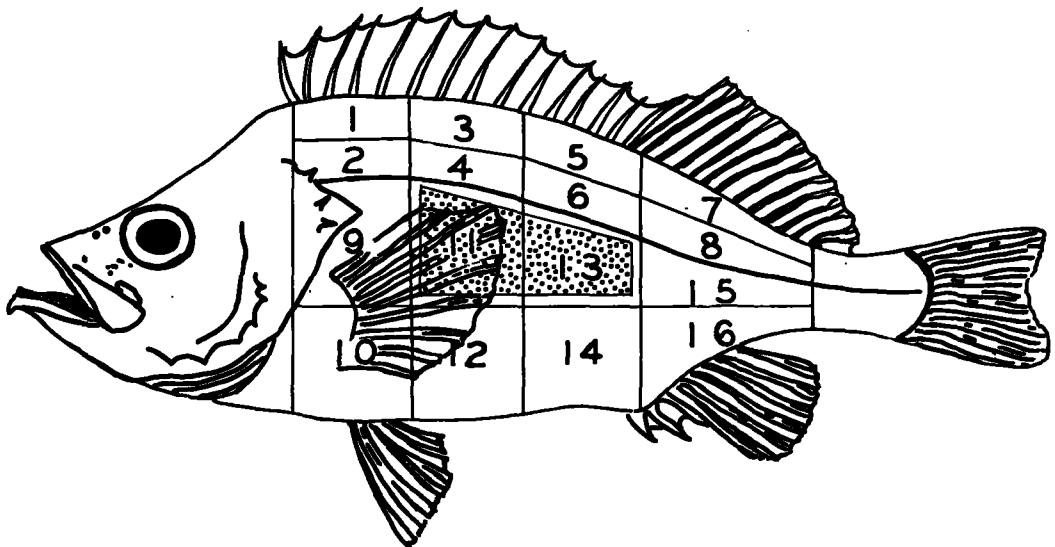


FIGURE 4.—Numbers indicate areas from which scales were removed for examination and study. The darkened patch on areas 11 and 13 is referred to in the text as the "pectoral patch."

TABLE 1.—*Circulus counts and anterior radii of rosefish scales from various body areas*

Area	Circulus count				Area	Anterior radius ¹			
	Specimen					Specimen			
	1 ²	2 ³	3 ⁴	4 ⁵		1 ²	2 ³	3 ⁴	4 ⁵
1	80	56	78	143	1	118	77	122	210
2	108	76	129	164	2	205	110	239	261
3	84	82	84	139	3	142	113	132	197
4	94	98	105	208	4	149	166	195	383
5	97	88	94	164	5	166	118	148	246
6	105	113	102	195	6	207	180	192	351
7	88	77	89	173	7	149	116	140	262
8	101	95	143	191	8	196	139	270	340
9	98	114	129	223	9	264	198	267	455
10	105	106	112	228	10	241	200	160	427
11	125	120	146	250	11	282	230	314	468
12	106	106	123	231	12	227	178	242	461
13	117	125	144	253	13	261	220	297	509
14	112	108	138	237	14	227	195	266	438
15	111	115	142	244	15	230	217	286	445
16	110	110	122	196	16	225	173	220	353

¹ In millimeters, magnified 100 times.

² Male, 174 mm., Jeffreys Ledge, January 1943.

³ Male, 154 mm., Jeffreys Ledge, January 1945.

⁴ Female, 198 mm., Cashes, October 1943.

⁵ Female, 304 mm., Cashes, October 1943.

reported fishing in only one biological area.² Only these "pure" trips were sampled in order to obtain homogeneous data from each area. The length of the fish was measured to the nearest millimeter by means of a measuring board.³ These samples have been continuously collected since August 1942. Early in 1943, it was noticed that random sampling of the commercial catch resulted in few samples of scales from fish under 200 mm. in length. To obtain more adequate sampling of the fish in this size category, scale collections were taken from as many fish under 200 mm. as could be procured.

PREPARATION AND METHOD OF EXAMINING SCALE SAMPLES

Scales were mounted in corn syrup, or glycerine-gelatin, or dry, on glass slides, or were impressed on celluloid, depending on the size of the scale. Clearest mounts were obtained of the smaller scales, either dry, or after alizarin staining, in the liquid media. The larger scales were more easily handled as celluloid impressions. Each slide was given a code number. Data on size, sex, and locality were omitted from the label to prevent their influencing the investigators in determining the age readings.

² From a study of the degree of infestation of rosefish with the copepod parasite (*Sphyrion lumpi*) and information on the life history of the parasite, plus determination of centers of fishing concentration and the size composition of the catch at these places, the rosefish stock was subdivided into population units, but enclosed in various biological areas as follows: Mount Desert-Matinicus; Monhegan-Jeffreys-Platts; East of Gloucester-Highlands; Channel; Cigar Ridge-Cashes; and Browns Bank (fig. 5).

³ Unless otherwise specified, all measurements of rosefish are from the tip of the snout to the fork of the tail.

All scales were read using a modification of the scale projector described by Van Oosten, Deason, and Jobs (1934). The machine was calibrated to produce an image 99.6 to 100.6 times the size of the object projected. Scale measurements used in the present analysis were based on an average magnification of 100 times. The projected image of the scale was measured along the median radius from the center of the focus to each annulus and to the anterior margin of the scale by marking off these distances on a strip of cardboard and then measuring them with a millimeter rule.

EXAMINATION OF SCALE MATERIAL

On the basis of scale studies on other species of fishes (Van Oosten 1929; Graham 1929), it is to be expected that the circulus bands present on rosefish scales represent periods of seasonal growth, a band of wide-spaced circuli being presumably the fast growth during summer, and a band of narrow-spaced circuli the slow growth in winter. Exploratory examination of the scales from all sizes of fish showed that the summer and winter bands were broad and could be most readily distinguished in fish less than approximately 235 mm. in length, but were narrow and difficult to determine with certainty for larger fish.

It was not possible to undertake a study of the age and growth of all sizes of rosefish because of limitations in facilities. Therefore, our study was confined to fish under 235 mm. in length. Size-at-maturity studies showed fish in this size category to be mainly

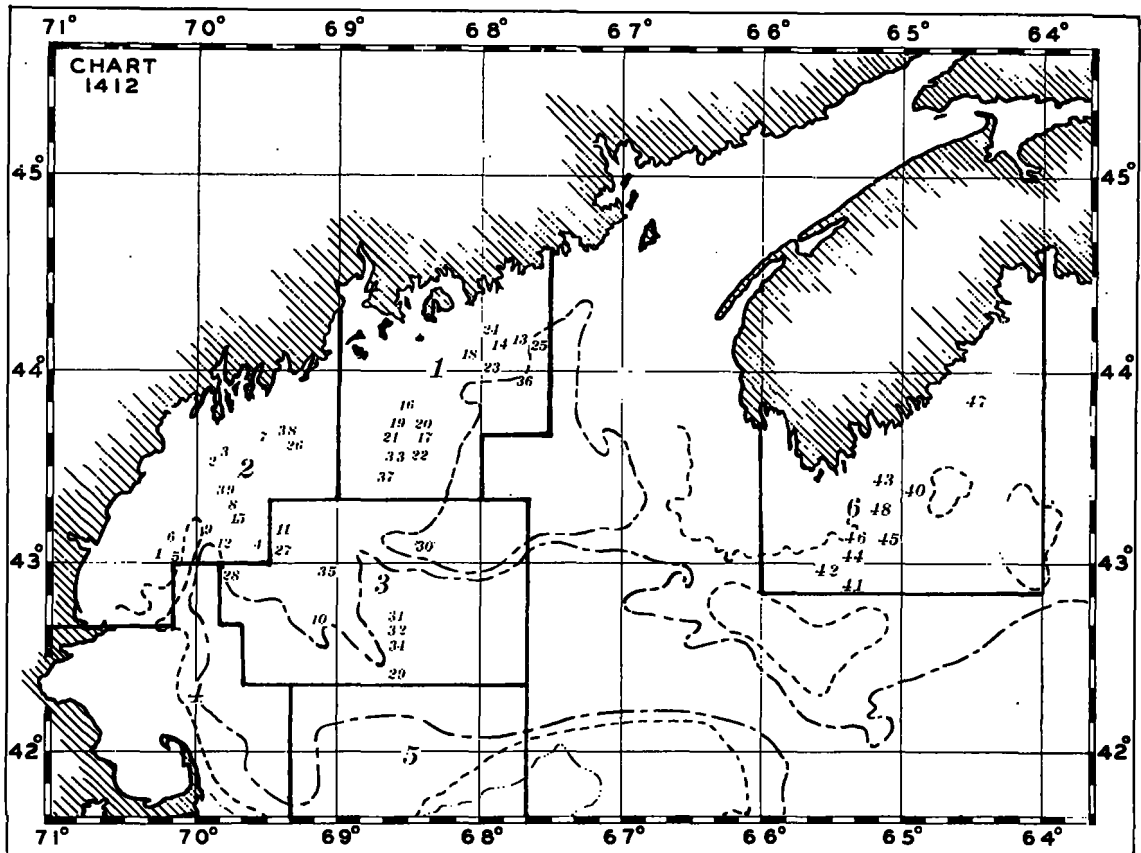


FIGURE 5.—Fishing concentration areas from which samples were obtained: area 1, Mount Desert-Matinicus; area 2, Monhegan-Jeffreys-Platts; area 3, Cigar Ridge-Cashes; area 6, Browns Bank area of western Nova Scotia (table 2). No collections of immature fish were obtained from area 4, east of Gloucester-Highlands, or from area 5, Channel, for the period studied.

