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FECUNDITY OF COHO SALMON FROM LAKE MICHIGAN [1]

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Abstract

Eggs from 17 mature coho salmon (Oncorhynchus kisutch) that were taken in October 1969 from the Platte River, a Lake Michigan tributary, were counted and their diameter measured. The presumed origin of these salmon was a plant of yearling coho in the Platte River in the spring of 1968. The yearlings had been obtained as eyed eggs from the Columbia River.

Number and average diameter of eggs in Platte River salmon ranged from 2,229 and 0.27 inch in a 21.6-inch salmon to 3,812 and 0.31 inch in a 30.8-inch salmon. Egg number was positively correlated with salmon length ($r = 0.80$) and weight ($r = 0.80$). The regressions were: egg number = 172 total length (inches) - 1,486, and egg number = 195 weight (pounds) + 1,594. Egg diameter was positively correlated ($r = 0.91$) with fish length. The regression was: egg diameter = .00542 fish length (inches) + 0.146. Lake Michigan coho salmon produced more eggs than West Coast coho salmon of comparable lengths.

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1 Investigations conducted under Dingell-Johnson Project F-31-R-4, Michigan

Thirty-three dead coho salmon from the Platte River were examined for egg retention; 27% retained 80% or more of their eggs. This was considerably greater than that recorded for West Coast coho salmon.

Introduction

Coho salmon stocked in streams tributary to the Great Lakes in 1966-68 have survived to maturity and have reproduced. Peck (1970) reported that this was the first instance of natural reproduction by coho salmon which had spent their entire life in fresh water. The fecundity of these fish is the subject of this report. The information is needed to determine coho spawning potential for a study of competition between the salmon and trout, and it should also be useful to hatchery and fish managers of the Great Lakes region.

Most of the coho salmon used in my study were selected from the 1969 spawning run on the Platte River, a tributary of Lake Michigan in Benzie County, Michigan. The 1969 spawning migration of coho salmon in the Platte River began on 8 October and extended to at least 10 December (Weaver, 1970). The presumed origin of these adult fish were yearling coho salmon planted in the Platte River in the spring of 1968. These yearlings, in turn, were from eyed eggs obtained from the Columbia River (Eagle Creek and Toutle River); the fish were reared in raceways in the Platte River for about 6 months before release (personal communication from John M. Robertson of Fish Division).

Methods

Collection of eggs. -- On 22 October, 19 females were dip-netted from a raceway at the Platte River spawn-taking facility and immediately killed. I attempted to get two fish from each inch group in the spawning run, but this was not always possible. After each fish was weighed and measured to the nearest ounce and 0.1 inch, it was hung by the head and the ventral abdominal wall slit from vent to gill isthmus. The eggs and connective tissue of the ovary were stripped into a pail and weighed, and then immediately preserved in 5% formalin. Eggs which were in the anterior part of the abdominal cavity were enclosed by the ovarian sac; in a few fish, all the eggs were retained in this sac. Few eggs were shed when the fish were handled. I conclude that the eggs were of full size and that the ovaries contained virtually all of the eggs produced for that year.

Seventeen salmon had spent 1 year in the hatchery and 2 years in Lake Michigan, whereas scale analysis showed that two atypical salmon (the smaller ones) had spent 1 year in the hatchery, 1 year in the stream, and 1 year in Lake Michigan. The two groups are discussed separately.

Besides the fish sampled on 22 October, the eggs remaining in 18 salmon found dead along the Platte River on 18 November 1969 were removed and counted. In addition, 15 salmon which were found dead along the Platte River were examined on 12 December 1967 and their percentage of egg retention was roughly estimated by visual inspection.

Egg counts and measurements. --The viable and nonviable eggs from each of the 19 salmon collected on 22 October were counted with an egg counter (Haskell, 1952). Viable eggs had a uniform orange-red color while the eggs believed to be nonviable when the salmon were killed were off color. Volume of all eggs in each salmon was then determined by water displacement.

