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FISH & GAME DEPARTMENT

Fisheries Division

AGE AND GROWTH CHARACTERISTICS OF
LAKE PEND OREILLE KOKANEE, 1957

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AGE AND GROWTH CHARACTERISTICS OF LAKE PEND OREILLE KOKANEE, 1957

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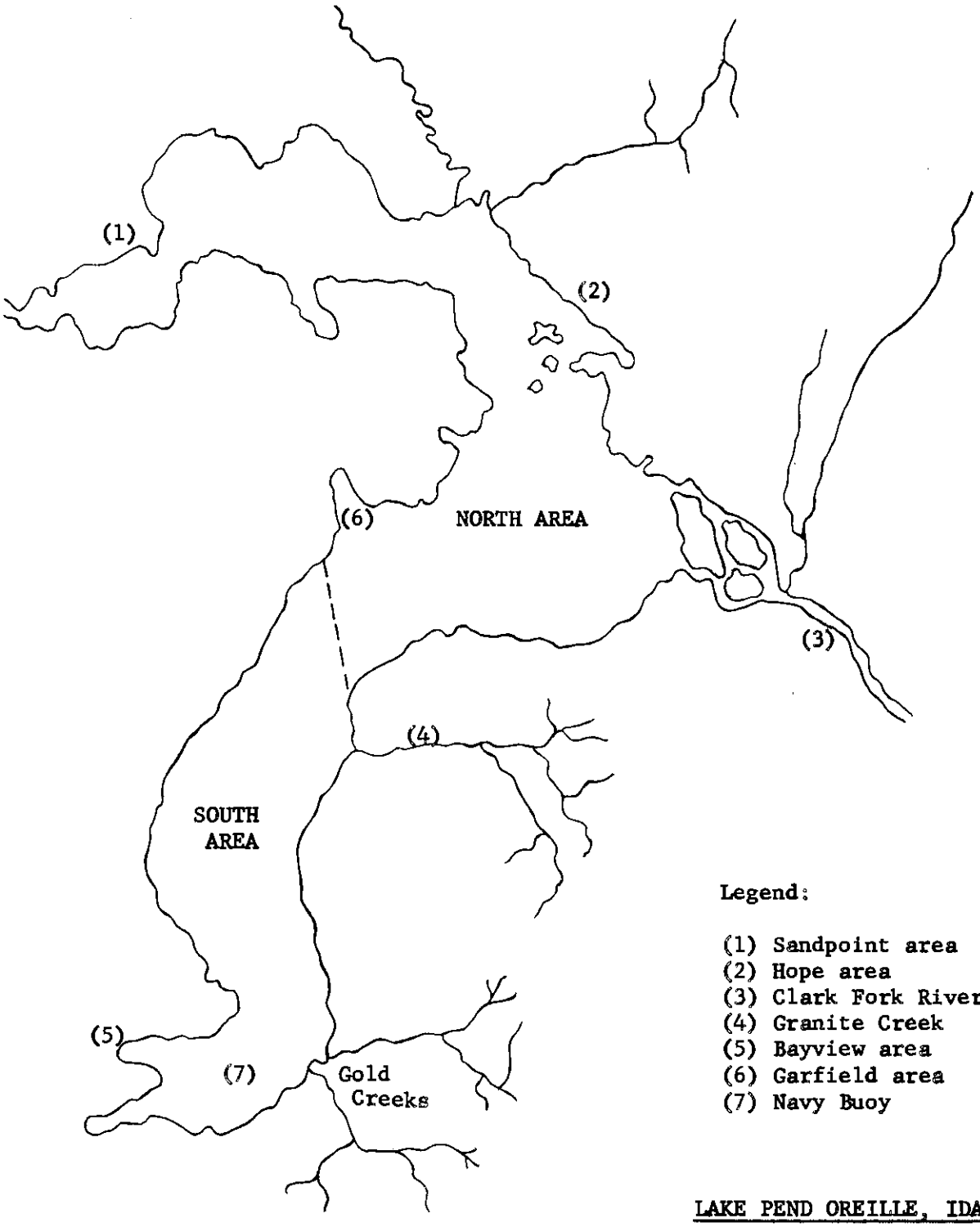

Legend:

(1) Sandpoint area
(2) Hope area
(3) Clark Fork River
(4) Granite Creek
(5) Bayview area
(6) Garfield area
(7) Navy Buoy

LAKE PEND OREILLE, IDAHO

Scale: ¼ inch = 1 mile

AGE AND GROWTH CHARACTERISTICS OF LAKE PEND OREILLE KOKANEE, 1957

OBJECTIVES

The objectives of this study are set forth in some detail in the 1956 age and growth report (Whitt, 1958) to *which* this report is a sequel. Briefly, however, the study is an attempt to determine the age-class composition of Lake Pend Oreille kokanee in the catch and on the spawning grounds. There is some indication that the life cycle of these fish fluctuates in duration with different years. If this is indeed the case, it is believed that this series of investigations will establish whether or not these fluctuations can be expected to follow any predetermined pattern.

Initially, the aging study was undertaken to aid in the analysis of creel census data obtained during the past six years (State of Idaho Department of Fish and Game, Project F 3-R). However, any information pertaining to the life cycle of Lake Pend Oreille kokanee would be of value for future management planning.

The collection and study of kokanee fry was undertaken to contribute to the general fund of information about this species. The size of kokanee fry at time of initial scale formation was considered to be of value if subsequent back calculations of growth were to be made from scale data.

TECHNIQUES USED

Collection of kokanee fry for study of growth, scale formation, and stomach contents.

During 1957 an effort was made to collect young kokanee which had hatched during the spring of that year. These fry, as well as fish in their second year of life, did not appear in the creels which were the chief source for samples of older fish.

The June collection was taken in downstream traps placed near the mouth of Granite Creek. This sample was made just prior to the end of the migration of fry from this stream to the lake. Consequently, it is probable that only the late-hatching fish are represented in the June sample.

Samples for July and succeeding months were taken at various areas in the south end of the lake by means of a tow net (Whitt, 1958a).

In an effort to determine time and extent of scale formation without expending the time required to examine the entire collection, the author conducted a cursory examination until a sample was found which contained fish both with and without scales. A more complete examination was then made of samples collected immediately before and after. The presence of

scales was determined by microscopic inspection of skin scrapings. This method was open to two sources of error. First, scales actually present could have been missed because they were few in number. Second, very small scale platelets may actually have been collected but not observed due to their extreme transparency. In this latter instance the error imparted to back calculated lengths taken from scale measurements would be slight be-cause of the difficulty which already exists in determining the exact focus of a larger scale.

Aging of kokanee (obtained from creel samples and spawning ground.)

During 1957, scale samples were obtained from the random sampling of creels. Basically this was carried out in the same manner as with the 1956 collection. Data collected along with the scales included date and location of catch, and total length of the specimen in every case. Additional data not recorded in every case included sex, maturity, weight, and general in-formation such as depth of catch. Prior to the closure of the commercial fishing season on May 31, 1957, samples were recorded as either sport or commercial catches and the type of tackle used, usually hand lines, was noted. After June 1, 1957, all catches were made on trolling gear and no notation was made of the tackle used.

The size of monthly scale collections was determined by the catch, with a total of one percent of the number checked in the creel census being used for age determination. Altogether, 1,331 fish were aged for 1957, with monthly samples ranging in size from 35 to 317 (Table 4).

Prior to June, 1957, collections were made by Messrs. White and Whitt with some recording of data made by members of the creel-census crew. From June to September, 1957, collections were made by the author with assistance in recording of the data by creel-census clerks and others who were kind enough to facilitate the author's work in this manner. The October, 1957 sample was collected by Mr. Whitt, the project leader. The spawning-ground samples for November and December, 1957 were taken by Mr. and Mrs. Frank Miller who conducted the fish counts on Granite Creek. All actual measurements or determinations were made by the author or those persons mentioned by name above.

Scales collected during the first months of 1957 were taken from that area of the fish between the dorsal fin and the lateral line. Scales collected by the author were taken from below the lateral line as suggested by the project leader. Scales collected from spawning runs were all from female fish and were taken in general from high on the dorsal surface where scale absorption was least pronounced. It was noted that, prior to the spawning season, scales taken from below the lateral line were larger and possibly easier to age, and this phenomenon occasioned the change in collection techniques starting in June, 1957. This change, however, has raised a possibility for error if disparity exists between ages as deduced from scales from these two body areas. Apparently there is little difference except in the average size of the scales, especially for the first year of life. However, disparity has been shown to exist for some species of fish, and it

has been suggested that comparison be made of kokanee scales taken from the ban body areas. No such analysis is undertaken in this report.

Discussion of age determination from scale readings. Four scales were selected for each specimen for uniformity and absence of apparent regeneration. These scales were cleaned and permanently mounted in a glycerin-gelatin medium. Readings were made by the author with the Eberbach scale projector provided by the Cooperative Wildlife Research Unit at the University of Idaho. This projector gave a magnification of 81 diameters on a glass screen (see photo-graphs in Appendix).

As in the case of other investigators attempting to age Lake Pend Oreille kokanee from scale readings, the author encountered some complicating factors inherent within the scales. The following will explain how these difficulties were resolved and present the criteria upon which final decisions were based. These observations may be of use to future investigators, if for no other reason than to evaluate the author's interpretation of kokanee scales.

There are four general conditions which tend to produce an element of doubt:

(1) Annuli are often somewhat indistinct and may be represented by little more than a single broken line lying between two wide circuli.

(2) As the fish become older, annual growth of the scales diminishes and a year's development may be represented by only a few circuli. This condition may be further affected by absorption or erosion of the scale in the marginal area prior to annulus formation. This results in the loss of a part of the scale development for the previous year.

(3) The presence of false annuli, especially during the second year of life, tends to favor over-aging of the fish.

(4) The time of annulus formation is of importance as samples taken prior to this time must be aged a year older than the apparent age as determined from the number of annuli present.

Indistinct annuli. Here the solution depended primarily upon close examination of the scales in question. Usually these annuli, although in-distinct at first inspection, could be found to extend continuously around the entire non-exposed portion of the scale. In this way true annuli could often be distinguished from irregular growth checks. However, in some instances the occurrence of two or more comparable growth checks in very close proximity made it difficult to pick out the exact position of the annulus, although there was little doubt that a single annulus was actually located in that general area.

Narrow year's growth. As with the indistinct annuli discussed above, this difficulty could only be resolved by close inspection and objective

comparison with the more clearly defined scales. This problem, moreover, was not so pronounced in 1957 as it was in 1956. A majority of the 1957 scales were patently from fish of a younger age class than those represented in the 1956 sample and were less apt to exhibit years of confusingly narrow growth in proximity to the margin.

False annuli. It was felt that this problem could be tackled in a some-what more concrete manner. The false annuli tended to show in approximately the same area for any given *year* of growth. This position was from one-half to two-thirds of the way through the annual growth increment. On the other hand, these false annuli displayed a markedly variable degree of clarity. They ranged from being practically absent to being as clear and definite as any check on the scale. It was those false annuli of medium clarity which, coupled with reports of false annuli received from prior investigators, led the author to conduct a more thorough study of this phenomenon. The formation of a false annulus was most pronounced during the second year of life.

Back-calculated lengths for the fish as derived from the scales would in all probability have indicated if these questionable annuli were true or false. This, however, would have necessitated the establishment of a body-scale relationship based only upon the older age classes, which alone were available for sampling. It was decided to work directly with the scales themselves, as in any event they would have been the major influencing factor in any back calculations.

A proportional-growth approach was discarded and absolute measurements applied for several reasons. The increment of growth for any given year could not be utilized when expressed as a proportion of the overall size of the scale because it was necessary to examine several age classes simultaneously. The very presence of the false annuli made it impossible to separate the fish into age classes. However, it was possible to separate the scales into "types" based upon growth patterns. The first growing season, although seldom in doubt, was not acceptable as a standard on which to gauge growth in subsequent years because of the great variability in scale development evident for that first year. Positive factors influencing the use of absolute measurements were the uniformity of the scales and the shorter amount of time consumed in calculations. While the overall size of the scales varied over a marked range for fish of any given length, it was found that this difference was not as great as first supposed. The variations apparently were uniformly distributed as the averaged sizes of several small samples were for all practical purposes identical.

The September, 1957 collection was chosen for analysis. It could be assumed that the annulus for 1957 had been laid down by this time and a large part of the year's growth completed. Also, the sample was the largest (317 scales) collected for any month of 1957, and it was felt that significant results could be obtained from it. More than one-third of the September sample was held in some measure of doubt due to false annuli occurring during the second year of life. In addition, this same type of check showed to a lesser degree in other years.

Measurements were made to all true annuli, the false annuli of the second year, if present, and the margins. All potential age class III

(three annuli) fish were so treated. The false annuli of the second year were pronounced in very few of the age class II fish, and measurements of only the two true annuli were recorded in this case. Some corroborating work was done with the small sample of false annuli present in both II's and IV's, but the results were not recorded. The position of the fourth annulus is recorded for the IV's which comprised a very small portion of the total sample. The aver-aged distances from the foci of the scales to the checks in question are re-corded in Table 1.

Inspection of Table 1 would indicate that all scale types listed as III's are, in actuality, from fish of the same age class. The false annuli recorded in two of the types are comparable, although differing greatly in degree of clarity. The II's and IV's, although representing fish hatched during different years, correlate with the III's insofar as the investigation was carried' out.

The false annuli were distinguishable by structural differences which set them apart from the true annuli and/or by their position between the true annuli. If these false annuli were assumed to be true annuli, the apparent year's growth following those checks would be of far less magnitude than that of the next following year. Since it was generally observed that Lake Pend Oreille kokanee scale growth following the second year becomes progressively less for each succeeding year, the above phenomenon was deemed to be cause for suspicion of the presence of a false annulus.

The position of the false annuli on the scales indicates that they are formed during the general growing season. This may account for the presence of marginal growth checks on some September scales. The growth of non-spawning fish has not been traced farther than the first week of October.

Time of annulus formation. The period during which annulus formation takes place was never determined to the complete satisfaction of the author. Since, as has already been mentioned, the approximate date of this occurrence must be determined if fish taken prior to that time are to be accurately aged, the author feels that the results recorded later in this report should be subjected to any re-analysis which may be indicated by future findings.

As shown by the rapid growth on the scales of first-year fish as late as the end of November, it may be concluded that an annulus is not laid down within the first year of the life cycle, which begins with the newly spawned egg. It is hoped that a continuation of the collection of juvenile fish during 1958 will determine the exact time of formation of this first annulus.

During 1956, selection was made for juvenile fish appearing in the creels. Thus it was found that scales possessing a single annulus were fairly well represented during the spring of 1956. It was not too difficult to follow these scales through to the formation of a growth check approximately in June. It was on these findings that Messrs. White and Whitt based their assumption of a June annulus. The author has reviewed a representative sample of the 1956 scales and agrees, at least in part, with these conclusions. However, a consecutive pattern of growth was not apparent for the older fish. This was hardly cause for worry in 1956 as several older age classes are present in the collection and the smaller amount of annual scale growth late in life made tracing of scale development almost impossible for these fish.

Table 1. Comparison of averaged absolute lengths in millimeters (x81) from radial measurements of annuli and scale margins of kokanee scales collected during September, 1957, Lake Pend Oreille, Idaho.

Age class (number of true annuli)	Measurements to annual growth checks (annuli) or scale margin					
	First	False	Second	Third	Fourth	Fifth
II	29.4	-	73.3	88.2 (margin)		
III without any indication of false annuli.	31.0	-	74.6	87.8	95.3 (margin)	
III with slight indication of false annuli.	31.0	(57.2)	74.7	88.0	95.2 (margin)	
III with false annuli comparable to the true annuli.	31.1	57.3	72.2	88.6	not recorded (margin)	
IV with false annuli comparable to the true annuli.	not recorded	present but not recorded	not recorded	not recorded	95.1	not recorded (margin)

In 1957, sampling of the creels was random without any selection for juveniles. Consequently, scales possessing only one annulus were almost entirely absent from the collection. This made it impossible for the author to trace the formation of the second annulus for the three-year-old fish. When these three-year olds first appeared significantly in the catch, they had al-ready formed the second annulus.

Again in 1957, as in 1956, it was impossible to trace the annulus development of the older fish. Moreover, in this case only two- and three-annuli scales were present in any numbers throughout the year. It was reasonable to suppose that the three-annuli scales when found early in the spring would subsequently lay down another annulus about the same time as the younger fish and would, therefore, belong to fish in their fifth year of life. However, five-year-old fish recorded after the purported time of annulus formation were very few in number and in no way comparable to the number aged as five-year olds under the assumption of a subsequent annulus formation. On the other hand, the number of scales showing three annuli was fairly consistent throughout the year. This also was true for those scales showing two annuli, but in this case, after review of the 1956 collection and a small selected sample of juveniles collected during February of 1958, the author was willing to concede that these two-annuli fish belong to four-year-old and three-year-old fish, respectively, before and after a period centering around June. This reasoning could be applied to the three-annuli fish as well, as it was in 1956, if some explanation could be advanced for the lack of five-year olds later in the year.

An objective record was made of scales throughout the entire year, separating them strictly by the number of annuli actually showing. The aver-age length of fish in each of the "classes" was calculated for each month. The results were then graphed. It was expected that a marked drop in average size would occur for each of these "classes" about the time of annulus formation as each "class" was assumed to be composed of two age classes, viz. three-annuli fish before annulus formation would be in their fifth year of life and three-annuli fish immediately after annulus formation would only be in the fourth year of life. Such delineation was not apparent, however, and this could be explained in part by the extensive growth of all fish following annulus formation coupled with a spread of several months during which individual fish were capable of forming an annulus. It was necessary, consequently, to examine each specimen subjectively and upon its own merits. For lack of any conclusive evidence to the contrary, the author accepted the premise that an annulus was indeed formed sometime from April through July, and the individual age determinations were so biased.

With the exception of the loss of a six-year-old population and the sudden drop in the number of five-year olds occurring in August (Table 4), the length-frequency and age-growth data, resulting from this assumption of annulus formation, seem to justify the author's decision.

Length-frequency data.

In addition to the 1957 scale collections, total lengths of a large number of fish were recorded to the nearest millimeter. Supplementary information accompanying the lengths was the same as that recorded with the scale

collections. Lengths obtained at the time of scale collection were included to form a part of the general length data.

Length collections ranging in size from 334 to 1,439 measurements a month were taken from the south area of the lake from February through October, 1957, for a total of 5,608 lengths. The north area was sampled from May through September with monthly collections ranging in size from 438 to 670 measurements, for a total of 2,643 lengths. All of the above lengths were taken from fish in the catch.