TABLE 2.—Collections used in the study of the age and growth of immature rosefish

Collection No.	Year	Date landed	Area ¹	Number of fish	Collection No.	Year	Date landed	Area ¹	Number of fish
1	1942	Sept. 14	2	15	25	1944	June 17	1	5
2	1942	Oct. 16	2	5	26	1944	June 19	2	1
3	1942	Oct. 22	2	27	27	1944	July 1	3	6
4	1942	Nov. 3	2	34	28	1944	Aug. 21	3	1
5	1942	Dec. 15	2	5	29	1944	Aug. 26	3	1
6	1943	Feb. 11	2	37	30	1944	Aug. 28	3	1
7	1943	Mar. 20	2	6	31	1944	Oct. 10	3	4
8	1943	Mar. 29	2	3	32	1944	Oct. 13	3	1
9	1943	May 26	2	1	33	1944	Oct. 26	1	11
10	1943	May 28	3	9	34	1944	Oct. 27	3	3
11	1943	June 14	3	21	35	1944	Nov. 14	3	2
12	1943	June 15	2	1	36	1944	Nov. 22	1	1
13	1943	June 15	1	6	37	1944	Dec. 4	1	7
14	1943	July 30	1	2	38	1944	Dec. 5	2	17
15	1943	Aug. 6	1	21	39	1944	Dec. 16	2	4
16	1943	Aug. 13	1	9	40	1942	Dec. 11	6	20
17	1943	Aug. 15	1	24	41	1943	Mar. 17	6	3
18	1943	Aug. 16	1	43	42	1943	Apr. 9	6	18
19	1942	Oct. 9	1	17	43	1943	June 4	6	11
20	1942	Oct. 29	1	8	44	1943	June 7	6	10
21	1942	Nov. 12	1	9	45	1943	June 8	6	2
22	1942	Nov. 20	1	8	46	1943	June 14	6	34
23	1942	Nov. 9	1	1	47	1943	Aug. 17	6	4
24	1942	Dec. 10	1	29	48	1943	Dec. 23	6	9

¹ Area 1 is the Mount Desert-Matinicus region; area 2, the Monhegan-Jeffreys-Platts region; area 3, the Cashes region; area 6, the Browns Bank region. See fig. 5 for a demarcation of these regions and the location of each collection point.

immature. For example, in 1943 and 1944 in the Gulf of Maine, 92 percent of the males and 99 percent of the females less than 235 mm. in length were immature, while in the Browns Bank area, 88 percent of the males and 98 percent of the females under 235 mm. were immature. The relatively few mature fish below 235 mm. were mostly in the size range from 225 to 234 mm., as shown in figure 6.

Scale samples obtained from random lots of the catch of the rosefish fleet included comparatively few from fish below 235 mm. in length, especially from those under 200 mm. To obtain a large amount of scale data for fish under 200 mm., scales were taken

from as many fish in this size category as possible. Despite inclusion of the selected scale samples from the smaller fish, the total number of scale samples for fish under 235 mm. that could be procured from the commercial catch was relatively small. In the Gulf of Maine region, 158 scale samples were collected in 1942, 183 in 1943, and 65 in 1944, and these could only be obtained from fish in areas 1, 2, and 3, the Mount Desert-Matinicus, Monhegan-Jeffreys-Platts, and Cigar Ridge-Cashes areas, respectively. In the Browns Bank area off western Nova Scotia, 20 scale samples were collected in 1942 and 91 in 1943 (tables 2 and 3, and fig. 5).

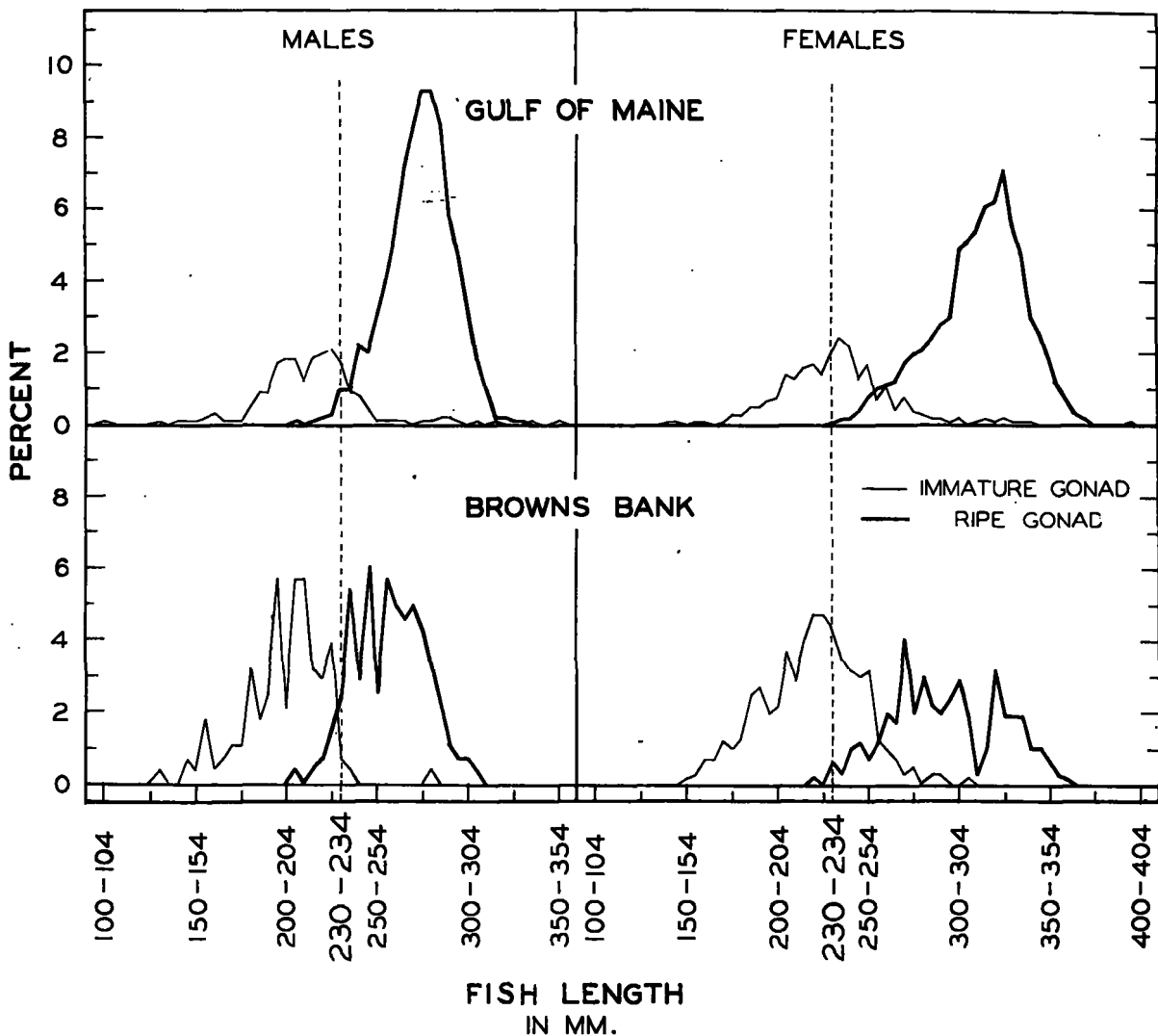


FIGURE 6.—Length-frequency distributions of immature fish by sex for the Gulf of Maine and the Browns Bank area. Gulf of Maine data: females examined in 1943 and 1944, 3,372; males examined in 1944, 1,644. Browns Bank data: females examined in 1943 and 1944, 591; males examined in 1944, 280.

Fishing selectivity largely accounts for the small numbers of fish less than 235 mm. found in the commercial catch and is due to the fact that rosefish less than 8 inches long (200 mm.) are not marketable at Gloucester. Consequently, the fishermen avoid concentrations of small fish. In most instances, this is not difficult, as there appears to be a definite segregation of the smaller or immature fish, from the larger or mature fish. Under normal conditions when small fish are inadvertently captured, they are culled and thrown overboard at sea. It is apparent, then, that large numbers of scale samples from small fish can best be procured by means of an experimental vessel fishing in the nursery areas. Pending such collection, it was deemed advisable to study the available data to obtain preliminary information on the age and growth of the rosefish.

PROCEDURE FOR DETERMINING AGE AND GROWTH FROM SCALES

SIGNIFICANCE OF CIRCULUS BANDS ON ROSEFISH SCALES

On the basis of scale studies on other species of fishes, it is to be expected that the circulus bands present on the rosefish scale represent periods of seasonal growth. To test this hypothesis a study was made of the scales of 229 fish less than 225 mm. in length taken in the Gulf of Maine in the period from April 1942 through June 1943. The part of the scale from the last circulus in the last band of narrow-spaced circuli to the edge of the scale was designated the "terminal-zone." It was observed that all specimens had only wide-spaced circuli in this zone in April through May 1942. By November 1942, the marginal circuli of the zone were closer together in some specimens and, in February 1943, in most specimens. By April 1943, all the circuli in the terminal-zone were once again widely separated.⁴ Furthermore, the circulus count and size of the terminal-zone increased from April-May 1942 until February-March 1943, when there was an abrupt decrease in these characters in a few of the fish, and by April 1943, in all of the fish (fig. 7, table 4). The sudden decrease in the circulus count and in the size of the terminal-zone in April 1943 can be explained by the completion of the band of

⁴ Bands of wide-spaced and narrow-spaced circuli are readily distinguishable from each other upon examination. Nevertheless, a more objective method of differentiating between wide- and narrow-spaced circuli was attempted by caliper measurements of circuli widths. Physical limitations in our apparatus plus certain inherent limitations in the material caused us to discontinue this technique.

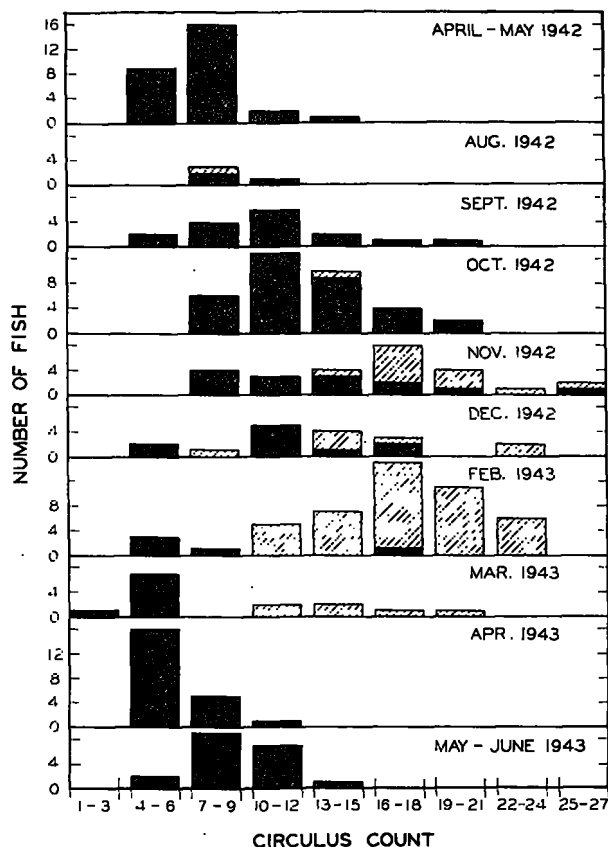


FIGURE 7.—Circulus counts from the last band of narrow-spaced circuli to the edge of the scale (terminal-zone) for scales collected from rosefish less than 225 mm. in length taken in the Gulf of Maine from April 1942 through June 1943. The solid bars indicate wide-spaced circuli, and the diagonal lines narrow-spaced circuli at the edge of the terminal-zone.

narrow-spaced circuli ending another year's growth and the inception of a new band of wide-spaced circuli starting the next year's growth.

