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Most all research on life histories of fish in which age and growth are considered is based on the theory that annual rings are formed on the scales which can be counted to determine age, and that scale diameters increase proportionately with the length of the fish which permits the calculation of growth for each year of life.

In the spring of 1947 a total of 556 adult yellow pikeperch, *Stizostedion v. vitreum* (Mitchill), commonly known as the walleye, was taken from State hatchery operated gill-nets, tagged and released in Spirit Lake as a part of a population appraisal (Rose, 1948). Scale samples, weights and measurements were taken from 252 of these fish for later analysis. In addition to these, scale samples were taken from 88 walleyes collected in 1946, 1948 and 1950 to obtain data on small and large adult size groups. From the examination of these scales and the length and weight data, an evaluation of the age and growth has been made which provides a practical basis for comparison with similar published material.

Age and Growth

Scales for this study were for the most part obtained from below the lateral line in the anterior portion of the fish, with no attempt to select them from "key" areas. Scales were mounted in water between glass slides for examination by microprojection. The relative location of each annulus from the focus to the anterior margin of the scale were marked on tag-board strips from which growth rates were determined by use of nomographs developed especially for this purpose (Carlander and Smith, 1944). Since key scales were not collected in 1947, it was virtually impossible to determine the body-scale relationship due to the vast variance in scale radial dimensions in fishes of the same length distributions. It was also necessary, as a consequence, to calculate growth starting from zero on the nomograph rather than from a compensatory point representing the presumed length of the fish at the time of scale formation. Had several hundred samples been obtained from each of the representative size groups, the body-scale relationship could have been determined even though key scales were not collected as has been shown by Carlander (1945). For our practical purposes, growth

Table I

Average Calculated and Actual Standard Lengths of Walleyes (Yellow Pikeperch) collected in April and May of 1947 (primarily, see text).

Age Class	Number Fish	Average Calculated Standard Lengths in Millimeters at Annulus										Av. Standard length at Capture
		1	2	3	4	5	6	7	8	9	10	
II	11	161	264									264
III	44	150	234	289								289
IV	44	157	238	310	361							361
V	167	157	240	311	366	408						408
VI	33	161	239	307	373	419	458					458
VII	9	163	256	327	389	444	489	529				529
VIII	2	152	233	313	375	436	479	507	537			537
X	2	137	210	306	386	430	472	501	531	557	597	597
Grand Average Stand. Length		155	239	309	376	427	476	512	533	557	597	
Average Total Length, inches		7.2	11.1	14.4	17.5	19.9	22.2	23.7	24.9	26.0	27.8	
Average Increment, inches		7.2	3.9	3.3	3.1	2.4	2.3	1.5	1.2	1.1	1.8	

Total Length—1.185 Standard Length

calculations were determined by direct proportion. From measurements of known age fish (see text) compared with the calculated growths, there does not seem to be too high a magnitude of error involved.

Averages of calculated and actual lengths of 320 Spirit Lake walleyes in eight age groups are shown in Table 1. It will be noted that actual lengths at capture are the same as the maximum calculated lengths. Since the fishes were obtained primarily during the spawning runs of late April and early May, it is assumed that this approaches the maximum growth for the year. Scale samples obtained early in July of 1946 and 1947, all had annuli at the extreme anterior margins; consequently it is assumed that for practical purposes the maximum length was obtained for each year at the time of collection. Therefore all age-classes listed in the table (Table 1) have actually one less annulus than is inferred, plus a full year's growth increment. Standard length is the distance between the tip of the snout of the fish to the base of the hypural plate, and total length the distance from the tip of the snout to the tip of the compressed lobes of the caudal fin.

As is customary for the walleye, the first year's growth far exceeds the increments for any of the succeeding years. It is apparent that a leveling off occurs in the older age-classes.

The growth of Spirit Lake walleyes appears to be somewhat above average in comparison with those examined from other Iowa waters, and considerably higher than those from northern Minnesota. Table No. 2 illustrates a comparison of these growth rates. A previous study (Carlander, 1948) of scales collected from Spirit Lake walleyes from 1941 to 1945 is included to indicate possible changes in growth rates in this lake following in improvement in environmental conditions from 1944 through 1947. In this latter period the lake and adjoining sloughs were all connected due to high water resulting in increased amounts of forage. This may explain the increased growth reported in this paper. Growth rates of fishes are of course not static for any lake. Many variable factors may influence increments consequently any reported studies reflect conditions prevalent only for the year-classes involved, and cannot be held as "normal".