Spawning fish were measured at Granite Creek during November and December, 1957. The totals for these months were 308 and 321 lengths, respectively.

Determination of sex and maturity.

All determinations of sex and sexual maturity prior to the spawning season were made from gonadal examinations. The sex of spawning fish could be determined from the external morphology, and these fish could also be assumed to be sexually mature.

FINDINGS

Study of growth, scale formation, and stomach contents of fry.

Growth. The lengths of fish taken in each sample are recorded in Table 2. These lengths have been averaged by sample and incorporated into a graph (Figure 1). In cases when the samples occur on consecutive *days,* or when the samples are relatively small and separated by only a few days, these samples have been combined and the weighted average used.

Examination of Figure 1 shows that during 1957 fish in their first year of live continue rapid growth as late as the latter part of November.

Scale formation. The lengths of fish examined in detail and the size and development of scales observed are recorded in Table 3. In general, when the complete sample for any date was not examined, the larger fish were selected from that sample.

Table 2 indicates that formation of scales prior to October occurs only in exceptional cases, possibly only on the most precocious fry. However, be-fore the middle of October fry with scales comprise approximately one-half of the sample. By the latter part of November, all fry, with the exception of one abnormally small fish, have well-developed scales.

The total length of Lake Pend Oreille kokanee fry at the time of initial scale formation is about 35 millimeters. This empirical value is comparable to the accepted length for most salmonids at this stage of development. Bjornn (1957) used a length of 30 millimeters in back calculating the lengths of Priest Lake kokanee. Bjornn derived this value in part from the regression-line intercept of a body-scale relationship graph. The Priest Lake kokanee population developed from Lake Pend Oreille stock.

Stomach contents. Qualitative examination was made of the stomach contents from 26 kokanee fry. Three to six fish were inspected from each of the following collection dates: June 21, July 26, August 30, September 23, November 26, and November 27, 1957. These fish ranged in length from 22 to 64 millimeters.

Phytoplankton. At no time during the sampling period was phytoplankton found-to comprise an appreciable portion of the stomach contents.

Insects. No evidence of larval insects was found in any of the samples. However, relatively large insectoid appendages were present in several of the larger fry collected in the latter part of the season. Also, a small Diptera and two small Hymenoptera of separate families were found intact in the stomach of a September fish. These adult insects were two to three times the linear size of the larger zooplankton present.

Table 2. Total length, in millimeters, of kokanee fry collected in 1957, with date and place of capture, Lake Pend Oreille, Idaho.

Granite Creek, near the mouth	Lakeview to Navy Buoy	Talache to Echo Bay	Echo Point to Twin Creek	Cape Horn to Talache	Cape Horn to Navy Buoy to Granite Creek	Cape Horn to Navy Buoy	Scenic and Idlewild Bays	Scenic Bay	Navy Buoy to Cape Horn	Scenic Bay and Area	Navy Barge at Scenic Bay	Navy Barge at Scenic Bay
6/21	7/9	7/26	8/23	8/30	9/23	9/24	10/9	10/10	11/1	11/7	11/26	11/27
24	27	30	31	30	30	37	40	42	48	41	64	62
23	24	26	30	37	34	32	38	36	44	38	50	54
23	27	28	34	28	27	36	27	45	39		46	50
25	27	33		30	36	35	37	37	34		48	56
22	25	31		31	30	39	35	38				45
24	25	25		28	31	29	35	34				47
26	28	26		29	34	30	36	35				45
23		29		28	35	35	34	38				44
22		25		27	24		34					46
23		27		29	33							36
23		27			31							
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Averages:												
23	26	27	32	30	31	34	35	38	41	40	52	48
			31		32		37		41		50	

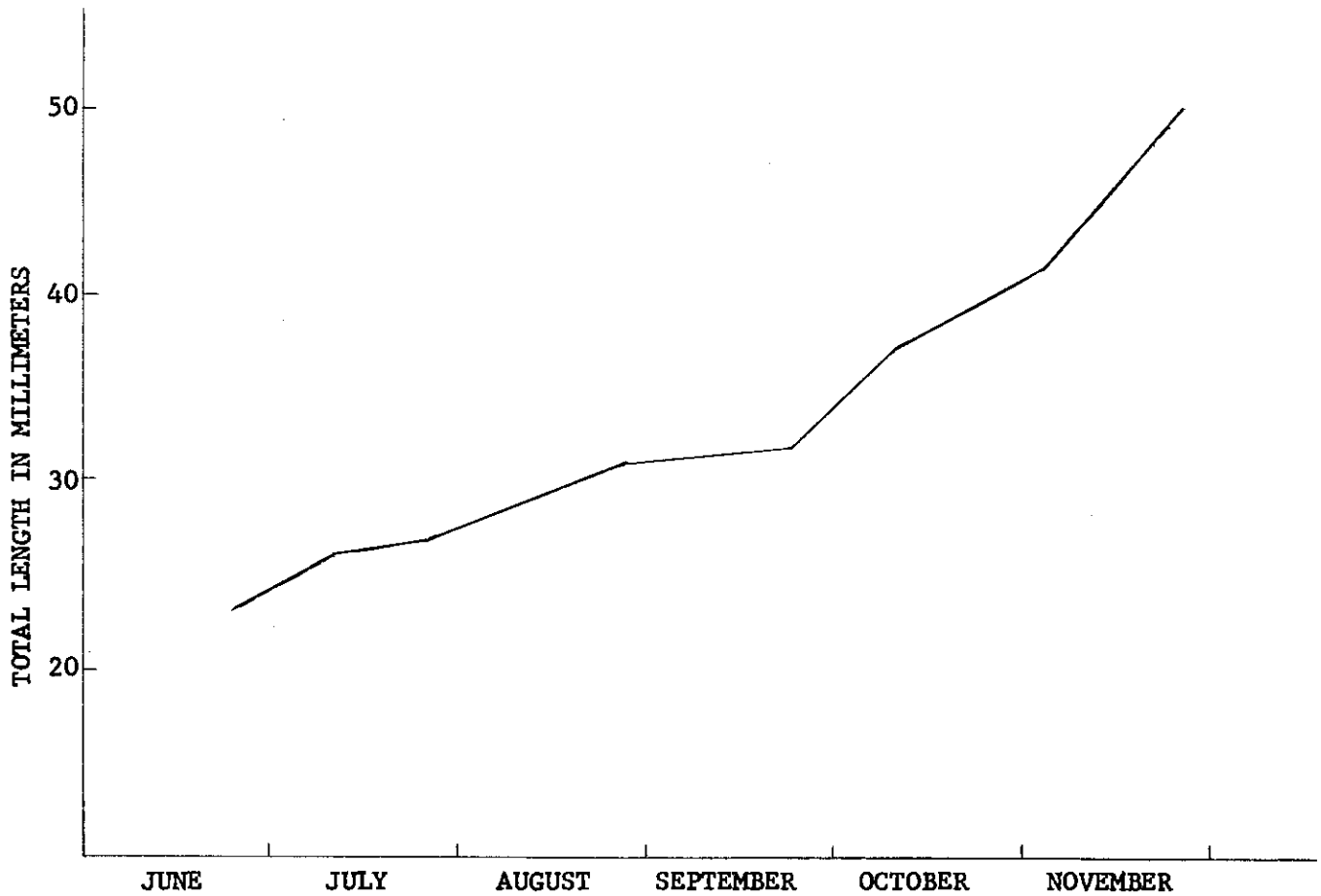

Figure 1. Average length of Lake Pend Oreille kokanee fry, June 21, 1957 to November 27, 1957.

Table 3. Scale formation of kokanee fry in selected sample from 1957 collection, Lake Pend Oreille, Idaho.

Date of capture	Total length (millimeters)	Number of circuli	Approximate scale diameter
August 21	34	-	no scale
August 30	31	-	no scale
	30	-	"
	37	1	0.2 mm
September 23	35	-	no scale
	34	-	"
	33	-	"
	30	-	"
	31	-	"
	30	-	"
	36	0	0.1 mm
October 9	40	-	no scale
	34	-	"
	34	-	"
	27	-	"
	37	-	"
	36	2	0.3 mm
	35	1	0.3 mm
	35	1	0.2 mm
	38	1	0.2 mm
October 10	45	4 & 3	0.5 mm & 0.4 mm
	Of the remaining seven fish in this sample, three possessed scales and four did not. Lengths were not recorded.		
November 26	64	9	0.7 mm
	50	5	0.5 mm
	46	5 & 6	0.4 mm
	48	5	0.4 mm
November 27	62	8	0.7 mm
	54	4	0.5 mm
	50	4 & 5	0.5 mm
	56	6	0.5 mm
	45	3 to 5	0.4 mm
	47	3 & 4	0.4 mm
	45	3 & 4	0.4 mm
	44	3 & 4	0.4 mm
	46	4	0.4 mm
	36	-	no scale

Zooplankton. Crustaceans were present in all the samples except those collected in June from Granite Creek. The stomachs of the June fry were empty of any recognizable material. The genera identified throughout the sampling period were Daphnia, Bosmina, Diaptomus, and Cyclops. From general observation it appeared that Daphnia formed a large part of the diet through-out the entire period. Bosmina was encountered sporadically, with a few large samples occurring in July and August. Of the Copepods, Cyclops formed the greater portion of the diet in July with Diaptomus assuming the majority as the year progressed.

Except for the lack of Leptodora and Epischura, these findings agree qualitatively with the genera found by Stross (1954) in the stomachs of older Lake Pend Oreille kokanee taken on hook and line. Disparity exists, however, in a quantitative comparison and may be due in part to the method of sight estimate used by the author in examining the fry.

Age and growth of kokanee in the catch.

Before examining the findings presented in this section, the reader should note that all of the data were obtained from random sampling of the fishermen's creels. For this reason the data are representative of the catch rather than the true population of the lake. The collection was biased by the availability of the fish to the fishermen and by any selectivity on the part of the fishermen themselves. Evidence of this is seen in the changing sex ratio of the catch and the low percentage of juvenile fish.

Table 4 shows the age composition of the catch as determined from scale readings, for the months of February through October. Monthly distribution of the 1,263 samples aged is also given in Table 4. The relative size of these monthly samples will give some indication of the distribution of the total catch throughout the year. Numerical estimates of the total catch by months may be found in "Lake Pend Oreille Creel Census" (Whitt, 1958c). Figure 2 indicates the growth pattern for each age class as represented by their average length by months. The length frequencies of each age class are presented by months in Table 5.

Back calculations of body length at the end of the first and second years of life were made for three random samples of 20 fish each from three-, four-, and five-year-old age classes. The results are averaged and presented in Table 6. These averages were made for comparison with a similar table in the 1956 age and growth report (Whitt, 1958) and calculations were made by the same method, viz. direct relationship of body and scale size without correction for body size at time of scale formation.

Table 4. Age composition of kokanee in the catch, by months, 1957, Lake Pend Oreille, Idaho.

Month		Age class 3-year	4-year	5-year	6-year	Total fish
February	Total	0	50	15	0	65
	Percent		76.9	23.1		
March	Total	4	113	34	1	152
	Percent	2.6	74.3	22.4	0.7	
April	Total	4	165	41	3	213
	Percent	1.9	77.5	19.2	1.4	
May	Total	7	96	66	2	171
	Percent	4.1	56.1	38.6	1.2	
June	Total	2	36	30	1	69
	Percent	2.9	52.2	43.5	1.4	
July	Total	11	44	25	0	80
	Percent	13.8	55.0	31.2		
August	Total	55	96	10	0	161
	Percent	34.2	59.6	6.2		
September	Total	104	205	8	0	317
	Percent	32.8	64.7	2.5		
October	Total	4	27	4	0	35
	Percent	11.4	77.2	11.4		
Total in each age class		191	832	233	7	1,263
Percent of total		15.1	65.9	18.4	0.6	

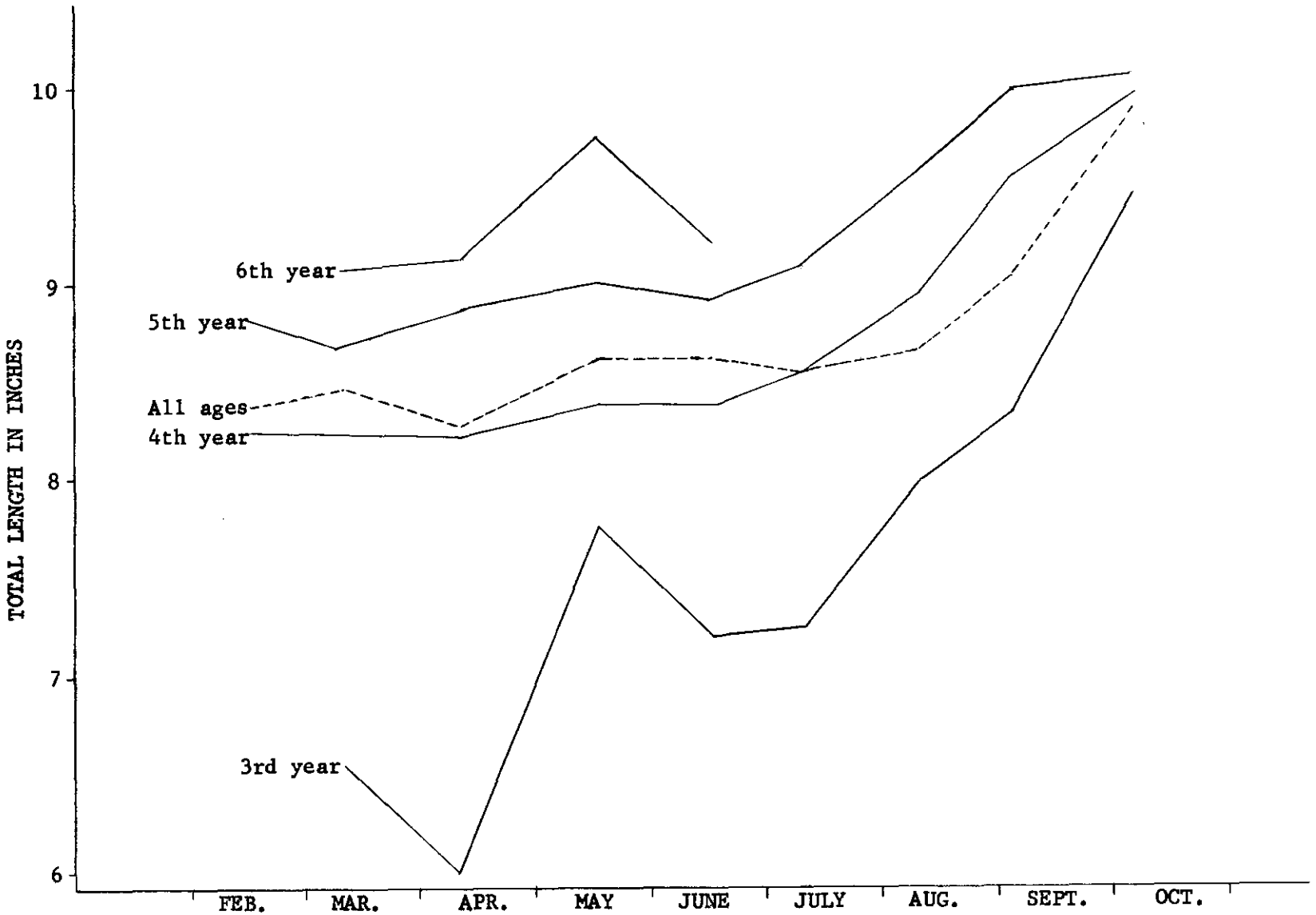

Figure 2. Average length in inches by age class for aged kokanee in catch, Lake Pend Oreille, Idaho, February through October, 1957.

Table 5. Length-frequency distribution of kokanee in the catch, by age class, February through October, 1957,* Lake Pend Oreille, Idaho.

Total length, inches	Age class 3-year	4-year	5-year	6-year
FEBRUARY				
7.5		7		
8.0		21	1	
8.5		18	5	
9.0		4	8	
9.5			1	
Average length, inches		8.2	8.8	
MARCH				
6.0	1			
6.5	2			
7.0	1			
7.5		16	1	
8.0		47	2	
8.5		39	15	
9.0		9	14	1
9.5		2	2	
Average length, inches	6.5	8.2	8.7	9.1
APRIL				
5.0	1			
5.5				
6.0	1			
6.5	2			
7.0		1		
7.5		24		
8.0		68	2	
8.5		54	17	1
9.0		18	19	1
9.5			2	1
10.0				
10.5			1	
Average length, inches	5.9	8.2	8.9	9.1

*Totals for each age class by months and percentage composition are given in Table 4.

Table 5, continued.

Total length, inches	Age class 3-year	4-year	5-year	6-year
MAY				
6.5	1			
7.0	1			
7.5	2	4		
8.0	1	37		
8.5	1	36	14	
9.0	1	19	38	1
9.5			12	
10.0			2	
10.5				1
Average length, inches	7.8	8.4	9.0	9.8
JUNE				
7.0	2	1		
7.5		3		
8.0		7	2	
8.5		15	8	
9.0		9	15	1
9.5		1	4	
10.0			1	
Average length, inches	7.2	8.4	8.9	9.3
JULY				
6.5	1			
7.0	5			
7.5	4	2		
8.0	1	13	1	
8.5		12	1	
9.0		14	14	
9.5		3	9	
Average length, inches	7.2	8.5	9.1	

Table 5, continued.

Total length, inches	Age class 3-year	4-year	5-year	6-year
AUGUST				
7.0	6			
7.5	18			
8.0	13	12		
8.5	10	15		
9.0	5	42	2	
9.5	3	24	5	
10.0		3	2	
10.5			1	
Average length, inches	8.0	8.9	9.6	
SEPTEMBER				
5.5	1			
6.0				
6.5				
7.0				
7.5	28	1		
8.0	20	5		
8.5	28	19		
9.0	20	57		
9.5	4	84	4	
10.0	3	34	2	
10.5		5		
11.0			2	
Average length, inches	8.3	9.3	10.0	
OCTOBER				
8.5	1	1		
9.0	1	1		
9.5	1	5	1	
10.0		14	2	
10.5	1	6	1	
Average length, inches	9.8	10.0	10.2	

Table 6. Calculated average lengths of kokanee from body-scale relationship, 1957, Lake Pend Oreille, Idaho.

Age class	Number of individuals	Calculated average length in inches at end of	
		first year	second year
3-year	20	2.7 (1955)*	6.8 (1956)
4-year	20	2.6 (1954)	6.9 (1955)
5-year	20	2.7 (1953)	6.5 (1954)

*Year in which growth occurred.