The total volume was not used in a direct way to get average diameter of eggs, because I wished to get a measure of variation in egg size within salmon. To get individual egg diameters and a measurement of variation, I used a 2% random sample of viable eggs from each salmon. I first measured the total volume of all eggs in the 2% random sample by water displacement. Then each egg was weighed separately on a precision balance, and total weight of all eggs in the 2% sample was obtained by adding the individual weights. The volume of each egg was computed separately by the formula: single egg volume equals single egg weight times egg volume of the 2% random sample divided by egg weight of the 2% random sample. The diameter of each egg was then calculated from its computed volume by applying the formula for volume of a sphere ($= 4/3\pi r^3$), so that: D (diameter) = $\sqrt[3]{6\ \mathrm{Vol}/\pi}$. A small error may have resulted from this procedure because the eggs were not quite spherical

Results and discussion

Number of eggs. --The number of eggs in 17 coho salmon collected 22 October ranged from 2, 124 in a 21. 6-inch fish to 4, 194 in a 30. 8-inch fish (Table 1). These salmon, which averaged 26. 7 inches long and 7. 8 pounds in weight, produced an average of 3, 109 eggs per fish. The linear regressions of egg number on length and weight of fish are shown in Figures 1 and 2. There were positive correlations between number of eggs and total length ($r = 0.80$) and weight ($r = 0.80$). Both of these regressions (egg counts on length of fish, and on weight of fish) rather closely approximate straight lines. This would not be expected if the egg counts represented fish over a much wider range in length, because you could not expect straight-line regressions on both length and weight where the length-weight curve is normally strongly curvilinear. The segment of the length-weight curve, over the range (21. 6-30. 8 inches) of salmon used in these counts, was virtually a straight line ($r = 0.98$), which explains the otherwise spurious result.

The weight of the ova comprised 18-28% of the weight of the whole fish and averaged 24% (Table 1). Variation in percentage was not associated with fish size. Volume of eggs ranged from 0. 42 quart in a 21. 6-inch fish to 1. 23 quarts in a 30. 6-inch fish. In two fish the number of nonviable eggs was 8 and 19% of the total; in other fish it was 3% or less (Table 1).

My Lake Michigan coho generally contained more eggs than has been reported for Pacific Coast salmon of comparable lengths; yet the eggs were equal in size (Table 2). The volumes of the ovaries of Michigan fish must have been correspondingly larger. Scott (1962) attributes variation in egg number in rainbow trout (Salmo gairdneri) to fish size, egg size and adequacy of diet. As the lengths of the salmon compared in Table 2 and the egg sizes were nearly identical, one possible explanation for the greater fecundity of the Michigan salmon is that they have a richer diet.

Size of eggs. --Egg diameter averaged 0.29 inch and varied but little within individual salmon from the Platte River (Table 1). The standard deviation for all salmon averaged 1.7% of the mean; the maximum was 3.8%. The average diameter of eggs was positively correlated ($r = 0.91$) with total length of fish (Fig. 3). Thus, the bigger fish produced bigger eggs, as well as more eggs. In contrast, Allen (1958) found no correlation between egg diameter and length of coho salmon. I cannot explain the contradiction between his data and mine, but possibly the relationship was obscured by other factors in his observations. Foerster (1968) mentions the difficulty of obtaining eggs from enough fish in exactly the same stage of development, which is necessary to show a relationship.

Number of residual eggs. --Egg retention (those not laid) has been high in Lake Michigan coho salmon, and considerably greater than that recorded for Pacific Coast salmon. The number of residual eggs

in 18 dead salmon picked up along Platte River on 18 November 1969 averaged 34% of the potential egg deposition (Table 3). In a previous examination (12 December 1967) of 15 dead salmon from Platte River, it was estimated that 41% of the potential deposition was retained (G. P. Cooper, personal communication). Combining these two records of 33 dead salmon examined from the Platte River, 27% retained 80% or more of their eggs. In contrast, Shapovalov and Taft (1954) reported that egg retention in West Coast coho salmon is very low. Pearson, Conover and Haas (1967) examined 20 dead adult coho salmon on the Willamette River; 2 of these, or 10%, had not spawned.