Length-Weight Relationship

An empirical formula for calculating the length-weight relationship of fishes has been determined (Hile, 1936), and is of practical value for comparing populations from year to year and with published data from other waters. It also provides a means for calcu-

Table II

Comparison of calculated growth of walleyes (yellow pikeperch) from Spirit Lake with other waters.

Name of Area	Number of fish	Average Calculated Total Length (inches) at Each Annulus									
		1	2	3	4	5	6	7	8	9	10
1. Lake of the Woods	2,898	6.5	9.2	11.5	13.5	14.8	16.6	18.1	19.8	21.5	22.6
2. Iowa Lakes	216	5.0	9.2	12.4	15.0	17.1	18.6	19.9	21.5	23.2	24.7
3. Clear Lake	319	5.9	10.9	14.5	17.2	19.3	21.4	23.6	26.3	27.0	
4. Spirit Lake (1941-45)	80	4.9	8.8	12.4	14.8	16.9	18.5	19.8	21.5	23.2	24.7
5. Spirit Lake	320	7.2	11.1	14.4	17.5	19.9	22.2	23.7	24.9	26.0	27.8

Note—Areas No. 1, 2 and 4 cited from Carlander (1948).
Area No. 3 from Cleary (1949).

lating approximate weights where lengths only are available, and vice versa.

The relationship is expressed by the equation:

$$W = cL^n$$

where W = weight in grams
L = standard length in millimeters
c and n = constants (derived empirically from measurements of the average length groups of fish).

From this, the following equation was determined by the least squares method, providing evaluation of c and n:

$$\text{Log } W = -5.01127 + 3.09036 \text{ Log } L$$

The data determined from the equation are included in Table 3, and graphically in Figure 1.

Coefficient of Condition

In addition to the length-weight relationship, another indicator used for comparative purposes is the coefficient of condition or, K factor. This is a measurement of the relative degree of plumpness in individual fish, and may be determined by the commonly used formula:

$$K = \frac{W10^5}{L^3}$$

where W = weight in grams
and L = standard length in millimeters

Table III
The Length-Weight Relationship and Coefficient of Condition of Spirit Lake Walleyes

Average Standard Length, millimeters	Number Fish	Weight in Grams		Average K
		Observed Average	Calculated*	
259	8	292	280	1.684
282	19	355	364	1.584
297	18	425	427	1.623
318	14	500	526	1.570
333	11	691	608	1.871
361	23	800	780	1.714
382	74	981	929	1.760
401	57	1075	1080	1.667
420	32	1213	1246	1.638
437	30	1339	1408	1.604
454	26	1578	1585	1.687
477	14	1761	1834	1.621
502	7	2220	2126	1.753
572	7	3029	3237	1.617
Total.....340			Grand Average.....	1.638

*Log $W = -5.01127 + 3.09036$ Log L.

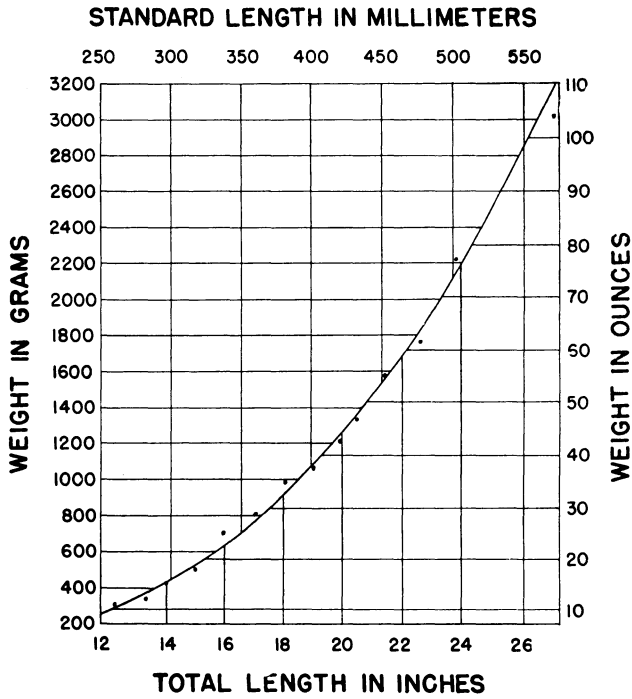

Fig. 1. The length-weight relationship of walleyes from Spirit Lake.

or more rapidly by the use of reciprocals (Carlander, 1950). The K factors for the Spirit Lake walleyes included in this study are averaged in Table 3. All determinations are based on spent females and males used in hatchery spawn taking operations. The mean K for all adult size groups and the grand average K (1.638) are high, indicating good growing conditions for the species in Spirit Lake.