Length-frequency distribution of kokanee in the catch.

The average lengths by month and area for the 8,251 fish measured from the creels are given in Table 7. The length data collected for each month have been graphed as length-frequency curves by the following method: Total lengths, recorded to the nearest millimeter, were first arranged in two-millimeter groups. The two-millimeter groups were smoothed by running threes. The vertical scales of the graphs were then altered so that all samples, regardless of size, were prorated to a value of 1,470 lengths. The 1956 length-frequency curves also are prorated to 1,470, and in this manner the areas under all curves have been rendered approximately equal. This facilitates comparison of months within and between the two years. The length-frequency curves are presented in Figures 3 to 16.

Maturity of kokanee in the catch.

To test for the possibility that a significant number of five-year-old fish might appear in the 1958 catch, a number of fish, which later would be aged, were examined for sexual development. This investigation was conducted for part of August and for September and October. In addition, a larger number of individuals, for which length data alone were recorded, were noted for maturity during these months. The terms mature and immature, as used in this report, delineate between those fish which may be expected to spawn at the end of the current year of life and those so obviously undeveloped that they could be expected to postpone spawning for at least another year. During the months when the investigation was conducted, potential spawners had developed to such an extent as to be easily differentiated.

Under the assumption that the larger immature fish would be almost as available to the fishermen as mature fish in the same size range, it was deemed that an excessively large proportion of immature four-year-old fish in the catch during 1957 would be an indication that a relatively large number of five-year-old fish would be found in the 1958 catch. However, as may be seen from Table 8, the number of immature four-year-old fish was not excessive during 1957. Length-frequency distributions of mature and immature fish during September and October, 1957, are given in Table 9.

Age, growth, and length frequency of Granite Creek spawners.

The age, length-frequency distribution, and average lengths of Granite Creek spawners, as derived from readable scales collected in December, 1957, may be found in Table 10. All of the data used in compiling Table 10 were obtained from female fish, as the scales of male kokanee were almost entirely absorbed at this time. Average lengths and length-frequency distributions of Granite Creek spawners during November and December, 1957, are presented in Table 11 and Figures 17 and 18.

Table 7. Average length, in inches, and sex composition by months for kokanee in the catch and on spawning grounds, February through December, 1957, Lake Pend Oreille, Idaho.

Month	Area	Average length (combined sexes)	Number of lengths	Average length Male	Average length Female	Number of lengths	Percent Male	Percent Female
February	South	8.3	572	8.7	8.5	16	56.3	43.7
March	South	8.3	869	8.3	8.2	194	52.6	47.4
April	South	8.3	1,439	8.3	8.3	171	45.0	55.0
May	South	8.7	442	8.8	8.6	152	63.2	36.8
	North	8.5	505	-	-	-	-	-
June	South	8.6	482	8.9	8.3	106	67.9	32.1
	North	8.3	438	8.4	8.5	110	68.2	31.8
July	South	8.6	428	8.8	8.8	104	61.5	38.5
	North	8.4	564	8.3	8.3	95	63.2	36.8
August	South	8.9	472	9.0	8.8	360	61.4	38.6
	North	8.5	670	8.5	8.4	446	57.8	42.2
September	South	9.1	593	9.0	8.9	250	60.0	40.0
	North	8.9	473	9.0	8.8	191	60.7	39.3
October	South	9.9	334	10.0	9.7	334	78.4	21.6
November*		10.3	305	10.5	10.1	261	46.4	53.6
December*		10.1	311	10.4	9.9	311	34.4	65.6

*November and December samples are from fish spawning in Granite Creek.

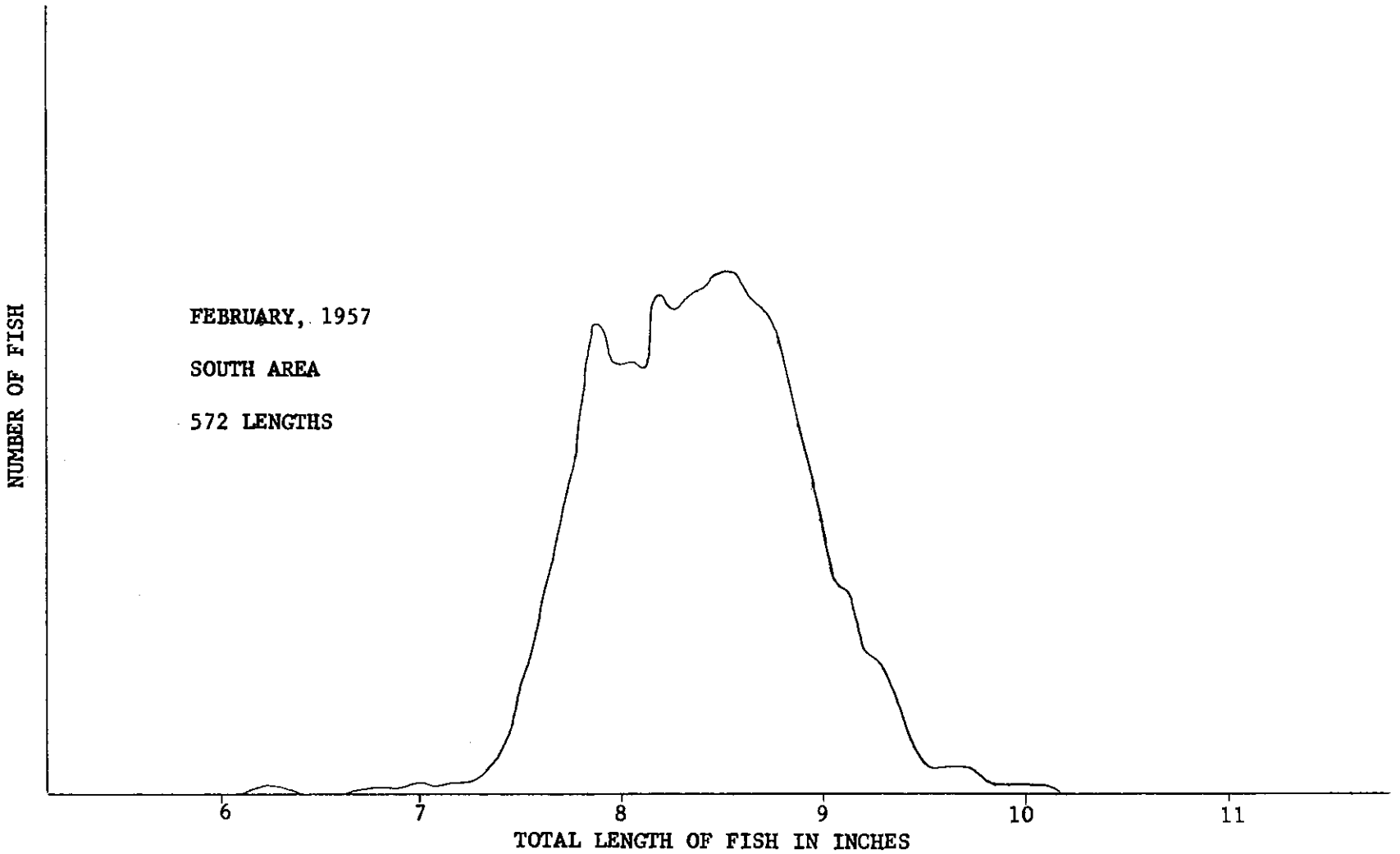

Figure 3. Length-frequency distribution of Lake Pend Oreille kokanee.

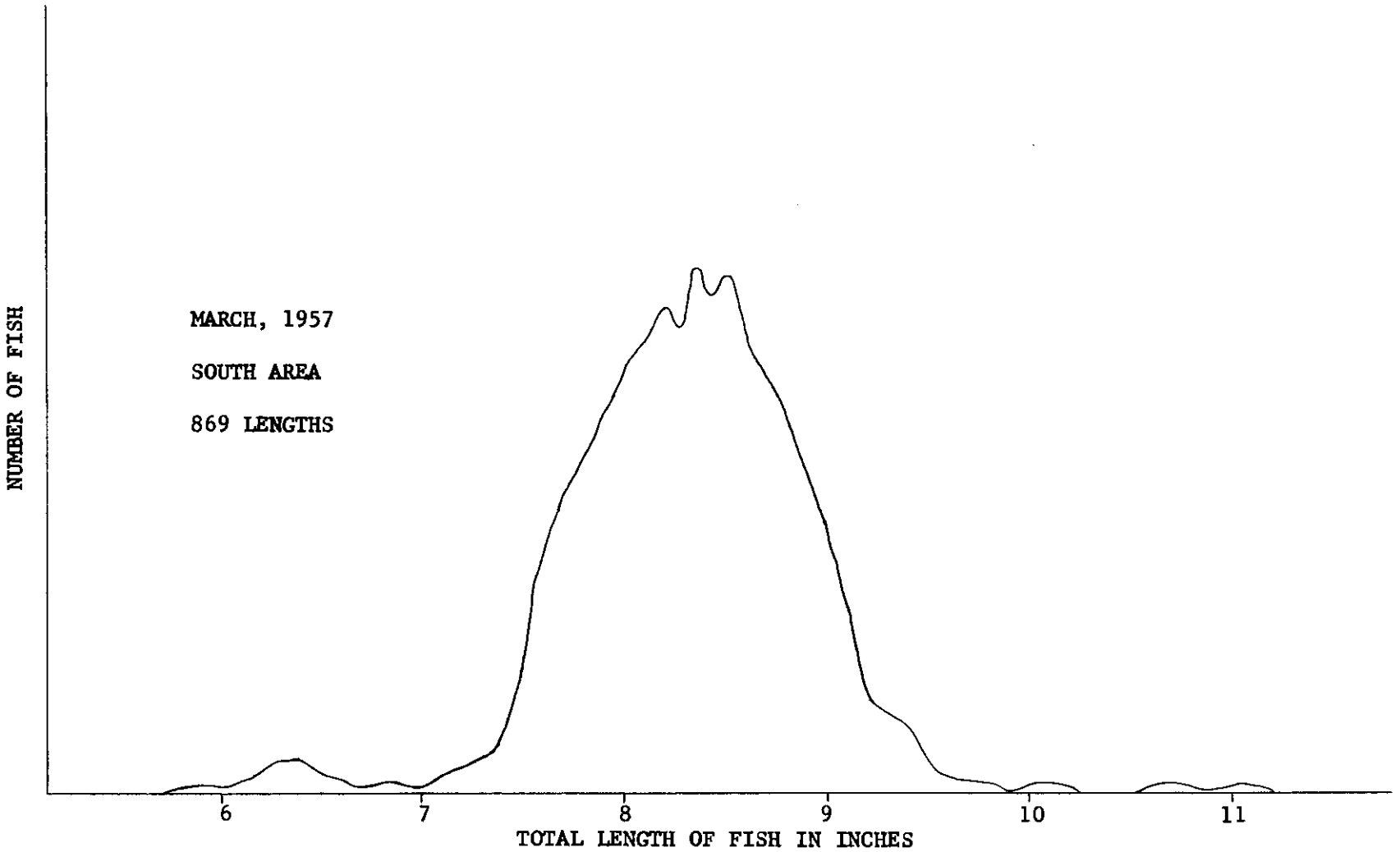

Figure 4. Length-frequency distribution of Lake Pend Oreille kokanee.

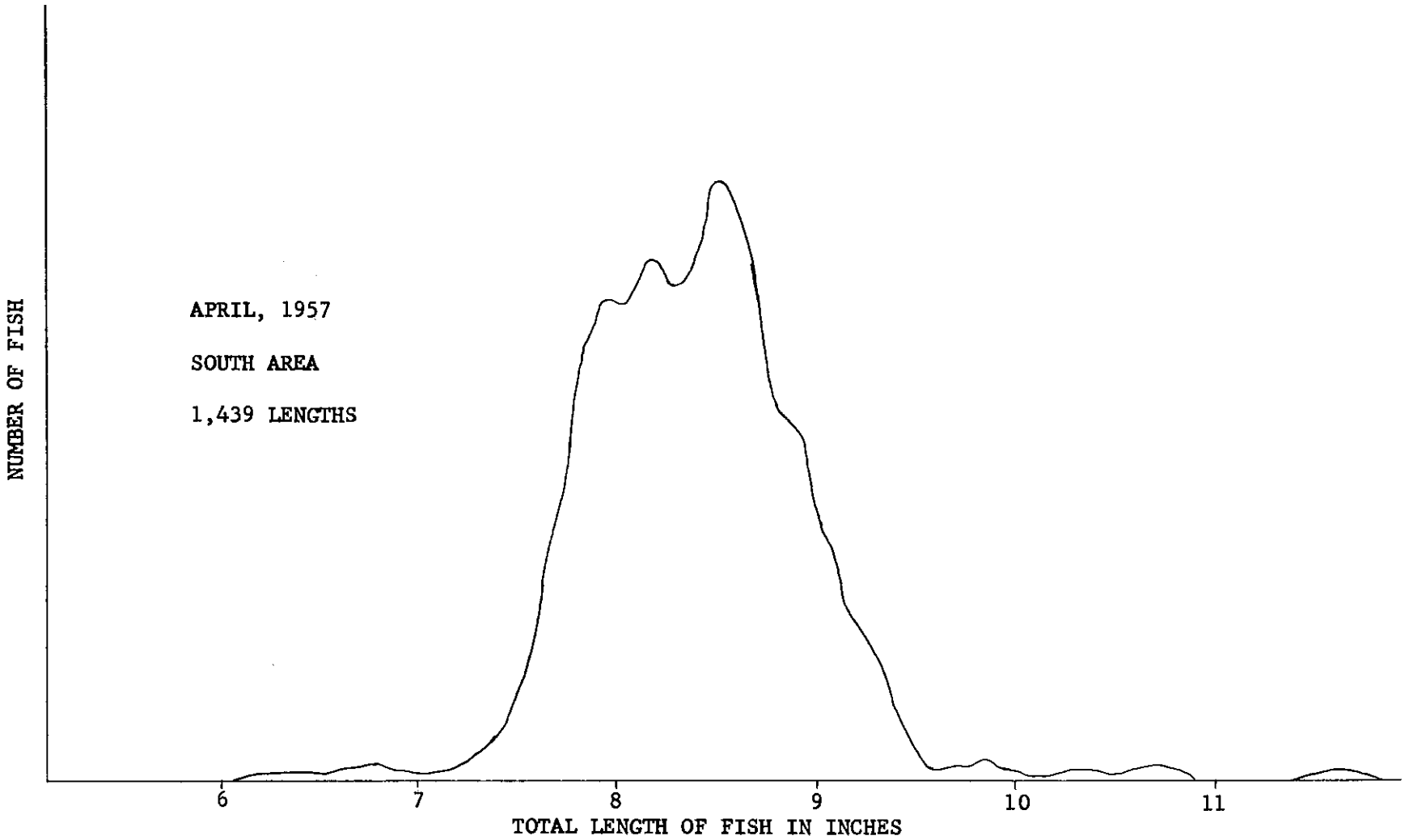

Figure 5. Length-frequency distribution of Lake Pend Oreille kokanee.

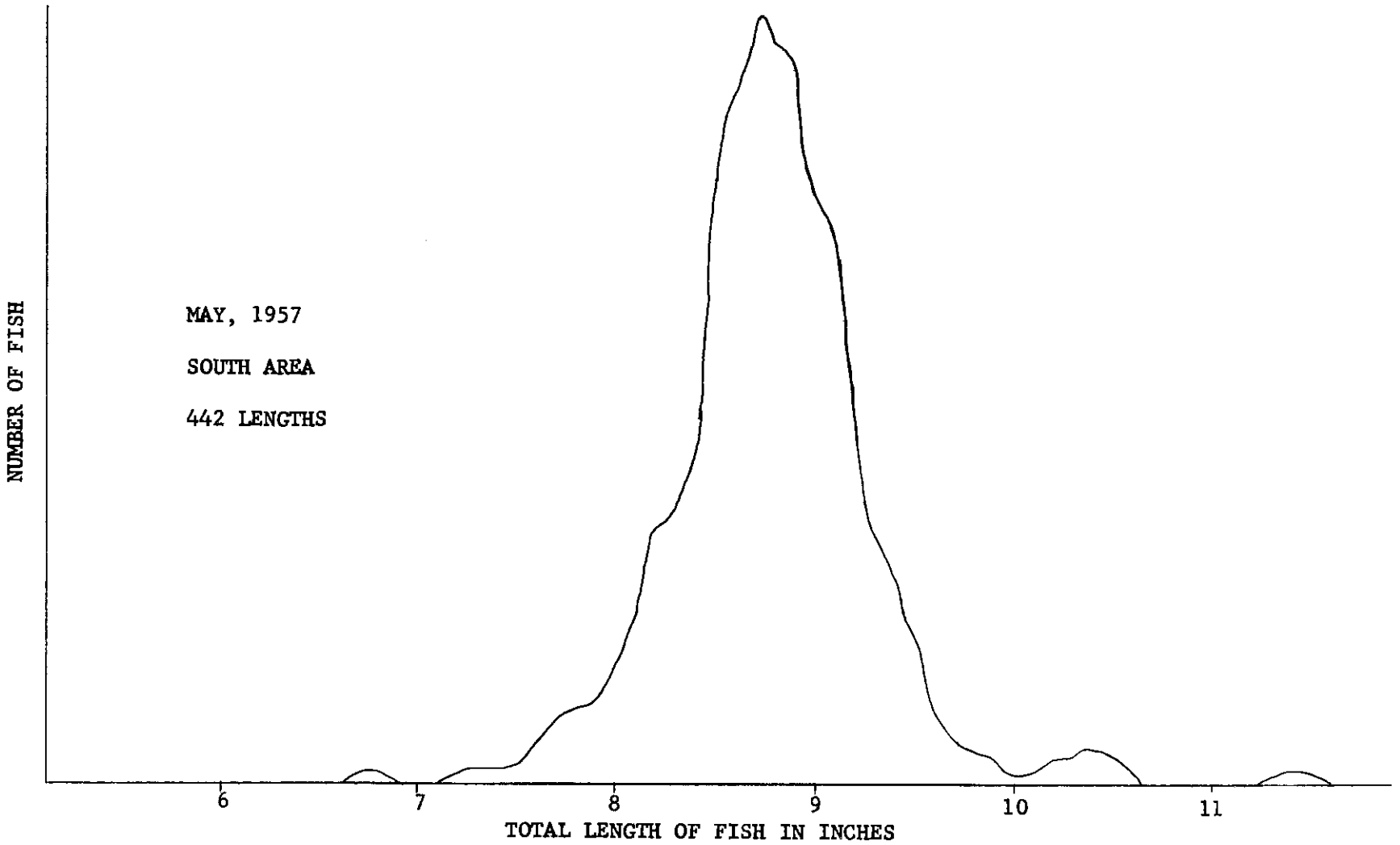

Figure 6. Length-frequency distribution of Lake Pend Oreille kokanee.

