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LENGTH-WEIGHT RELATIONSHIP, AGE, SEX RATIO AND FOOD HABITS
OF THE SMELT (OSMERUS MORDAX) FROM CRYSTAL LAKE,
BENZIE COUNTY, MICHIGAN

by

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A review of the literature on the smelt reveals a lack of information on the length-weight relationship. In order to add some information on this subject, Dr. John Van Oosten of the United States Fish and Wildlife Service, and Dr. A. S. Hazzard of the Michigan Institute for Fisheries Research collected data on the length, weight, sex and sexual maturity of smelt caught by hook and line in Crystal Lake, Benzie County, Michigan, on February 29, 1940 and February 20-21, 1941. Scale samples were also taken and a cursory field determination of the stomach contents was made by the collectors. On June 12-21, 1940, some additional specimens were collected by means of gill nets (2 to 4 inch stretched measure) and a 100-foot bag seine (3/4 inch stretched measure) from the same lake by a lake inventory party of the Institute. The scale samples and data were turned over to the writer for analysis and compilation.

The smelt in Crystal Lake are descendants of the original stocking made in 1912. The eggs which were planted were obtained from the hatchery at Green Lake, Maine. From Crystal Lake the smelt have spread throughout most of the Great Lakes drainage (except Lake Ontario).

Length-Weight Relationship

Figure 1 shows graphically the length-weight relationship. The dots represent the empirical averages of the standard length and weight (the data

were tabulated originally by 5-millimeter intervals of total length). The smooth curve is the graph of the parabola whose logarithmic form is,

$$\log \underline{W} = -4.59918 + 2.8095 \log \underline{L},$$

where \underline{W} = weight in grams,

and \underline{L} = standard length in millimeters.

The equation was derived by fitting a straight line to the logarithms of the average lengths and weights of the smelt. The value 2.8095 shows that the weight of the smelt increases at a rate somewhat less than the cube of the length. Figure 1 has been so arranged as to permit ready conversions from standard lengths in millimeters and weights in grams to total lengths in inches and weights in ounces.

(Insert Figure 1)

Relationship Between Standard Length and Total Length

The various factors for conversions between standard and total length, with and without change in units of measurements, are given in Table 1.

These factors were not found to vary significantly with the length of the fish (most of the 5-millimeter intervals from 80 to 230 millimeters standard length were represented).