Salmon with 1 year of lake growth. --The two smallest salmon, which had experienced only 1 year or less of growth in Lake Michigan, produced appreciably fewer and smaller eggs than did those with 2 years of lake growth (Table 1). These small females did not differ from the large ones in the ratio of ovary weight to fish weight.

Management implications. --Coho salmon eggs for hatchery production of smolts should be taken from large salmon. This is to get large eggs in which survival rates probably are better than in small eggs (Svärdson, 1949). In transferring adult coho salmon to new waters, or in estimating natural reproduction, fishery managers of the Great Lakes region should consider the high incidence of egg retention. The number of eggs produced may also be a measure of the well being of coho salmon (Scott, 1962), and might be useful in computing optimum stocking rates.

Acknowledgments

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Table 1.--Fecundity of coho salmon from Lake Michigan collected at Platte River, 1969

Whole fish		Ovaries		Average egg diameter (inches) and standard deviation	Number of eggs	
Total length (inches)	Weight (pounds)	Percentage of fish weight	Solid volume (quarts)		Viable	Non-viable
16.7	1.6	23	0.16	0.224 ± 0.004	1,383	9
18.3	2.6	22	0.21	0.208 ± 0.008	2,355	0
21.6	4.1	25	0.42	0.266 ± 0.005	2,069	55
22.3	4.1	24	0.39	0.252 ± 0.006	2,508	18
23.8	5.6	26	0.58	0.276 ± 0.004	2,712	92
23.9	5.0	24	0.52	0.273 ± 0.004	2,552	58
25.0	5.8	26	0.63	0.285 ± 0.007	2,738	48
25.2	6.4	22	0.63	0.287 ± 0.005	2,660	7
25.9	6.6	28	0.79	0.285 ± 0.006	2,840	687
26.4	7.3	26	0.80	0.307 ± 0.004	2,540	232
26.9	7.9	22	0.85	0.290 ± 0.004	3,305	5
27.6	8.0	18	0.60	0.294 ± 0.004	2,310	21
27.9	8.9	27	1.02	0.307 ± 0.005	3,471	45
28.5	10.0	19	0.82	0.301 ± 0.006	3,076	14
28.8	10.4	23	0.99	0.298 ± 0.003	3,656	11
29.1	9.8	24	0.97	0.304 ± 0.003	3,676	4
29.2	9.7	25	1.05	0.302 ± 0.006	3,855	45
30.3	10.8	20	0.94	0.304 ± 0.003	3,342	13
30.8	11.8	24	1.23	0.310 ± 0.003	4,186	8

Table 2.--Number and diameter of coho salmon eggs from Lake Michigan and the Pacific Ocean

Reference	Area	Average total length of salmon (inches)	Average egg diameter[1] (inch)	Calculated number of eggs at fish lengths (inches): 21	25	29
Stauffer, 1970	Lake Michigan	26.7	0.29	2100	2800	3500
Allen, 1958	West Coast	27.0	0.29	1700	2600	3600
Shapovalov and Taft, 1954	West Coast	-	0.29	-	1800	2800
Salo and Bayliff, 1958[2]	West Coast	-	-	-	2300	3100
Salo and Bayliff, 1958[3]	West Coast	-	-	-	2100	2900

[1] Eggs of Lake Michigan salmon were measured after preservation, but West Coast salmon eggs were measured while fresh.

[2] 1937 spawning run.

[3] 1939 spawning run.

Table 3. --Egg retention in 18 dead coho salmon collected from Platte River, 18 November 1969

Total length of salmon [1] (inches)	Calculated potential egg number [2]	Percentage of eggs retained
27.2	3,192	1
27.8	3,296	0
28.0	3,330	0
28.1	3,347	0
28.1	3,347	2
28.1	3,347	66
28.4	3,399	18
28.6	3,433	1
28.6	3,433	83
28.8	3,468	64
29.0	3,502	92
29.1	3,519	100
29.2	3,536	1
29.2	3,536	53
30.5	3,760	11
30.6	3,777	26
31.4	3,915	9
31.4	3,915	85

[1] Derived from standard length measurements by the formula TL = 1.207 SL.