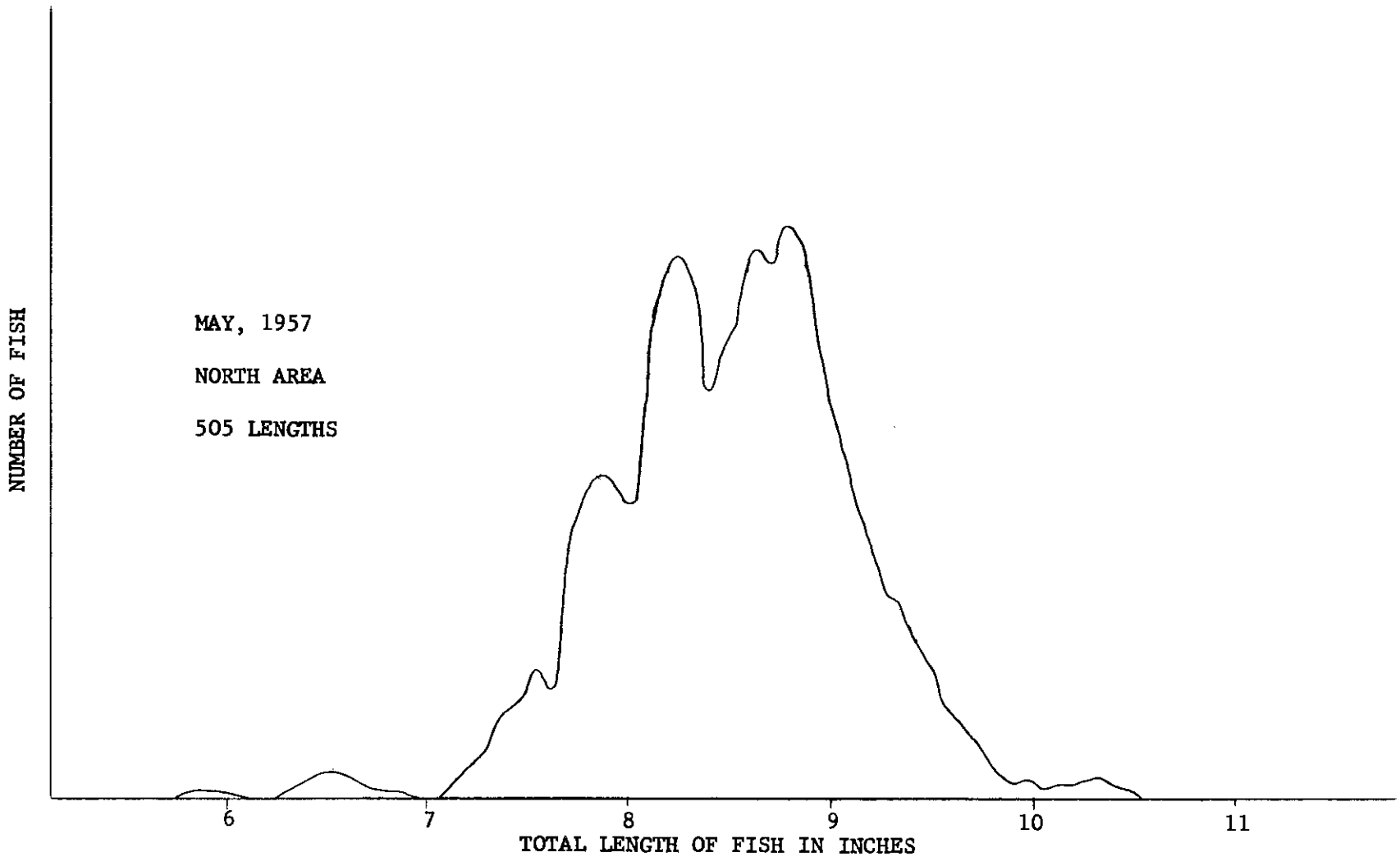

Figure 7. Length-frequency distribution of Lake Pend Oreille kokanee.

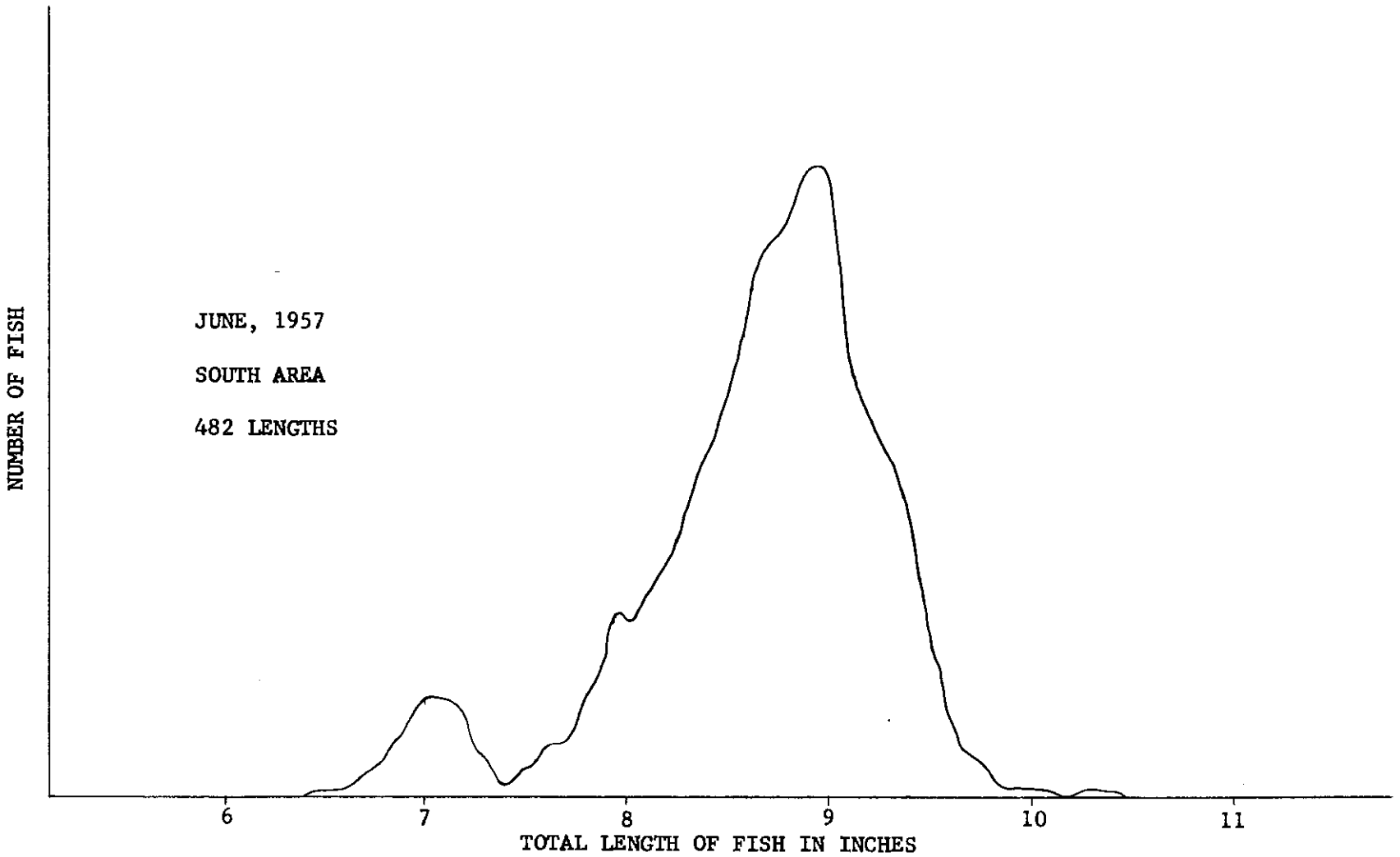

Figure 8. Length-frequency distribution of Lake Pend Oreille kokanee.

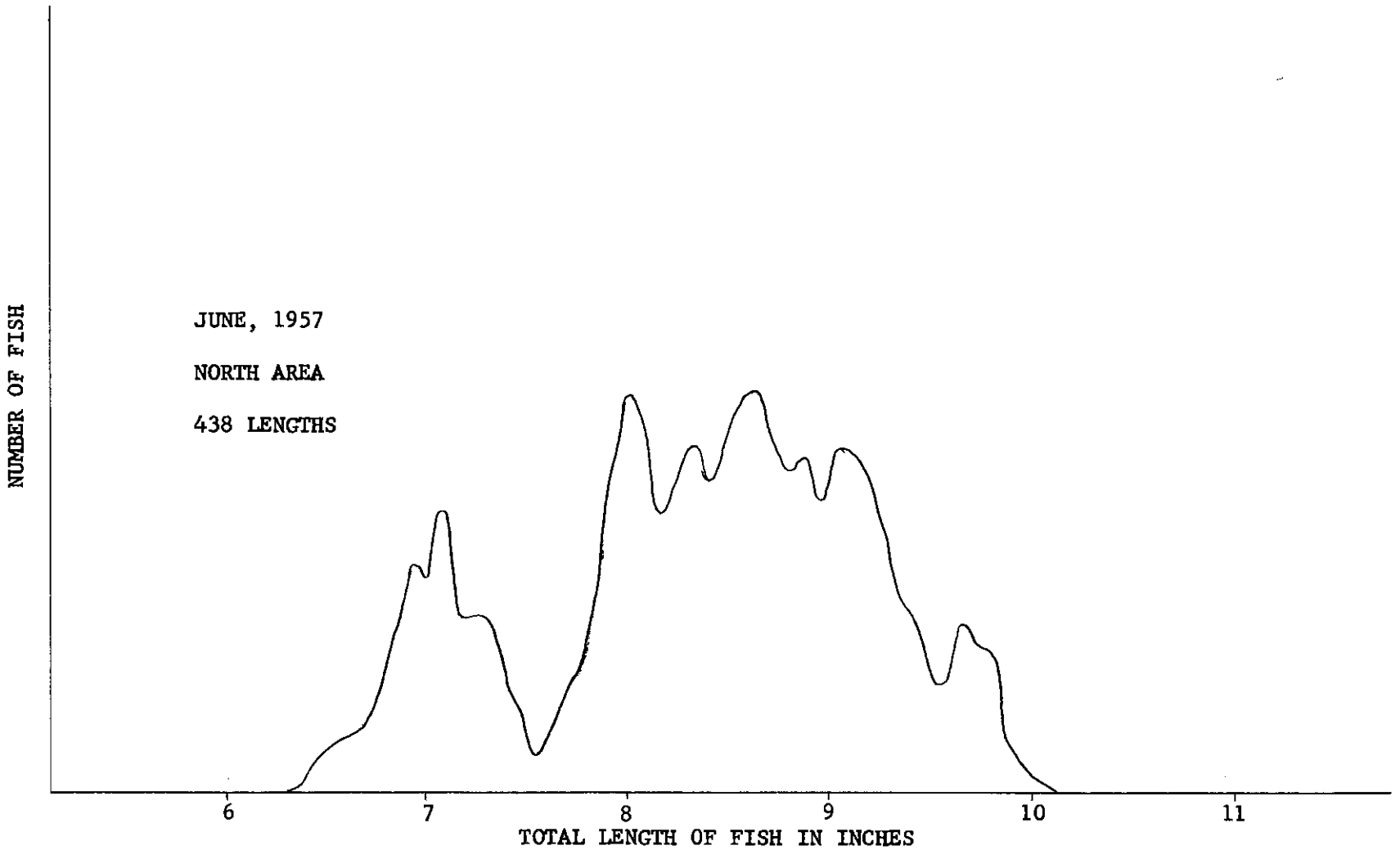

Figure 9. Length-frequency distribution of Lake Pend Oreille kokanee.

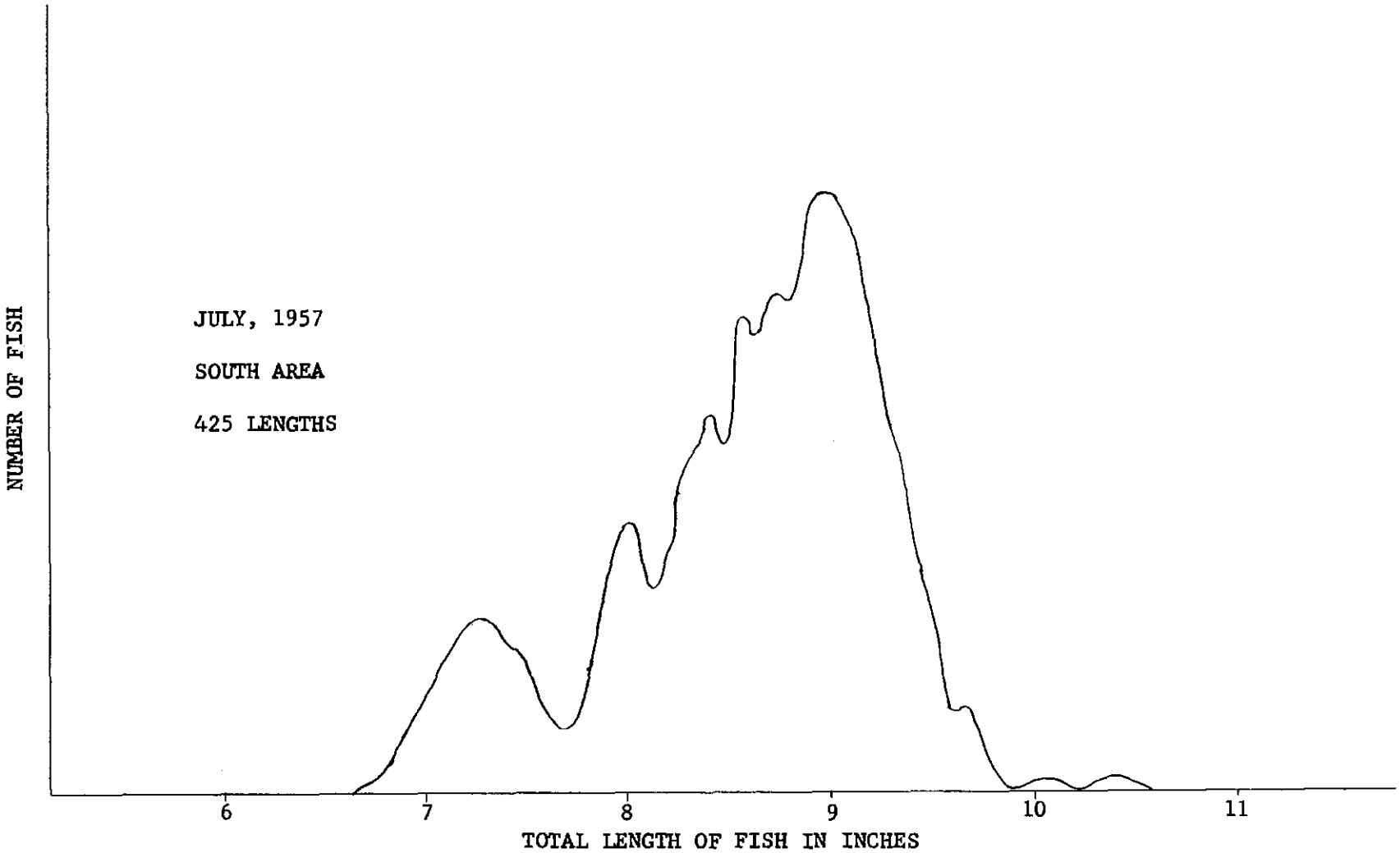

Figure 10. Length-frequency distribution of Lake Pend Oreille kokanee.

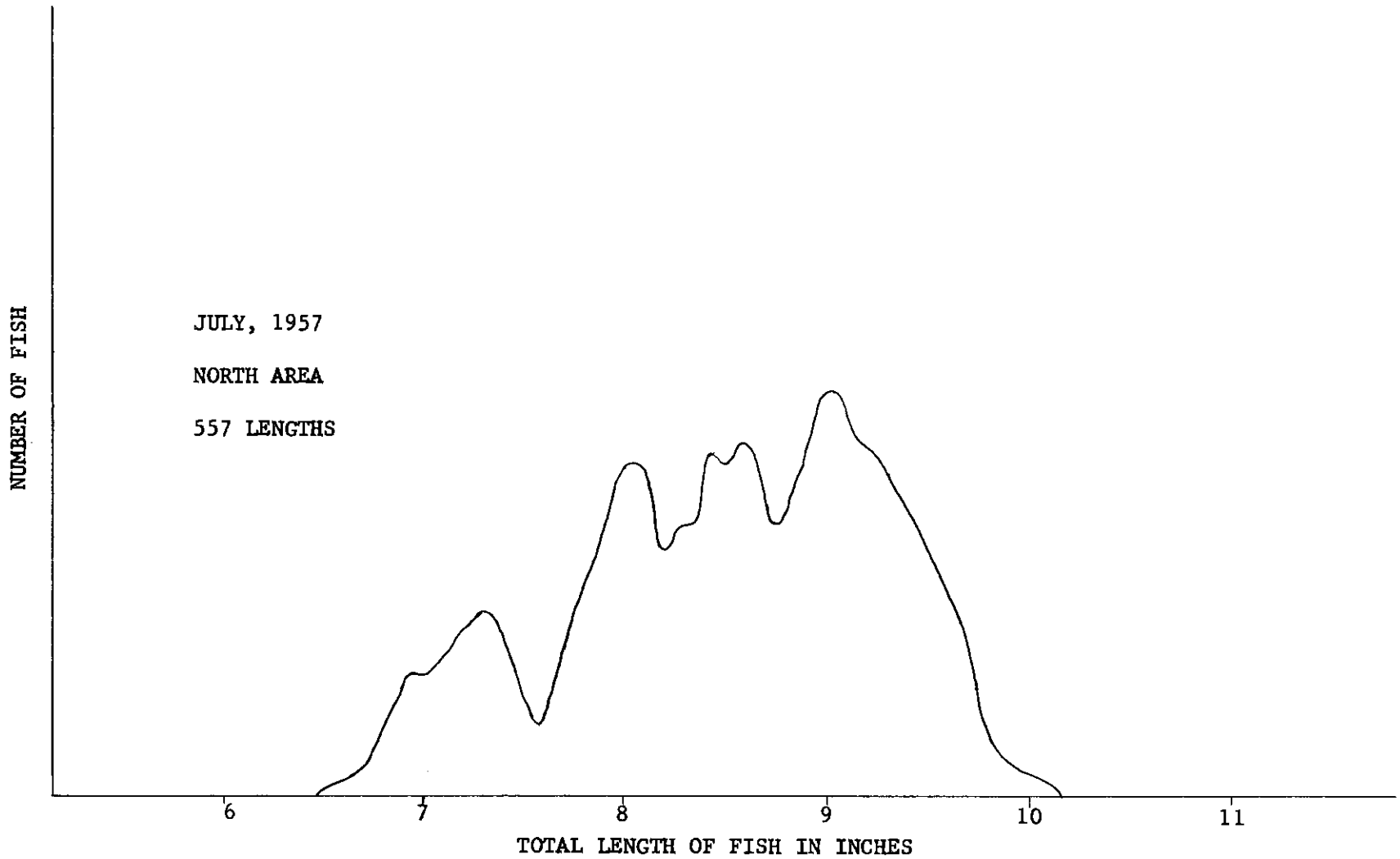

Figure 11. Length-frequency distribution of Lake Pend Oreille kokanee.