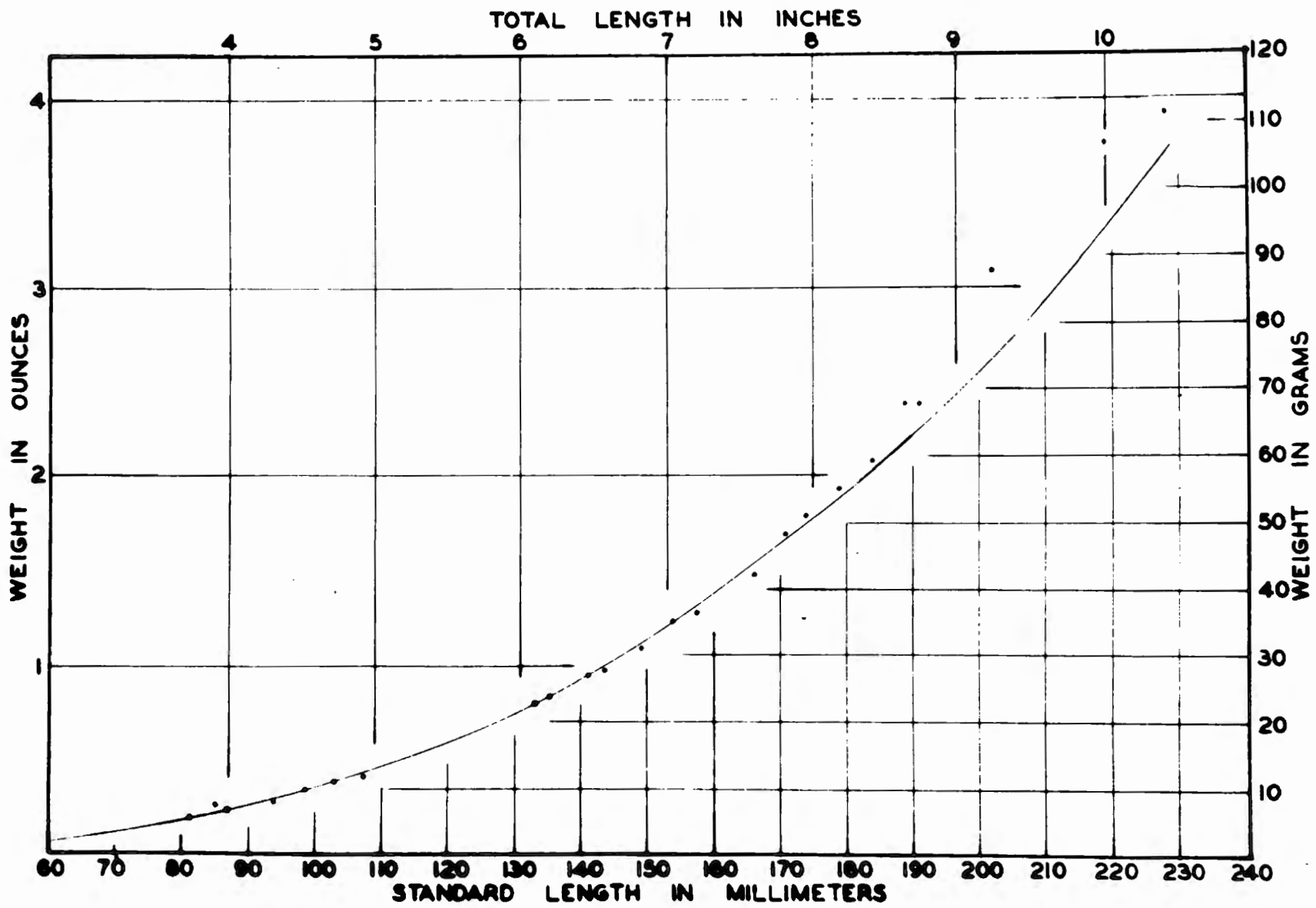


Table 1

Factors for the Conversion of Total and Standard Lengths of
the Smelt from Crystal Lake, Michigan

Number of fish	Conversion factors			
	T. L. † to S. L. † (no change in units of length)	S. L. to T. L. (no change in units of length)	S. L. (in millimeters) to T. L. (in inches)	T. L. (in inches) to S. L. (in millimeters)
241	0.858	1.165	0.045866	21.79

†T. L. = total length; S. L. = standard length

Average Length and Weight of the Age-Groups

The smelt grew most rapidly in both length and weight during the first two years of life (Table 2). The sex difference in the rate of growth was very small, although the females had a slight advantage over the males, especially in age-group III.

Table 2

Age and Size of the Smelt from Crystal Lake, Michigan

Month and year of collection	Number of fish	Sex	Age-group	Average standard length in millimeters	Average total length in inches	Average weight	
						grams	ounces
June 1940	10	unknown	I	92	4.2	8	0.28
June 1940	1	Male	I	133	6.1	23	0.80
June 1940	1	Female	I	107	4.8	12	0.42
Feb. 1940	23	Male	II* ↓	152	6.9	34	1.20
June 1940	6	Male	II	150	6.9	31	1.09
Feb. 1941	15	Male	II*	152	7.0	34	1.20
Feb. 1940	30	Female	II*	155	7.1	36	1.27
June 1940	8	Female	II	152	6.8	36	1.27
Feb. 1941	10	Female	II*	154	7.1	34	1.20
Feb. 1940	15	Male	III*	164	7.5	42	1.48
June 1940	4	Male	III	167	7.7	45	1.59
Feb. 1941	21	Male	III*	164	7.6	41	1.44
Feb. 1940	25	Female	III*	174	7.8	51	1.80
June 1940	1	Female	III	193	8.7	71	2.50
Feb. 1941	34	Female	III*	172	7.8	50	1.76
Feb. 1941	5	Male	IV*	175	7.8	52	1.83
Feb. 1940	4	Female	IV*	182	8.2	56	1.98
Feb. 1941	26	Female	IV*	180	8.3	58	2.04
Feb. 1941	1	Male	V*	174	8.1	54	1.90
Feb. 1941	1	Female	V*	184	8.4	61	2.14

↓ The asterisk after the age numeral indicates that the age exceeds by one the number of annuli observed on the scales. The fish had presumably finished the year's growth by February but the annulus would not be formed until more rapid growth was resumed in the spring.