[2] Potential egg number = 172 TL - 1486.

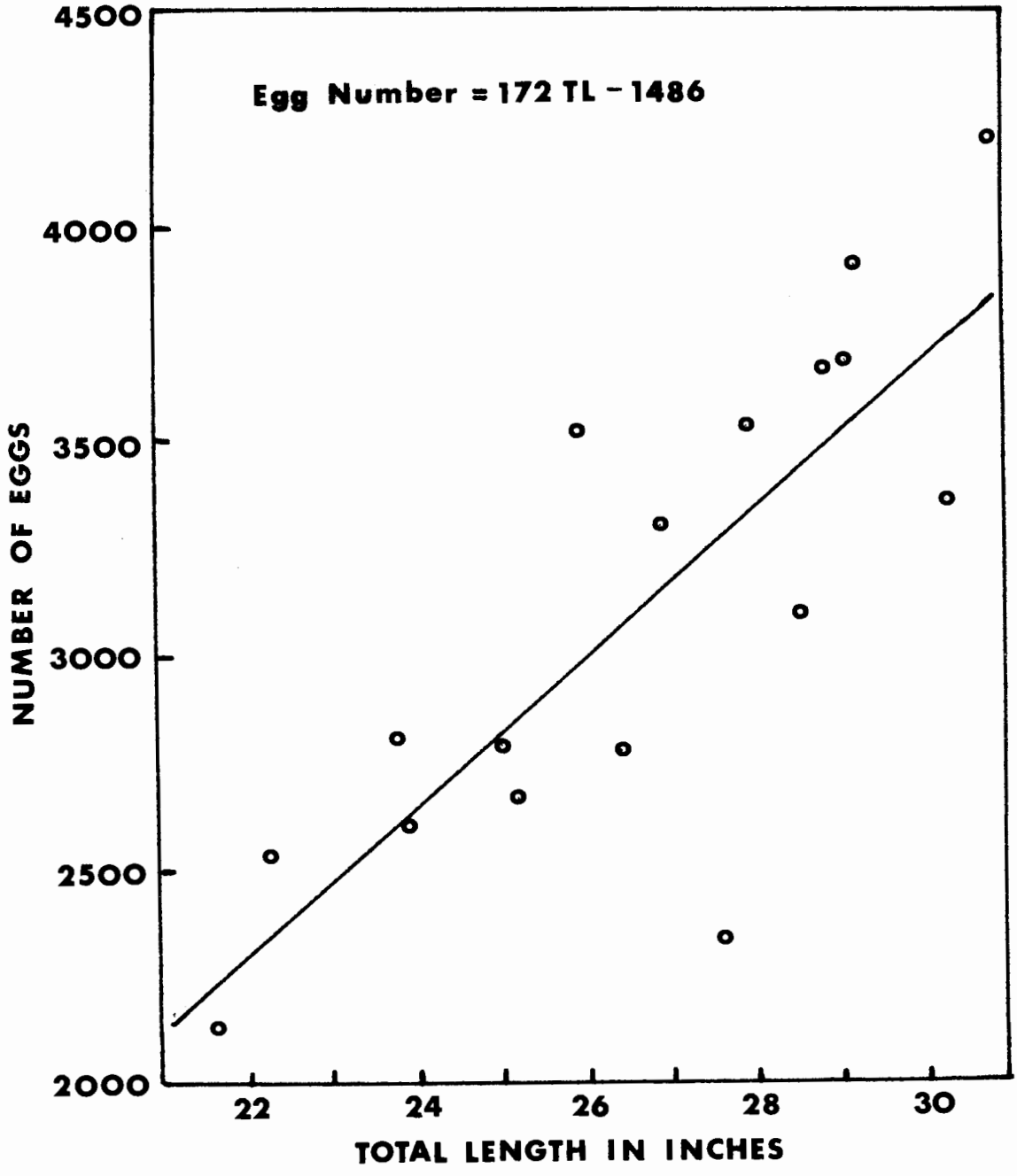

Figure 1. --Relationship of egg number to length of coho salmon, Platte River, 1969.