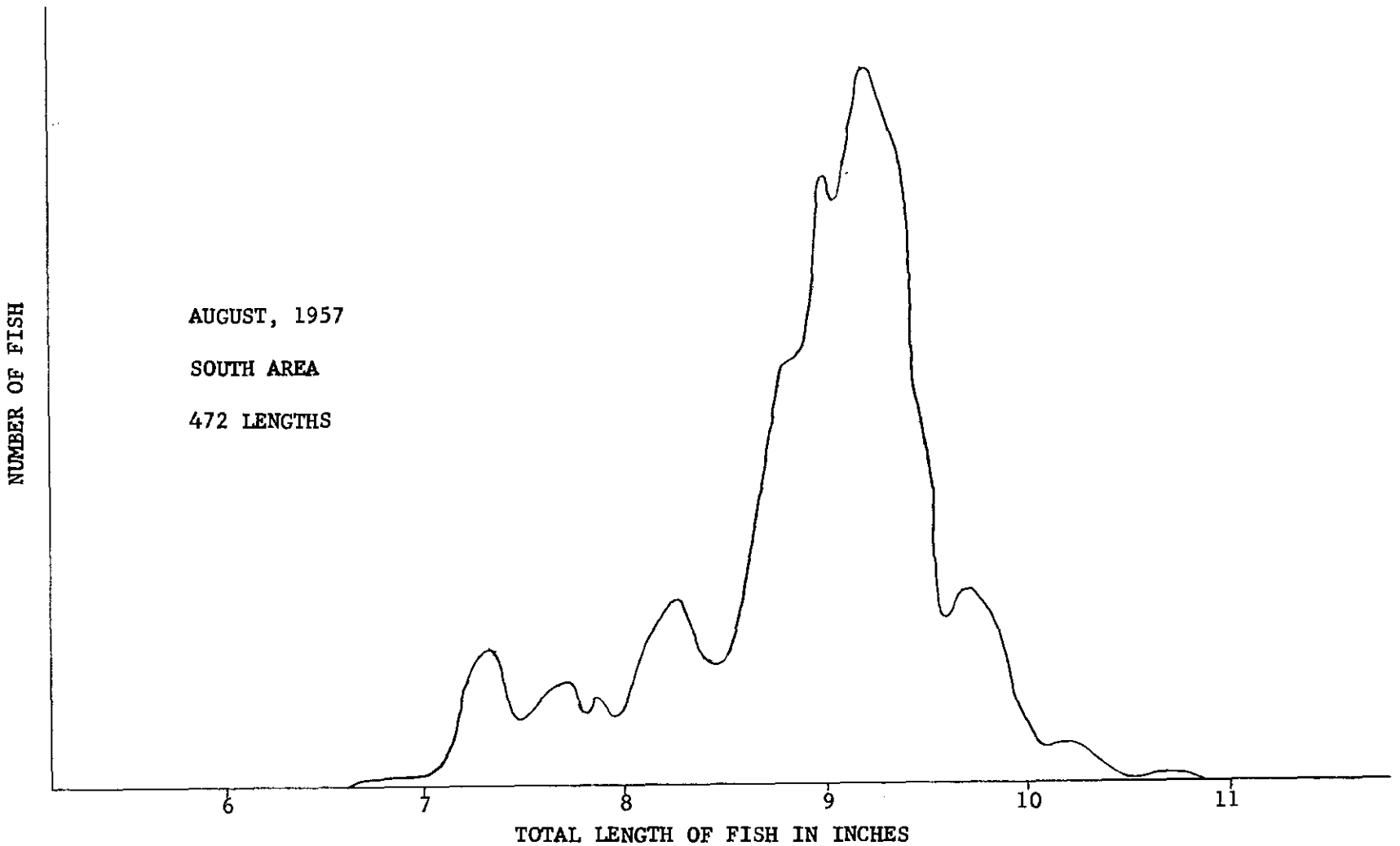

Figure 12. Length-frequency distribution of Lake Pend Oreille kokanee.

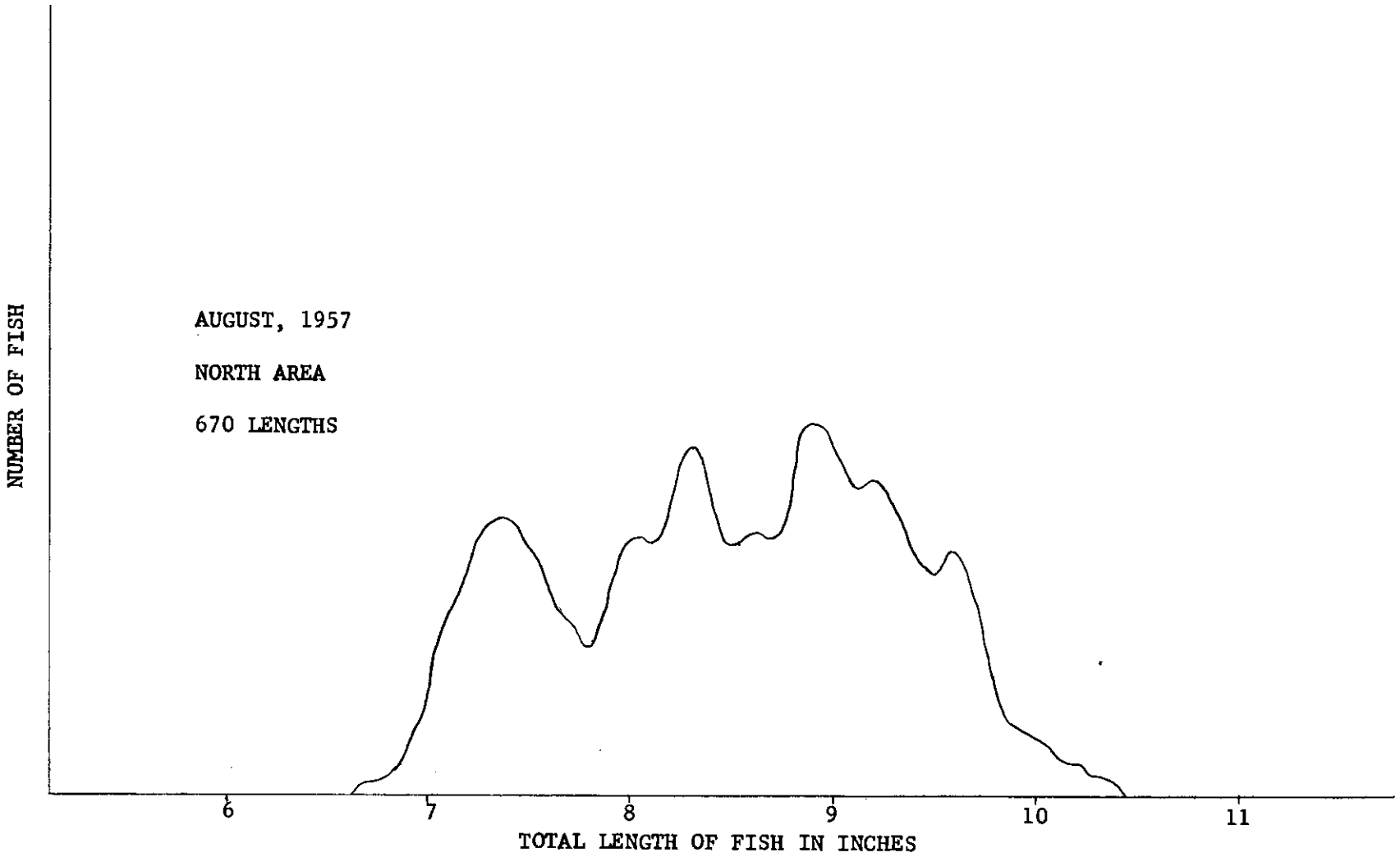

Figure 13. Length-frequency distribution of Lake Pend Oreille kokanee.

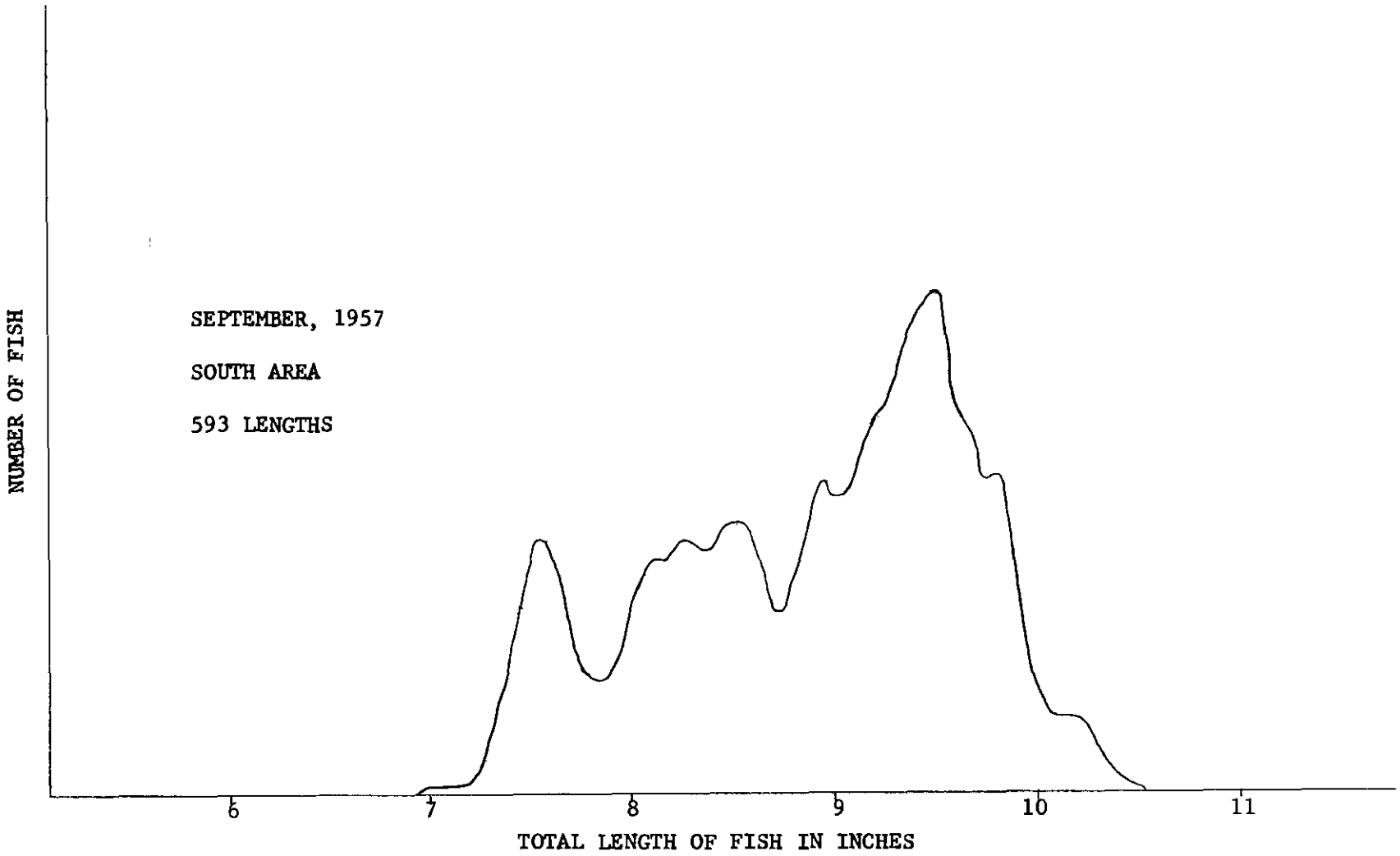

Figure 14. Length-frequency distribution of Lake Pend Oreille kokanee.

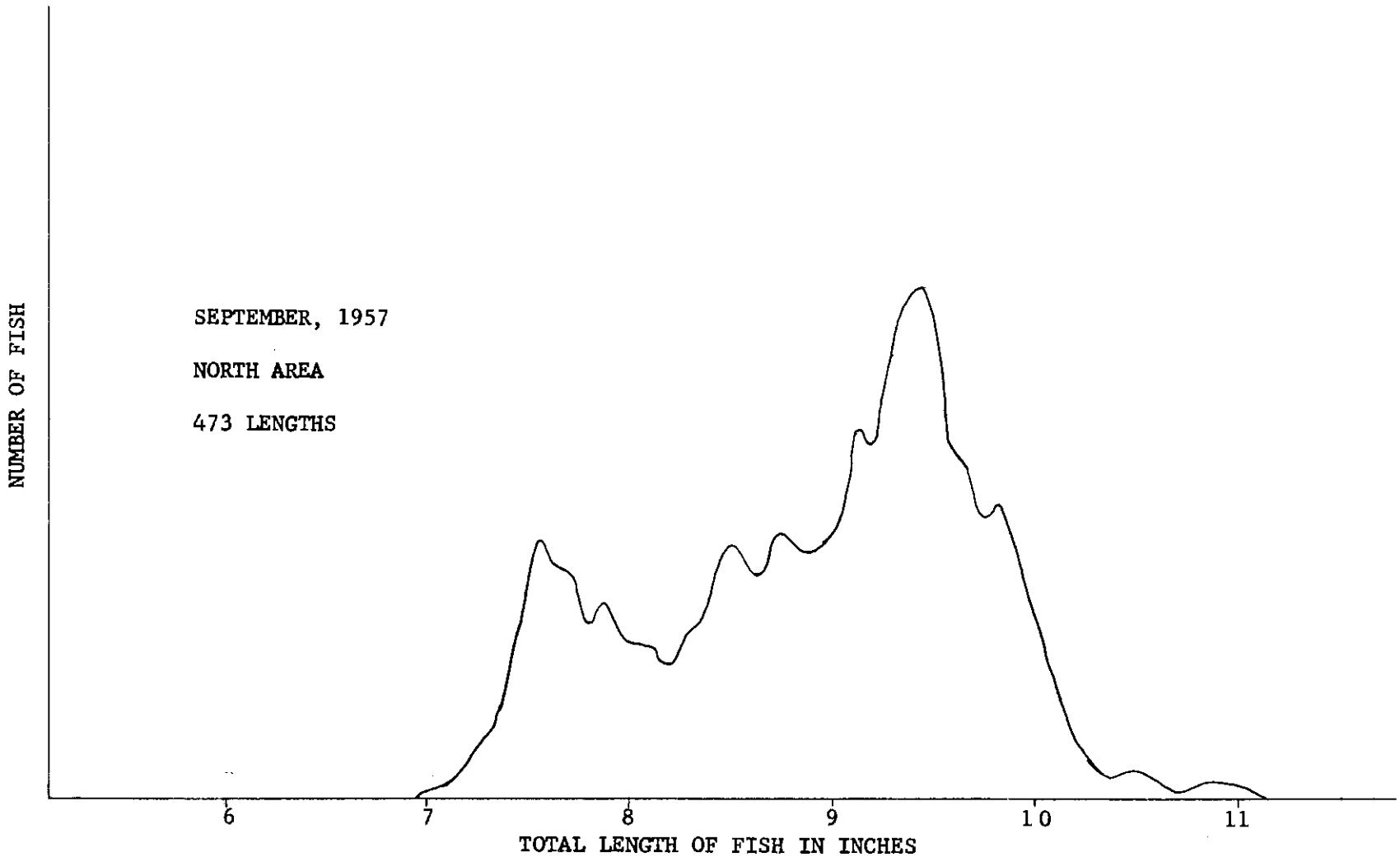

Figure 15. Length-frequency distribution of Lake Pend Oreille kokanee.

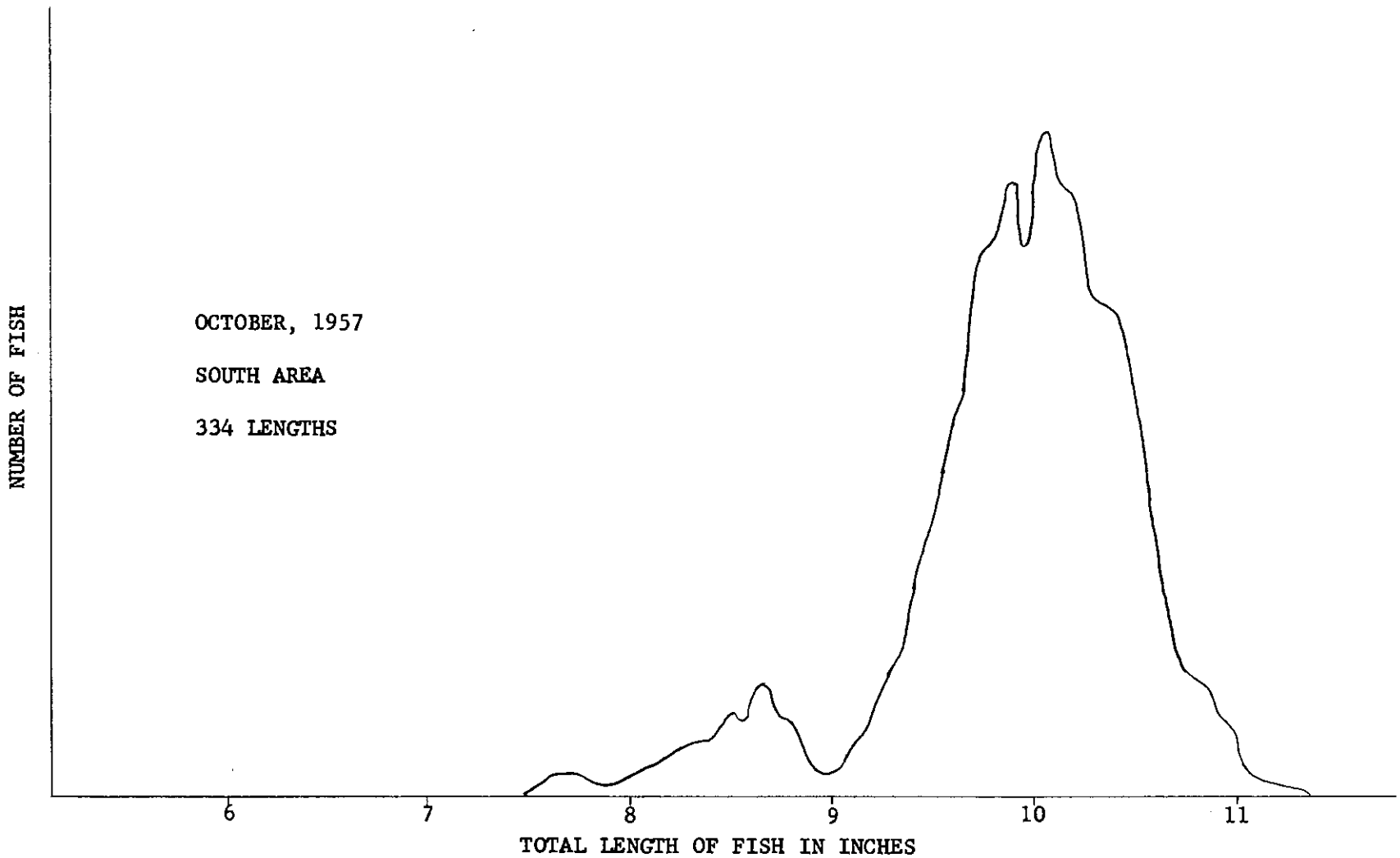

Figure 16. Length-frequency distribution of Lake Pend Oreille kokanee.