The smelt in Crystal Lake averaged $4 \frac{3}{8}$ inches (total length) at the end of the first year, 7 inches at 2 years, $7 \frac{3}{4}$ inches at 3 years, $8 \frac{1}{4}$ inches at 4 years, (Figure 2). Creaser (1929) found the average standard length of smelt from the same lake to average 92 millimeters at 1 year, 156.9 millimeters at 2 years, and 171 millimeters at 3 years.

Metzelaar and Langlois (unpublished manuscript) measured a large number of smelt from Crystal Lake in 1928. The average lengths of their sample also agree very closely with those obtained in 1940 and 1941. It appears that little change has occurred in the rate of growth of the smelt in Crystal Lake.

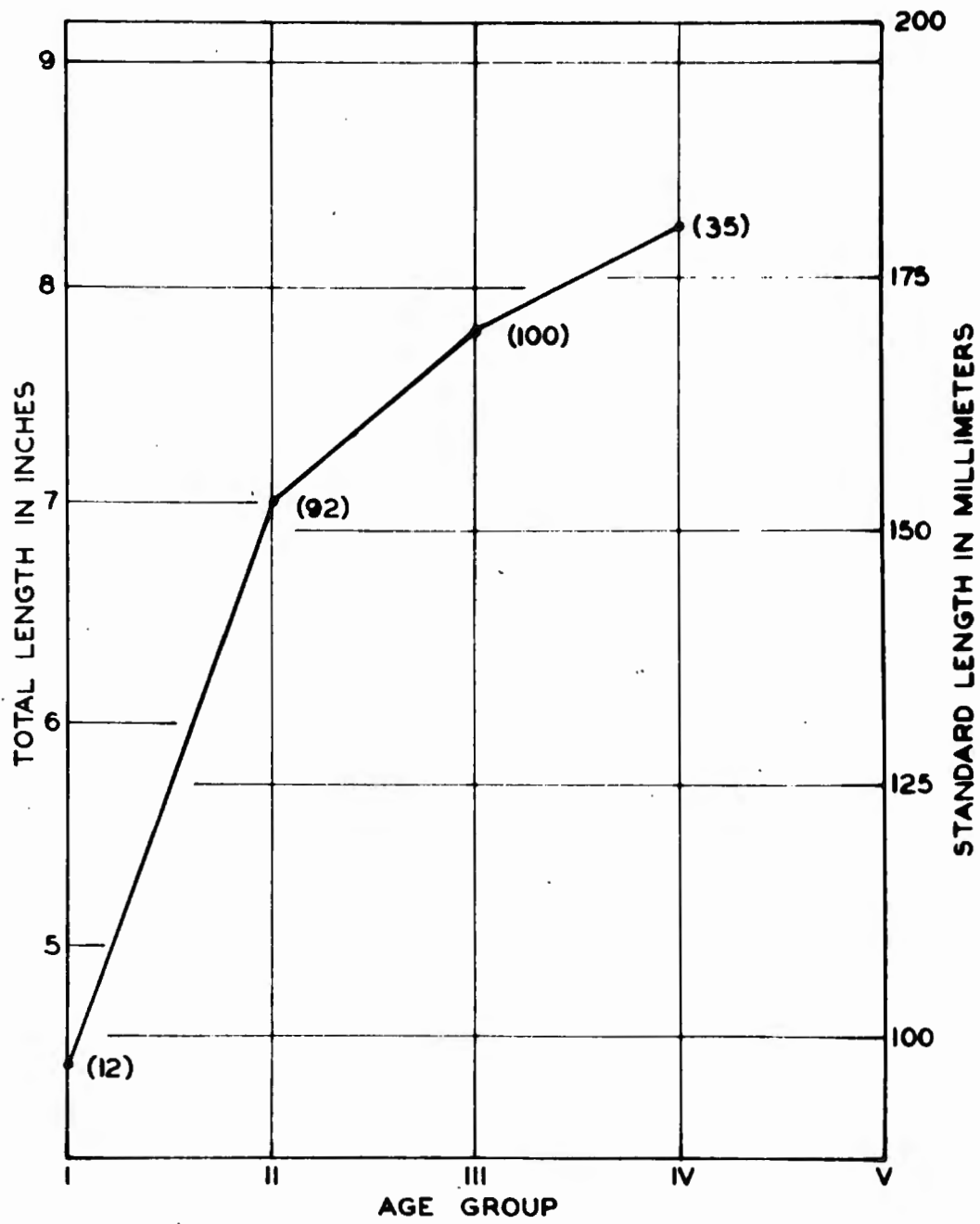
(Insert Figure 2)