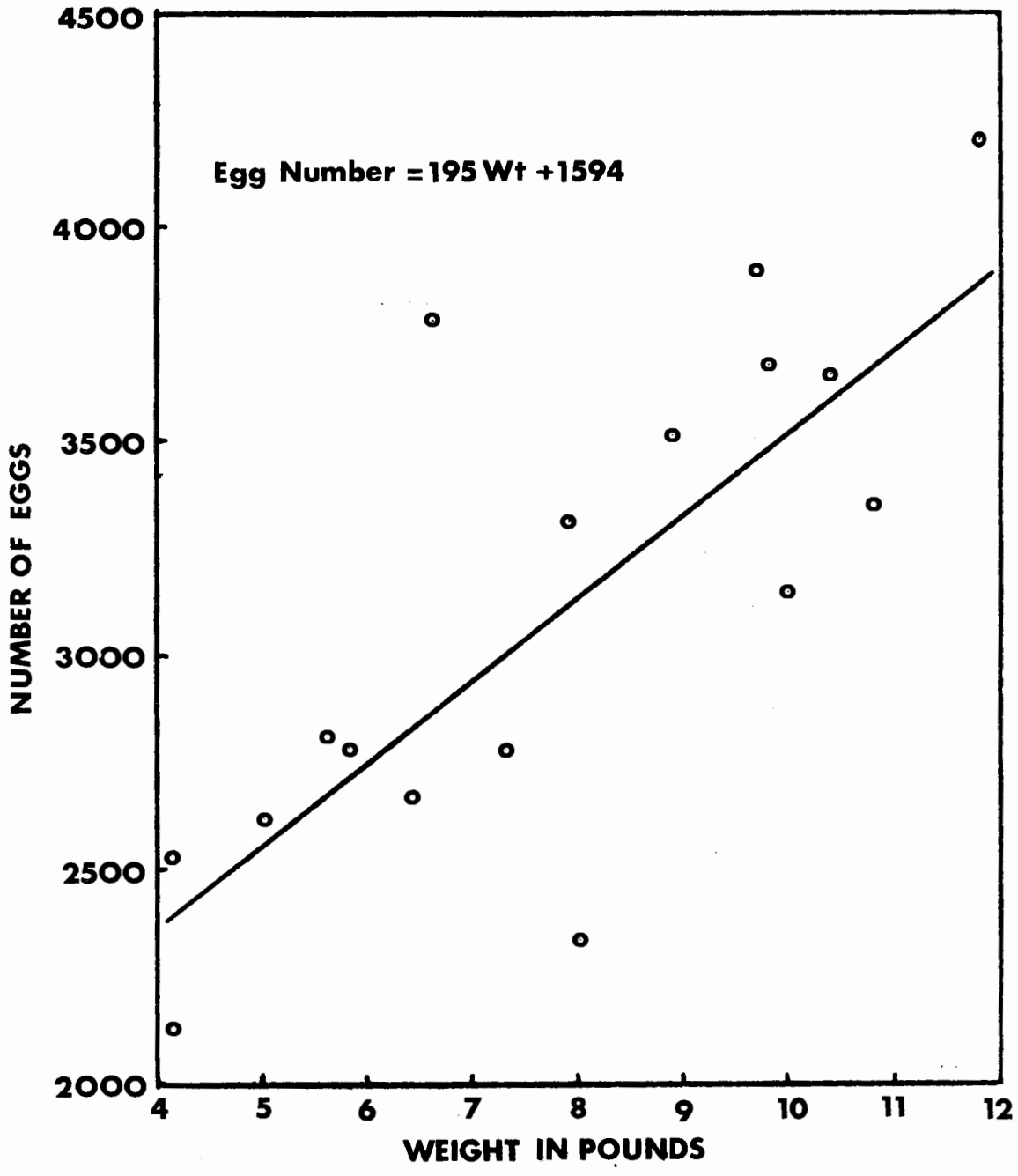

Figure 2. --Relationship of egg number to weight of coho salmon, Platte River, 1969.