Table 8. Composition of mature and immature kokanee in catch for August, September, and October, 1957, Lake Pend Oreille, Idaho.

Age class	Mature	Immature	Total	Percent immature
AUGUST*				
3-year	12	31	43	72.1
4-year	55	6	61	9.8
5-year	6	0	6	0.0
All ages	73	37	110	33.6
SEPTEMBER				
3-year	24	80	104	76.9
4-year	179	26	205	12.7
5-year	8	0	8	0.0
All ages	211	106	317	33.4
OCTOBER				
3-year	3	1	4	25.0
4-year	26	1	27	3.7
5-year	4	0	4	0.0
All ages	33	2	35	5.7

*Of the 161 fish aged for August, notation of state of maturity was made for only 110.

Table 9. Length-frequency distribution of immature and mature kokanee in catch during September and October, 1957, Lake Pend Oreille, Idaho.

Total length, inches	South Area		North Area	
	Immature	Mature	Immature	Mature
SEPTEMBER				
7.25			2	
7.50	6		10	1
7.75	3		10	
8.00	10		8	1
8.25	16	1	5	2
8.50	7	2	9	
8.75	5	3	7	6
9.00	5	16	3	14
9.25		28		22
9.50		29		23
9.75		22		15
10.00		2		10
10.25		6		4
10.50				2
10.75				1
11.00				1
Total	52	109	54	102
OCTOBER				
7.50	1			
7.75	2			
8.00	2			
8.25	5	1		
8.50	8	1		
8.75	6	2		
9.00	1	2		
9.25		13		
9.50		32		
9.75		63		
10.00		67		
10.25		67		
10.50		41		
10.75		13		
11.0		7		
Total	25	309		

Table 10. Length-frequency distribution by age class for female kokanee spawning in Granite Creek, December, 1957, Lake Pend Oreille, Idaho.

Total length, inches	Age class		
	3-year	4-year	5-year
9.0		4	
9.5	1	29	
10.0	2	23	2
10.5		4	1
11.0		2	
Total	3	62	3
Percent	4.4	91.2	4.4
Average length, inches	9.8	9.8	10.2

Table 11. Average total length, in inches, and sex composition by months for kokanee spawning in Granite Creek, November and December, 1957, Lake Pend Oreille, Idaho.

Month	Average length		Number of lengths	Percent	
	Male	Female		Male	Female
November	10.5	10.1	261	46.4	53.6
December	10.4	9.9	311	34.4	65.6

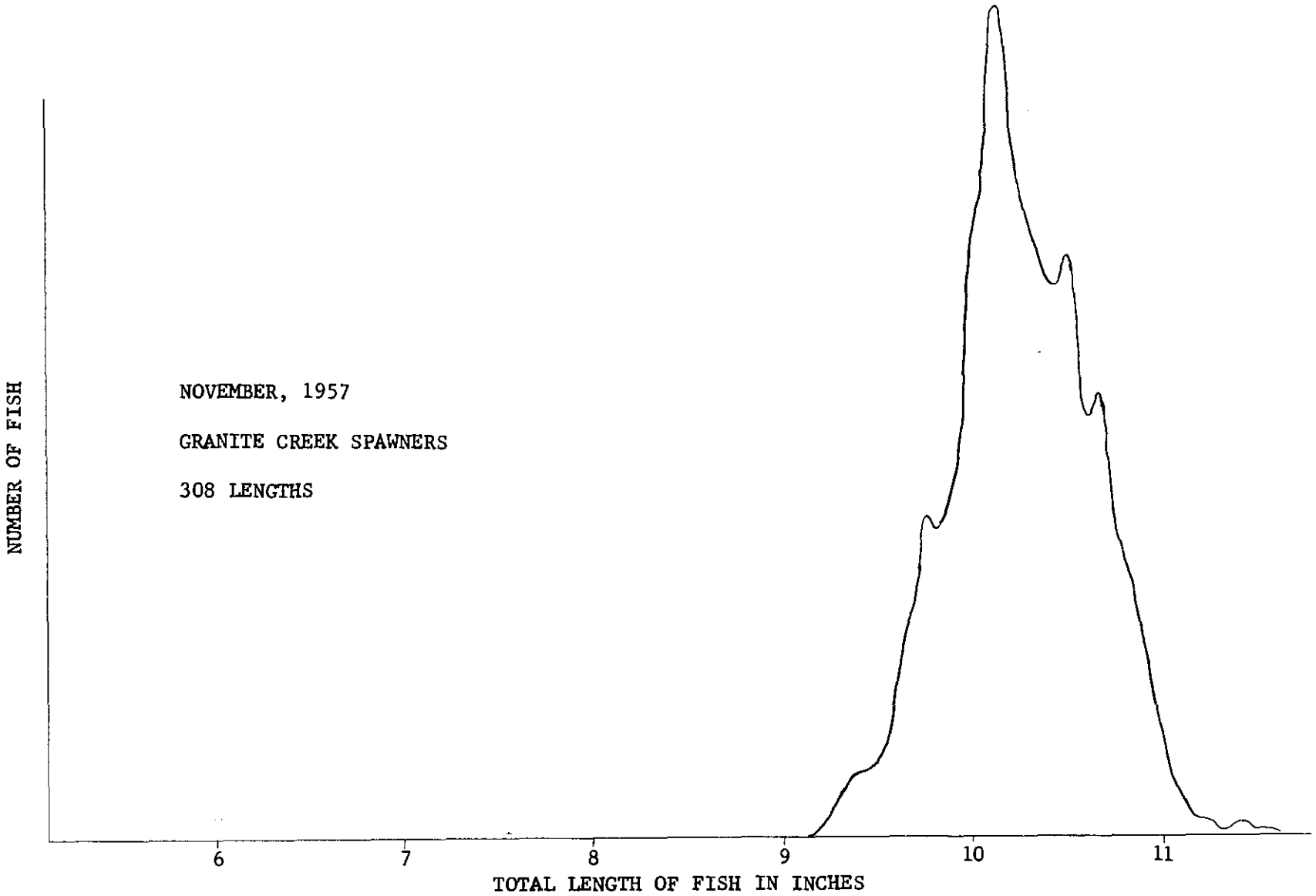

Figure 17. Length-frequency distribution of Lake Pend Oreille kokanee.

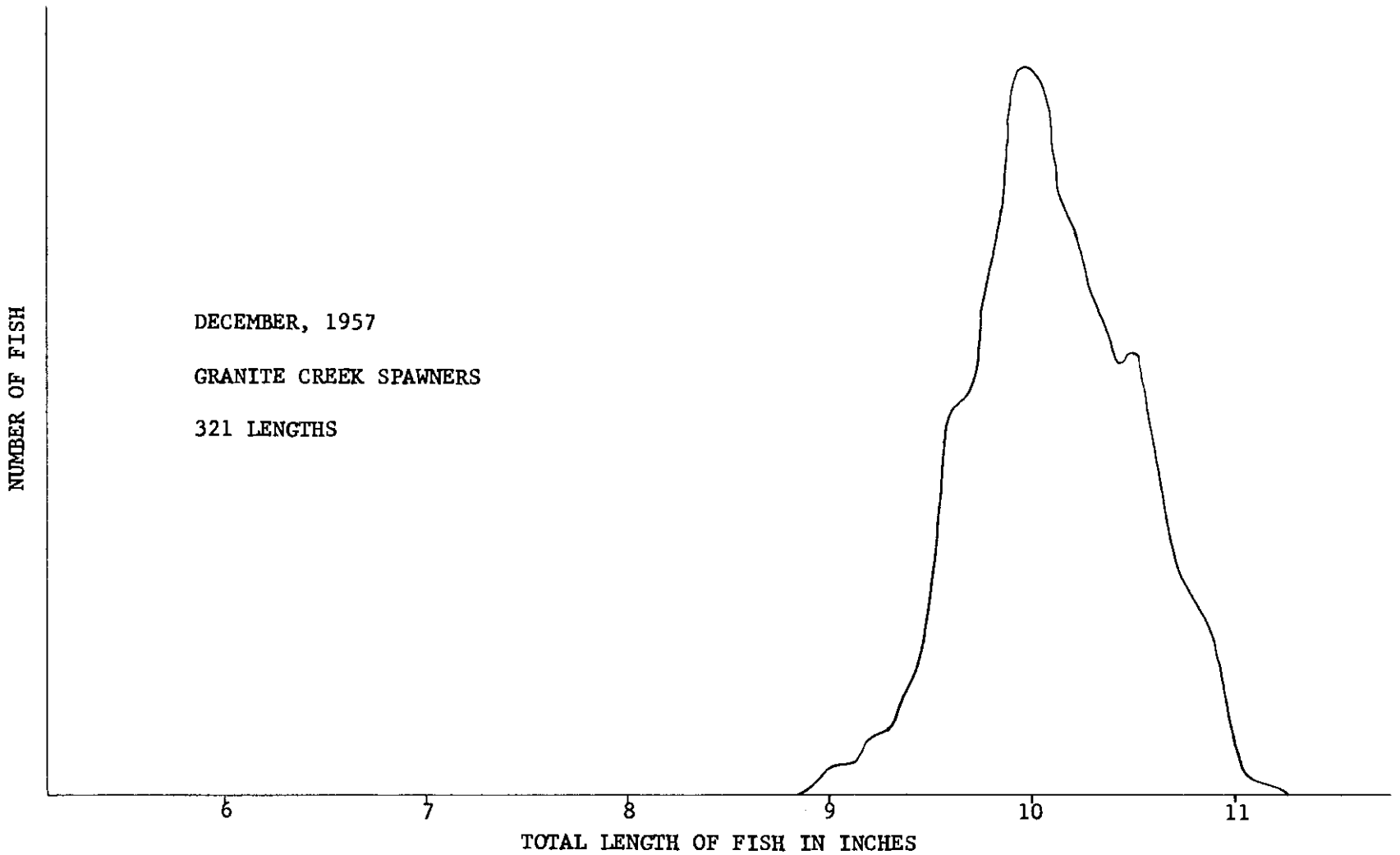

Figure 18. Length-frequency distribution of Lake Pend Oreille kokanee.

Sex composition of kokanee in the catch and on the spawning grounds.

The sex composition of kokanee appearing in the creels and on the spawning grounds may be found in Tables 7 and 11. This information is reproduced in Table 12.

Lengths of two-year-old kokanee in special collection.

During the summer and fall of 1957 it was possible to build up a small collection of kokanee of a size range between the fry and the fish in the creels. All but one of these kokanee were recovered from'the stomachs of larger game fish. Many of the ingested fish were badly decomposed and unsuitable for sampling, but nine were measured and scales collected from eight of these. In every case the scales indicated that these fish were in their second year of life. Lengths of the fish are listed in Table 13; the one fish lacking scales has been included on the basis of size alone.

Table 12. Sex composition of kokanee in the catch and on the spawning grounds, February through December, 1957, Lake Pend Oreille, Idaho.

Month	Area	Number of individuals	Percent Male	Percent Female
FISH IN THE CATCH				
February	South	16	56.3	43.7
March	South	194	52.6	47.4
April	South	171	45.0	55.0
May	South	152	63.2	36.8
June	South	106	67.9	32.1
	North	110	68.2	31.8
July	South	104	61.5	38.5
	North	95	63.2	36.8
August	South	360	61.4	38.6
	North	446	57.8	42.2
September	South	250	60.0	40.0
	North	191	60.7	39.3
October	South	334	78.4	21.6
FISH ON THE SPAWNING GROUNDS				
November	Granite Creek	261	46.4	53.6
December	Granite Creek	311	34.4	65.6

Table 13. Total lengths in inches of two-year-old kokanee in special collection, 1957, Lake Pend Oreille, Idaho.

Date	Sampling method and location	Total length, inches
7/10	found floating in Garfield Bay	4.1
7/28	from stomach of 1½ lb. Kamloops caught near Hope	4.0 3.5 5.0
9/26	from stomach of 3½ lb. Dolly Varden caught near Talache	5.0 5.5 (no scales)
10/10	from stomach of 3½ lb. Dolly Varden caught near Hope	4.6 4.9
10/12	from stomach of 3½ lb. Dolly Varden caught near the Green Monarchs	4.5
10/18	from stomach of 3½ lb. Dolly Varden caught near the Green Monarchs	4.4

ANALYSIS AND DISCUSSION

This report is a sequel to the 1956 age and growth study (Whitt, 1958), and, as such, cross reference will occasionally be made to the 1956 report which contains data from 1948 through 1954 as well as 1956. The term "age class" has been used in this report in two connotations which, although not contradictory, might have caused some confusion. The following examples should clarify the situation. An age class III fish would be one whose scales possessed three annuli (yearly growth checks). Such a fish could be in either its fifth or fourth year of life depending on whether or not the current annulus had already been laid down for that year of life. An age class three-year fish, also for convenience called a three-year-old fish, would, on the other hand, be in its third *year* of life following conception at spawning time. This fish could have scales possessing either one or two annuli depending on the time of the year when it was collected.

Development of kokanee fry.

The fry collected during 1957 had completed several months of their first year of life when they quit the gravel of the spawning grounds and took up an active existence in the lake. Their diet for the remainder of the year was qualitatively similar to that of their elders. By October, the time of general formation of discernible scales, the fry averaged about 1-1/2 inches in total length. Accelerated growth was still continuing towards the end of November. Lack of further samples stopped the tracing of growth at this point, but as yet there was no sign of the beginning of annulus formation on the scales. A selected sample of small fish collected during February, 1958 yielded scales possessing only one annulus. However, this annulus was fol.-haled by extensive scale development, and the fish ranged in size from 5-1/2 .to 7 inches. The 1957 fry averaged only 2 inches in length by the end of November; therefore, these one-annulus fish of 1958 had obviously grown another year. The author also examined a few scales from kokanee in the 4-to 5-inch range recovered from the stomachs of larger game fish after June, 1957. These scales displayed a single annulus lying close to the margin. This led the author to conclude that the fry of 1957 will lay down their first annulus sometime during the first half of their second year of life.

Development L older kokanee, During 1957, only 19.0 percent of all the fish aged were five years old

or older (Table 4). Five-year olds formed by far the greater part of this number, and seven-year-old fish were completely absent. When the percent-ages of the age groups by months (Table 4) were applied to the estimated catch by month (Whitt, 1958c), a total of 18.7 percent of the entire catch for 1957 was calculated to be fish in their fifth or sixth year of life. This may be compared to a value of 57.6 percent in. the 1956 catch (Whitt, 1958). Mr. Whitt has stated that the data for the years 1948 through 1954, although meager, indicate that the catch for these years was composed of

fish predominately four-years old. Therefore, as Mr. Whitt has already surmised, the longevity of the 1956 kokanee might indeed be a temporary phenomenon.

The back-calculated lengths for year classes in Table 6 indicate that fish taken in 1957 displayed slightly greater growth at the time of formation of both the first and the second annulus than did the fish collected in 1956. This is surprising as fish taken in 1957 were supposed to be noticeably smaller on the whole than those taken in 1956, as further evidenced by comparisons of average lengths by months for both of these years.

As was noted for 1956, inspection of Figure 2 reveals that older fish in the catch display little growth prior to June. Fish in the third year of life, however, may well be showing marked growth prior to June. The sample of threes is small for these months, but any selectivity in size would be towards the larger fish, as the smallest threes would be less accessible to the type of tackle used and many slightly larger threes would be discarded from the creels. The irregularity of the growth curves for both three-year-old and six-year-old fish is possibly due to the small size of the samples (Table 4). The growth pattern of these fish may also be derived from examination of the length-frequency curves (Figures 3 to 18), but here the observer should keep in mind that the age composition of the fish sampled is constantly changing as shown in Tables 4 and 10. Also, the sex ratio varies throughout the year, and, as the females are generally somewhat smaller than the males, this will have some effect on length frequencies.

It is interesting to note the difference between the characteristic length-frequency curves for the north and south areas of the lake. Unfortunately, length data for the north area could only be collected from May through September, and the age distribution of the fish has not been broken down by area. The curves for the north area seem to indicate the presence of three modes, chose for the larger fish lying relatively close together. This may be due
the presence of three separate age classes in relatively large numbers. However, this possibility is diminished by an examination of Table 4. Although Table 4 has not been separated as to north or south area, the marked predominance of only two age classes for each month (86.2 to 100 percent four- and five-year olds before August, and 88.6 to 97.5 percent three- and four-year olds after) would indicate that this condition exists for both areas of the lake. The presence of three modes is also apparent for the south-area curve of September, and this further refutes the possibility that the three modes indicate three age classes. The trimodality may be due to a racial difference in the fish, existing within as well as between the north and south areas.