From these data it can be seen that the narrow-spaced and wide-spaced circulus bands on the rosefish scale, as on the scales of other fishes, denote seasonal growth intervals. During April through October, growth is most rapid and a band of wide-spaced circuli is formed. From November through March, growth slows down and a band of narrow-spaced circuli results. The narrow-spaced band of circuli is considered the annular band or annulus. In the annular band, the circuli do not continue posteriorly along the lateral margins of the scale as they do in the band of wide-spaced circuli, but instead, most of them end abruptly or merge at the lateral margin of the scale forming a characteristic broken pattern. Examples of scales with varying

TABLE 4.—Time of formation of narrow and wide bands in rosefish less than 225 mm. in fish length

Number of circuli ¹	Number of fish																			
	April-May 1942		August 1942		September 1942		October 1942		November 1942		December 1942		February 1943		March 1943		April 1943		May-June 1943	
	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³
1-3																				
4-6					2						2				1					
7-9	9		2	1	4			6		4			3		7			16		2
10-12	6				4			9		3			5		2			5		9
13-15	2		1		6		13	3		3			1		2			1		7
16-18	1				2		9	1		3		1	5		7			2		1
19-21					1		4	2		6		2	1		14			1		
22-24					1		2	1		3		1	11		1					
25-27										1			6							
28-30																				
Total	28		3	1	16		34	1	14	12	10	7	5	43	8	6	22		19	

Zone growth ⁴	Number of fish																			
	April-May 1942		August 1942		September 1942		October 1942		November 1942		December 1942		February 1943		March 1943		April 1943		May-June 1943	
	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³	Wide ²	Narrow ³
0-4																				
5-9				1											2			3		
10-14	6				1		1		1		1			6			10			
15-19			2		1		4		2				3				6			
20-24	4				6		5		2				1		2		2		4	6
25-29			1		1		10		2			1	2		1		3		2	5
30-34	2				3		7	1	1		3	1	1		6		2		7	2
35-39							3		1		1	1	2		1		1			
40-44	1				2		3		2		5	2	1		9		1			
45-49					1				2		2				2					
50-54							1		2		2				3					
55-59									2		2				1					
60-64															2					
65-69															1					
70-74															1					
Total	28		3	1	16		34	1	14	12	10	7	5	43	8	6	22		19	

¹ Number of circuli from the edge of the last band of narrow-spaced circuli to the scale margin.

² Wide phase; wide-spaced circuli only.

³ Narrow phase; wide-spaced circuli followed by narrow-spaced circuli at the scale margin.

⁴ The median radial distance in millimeters from the edge of the last band of narrow-spaced circuli to the scale margin, magnified 100 times.

numbers of annuli are shown in figures 8 through 15. Figures 8 and 9 are scales from fish 30 and 50 mm. in length, respectively, which were captured in October. They show no annuli but consist entirely of wide-spaced circuli. Figure 10, a scale from a fish 59 mm. in length, has one annulus, and figures 11 through 15 contain two, three, four, six, and eight annuli, respectively.

AGE OF ROSEFISH AT TIME OF SCALE FORMATION

Although scale readings give the age of the rosefish from inception of the scale to the time of capture, they do not furnish any information on the extent of the period preceding initial scale formation. The rosefish is ovoviviparous, and from a study of the relative frequency of various developmental stages of the embryos contained in the ovaries

of the fish throughout the spring and summer, it was found that the Gulf of Maine rosefish extrude the young from mid-May through early September, with the peak birth period in July. The size at birth is indicated by larvae taken from a 297-mm. fish caught in the Mount Desert-Matinicus area in August 1943. These larvae still retained the yolk sac but swam actively when placed in a container of salt water. A sample of the specimens ranged from 7.1 to 7.5 mm. in total length. Our findings on the rosefish in Gulf of Maine waters confirm those of Bigelow and Welsh (1925:308) and are also in agreement with those of Frost (1938:15) in Newfoundland waters, which suggest a similar rosefish birth period in both areas.

According to Bigelow and Welsh (1925:311, fig. 147) rosefish larvae 20 mm. in length do not have scales. Therefore, in order for newly born larvae

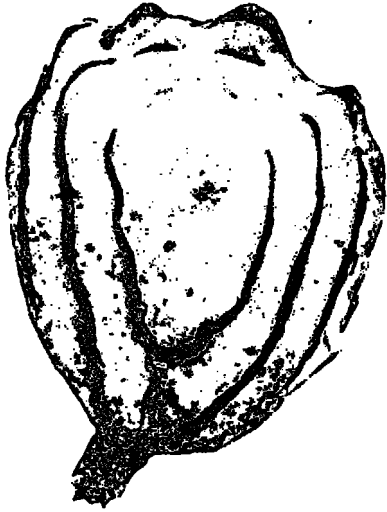


FIGURE 8.—Scale showing only four wide-spaced circuli, no annuli, from a fish 30 mm. long captured in the Cigar Ridge-Cashes area, October 1946.

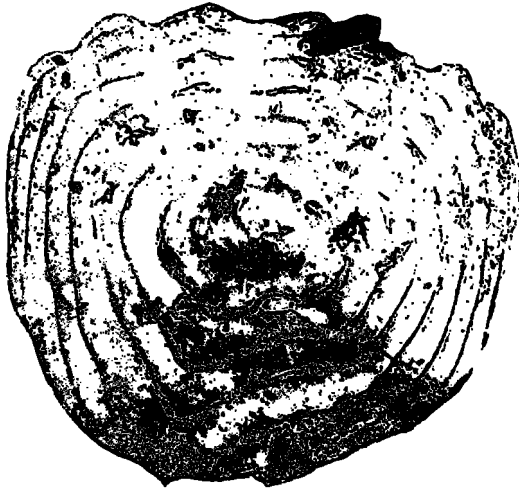


FIGURE 9.—Scale showing only eight wide-spaced circuli, no annuli, from a fish 50 mm. in length captured in the Mount Desert-Matinicus area, October 1944.

to show the first annular ring in April of the following year, they must grow longer than 20 mm. by the fall of the year in which they are born so that a series of wide-spaced circuli can be formed. Information on the growth of larval rosefish on the Gulf of Maine or Nova Scotian fishing grounds is not available but is indicated by data obtained from Newfoundland grounds. During cruises of the research vessel *Cape Agulhas* in Newfoundland waters in the spring and summer of 1932 to 1935, a large series of rosefish larvae were taken, chiefly by

plankton nets.⁵ The lengths of these larvae are summarized by months and years of collection in table 5.

An examination of these data shows that for all years combined the mode of the length frequency was 7 mm. in May, 8 mm. in June, 9 mm. in July and August, and 10 mm. in September, indicating

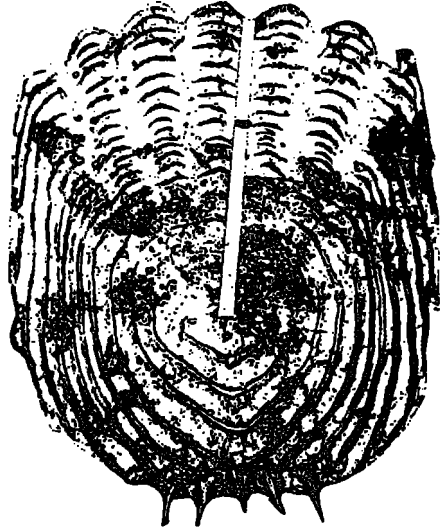


FIGURE 10.—Scale showing one annulus and initial formation of the wide-spaced circuli band of the second year band. From 59-mm. male captured in the Monhegan-Jeffreys-Platts area, April 1946.

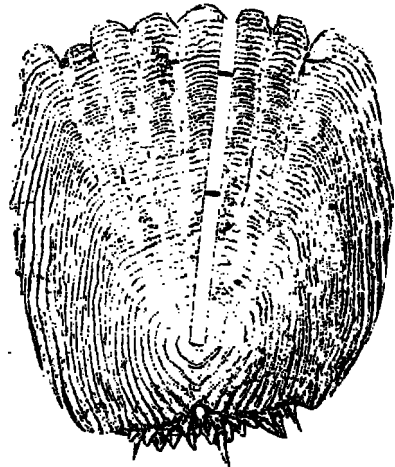


FIGURE 11.—Scale showing two annuli and initial formation of the wide-spaced circuli band of the third year band. From a female 102 mm. long, captured in the Monhegan-Jeffreys-Platts area, June 1946.

⁵The general area of capture for these fish is shown in a paper by Frost (1938). A copy of the original length data was made available by the Newfoundland Department of Natural Resources through the courtesy of the director Dr. Wilfred Templeman.

extremely slow growth. In May at the beginning of the birth period, two fish, 20 and 21 mm. in length, were also taken. According to the growth data, these fish could not have reached so large a size if they had been born in April or May of the year in which they were captured. They must have been born in the previous year because fish of this size do not have scales.

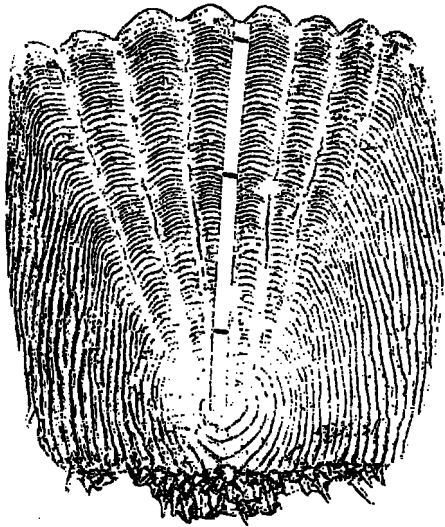


FIGURE 12.—Scale showing three annuli. From a male, 122 mm. long, captured east of Gloucester-Highlands area, March 1946.