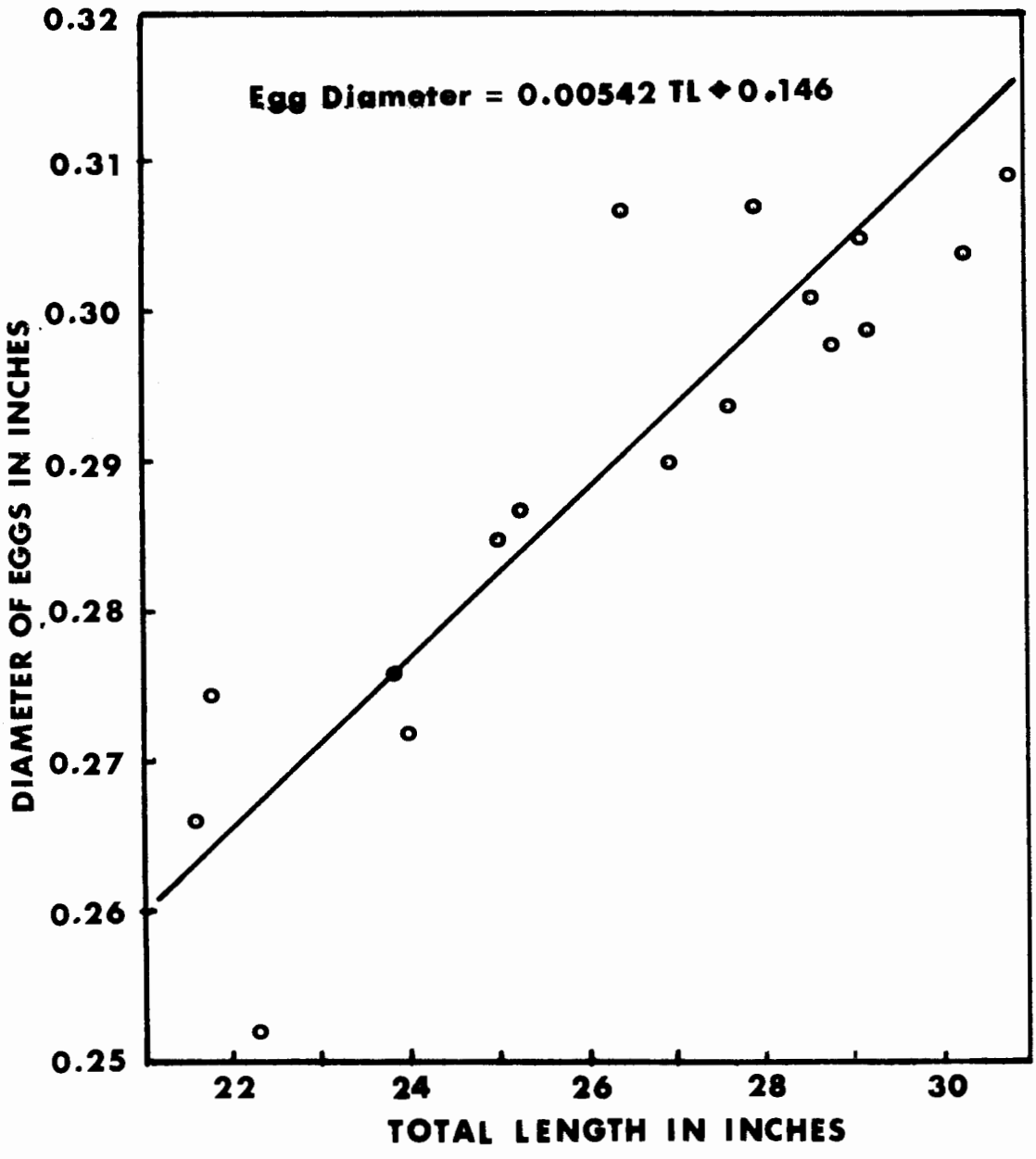

Figure 3. --Relationship of mean egg diameter to length of coho salmon, Platte River, 1969.