During 1956, fish from the north end of the lake averaged slightly longer than those from the south end. Mr. Whitt states that this phenomenon has also been noted for previous years by the commercial fishermen, and it was evidenced by greater poundage per limit catch. However, in 1957, fish caught in the north area were on an average shorter than those taken in the south area (Table 7). Examination of Figures 6 to 15 indicates that fish in the shorter-length group, possibly immatures (Tables 8 and 9), form a larger proportion of the north area curve. This might account for the smaller average length evinced by north area fish. Mr. Whitt has noted the occurrence of 10 percent immatures in the north area catch for May of 1956 compared to four percent for the south area. May, 1956 was the one month out of the five that north

area fish averaged shorter. It also might be noted from Table 7 that, in September, 1957 when the ratio of immature fish for both areas was nearly equal (Table 9), the average length of sexed fish from both areas corresponded closely within sexes. Therefore, it may be concluded that this difference in average length is primarily due to the inclusion of a disproportionately large number of immature and/or stunted fish in the north area catch rather than a slight difference in the length of the larger fish.

As in 1954 and 1956, male fish dominated the catch in 1957 (Table 12). Cross reference to Tables 9 and 12 and Figure 16 for sex, maturity, and size distribution of the catch seems to substantiate Mr. Whitt's (1958) conjecture that the predominance of males in the catch is a measure of their aggressiveness and the result of sex, maturity, and size. Fish on the spawning ground are predominantly females (Table 12).

Three-year-old fish, as might be expected, displayed more rapid growth during 1957 than did the older fish. The more precocious three-year olds approached the older age classes in size as the year progressed (Table 5), and by August and September a considerable number are listed as mature fish destined to spawn that current year (Table 8). The rather marked delineation in size between mature and immature fish, as shown in Table 9, indicates that the ability to spawn is more closely related to size than it is to age. Therefore, the error would probably not be great if these kokanee were judged for maturity on the basis of size alone. However, size can hardly be used as an accurate criteria of age, as a good many of the four-year-old fish were no larger than the average three (Table 5), and about 10 percent of the four-year olds are immature (Table 8). The small number of immatures in the October catch is no doubt due to the aggressiveness of the mature males, which has already been discussed. Three of the 4 three-year-old fish aged for October were sexually mature (Table 8). About four percent of the Granite Creek spawners were aged as being three-years old (Table 10).

The aged spawners, taken in December, were all females. This sample of 68 fish showed more than 91 percent to be ending their fourth year of life (Table 10). The remainder were divided evenly between three-year-cycle and four-year-cycle fish. Table 11 indicates that December spawners are slightly smaller than those appearing on the spawning grounds in November. This may be a further indication of a relationship between size and maturity. Also, a larger percentage of males was noted on the spawning grounds in November than in December.

RECOMMENDATIONS

In view of the ambiguities involved in aging Lake Pend Oreille kokanee from scale readings, the author feels that further corroborating investigation should be carried on in this field, if the age-growth study is destined to be continued. A relatively small sample of known-age fish would substantiate determinations made from scale readings, and a large proportion of the younger fish can be aged with reasonable certainty. If some method were devised to collect these immatures and mark them without injury, a few scales could be collected for again purposes and the fish released to appear again in the catch or on the spawning ground. However, the 1957 tagging experiment (Whitt, 1958b) has shown that a large number of fish would have to be tagged to ensure a suitable recovery, and for best results each fish would have to carry some identifying feature, such as a numbered tag. Early in 1958, some work wzs done with otoliths. The otoliths were reasonably easy to collect, but preliminary investigation suggests that they may present as much or more of a challenge to interpretation than do the scales.

The possibility of racial differences existing between small areas in the lake has been noted by prior investigators. Such an analysis was not attempted in the 1957 report, but raw data for individual localities were kept separate and are available for interpretation. In this connection, it might be noted that all of the spawning data were derived from one area, and if schooling and homing instincts are pronounced in this species, only one race may be represented in this sample. It is suggested that representative samples be taken from other spawning grounds.

While the sizes of the length-frequency collections were fairly comparable throughout the year, the size of scale samples varied markedly, as they were determined by the size of the catch. Consequently, the aged samples for some months are too small to be significant, and others are so large as to become clumsy. Therefore, it is advised that samples of a more uniform size be taken, and that complete information as to sex, maturity, and weight be taken with each sample.

The author has noted what he believes to be selectivity on the part of fishermen. Obviously, individual fishermen vary as to the size of fish they will retain in their creels; that a large number are discarded is evidenced by the number of small fish, brought in on request during February of 1958, which otherwise would not have appeared in the catch. On June 29, 1957, the author recorded the lengths of 84 fish taken in a single catch from the north area of the lake. These 84 fish comprised about 19 percent of the complete length sample for that end of the lake, and they averaged almost 0.8 inches less in total length than did the average for all other fish from that area. Therefore, this one large sample had a marked effect upon the average length recorded for the north area in June. Many fishermen, on catching so large a number of small fish, would have transferred their fishing effort to another area where larger fish could be had; the fishermen in question did not. Also, the author noted that, in spite of the sex ratio established for the catch (Table 12), many fishermen brought in fairly large catches comprised wholly of fish of one sex or the other. When questioned, these individuals admitted that they had fished in only a limited area. This

would suggest that these kokanee school separately by sex, and the inclusion of exceptionally large samples might also influence the sex-ratio data. Therefore, the author suggests that in the future large individual samples be excluded from the data. More accurate results might be obtained from less total data if a greater number of fishermen were sampled. At the same time, the collection of data from isolated areas of the lake could be more uniformly taken to test for racial differences.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the aid of Messrs. White and Whitt, and Mr. and Mrs. Miller in the collection of data for this report; to all members of the creel-census crew, my wife, and others who recorded data for the author; and to Mr. Charles Whitt, Project Leader, and Mr. Forrest Hauck, Fisheries Research Supervisor, Idaho Fish and Game Department, for their assistance in the preparation of this report.

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1958b. Kokanee tagging experiments, 1957. Idaho Fish and Game Department, Annual Progress Report, Project F 3-R-7.

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1958c. Lake Pend Oreille creel census, 1957. Idaho Fish and Game Department, Annual Progress Report, Project F 3-R-7.

DATA AND REPORTS:

All data and reports are on file in the offices of the Idaho Fish and Game Department at Boise, Idaho, and the project biologist at Athol, Idaho.

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Date: April 4,1958

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APPENDIX

PHOTOGRAPHS OF KOKANEE SCALES

WITH

POSITION OF ANNULI NOTED

Photographs of kokanee scales.

Several photographs were made of scales from fish of the various age classes taken throughout the year. These are found in Plates 1 to 24. True annuli are denoted by the numbers I, II, III, etc.; false annuli are indicated by an "F".

The author wishes to point out that the age of each specimen, as indicated in the caption, has been determined from all of the readable scales mounted for that fish. Therefore, the scales photographed did not alone influence the determined age of the specimen. Many of the scales with false annuli indicated have been specially selected to demonstrate the clarity of these growth checks; other scales from the same fish may not have possessed so clearly defined false annuli. The same also applies to the absorbed scales. Plate 21 was included primarily to demonstrate the relatively great absorption which has taken place by October on the scales of male kokanee, as compared with the scales of female kokanee (Plate 20). The actual age of the fish of Plate 21 was determined from the remaining scales.

The reader's attention is drawn to the opening paragraph under "Analysis and Discussion" which explains why fish having scales with the same number of annuli may be aged a year apart, depending upon the time of year and overall scale development.

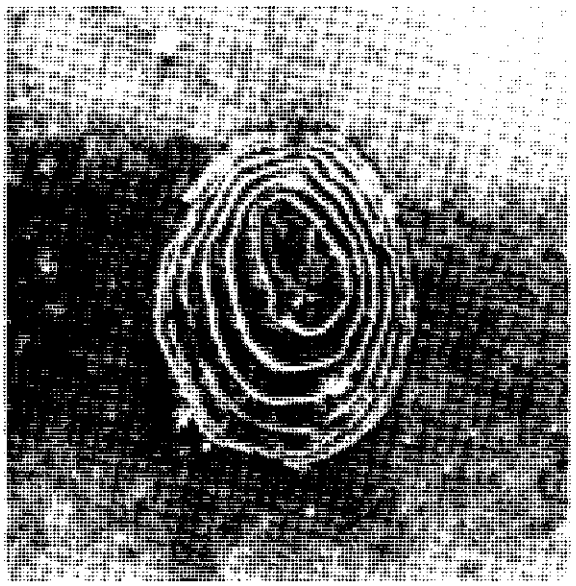

Plate 1. Precocious one-year-old kokanee (abnormally great scale development), 1.5 inches total length; south area, October 9, 1957.

Plate 2. Typical scale from one-year-old kokanee, 1.8 inches total length; south area, October 10, 1957.

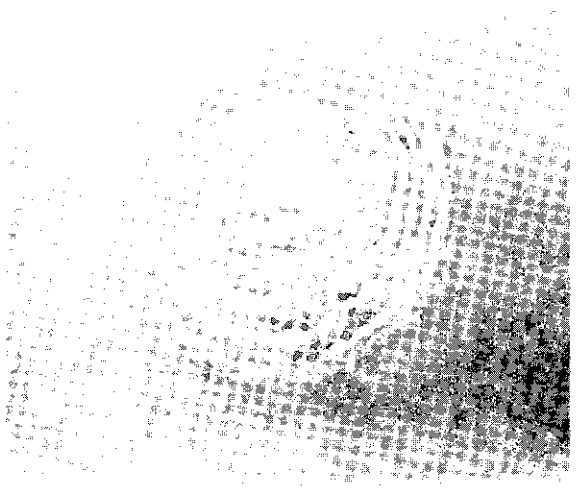

Plate 3. Typical scale from one-year-old kokanee, 2.1 inches total length; south area, November 27, 1957.

Plate 4. Two-year-old kokanee, 4.1 inches total length; north area, July 20, 1957.

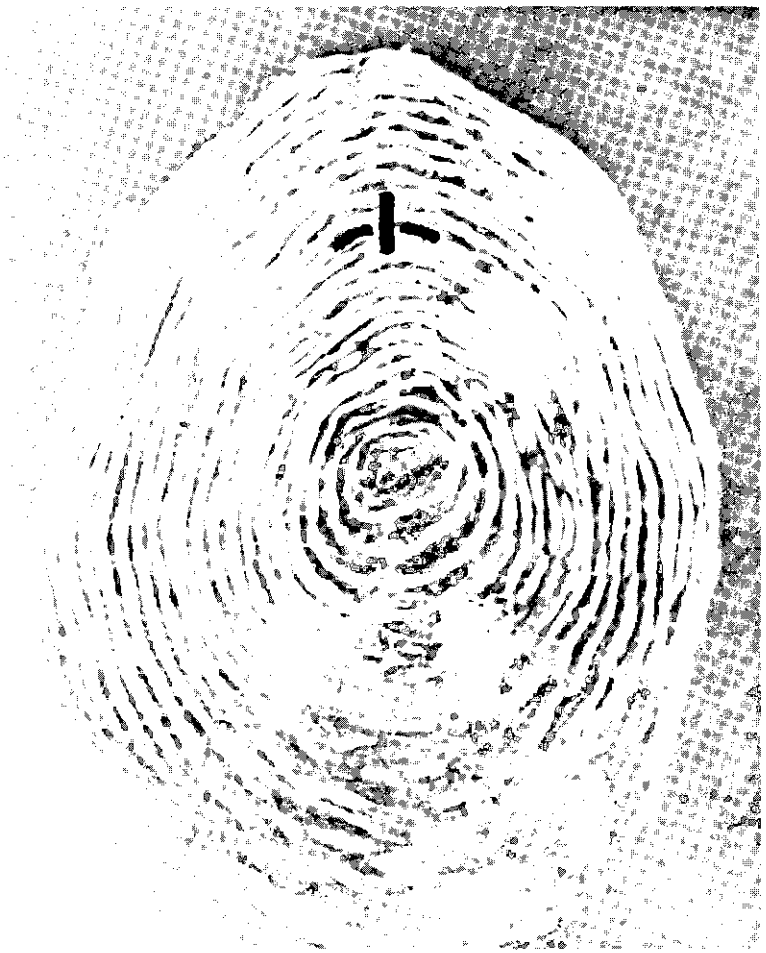

Plate 5. Two-year-old kokanee, 4.5 inches total length; north area, October 12, 1957.

Plate 6. Scale #2302: three-year-old kokanee, sex unknown, 6.3 inches total length; south area, March 13, 1957.

Plate 7. Scale #2213: four-year-old kokanee, sex unknown, 8.2 inches total length; south area, March 2, 1957.

Plate 8. Scale #2641: five-year-old kokanee, sex unknown, 9.0 inches total length; south area, April 13, 1957.

Plate 9. Scale #2672: six-year-old male kokanee, 9.3 inches total length; south area, April 15, 1957.

Plate 10. Scale #2772: four-year-old kokanee, sex unknown, 8.9 inches total length; north area, May 15, 1957.

Plate 11. Scale #3104: six-year-old kokanee, sex unknown, 9.2 inches total length; north area, June 16, 1957.

Plate 12. Scale #3224: three-year-old male kokanee, 7.2 inches total length; south area, June 22, 1957.

Plate 13. Scale #3149: four-year-old kokanee, sex unknown, 7.8 inches total length; south area, June 16, 1956.

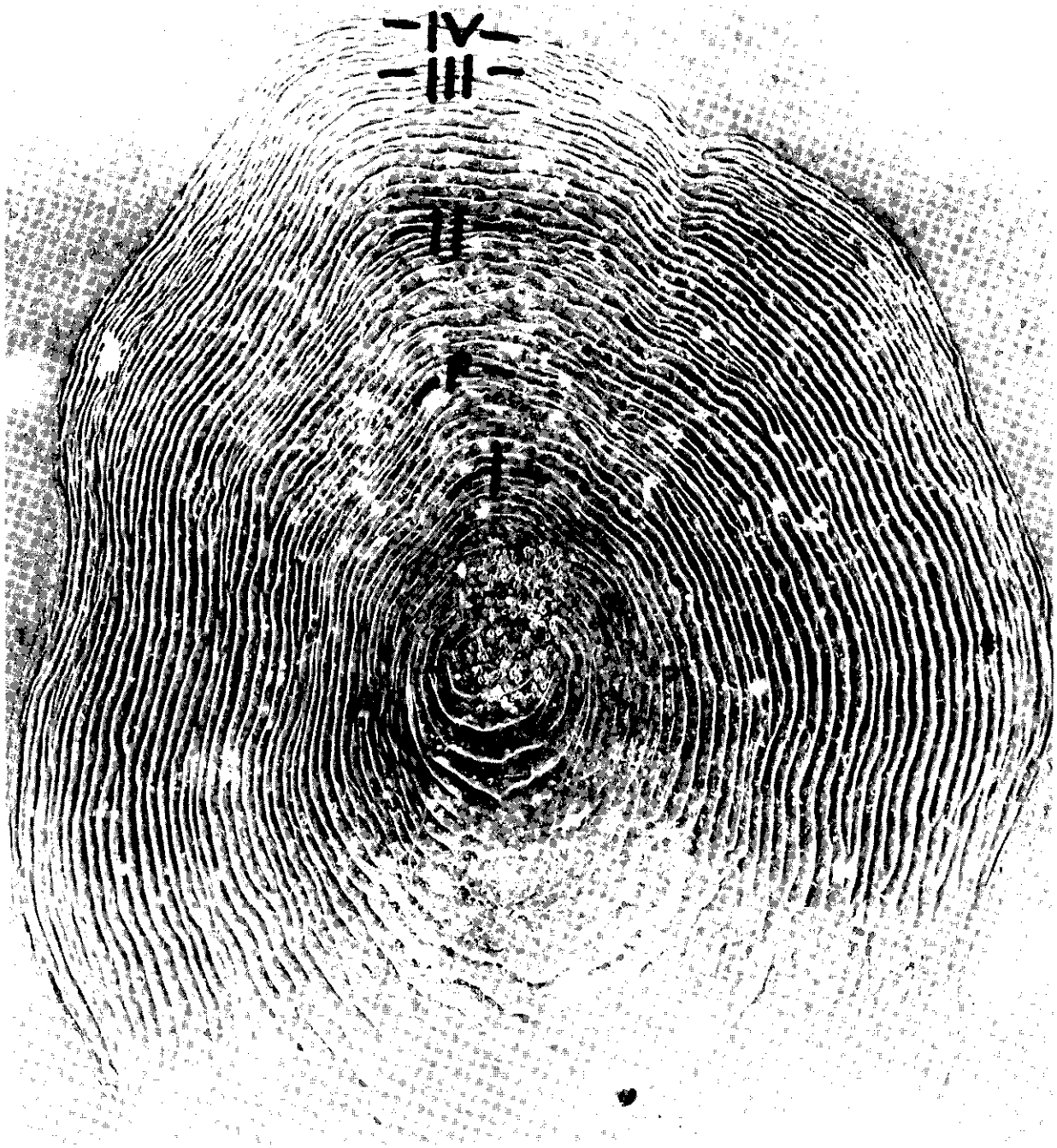

Plate 14. Scale #3235: five-year-old male kokanee, 8.1 inches total length; north area, June 23, 1957.

Plate 15. Scale #4461: three-year-old male kokanee, 8.7 inches total length; north area, September 3, 1957.