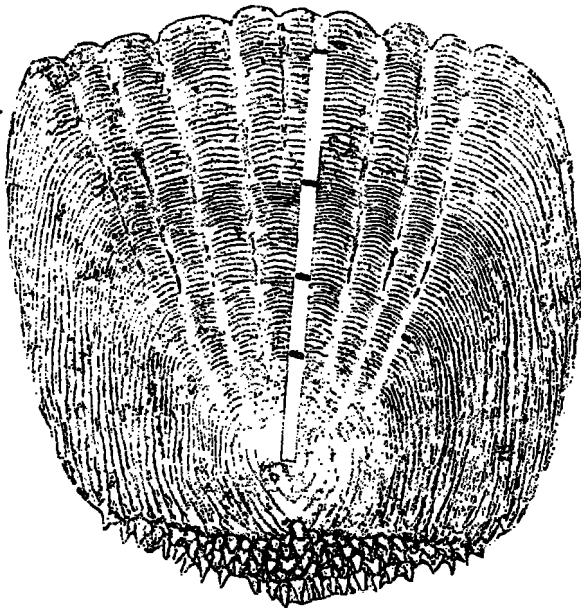


FIGURE 13.—Scale showing four annuli. From a female, 144 mm. long, captured in the Monhegan-Jeffreys-Platts area, April 1946.

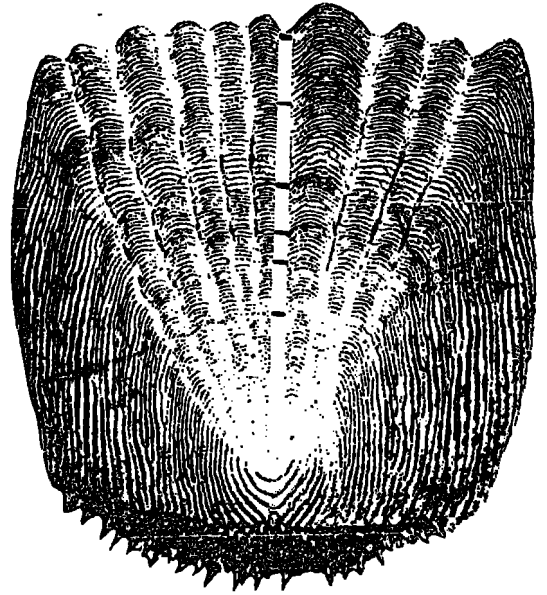


FIGURE 14.—Scale showing six annuli. From a male, 159 mm. long, captured in the Browns Bank area, May 1946.

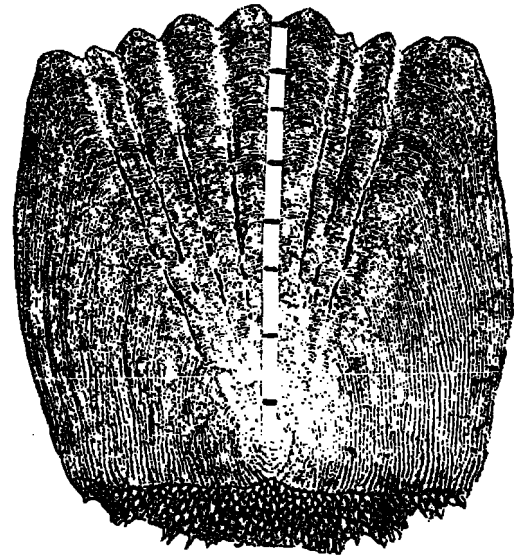


FIGURE 15.—Scale showing eight annuli. From a male, 234 mm. long, captured in the Monhegan-Jeffreys-Platts area, April 1946.

Rosefish, 37 to 55 mm. in total length, obtained in the Gulf of Maine in October of 1944⁶ and 1946⁷ show scales having a band of wide-spaced circuli and a few narrow-spaced circuli. The scales must have formed when the fish were more than 20 mm. and less than 37 mm. in length and, apparently, during the year in which the fish were captured. On the

⁶ Five fish, 50-55 mm. long, taken in the Mount Desert-Matinicus area.

⁷ Six fish, 37-51 mm. long, taken in the Cigar Ridge-Cashes area.

TABLE 5.—Lengths of larval rosefish taken in Newfoundland waters¹

Larva length in millimeters	May		June				July			August					September				All years				
	1932	1932	1933	1934	1935	1933	1934	1935	1931	1932	1933	1934	1935	1931	1932	1933	1935	May	June	July	August	September	
	5	1	1						1	16									1	1	1	17	1
6	7		11	1			1	1	7									7	12	2	2		
7	23	3	28	21	2	1	15	5	33					1				23	54	21	33	2	
8	5		75	34	23	16	20	4	27	2				1				5	132	40	30	2	
9			20	16	3	24	6	12	53	1	3		2		1				39	42	59	2	
10				5		4	1	6	41	1	2		3	1	2				5	11	47	3	
11	1	1	1	1					10	1	1		1		1			1	2		12	1	
12	1	1	1	1					1	1	2		1		1				1	3	1		
13				1								2								1	3		
14									1				1								1		
15												1	1								2		
16									1												1		
17																							
18																							
19																					1		
20																		1					
21	1																						
22	1																						
23																							
24																							
25																							
26																		1				1	
27																							
28																							
29																							
30																							
31																							
32																							
33																							
34																							
35																							
36																							
37																						1	
Total	40	6	135	80	28	45	43	29	185	5	6	4	7	4	4	2	3	40	249	117	207	13	

¹ These fish were caught by the research vessel *Cape Agulhas*. The general area of capture is shown in a paper by Frost (1938).

basis of the foregoing information, these fish must have been born in 1943 and 1945, respectively. The scales began to form in 1944 and 1946, respectively, and by March 1945 and 1947, respectively, would show the first annular ring. Therefore, in the present age and growth study, the calendar year of birth of a rosefish is obtained by adding one additional year to the total number of annuli shown on the scale.

METHODS OF ANALYSIS

Two procedures were followed in estimating the lengths of rosefish at past ages from the spacing of the annuli. In both, a straight line was fitted to the logarithmic values for fish lengths plotted against scale radius. In the first use of this line the constant term in the logarithmic equation was employed in deriving the following formula by means of which lengths were computed directly from scale measurements.

$$L_n = C + \frac{S_n}{S} (L - C)$$

C —is the intercept value at the X axis of a straight line fitting the data.

L —the log of the length of the fish when caught.

L_n —the log of the computed length of the fish at the end of any year.

S —the log of the anterior scale radius of the fish when caught.

S_n —the log of the anterior scale radius to any annulus.

The second method follows the procedure used by Hile (1941) in the study of the age and growth of the rock bass (*Ambloplites rupestris*). Essentially, it involves the solution of the logarithmic equation to build up a table of theoretical scale lengths at different body lengths. Before the measurements for a particular scale can be used for reading the calculated length from the table, each must be adjusted according to the ratio of the theoretical to the actual scale size.

On theoretical grounds the two procedures can give identical results only if before application of the formula (first procedure) the scale measurements are adjusted to the theoretical values in the same manner as that followed by Hile. It is easy to demonstrate that strictly accurate results are obtained from

TABLE 6.—Comparison of average calculated fish-length values, in millimeters, at each annulus

[Material collected in Monhegan-Jeffreys-Platts area, October-December 1942]

Calculated from fish born in—	Annulus																Number of fish		
	1		2		3		4		5		6		7		8			9	
	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²		A ¹	B ²
1932.....	47	47	70	70	98	98	111	112	132	132	149	149	167	166	191	191	204	203	2
1933.....	49	49	72	72	89	88	120	120	144	144	166	166	184	184	200	199	204	203	2
1934.....	44	44	73	72	95	95	119	118	139	139	157	157	175	175	.....	.....	.....	.....	9
1935.....	50	50	74	74	97	97	118	118	137	136	158	158	.....	.....	.....	.....	.....	.....	19
1936.....	46	46	79	79	107	107	131	131	154	154	.....	.....	.....	.....	.....	.....	.....	.....	9
1937.....	51	51	78	78	111	111	131	131	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12
1938.....	50	50	73	73	105	104	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11
1939.....	50	50	91	91	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5
1940.....	57	57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Weighted mean.....	49	49	76	76	102	102	123	123	141	141	158	158	175	175	196	193	204	203	.....
Number of fish.....	70		69		64		53		41		32		13		4		2		.....

¹ Method 1.—Calculations were based on a straight line fitted to the logarithmic values for fish lengths and scale radii obtained from material collected from October-December 1942 in the Monhegan-Jeffreys-Platts area; collections 2-5, 71 fish. Scales for 1 fish could not be read because no good scales were on the slide.

² Method 2.—Calculations were based on a curve fitted to the arithmetical values for fish lengths and scale radii for the same material analyzed by method 1.

TABLE 7.—Comparison of average calculated fish-length values, in millimeters, at each annulus

[Material collected in Mount Desert-Matinicus area, July-September 1943]

Calculated from fish born in—	Annulus														Number of fish				
	1		2		3		4		5		6		7						
	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²					
1935.....	50	49	60	60	94	93	116	116	131	131	145	145	159	159	.....	.....	.....	.....	1
1936.....	53	54	74	74	90	90	104	104	129	129	144	144	.....	.....	.....	.....	.....	.....	5
1937.....	55	54	76	76	97	96	113	113	133	133	.....	.....	.....	.....	.....	.....	.....	.....	9
1938.....	54	54	73	73	92	92	110	110	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23
1939.....	58	58	77	77	96	96	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14
1940.....	60	60	78	79	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25
1941.....	67	67	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4
Weighted mean.....	57	57	76	76	94	94	110	110	132	132	144	144	159	159	.....	.....	.....	.....	.....
Number of fish.....	81		77		52		38		15		6		1		.....	.....	.....	.....	.....

¹ Method 1.—Calculations were based on a straight line fitted to the logarithmic values for fish lengths and scale radii obtained from material collected from July-September 1943 in the Mount Desert-Matinicus area (collections 13, 14, 16, 17, 18; 84 fish). 3 fish could not be read because no good scales were on the slide.

² Method 2.—Calculations were based on a curve fitted to the arithmetical values for fish lengths and scale radii for the same material analyzed by method 1.

the formula only when the scale measured is of exactly the theoretical length. That the errors arising from deviations of the measured scales from the theoretical values have no important effect on the averages of calculated lengths for groups of fish is demonstrated, however, by the extremely close agreement between the results obtained independently by the two procedures (tables 6 and 7). The discrepancies were few and always no more than a millimeter. For practical purposes either procedure can be followed. The second is preferable, not only because it is easier to follow, but also because it gives accurate calculations for individual fish as well as for group averages.

VARIATIONS IN THE FISH LENGTH-SCALE RADIUS RELATIONSHIP

Since both methods of calculating from scales the size at a previous age employ the fish length-scale radius relationship, variations in this relationship from season to season or from one biological area to another would result in different values for estimated lengths. A comparison of the slope of the lines describing the fish-length and scale-length relationship at different seasons in various areas was attempted but discontinued because of the small amount of data available for many of these seasonal-area units. Instead, a more general approach was employed.

