Fecundity of Hatchery-Origin and Wild Lake Trout in Lake Superior

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[1] Contribution from Dingell-Johnson Project F-53-R, Michigan

ABSTRACT

Fecundity (egg number) of contemporary hatchery and wild lake trout collected in inshore waters of Lake Superior during 1977–1982 was not significantly different, so the following combined-data relationships with total length (TL) and round weight (RW) were calculated:

$$\text{Fecundity} = -19{,}019 + 34.26\,\text{TL(mm)}$$

$$\text{Fecundity} = -3{,}400 + 2{,}450\,\text{RW(kg)}$$

Fecundity was greater than for former native stocks and increased with increasing fish body weight. Hatchery influence through selection and culture of broodstock appeared to be most responsible for greater fecundity of contemporary lake trout in Lake Superior.

INTRODUCTION

Fecundity (number of eggs) of lake trout (Salvelinus namaycush) in Lake Superior has been documented only by Eschmeyer (1955). His data were for native lean and siscowet lake trout populations in 1950–1954. Inshore lean lake trout were subsequently decimated by sea lamprey (Petromyzon marinus) predation and excessive fishing. These trout populations have since been restored in most Michigan waters mainly by extensive planting of hatchery yearlings. Practically all of these yearlings were progeny of Lake Superior lean lake trout held as broodstock at the Marquette State Fish Hatchery at Marquette, Michigan.

Reproduction by these hatchery trout has occurred, perhaps as early as the late 1960s (Peck 1979, 1982, 1984). Both hatchery (fin clipped) and wild (unclipped) lake trout were present on traditional reefs sampled in 1973–1976 (Peck 1979). The wild trout were mostly males and too young to be remnant native lake trout from the 1950s and early 1960s. They were suspected to be progeny of the more abundant and older hatchery trout. Populations of spawning lake trout on certain of these traditional reefs, resampled in 1982–1984, were made up of mostly wild trout with age composition and wild female abundance typical of that documented for self-sustaining populations (Martin and Olver 1980). Composition changed similarly on man-made reefs in Presque Isle Harbor, Lake Superior. Hatchery trout were most abundant and wild trout were mostly young males in 1977–1980 (Peck 1984). However, by 1983, wild trout were most abundant and representation of wild females was typical of a self-sustaining population (Marquette Fisheries Research Station, unpublished data).

I examined hatchery (fin clipped) and wild (unclipped) lake trout in 1977–1983 to determine: (1) fecundity, (2) if fecundity differed between origins, and (3) if fecundity of these contemporary stocks was different from the former native lean stocks studied by Eschmeyer (1955).

METHODS

Lake trout were collected on or near spawning reefs in south-central Lake Superior between Keweenaw Point and Munising. Hatchery trout were obtained during August-October 1977–1983 and wild trout were collected during October 1982–1983. Spawning usually occurred from mid-October to mid-November with the peak between October 24 and November 2 (Peck 1984). Only pre-spawning lake trout with eggs still in the ovarian sac were used in this study. Lake trout were measured (total length in millimeters) and weighed (kilograms); then the ovarian sacs were removed and preserved in 5% formalin. The eggs from each fish were subsequently counted and a 2% random sample was taken from lake trout captured in October to determine egg diameter. I measured egg diameter volumetrically, using the formula:

$$D = [v/\pi N]^{1/3}$$

where: D = mean egg diameter (cm), v = volume (ml), and N = number of eggs in the 2% random sample.

RESULTS

I determined fecundity from 32 hatchery and 24 wild lake trout. Hatchery trout averaged slightly larger than wild trout, but there was no significant difference between trout size or any of the fecundity parameters (Table 1). I calculated the following linear relationships between fecundity and total length (TL) and between fecundity and round weight (RW) for hatchery and wild lake trout:

$$\text{Fecundity (hatchery)} = -17{,}878 + 32.88\ \text{TL(mm)};\ r = 0.80$$
$$\text{Fecundity (wild)} = -20{,}100 + 35.54\ \text{TL(mm)};\ r = 0.85$$

$$\text{Fecundity (hatchery)} = -3{,}919 + 2{,}505\ \text{RW(kg)};\ r = 0.85$$
$$\text{Fecundity (wild)} = -3{,}474 + 2{,}544\ \text{RW(kg)};\ r = 0.93$$

All of the relationships were positive and highly significant. However, there was no significant difference between relationships for hatchery and wild trout as indicated by overlapping 95% confidence limits for the entire size range of fish sampled (Figs. 1 and 2). Slopes of the relationships with length ($t = 0.393$, df = 53) and weight ($t = 1.680$, df = 24) also were not different. Therefore, I combined hatchery and wild trout data and calculated the following fecundity relationships:

$$\text{Fecundity} = -19{,}019 + 34.26\ \text{TL};\ r = 0.82$$
$$\text{Fecundity} = -3{,}400 + 2{,}450\ \text{RW};\ r = 0.89$$

I calculated both linear and curvilinear fecundity relationships but linear relationships provided a slightly better fit for both length ($r = 0.82$ versus $r = 0.78$) and weight ($r = 0.89$ versus $r = 0.87$).