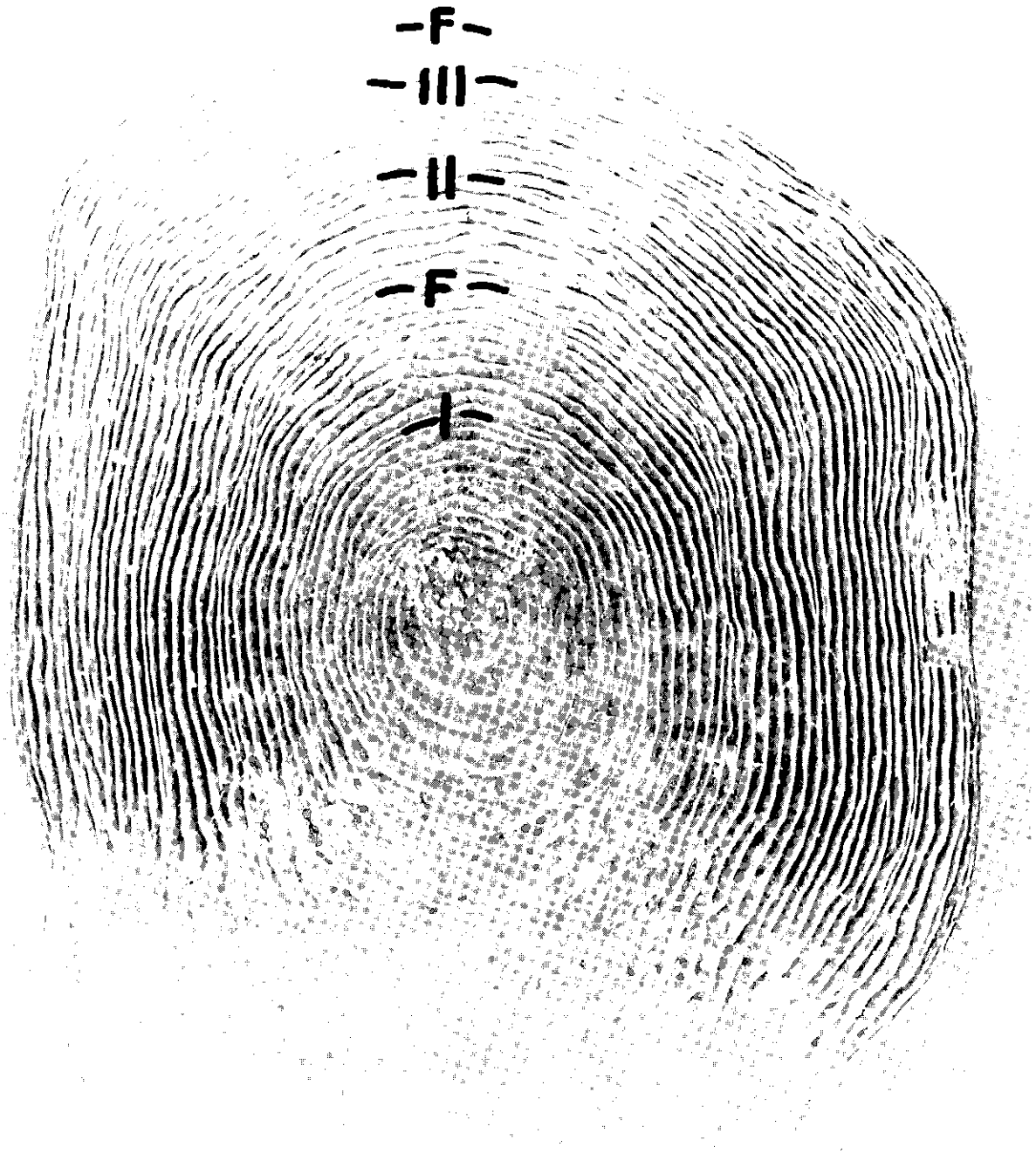

Plate 16. Scale #4465: four-year-old female kokanee, 9.9 inches total length; north area, September 3, 1957.

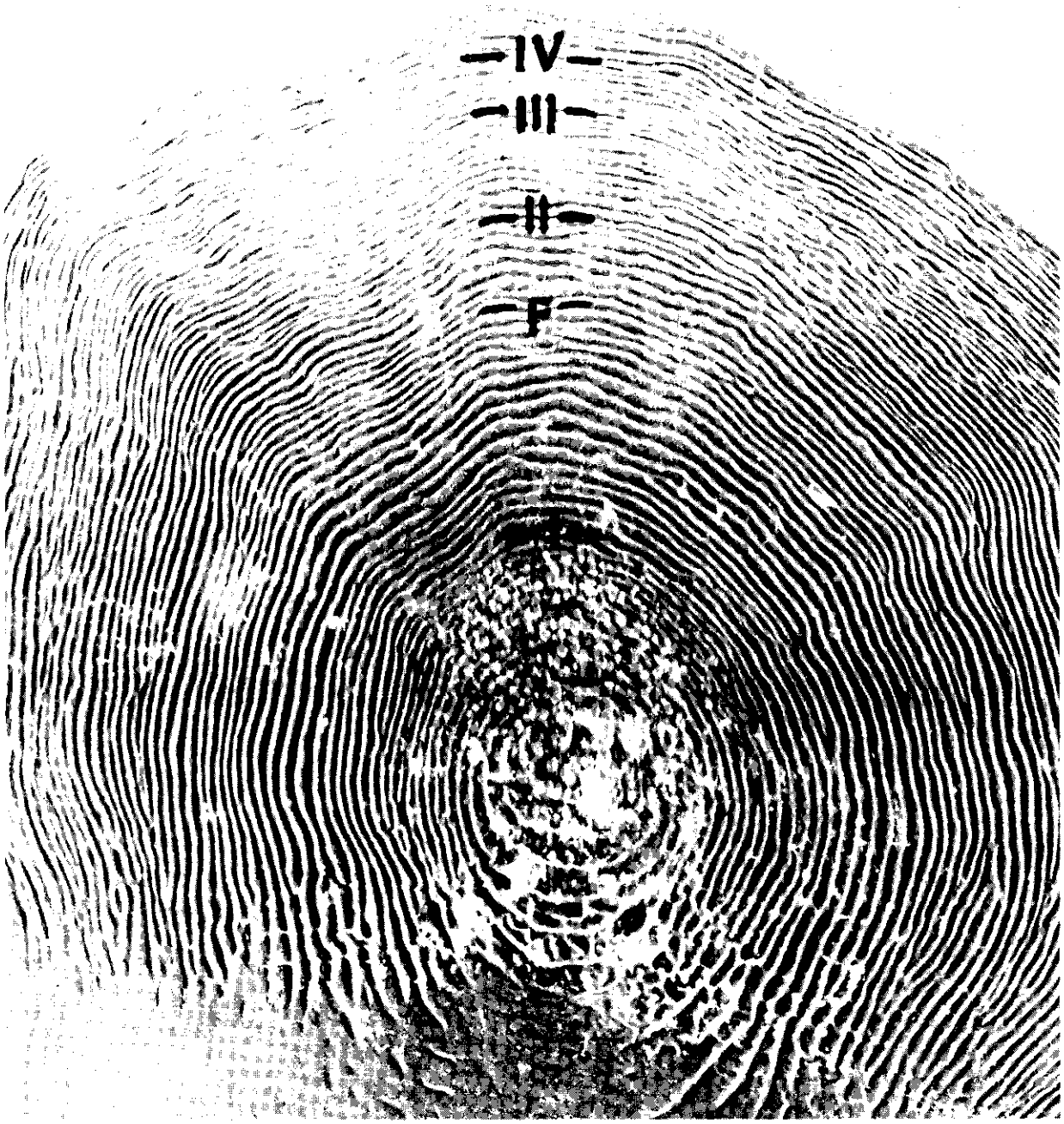

Plate 17. Scale #4498: five-year-old male kokanee, 10.9 inches total length; north area, September 3, 1957.

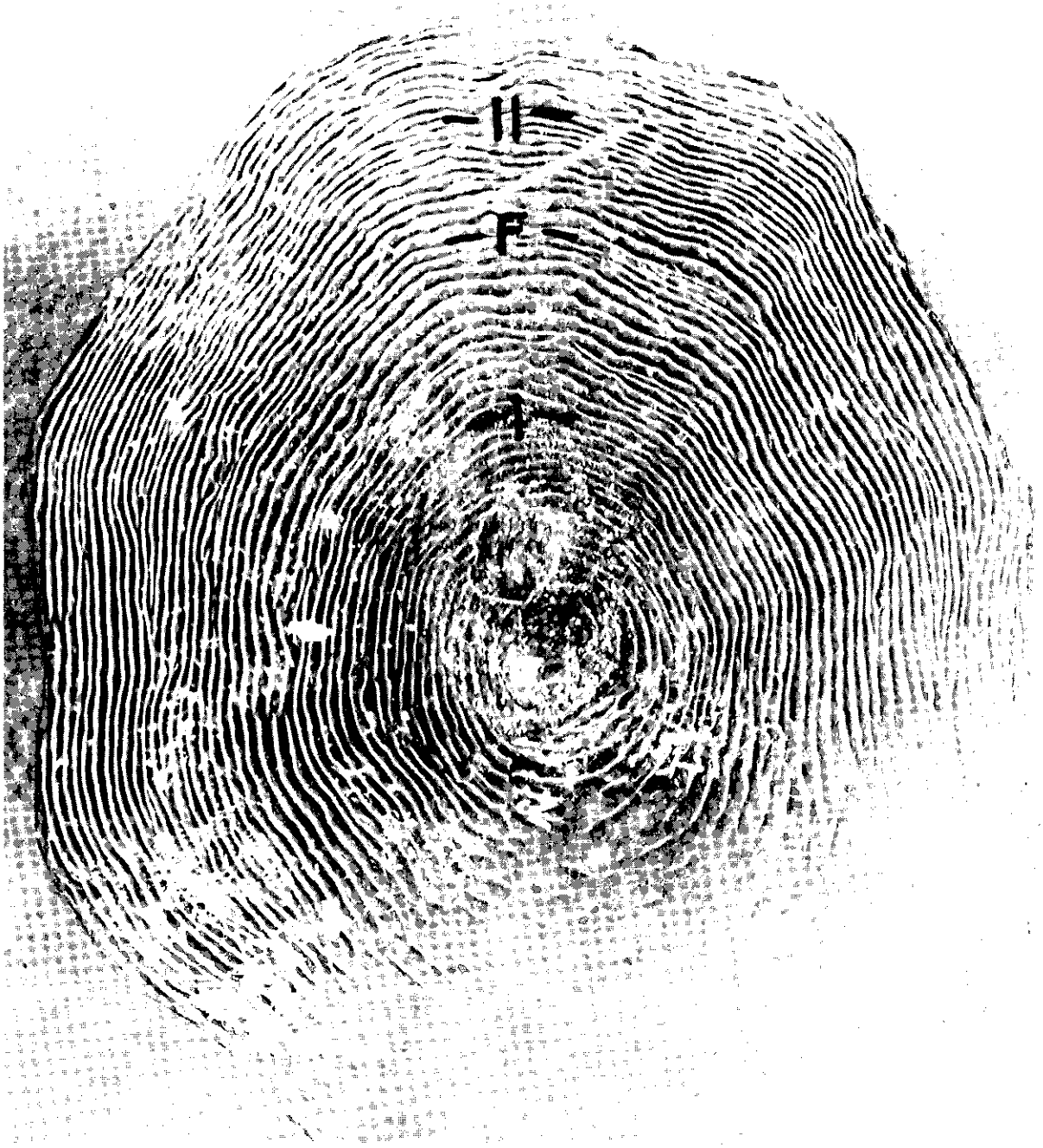

Plate 18. Scale #4526: three-year-old female kokanee, 7.7 inches total length; north area, September 3, 1957.

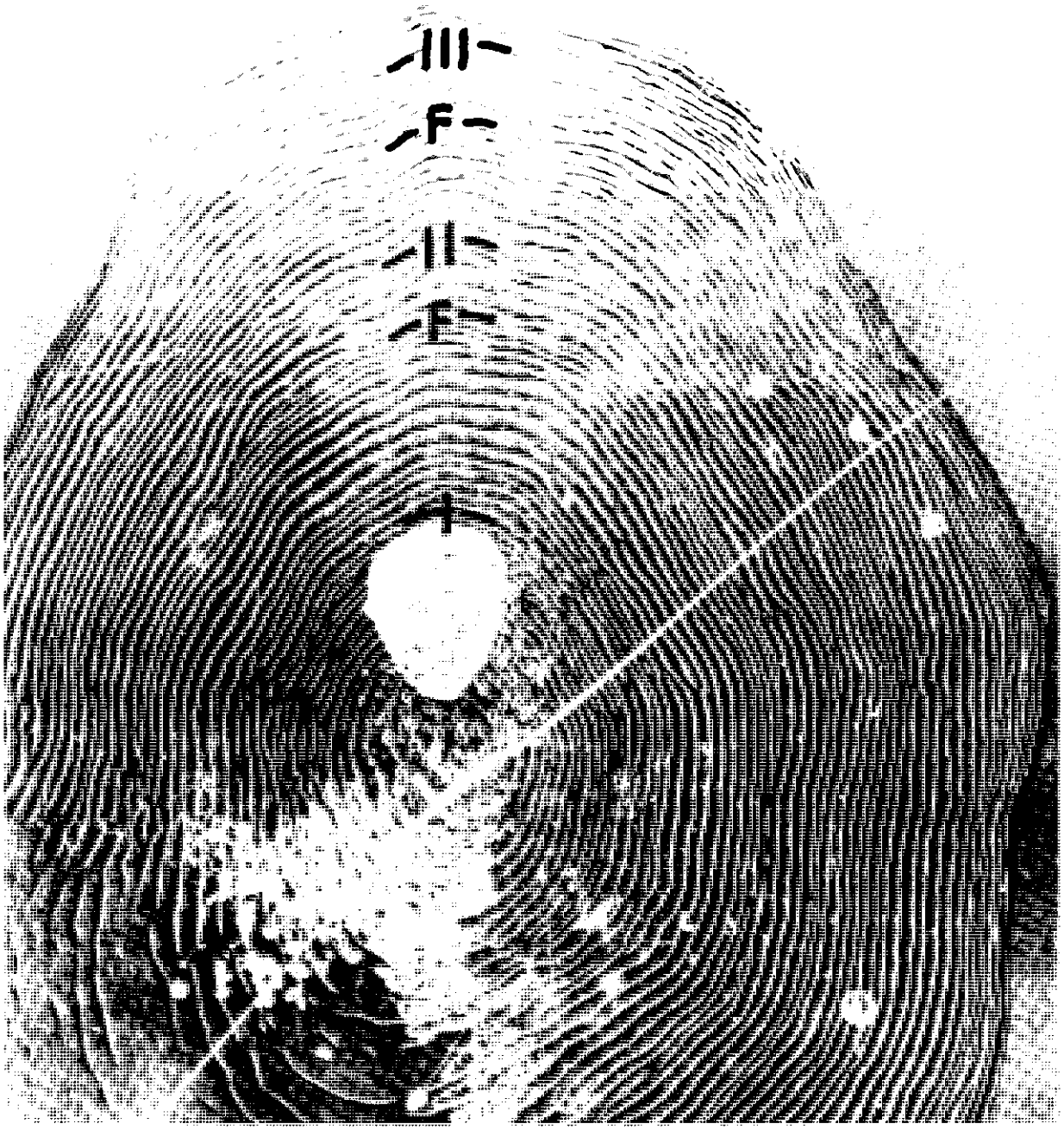

Plate 19. Scale #4610: four-year-old male kokanee, 10.4 inches total length; north area, September 4, 1957.

Plate 20. Scale #4635: four-year-old female kokanee, 10.4 inches total length; south area, October 7, 1957.

Plate 21. Scale #4648: four-year-old male kokanee, 10.2 inches total length; south area, October 7, 1957.

Plate 22. Scale #4668: three-year-old female spawner, 9.8 inches total length; Granite Creek, December 10, 1957.

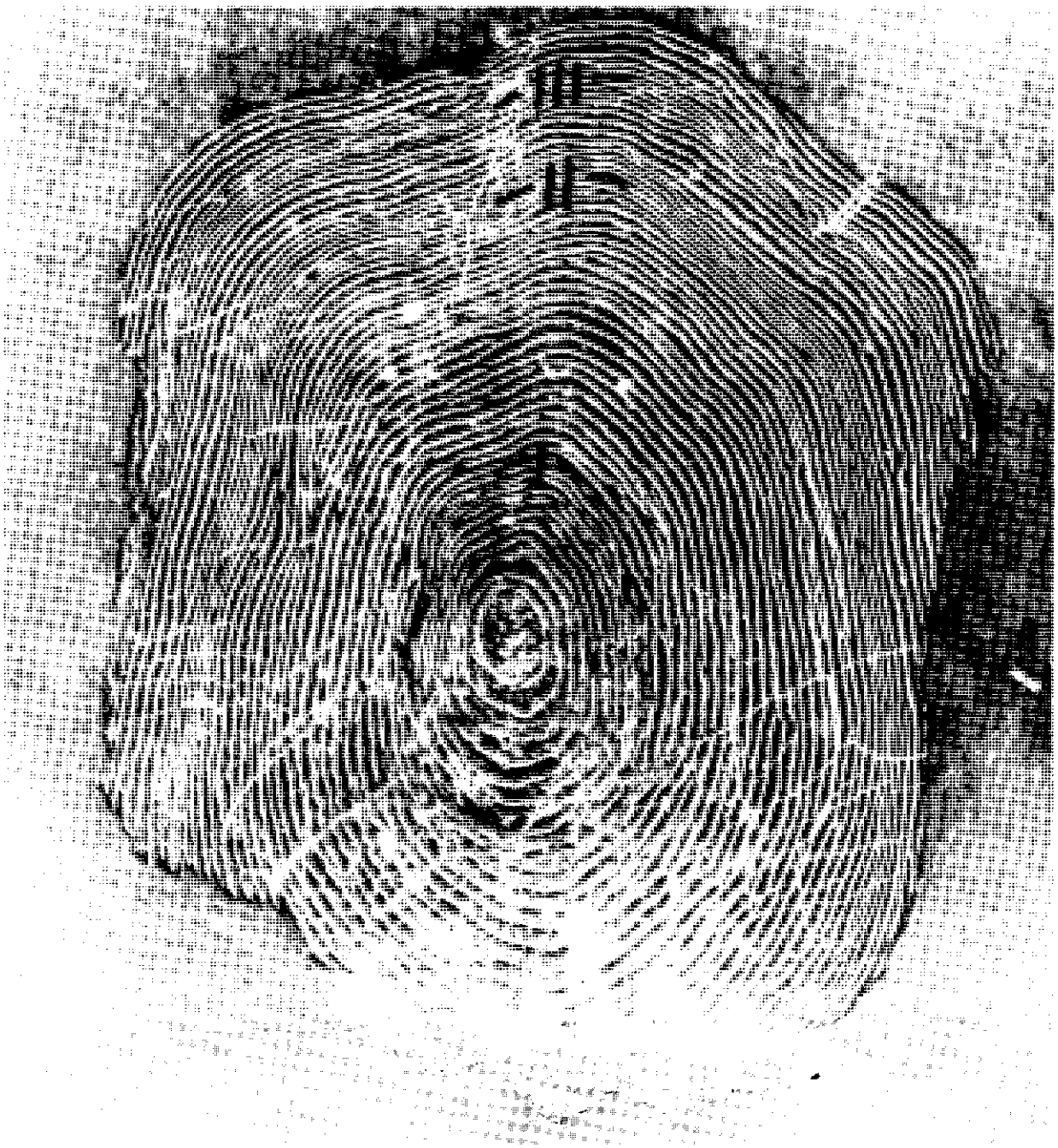

Plate 23. Scale #4702: four-year-old female spawner, 10.0 inches total length; Granite Creek, December 17, 1957.

Plate 24. Scale #4721: five-year-old female spawner, 10.3 inches total length; Granite Creek, December 21, 1957.