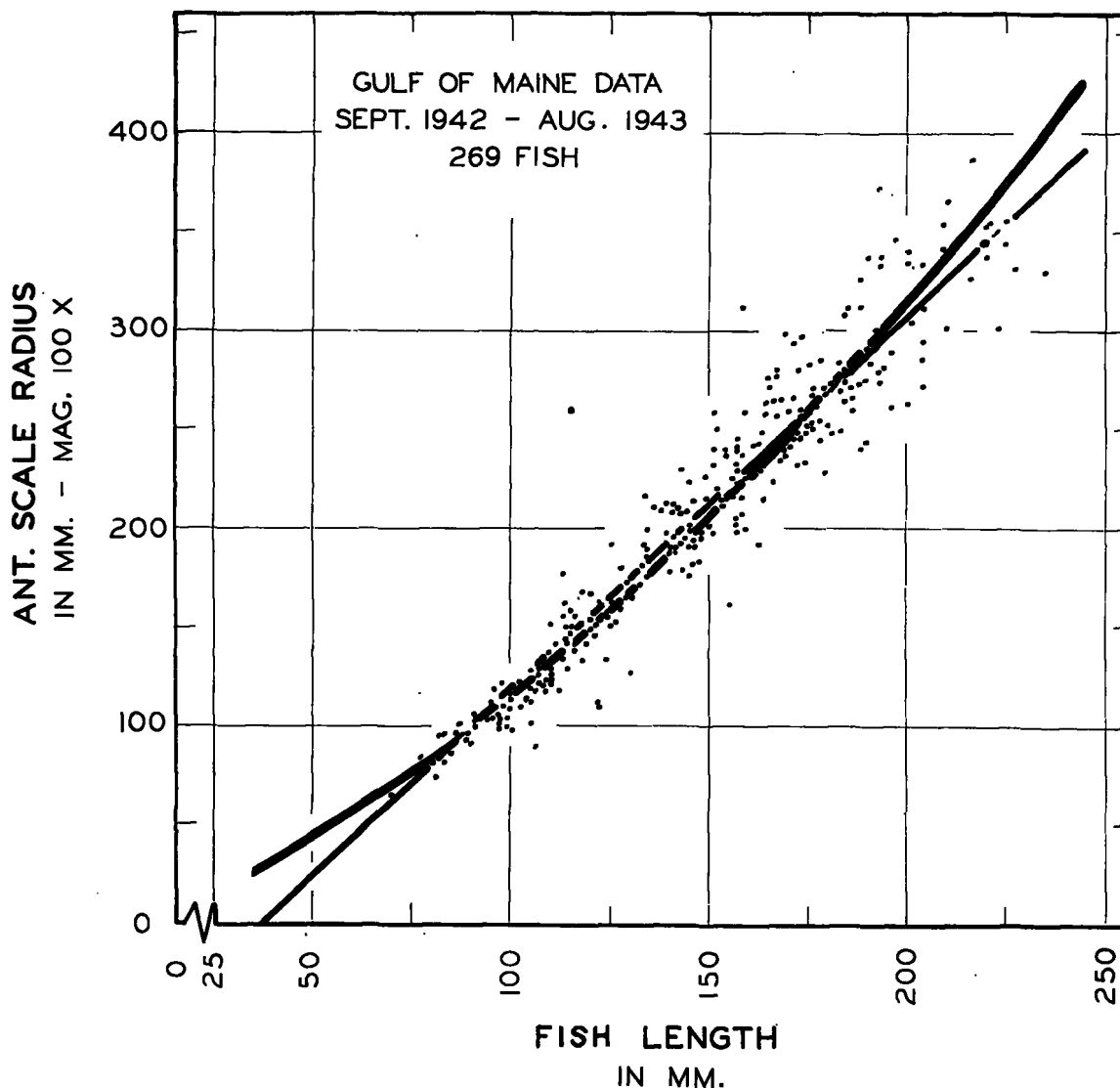


FIGURE 16.—Relationship in arithmetical terms of the anterior scale radius to the length of rosefish for 269 fish 235 mm. or less, taken in the Gulf of Maine from September 1942 through August 1943. Both the straight line and curve were calculated to fit the data. The formula for the straight line is $y = -68.84 + 1.88x$.

Examination of the individual collections made in the Gulf of Maine from September 1942 through December 1944 shows three series of collections containing a relatively large number of fish which fall into one biological area during a single calendar quarter; namely, a series in the Mount Desert-Matinicus area from October through December 1942,⁸ in the same area from July through September 1943,⁹ and in the Monhegan-Jeffreys-Platts area from

October through December 1942.¹⁰ The estimated length at each age was calculated independently for each of the three sets of data. The resulting values were then combined and the average calculated lengths at each age obtained (table 8, column A).

At the same time, the fish length-scale radius relationship was determined for all material collected in the Gulf of Maine from September 1942 through August 1943.¹¹ On the basis of this rela-

⁸ Collections 19-24: 72 fish; table 2, fig. 5.

⁹ Collections 13, 14, and 16-18: 84 fish; table 2, fig. 5.

¹⁰ Collections 2-15: 71 fish; table 2, fig. 5.

¹¹ Collections 1-18: 269 fish; figures 16 and 17.

TABLE 8.—Comparison of average calculated fish length values, in millimeters, at each annulus computed from lines fitted separately to length—scale data for various areas at various time intervals and from a single line fitted to length—scale data

[Collections made in the Gulf of Maine from September 1942 through August 1943]

Calculated from fish born in—	Annulus																		
	1		2		3		4		5		6		7		8		9		
	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	A ¹	B ²	
1932.....	47	48	74	79	96	104	118	112	137	133	155	146	172	163	189	186	202	195	195
1933.....	49	52	76	75	98	98	122	120	141	141	163	158	182	174	201	192	218	218	218
1934.....	47	51	75	75	99	96	123	116	144	133	164	151	183	167	190	190	190	190	190
1935.....	49	55	73	77	98	99	119	120	139	137	161	157	159	174	162	162	162	162	162
1936.....	49	50	77	76	103	103	124	123	146	145	144	150	157	157	157	157	157	157	157
1937.....	53	52	78	78	104	104	124	125	133	138	149	149	149	149	149	149	149	149	149
1938.....	52	51	73	75	97	100	110	120	120	120	120	120	120	120	120	120	120	120	120
1939.....	56	52	80	76	96	96	124	124	124	124	124	124	124	124	124	124	124	124	124
1940.....	59	54	75	74	95	95	124	124	124	124	124	124	124	124	124	124	124	124	124
1941.....	67	58	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
1942.....	67	55	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81
Weighted mean.....	52	52	75	76	99	99	120	121	141	139	161	154	180	169	196	189	202	218	218
Number of fish.....	222	308	218	297	186	251	158	203	116	139	89	90	51	38	23	12	10	3	3

¹ Straight lines were fitted independently to logarithmic values for fish lengths and scale radii obtained from material collected in the Mount Desert-Matinicus area from July-September 1943 (collections 13, 14, 16, 17, 18; 84 fish); in the same area from October-December 1942 (collections 19-24; 72 fish); in the Monhegan-Jeffreys-Platts area from October-December 1942 (collections 2-5; 71 fish). No good scales were available for 1 fish in collection 2, for 1 fish in collection 16, and for 2 fish in collection 18. The data collected in each area during each 3-month interval was analyzed by method 1 using the corresponding line.

² A curve was fitted to the values for fish lengths and scale radii obtained from material collected throughout the Gulf of Maine from September 1942 through August 1942 (collections 1-18; 269 fish). Data collected throughout the Gulf of Maine in 1942 (collections 1, 3, 4, 6; 113 fish) in 1943 (collections 10, 11, and 13-18; 131 fish), and in 1944 (collections 25-39; 65 fish) were analyzed by method 2 using this curve.

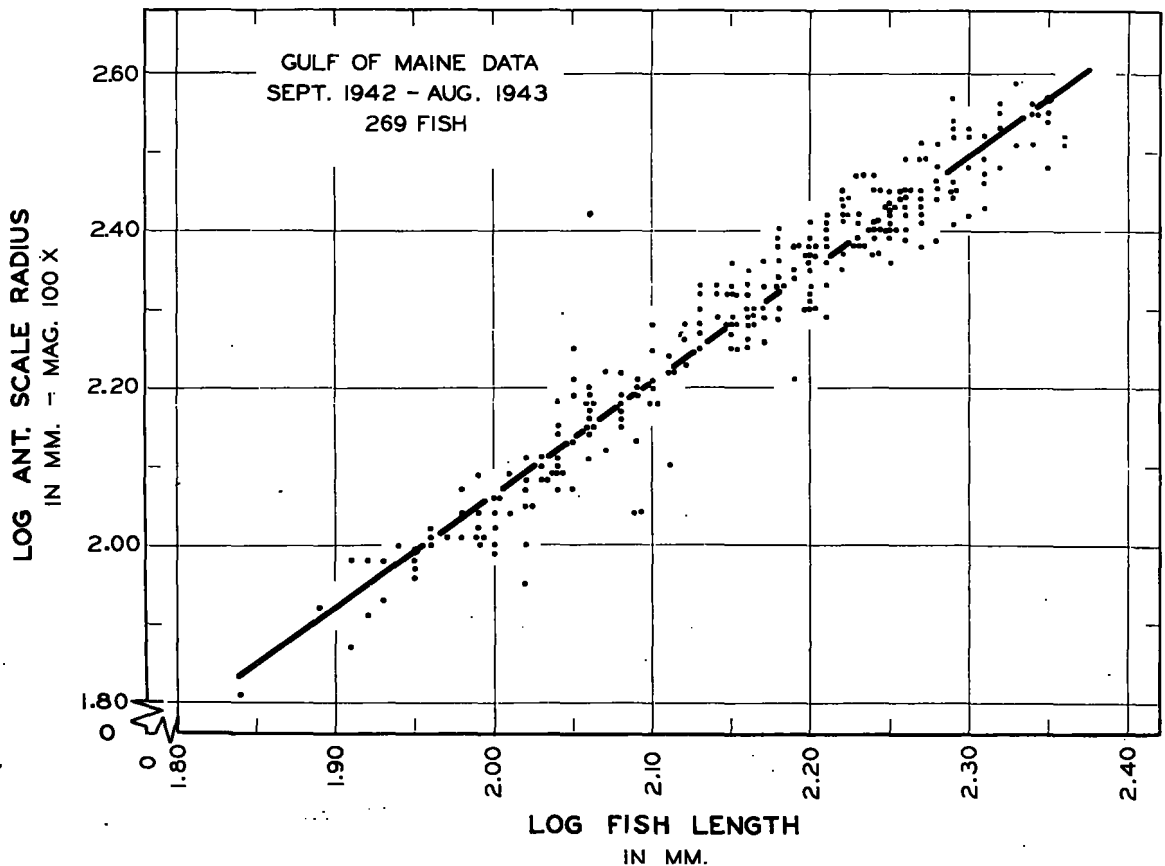


FIGURE 17.—Relationship in logarithmic terms of the anterior scale radius to the length of rosefish for 269 fish 235 mm. or less, taken in the Gulf of Maine from September 1942 through August 1943. The straight line was calculated to fit the data. Its formula is $\log y = -.831 + 1.447 \log x$.