Clear Lake in Cerro Gordo County, supports a large population of walleyes, and is similar to Spirit Lake in many physical and biological features. The average K of the walleyes in this lake (Cleary, 1949) was 1.507 for fish collected from 1941 through 1947.

The average K of Spirit Lake walleyes is exactly equal to the highest reported for this species (Carlander, 1950) in the United States and Canadian waters.

Age and Growth of Known Age Fish

All fingerling walleyes stocked in Spirit Lake from the nursery ponds are permanently marked by fin-clipping prior to stocking in order to evaluate by later sampling, the stocking program and other pertinent factors in the management of the species. These fish are

about 5 months old at the time of stocking, and range from 4 to 7 inches in total length as a rule. In order to recognize these fish in later years one of the paired fins is removed at the time of stocking. To avoid confusion concerning the age at recapture, a different one of the paired fins is removed from each year's supply. Several recaptures of these fish have been obtained during succeeding years of spring gill-netting operations on the lake. Some of these have been weighed, measured and scale samples taken for growth and age analysis by the scale method. The age determination in each of these recaptured fish accurately corresponds to the known age of the fish and the growth analysis compares favorably with the calculated growth of the unmarked fish reported in Table 1. The growth analysis of these recaptured fin-clipped walleyes on which complete data is available, is included in Table 4. Scales from each of these fish bore the exact number of annuli corresponding to the known number of years of life, thus clearly demonstrating the validity of the annulus as a true year mark. Inasmuch as the fish were collected in April, the last year's increment is considered a full year even though the annulus was not laid down.

Summary

It is apparent that conditions in Spirit Lake for the growth of walleyes approached the optimum for this latitude and for the year classes included in this study. Growth rates of 312 adult walleyes were calculated by the direct proportion method from examination of scales.

The length-weight relationship was determined and is described by the formula: $W = -5.01127 + 3.09036 \log L$.

The average coeffecient of condition, or K, was 1.638 for spent females and males, which is considerably above most previous reports from other waters.

Further evidence of the validity of the annulus as a true year mark is presented from data obtained from known age walleyes.

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Table V

Growth of Fin-clipped Fingerling Walleyes from Nurseries after Stocking in Spirit Lake.

Serial Number	Sex	Weight Grams	"K"	Year Class	Age Group	Calculated Length at Annulus					Fin Clipped	Year	Recapture
						1	2	3	4	5			
T 1024	M	272	1.21	1945	I I	189	282*				R.V.	1945	April, 1947
T 1010	M	408	1.64	1944	I I I	144	238	292*			L.V.	1944	April, 1947
T 1250	M	362	1.45	1944	I I I	154	200	292*			L.V.	1944	April, 1947
E 380	F	425	1.64	1944	I I I	132	228	296*			L.V.	1944	April, 1947
506	F	865	1.87	1944	I V	116	198	305	359*		L.V.	1944	April, 1948
E 1	M	1134	2.22	1941	V	129	222	296	348	371*	L.P.	1941	April, 1946
E 4	F	1204	2.17	1941	V	138	204	276	336	381*	L.P.	1941	April, 1946
E 8	M	1332	1.65	1941	V	194	258	360	410	432*	L.P.	1941	April, 1946
E 5	M	1020	1.83	1941	V	154	232	319	356	382*	L.P.	1941	April, 1946
E 31	M	1021	1.36	1941	V	153	217	314	384	422*	L.P.	1941	April, 1946
E 7	M	1077	1.53	1941	V	120	192	288	351	412*	L.P.	1941	April, 1946
E 6	F	1134	1.52	1941	V	159	226	314	393	418*	L.P.	1941	April, 1946
E 28	F	836	1.76	1941	V	113	170	226	332	362*	L.P.	1941	April, 1946
E 2	M	1381	2.06	1941	V	194	284	342	379	406*	L.P.	1941	April, 1946
Average			1.71			149	225	302	366	398			

*Standard length at recapture in April—considered a full year's growth.
All calculated lengths are in standard length.

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