The rate of growth of the smelt is slower in Crystal Lake than in Green Bay or Lake Erie. In Green Bay the smelt averaged 7 inches in length in the second year, 10 inches in the third year, 12 inches in the fourth year, and 14 inches in the fifth year (Schmeberger, 1937), whereas in Lake Erie the length of five 2-year-old smelt varied from 8.1 to 9.4 inches (Van Oosten, 1940). All of the above are total lengths.

Sex Ratio

Most of the published data on the sex ratio of smelt were based on spawning-run samples. Various workers have shown that the proportion of males and females change during the breeding season, and even during the same night. Males are usually dominant at the beginning of the run. Thus the sex ratio would vary greatly according to the time the sample was taken.

The data presented here (Table 3) were taken from sexually mature fish caught by hook and line during the winter, about 6 weeks before the beginning



of the spawning season, and from the sexually mature fish taken in gill nets and bag seine in June, after the spawning season.

The females were dominant in all well represented age-groups except age-group II taken in February 1941, and age-group III collected in June 1940. The relative abundance of the females increased progressively with increase in age. The sex ratio of the combined collections was 154 females (61 per cent) to 100 males.

Table 3
Sex ratio of the smelt from Crystal Lake, Michigan

Month and year of collection	Age-Group	Number of males	Number of females	Ratio (females per 100 males)	Percentage of males	Percentage of females
June 1940	I	1	1	100	50	50
Feb. 1940	II* ↓	23	30	130	43	57
June 1940	II	6	8	133	43	57
Feb. 1941	II*	15	10	67	60	40
Combined	II	44	48	109	48	52
Feb. 1940	III*	15	25	166	38	62
June 1940	III	4	1	25	80	20
Feb. 1941	III*	21	34	162	38	62
Combined	III	40	60	150	40	60
Feb. 1940	IV*	0	4	F 2	0	100
Feb. 1941	IV*	5	26	520	16	84
Combined	IV*	5	30	600	14	86
Feb. 1941	V*	1	1	100	50	50
All collections combined		91	140	154	39	61

↓ see footnote of Table 2

2 all females

Food Habits

The stomachs of the smelt caught in February 1940 and 1941 were examined (Table 4). Of the 210 stomachs examined, 122 (56 per cent) were empty. All recognizable fish were minnows (Notropis sp.). Specific identification was made on 5 Lake Emerald Shiners (N. atherinoides), and one Spot-tailed shiner (N. h. hudsonius). One stomach contained a fish that appeared to be a small smelt, but positive identification could not be made. As minnows were used for bait, a distinction was made between bait minnows and non-bait minnows found in the stomachs. Bait minnows usually could be recognized by hook marks. It is possible that some bait minnows which had been digested beyond the point at which hook marks could be detected may have been classified erroneously as "non-bait". Twenty-five per cent of the 210 stomachs contained non-bait minnows, and 15 per cent contained bait. Unidentifiable fish remains and other food were found in 4 per cent of the stomachs.

Table 4

Contents of 210 stomachs from smelt from Crystal Lake, Michigan

Date	Number of stomachs empty	Number of stomachs containing			
		Bait minnows	Non-bait minnows	Unidentifiable fish remains	Other food
Feb. 29, 1940	55	2	37	3	2 (1 scud 1 eggs)
Feb. 20, 21, 1940	67	31	18 ↓	4	1 (mayfly)
Total	122	33	55	7	3

↓ 2 possibly contained bait.

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Captions for Figures

Figure 1. Length-weight relationship of the smelt of
Crystal Lake, Michigan.

Figure 2. Average size of age-groups of Crystal Lake smelt.
(Number of specimens in parentheses.)