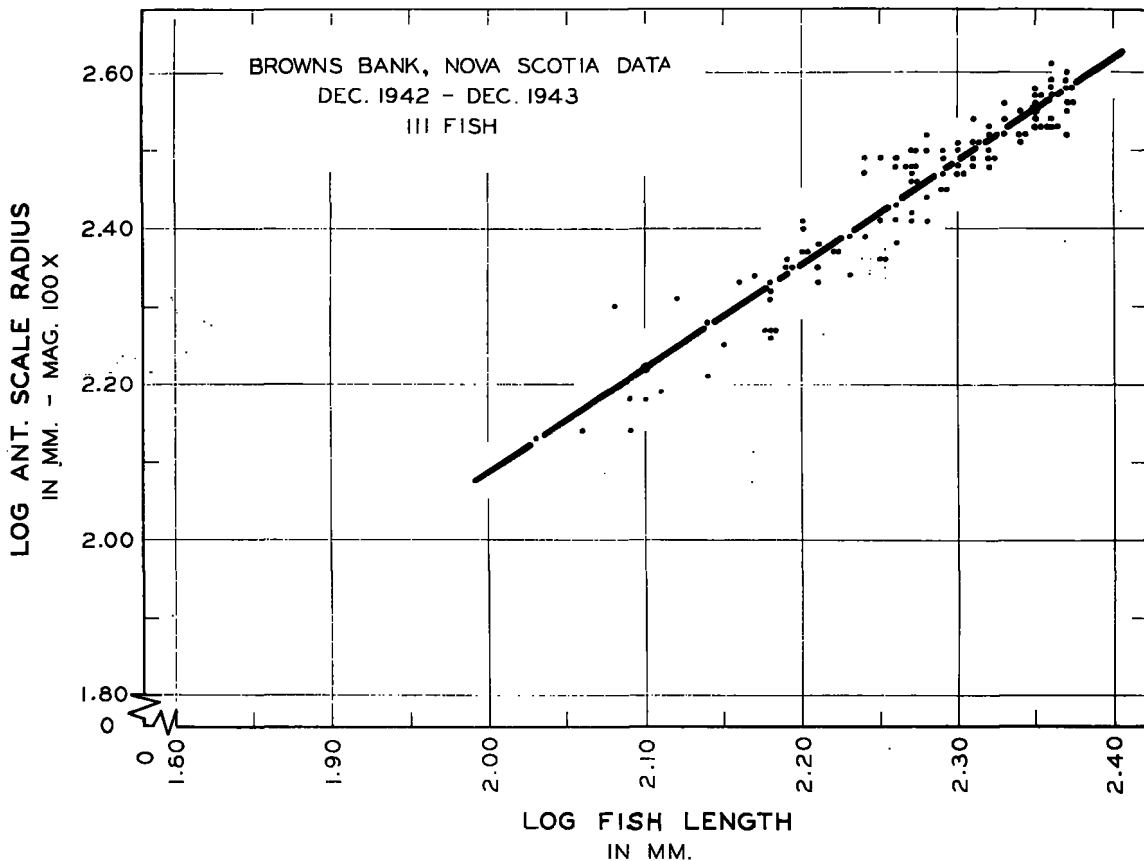


FIGURE 18.—Relationship of the anterior scale radius to the length of rosefish for 111 fish, 235 mm. or less, taken in the Browns Bank area of western Nova Scotia from December 1942 through December 1943. The straight line was calculated to fit the data. Its formula is $\log y = -.596 + 1.340 \log x$.

tionship, the estimated age at each annulus was calculated for data collected throughout the Gulf of Maine in 1942,¹² 1943,¹³ and in 1944.¹⁴ The average calculated lengths obtained are shown in table 8, column B.

The values for average calculated lengths at each annulus obtained from computations based on the individual sets of data and the total data are in close agreement. This would indicate that variation in fish length-scale radius relationship, both seasonal and from one biological area to another, does not greatly affect the accuracy of calculated length values. Therefore, the calculated length values for the combined data were accepted as the best available estimates of rosefish length at a given age. Similarly, the estimated age at each annulus was calculated from the fish length-scale radius relationship for all data collected from December 1942

through December 1943 in the Browns Bank area of western Nova Scotia (fig. 18).

RESULTS

CALCULATED LENGTHS AT EACH ANNULUS

The data collected in 1942, 1943, and 1944 were analyzed separately, and the calculated sizes obtained for the 3 years are summarized in table 9. The estimated average length of the fish at each annulus varies at random among the different year classes but the variation is remarkably small. The weighted mean estimated length at each annulus of all the year classes is as follows: annulus 1, 52 mm.; annulus 2, 76 mm.; annulus 3, 99 mm.; annulus 4, 121 mm.; annulus 5, 139 mm.; annulus 6, 154 mm.; annulus 7, 169 mm.; annulus 8, 189 mm.; and annulus 9, 218 mm. (table 10, fig. 19). The estimated average lengths of the rosefish at each annulus in the Browns Bank area of western Nova Scotia are similar to those obtained in the Gulf of

¹² Collections 1, 3, 4, 6: 113 fish.

¹³ Collections 10, 11, and 13-18: 131 fish.

¹⁴ Collections 25-39: 65 fish.

TABLE 9.—Average calculated fish length, in millimeters, at each annulus¹

[Calculations² based on method²]

Calculated from fish born in—	Annulus								
	1	2	3	4	5	6	7	8	9
1932 ³	48	79	104	112	133	146	163	186	195
1933.....	52	75	98	120	141	158	174	192	218
1934.....	51	75	96	116	133	151	167	190	.....
1935.....	55	77	99	120	137	157	174	162	.....
1936.....	50	76	103	123	145	150	157	.....	.....
1937.....	52	78	104	125	138	149	.....	.....	.....
1938.....	51	75	100	120	143	.....	.....	.....	.....
1939.....	52	76	96	124	.....	.....	.....	.....	.....
1940.....	54	74	95	.....	.....	.....	.....	.....	.....
1941.....	58	81	.....	.....	.....	.....	.....	.....	.....
1942.....	55	.....	.....	.....	.....	.....	.....	.....	.....
Weighted mean.....	52	76	99	121	139	154	169	189	218
Standard deviation.....	7.92	10.53	14.62	17.37	16.89	16.72	19.47	16.51	.....
Number of fish.....	308	297	251	203	139	90	38	12	3

¹ Includes materials collected in the Gulf of Maine in 1942 (collections 1, 3⁴ 4, 6; 113 fish), in 1943 (collections 10, 11, and 13-18; 131 fish), and in 1944 (collections 25-39; 65 fish). Data combined for the years 1942, 1943, and 1944.

² Data collected throughout the Gulf of Maine from September 1942 through August 1943 (collections 1-18; 269 fish) were used in deriving the curve employed in obtaining calculated lengths at each annulus by means of method 2.

³ Only 1 fish was available, and it has not been included in the statistical calculations.

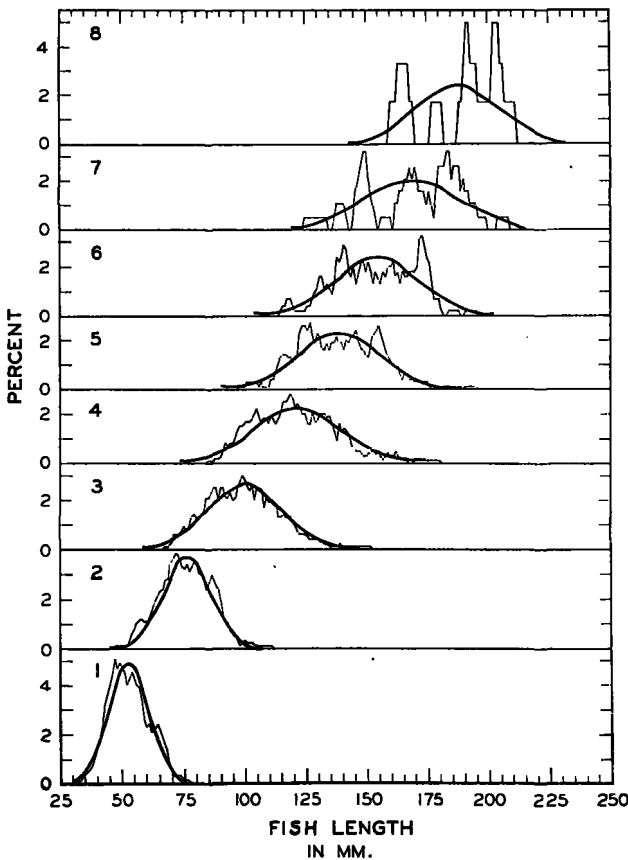


FIGURE 19.—Length-frequency distributions of Gulf of Maine rosefish at each annulus for annuli 1 through 8. Lightly lined irregular curves are the actual frequency distributions smoothed by a moving average of five. Heavily lined smooth curves are normal curves fitted to the actual frequency data.

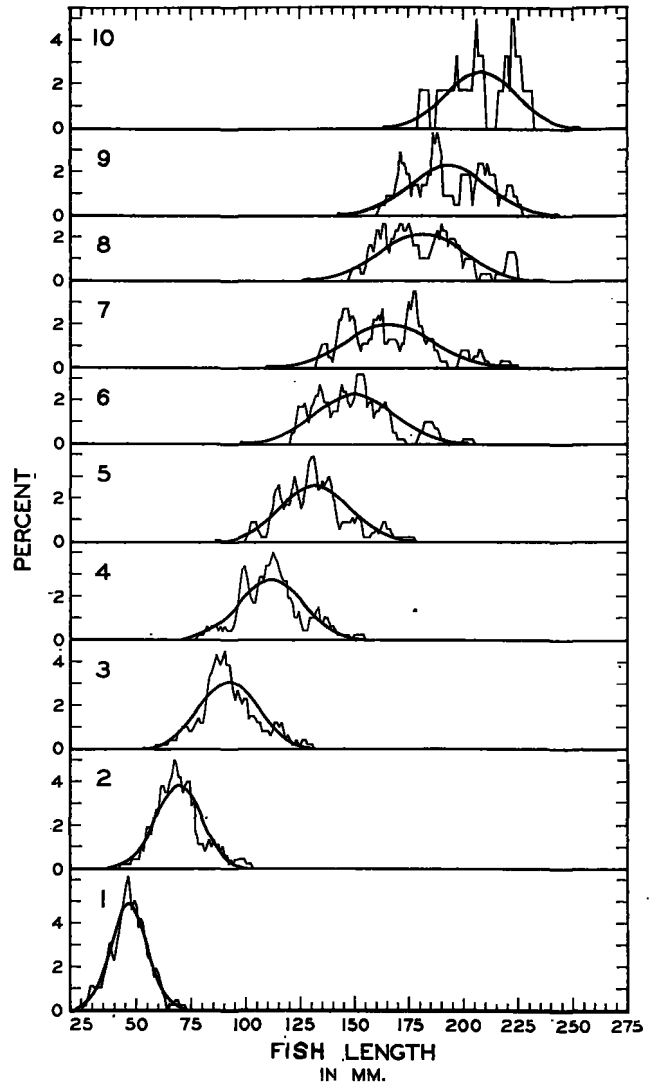


FIGURE 20.—Length-frequency distributions of rosefish from the Browns Bank area of western Nova Scotia for each annulus of annuli 1-10. Lightly drawn irregular curves are the actual frequency distributions smoothed by a moving average of five. Heavily drawn smooth curves are the normal curves fitted to the actual frequency data.

Maine. The size at the first annulus is 47 mm.; annulus 2, 69 mm.; annulus 3, 92 mm.; annulus 4, 112 mm.; annulus 5, 132 mm.; annulus 6, 150 mm.; annulus 7, 167 mm.; annulus 8, 181 mm.; annulus 9, 193 mm.; annulus 10, 208 mm. (table 11, fig. 20).

COMPARISON OF THE ACTUAL AND CALCULATED AVERAGE LENGTH AT ANNULUS 1

The accuracy of the calculated average length of rosefish at annulus 1 is indicated by a comparison with the actual average length of a series of fish

TABLE 10.—*Calculated fish length, in millimeters, at each annulus to the ninth annulus of rosefish taken in the Gulf of Maine*[Calculations¹ based on method 2]

Fish length, in millimeters	Annulus								
	1	2	3	4	5	6	7	8	9
30-34	1								
35-39	10								
40-44	36								
45-49	78	1							
50-54	62	2							
55-59	60	16							
60-64	33	22							
65-69	23	42	1						
70-74	5	56	8						
75-79		46	10						
80-84		45	18						
85-89		41	32	1					
90-94		17	28	8					
95-99		4	32	13					
100-104		3	30	17	2				
105-109		2	30	17	2				
110-114			24	18	3				
115-119			17	25	10	2			
120-124			9	24	10	1			
125-129			5	16	19	2	1		
130-134			4	20	12	7	1		
135-139			1	13	13	6	1		
140-144			1	13	14	12	1		
145-149			1	5	13	8	4		
150-154				4	14	8	3		
155-159				2	13	8	1		
160-164				5	6	7	2	1	
165-169					4	7	4	2	
170-174				1	2	14	3	1	
175-179				1		6	2	1	
180-184					1		5		
185-189						1	5		
190-194					1		3	3	
195-199							1	1	
200-204								3	
205-209							1	1	1
210-214									
215-219									1
220-224									
225-229									
230-234									1
Total number of fish	308	297	251	203	139	90	38	12	3
Mean	52	76	99	121	139	154	169	189	218
Standard deviation	7.9	10.5	14.6	17.4	16.9	16.7	19.5	16.5	

¹ Calculations were based on a curve fitted to the values for fish lengths and scale radii obtained from material collected throughout the Gulf of Maine from September 1942 through August 1943 (collections 1-18; 269 fish). Data collected throughout the Gulf of Maine in 1942 (collections 1, 3, 4, 6; 113 fish); in 1943 (collections 10, 11, and 13-18; 131 fish); and in 1944 (collections 25-39; 65 fish) were analyzed using this curve. 1 fish born in 1932 is not included in the above data.

showing one annulus on their scales. Sixty-one specimens, the total catch of rosefish taken incidentally by a shrimp trawler fishing in the Monhegan-Jeffreys-Platts area in March 1947, ranged in size from 46 to 63 mm. and averaged 56 mm. in length. Scales from 12 of these fish taken at random had 1 annulus, with 2 of the 12 showing initial growth toward the second annulus. The calculated length of rosefish at annulus 1 in the Gulf of Maine has been established as 52 mm. which is in close agreement with the 56-mm. length obtained above.

GROWTH BETWEEN ANNULI

The rate of growth of rosefish from the Gulf of Maine and off the Browns Bank area of western Nova Scotia was computed by averaging the differ-

ences between the calculated lengths of individual fish at each annulus. For the Gulf of Maine data, the growth rate between annuli of individual year classes was determined separately (table 12). The average growth between annuli shows little variation within year classes. The average rate of growth for all year classes to annulus 1 is 52 mm.; between annulus 1 and 2, 24 mm.; 2 and 3, 24 mm.; 3 and 4, 22 mm.; 4 and 5, 19 mm.; 5 and 6, 19 mm.; and between 6 and 7, 7 and 8, 8 and 9, 16 mm. (table 13, fig. 21).

In the Browns Bank area of western Nova Scotia, the average growth to annulus 1 is 47 mm.; between annulus 1 and 2, 22 mm.; annulus 2 and 3, 23 mm.; annulus 3 and 4, 21 mm.; 4 and 5, 20 mm.; 5 and 6, 19 mm.; between 6 and 7, 7 and 8, 8 and 9, 17 mm.; and between 9 and 10, 16 mm. (table 14, fig. 21).

TABLE 11.—*Calculated fish length, in millimeters, at each annulus to the eleventh annulus of rosefish taken in the Browns Bank area of western Nova Scotia*[Calculations ¹ based on method 1]

Fish length, in millimeters	Annulus										
	1	2	3	4	5	6	7	8	9	10	11
25-29	1										
30-34	5										
35-39	13										
40-44	18										
45-49	28	1									
50-54	22	5									
55-59	11	8									
60-64	4	20	1								
65-69	1	36	2								
70-74	1	20	5								
75-79		9	6								
80-84		5	13	3							
85-89		6	21	2							
90-94		1	20	2							
95-99		2	12	12							
100-104		1	8	9	4						
105-109			4	14	1						
110-114			4	19	7						
115-119			4	13	7						
120-124			1	5	14	2					
125-129			2	2	10	8					
130-134				6	15	9					
135-139				5	13	8	4				
140-144				1	4	6	5				
145-149				1	4	8	10				
150-154				1	5	13	4	2			
155-159					1	8	5	5			
160-164					3	7	8	6	1		
165-169					2	4	5	6	2		
170-174					1	1	4	8	5		
175-179					1		13	5	3		
180-184						4	5	3	3		1
185-189						3	3	6	7		
190-194							1	7	2		1
195-199								5	1		2
200-204						1	3	3	4		1
205-209							3		5		2
210-214								1	4		
215-219							1	1	2		1
220-224								4	3		3
225-229											1
230-234											
Total number of fish	104	104	103	95	92	82	74	62	42	12	1
Mean	47	69	92	112	132	150	167	181	193	208	225
Standard deviation	8.2	10.4	12.9	14.1	15.5	17.3	19.5	18.6	17.0	15.0	---

¹ Based on a straight line fitted to the logarithmic values for fish lengths and scale radii obtained from material collected from December 1942 through December 1943 in the Browns Bank area (collections 40-48; 111 fish). 7 fish could not be read because no good scales were available.

TABLE 12.—Average calculated growth, in millimeters, between annuli of rosefish captured in the Gulf of Maine¹

[Calculations² based on method 2]

Growth in year ³	Annulus								
	0-1 ⁴	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
1933 ⁵	48	31	25	8	21	13	17	23	9
1934	52	23	23	22	21	17	16	18	16
1935	51	24	21	20	17	18	16	15	
1936	55	22	22	21	18	20	15	12	
1937	50	26	26	21	22	19	14		
1938	52	26	26	21	20	16			
1939	51	24	25	22	22				
1940	52	24	22	28					
1941	54	21	28						
1942	58	26							
1943	55								
Weighted mean	52	23	24	22	19	19	16	16	16
Standard deviation	7.92	8.91	8.79	7.24	6.01	6.01	4.42	6.78	3
Number of fish used	308	297	251	203	139	90	38	12	

¹ Includes materials collected in 1942 (collections 1, 3, 4, 6: 113 fish); in 1943 (collections 10, 11, and 13-18: 131 fish); and in 1944 (collections 25-39: 65 fish). Data combined for years 1942, 1943, and 1944.

² Data collected throughout the Gulf of Maine from September 1942 through August 1943 (collections 1-18: 269 fish) were used in deriving the curve employed in obtaining calculated lengths at each annulus by means of method 2.

³ Extends from April of the indicated year through March of the following year, as shown by the study of time of annular band formation.

⁴ This includes the size at birth, growth until scale formation, and subsequent growth until the completion of the first annulus. Spawning occurs from mid-May through early September, and scales are formed in the following year. The first annular ring forms in the second year after the birth of the fish.

⁵ Only 1 fish was available, and it has not been included in the statistical calculations.

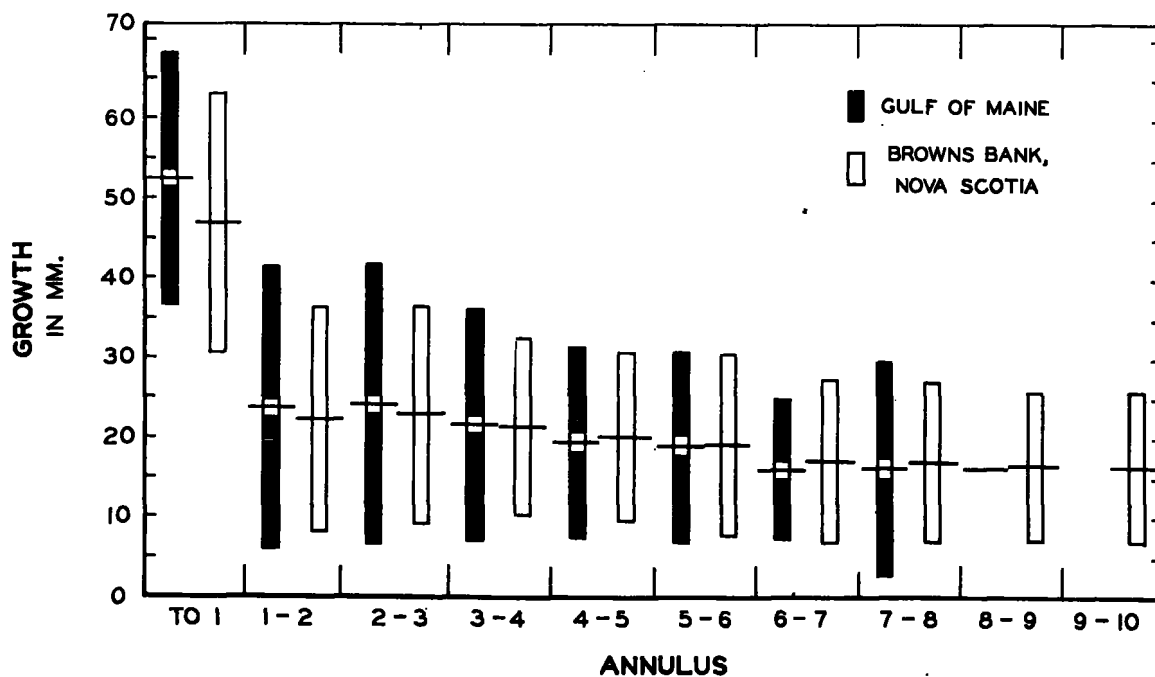


FIGURE 21.—Growth, in millimeters, between annuli of immature rosefish taken in the Gulf of Maine and off the Browns Bank area of western Nova Scotia. The horizontal lines represent the average growth to each annulus and the vertical bars two standard deviations above and below the mean.

TABLE 13.—Calculated growth, in millimeters, per annulus to the ninth annulus of rosefish taken in the Gulf of Maine

[Calculations¹ based on method 2]

Growth to first annulus		Growth between annuli								
Millimeters	Number of fish	Milli-meters	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
			Number of fish							
34	1	5								
35		6		1						
36	3	7			1		3	2		
37	2	8	1	1	2	2	1			
38	2	9	3	1	3	1	2		1	
39	3	10	4	1		3	1	2	2	
40	3	11	9	1	4	6	1			1
41	8	12	12	3	2	6	2	1	1	1
42	8	13	11	9	10	7	4	3	1	
43	7	14	8	10	13	6	5	5	2	
44	10	15	17	9	7	7	9	6		
45	16	16	10	17	10	8	4	6	1	
46	14	17	5	11	13	12	11	2	1	
47	15	18	15	13	13	5	7	2		
48	14	19	9	15	19	10	2	4		
49	19	20	11	8	8	8	5	1		
50	11	21	14	15	13	13	3			
51	16	22	16	15	7	5	7			
52	13	23	14	13	2	8	5	1		
53	10	24	14	7	7	8	2		1	
54	12	25	13	9	6	4	4	1		
55	15	26	9	8	9	5	1	1		1
56	19	27	9	7	11	2	3			
57	11	28	3	2	10	3	1		2	
58	5	29	15	7	3	3	1	1		
59	10	30	7	4	2	1				
60	7	31	11	11	3	1	3			
61	6	32	7	5	4	1				
62	8	33	7	9	2		2			
63	6	34	3	7	6	1				
64	6	35	6	1	4	1				
65	8	36	4	5	2	1				
66	9	37	9	2	3					
67	4	38	2	2	3					
68	1	39	4			1				
69	1	40	5	5	1					
70		41	2	5						
71	2	42	2	2						
72	1	43		4						
73	1	44	1	3						
74	1	45								
75		46	1							
76		47		1						
77		48	2	1						
78		49								
79		50		1						
80		51	1							
81		52								
82		53								
83		54								
84		55	1							
Total number of fish	308		297	251	203	139	90	38	12	3
Mean	52.42		23.72	24.15	21.62	19.40	18.86	16.05	16.25	16.33
Standard deviation	7.92		8.91	8.79	7.24	6.01	6.01	4.42	6.76	

¹ Based on a curve fitted to the values for fish lengths and scale radii obtained from material collected throughout the Gulf of Maine from September 1942 through August 1943 (collections 1-18; 269 fish). Data collected throughout the Gulf of Maine in 1942 (collections 1, 3, 4, 6; 113 fish); in 1943 (collections 10, 11, and 13-18; 131 fish); and in 1944 (collections 25-39; 65 fish) were analyzed using this curve. 1 fish born in 1932 has not been included in the above analysis.

TABLE 14.—Calculated growth, in millimeters, per annulus to the eleventh annulus of rosefish taken in the Browns Bank area of western Nova Scotia

[Calculations¹ based on method 1]

Growth to first annulus		Growth between annuli										
Millimeters	Number of fish	Milli- meters	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11
			Number of fish									
28	1	5	---	---	---	---	---	1	---	---	---	---
29	---	6	---	---	---	---	---	---	---	---	---	---
30	2	7	---	---	---	---	---	1	---	---	1	---
31	3	8	---	---	---	---	1	---	1	---	---	---
32	---	9	1	---	---	1	1	1	---	---	---	---
33	---	10	1	---	---	1	---	5	2	3	---	---
34	2	11	---	2	---	3	2	3	5	3	1	---
35	3	12	3	3	1	2	6	1	5	3	---	---
36	3	13	3	2	4	3	2	5	7	5	1	---
37	3	14	6	3	3	5	6	7	5	5	1	---
38	2	15	4	3	8	5	6	5	4	4	---	---
39	3	16	6	4	5	7	8	3	3	3	1	---
40	5	17	6	9	7	8	8	6	1	2	1	---
41	---	18	4	4	7	4	5	8	3	3	3	---
42	2	19	6	6	6	8	6	6	6	3	1	---
43	5	20	6	7	3	6	4	10	6	4	---	---
44	6	21	7	4	6	5	1	---	---	1	---	---
45	9	22	5	8	5	6	5	3	5	1	---	1
46	3	23	5	6	8	7	5	2	2	2	---	---
47	6	24	3	5	7	2	---	1	3	---	---	---
48	8	25	3	4	2	5	---	1	---	4	1	---
49	2	26	3	4	7	3	2	1	3	---	---	---
50	5	27	6	2	2	---	2	2	---	---	---	---
51	5	28	4	3	3	7	5	---	---	---	---	---
52	5	29	5	4	2	1	5	---	---	---	---	---
53	3	30	2	2	---	4	---	1	---	---	---	---
54	4	31	3	5	3	---	1	---	---	---	---	---
55	4	32	5	4	1	1	---	---	1	---	---	---
56	1	33	---	1	4	---	1	---	---	---	---	---
57	1	34	1	1	---	---	---	---	---	---	---	---
58	2	35	---	1	---	---	---	---	---	---	---	---
59	3	36	---	3	1	---	---	---	---	---	---	---
60	1	37	---	1	---	---	---	---	---	---	---	---
61	3	38	1	---	---	---	---	---	---	---	---	---
62	---	39	---	2	---	---	---	---	---	---	---	---
63	---	40	---	---	---	---	---	---	---	---	---	---
64	---	41	1	---	---	---	---	---	---	---	---	---
65	---	42	1	---	---	---	---	---	---	---	---	---
66	---	43	---	---	---	---	---	---	---	---	---	---
67	1	44	---	---	---	---	---	---	---	---	---	---
68	---	45	1	---	---	---	---	---	---	---	---	---
69	---	---	---	---	---	---	---	---	---	---	---	---
70	1	---	---	---	---	---	---	---	---	---	---	---
Total number of fish	104	---	104	103	95	92	82	74	62	42	12	1
Mean	46.91	---	22.26	22.89	21.41	20.13	19.07	17.11	17.02	16.52	16.42	22.00
Standard deviation	8.15	---	7.06	6.80	5.62	5.33	5.75	5.15	5.05	4.69	4.72	---

¹ Based on a straight line fitted to the logarithmic values for fish lengths and scale radii obtained from material collected from December 1942 through December 1943 (collections 40-48; 111 fish). The scales from 7 fish could not be read because no good scales were available.

CONCLUSIONS

Compared with other North Atlantic species of commercial importance such as haddock, cod, and mackerel, the rosefish is extremely slow growing, averaging less than a 25-mm. increase in length per annulus to the ninth annulus in both the Gulf of Maine and off the Browns Bank area of western Nova Scotia. Since these results were obtained for primarily immature fish, it is to be expected that the

mature fish will have a slower rate of growth. Marketable rosefish, those 200 mm. in length or greater, are mostly more than 10 years of age, and a superficial examination of the scales of the larger fish indicate that many must be 20 or more years old. A comparable slow rate of growth is reported for rosefish in the Barents Sea. Veschezerov (1941) presents data which show an average growth of 27.8 mm. per annulus to the ninth annulus for fish in that region.

LITERATURE CITED

- BIGELOW, HENRY B., and WILLIAM W. WELSH.
1925. Fishes of the Gulf of Maine. Bulletin, Bureau of Fisheries, U. S. Dept. Commerce, Vol. XL (1924), Pt. 1: 567. Washington.
- FROST, NANCY.
1938. Some fishes of Newfoundland waters (with notes on the distribution of eggs and larvae). Newfoundland Department of Natural Resources, Res. Bull. No. 4: 16.
- GRAHAM, MICHAEL.
1929. Studies of age-determination in fish. Part II. A survey of the literature. Ministry of Agriculture and Fisheries, Fishery Investigations, Series II, Vol. XI, No. 3: 50.
- HILE, RALPH.
1941. Age and growth of the rock bass, *Ambloplites rupestris* (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wisconsin Academy of Sciences, Arts and Letters, Vol. 33: 189-337.
- VAN OOSTEN, JOHN.
1929. Life history of the lake herring (*Leucichthys artedii* Le Sueur) of Lake Huron as revealed by its scales, with a critique of the scale method. Bulletin, Bureau of Fisheries, U. S. Dept. Commerce, Vol. XLIV (1928): 265-428. Washington.
- VAN OOSTEN, JOHN, H. J. DEASON, and FRANK W. JOBS.
1934. A microprojection machine designed for the study of fish scales. Journal du Conseil, Vol. IX, No. 2: 241-248.
- VESCHEZEROV, V. V.
1944. Materials on the biology and fisheries of marine perch in the Barents Sea [in Russian]. The Knipovich Polar Scientific Institute of Sea-Fisheries and Oceanography, No. 8: 236-270.