Larger lake trout produced more eggs per kg of body weight than smaller trout. This increase in egg production with body weight was described by the significant ($r = 0.61$) relationship $Y = 548 + 246\ X$, where Y = egg/kg of body weight and X = kg of body weight.

Egg diameters of hatchery and wild lake trout were not significantly different (Table 1). I found no significant relationships between egg diameter and either fish length or weight.

DISCUSSION

Contemporary hatchery and wild lean lake trout did not differ in fecundity, but were more fecund than former native stocks. The numbers of eggs per kg of body weight in my samples were slightly more than the 1,424 eggs per kg reported by Eschmeyer (1955). To better illustrate this difference in fecundity, I used the linear relationships determined in my study to calculate egg number for lengths and weights of native trout sampled by Eschmeyer. In the text table below, my calculated egg number for all lengths and weights was greater than the average egg number reported by Eschmeyer:

Eschmeyer (1955)			Calculated (my study) egg number ±95% C.L.	
Average size		Average egg number		
mm	kg		For length	For weight
660	2.82	3,383	3,594±624	3,509± 624
711	3.36	4,253	5,342±433	4,832± 629
765	4.27	4,995	7,192±460	7,061± 597
818	5.27	8,667	9,008±688	9,511± 920
853	6.32	8,881	10,208±881	12,083±1,401

Lake Superior lean lake trout were less fecund than contemporary or former native lake trout in Lake Michigan. Chiotti (1973) found that hatchery lake trout produced an average of 1,748 eggs per kg of body weight, and former native trout stocks averaged 1,711 per kg (Eschmeyer 1955). Both figures are considerably more than my per kg averages for wild and hatchery lake trout in Lake Superior. Likewise, most eggs per kg averages reported for lake trout from North American inland lakes are greater than in Lake Superior (Martin and Olver 1980).

The increase in eggs per kg of body weight with increasing body weight, I observed was also reported by Eschmeyer (1955), for former native stocks. However, this characteristic was not evident for lake trout in other waters (Martin and Olver 1980). If this is a valid characteristic of lean trout in Lake Superior and, if the size range of these stocks continued to expand upward, a curvilinear rather than linear relationship may be required to adequately describe fecundity.

Hatchery influence through selection and culture of broodstock appears to be most responsible for greater fecundity of contemporary lake trout in Lake Superior. Donaldson and Olson (1956) selected rainbow trout (Salmo gairdneri) broodstock for characteristics of size, strength, early maturity, spawning time, and fecundity. They were able to increase egg production fourfold in just over 20 years. According to John Driver, Hatchery Biologist, Marquette State Fish Hatchery (personal communication), lake trout broodstock are sorted to remove the least fecund and the larger and more robust progeny are saved for future broodstock. Hatchery trout, and the presumed hatchery trout parents of the wild trout in my study, were progeny of first and second generation broodstock. First generation broodstock were from eggs taken from Lake Superior native stocks. Sorting of the first generation to remove the least fecund, and selection of the larger progeny for the second generation, very likely resulted in a broodstock with fecundity greater than in the unselected native stock. This greater fecundity appears to have been transmitted to broodstock progeny planted in Lake Superior and in turn to the progeny of these planted fish.

Growth and exploitation are other factors that are reported to govern egg number in lake trout (Martin and Olver 1980). Greater fecundity would be expected if contemporary lake trout were growing faster than former native trout. However, Busiahn (1985) studied lake trout growth in Lake Superior and concluded that lake trout were growing slower in the 1970s than in the 1950s. On the basis of growth, fecundity of contemporary lake trout should have been less than for native stocks. Healy (1978) tentatively suggested that lake trout fecundity may increase in response to increased exploitation. However, lake trout in my study were exploited much less than the native stocks sampled by Eschmeyer because of effective sea lamprey control and restrictions on commercial fishing which have been imposed since 1962. Annual harvest of lake trout in Michigan waters by all fisheries since 1962 has been less than 500,000 pounds (Marquette Fisheries Research Station, unpublished data); whereas annual harvest in the early 1950s was nearly 2 million pounds (Baldwin et al. 1979).

The similar fecundity of contemporary hatchery and wild trout indicates that wild trout are more likely to be progeny of hatchery trout than progeny of remnant native stocks. This evidence of natural reproduction by the hatchery trout and greater fecundity are positive signs for lake trout rehabilitation in Lake Superior.

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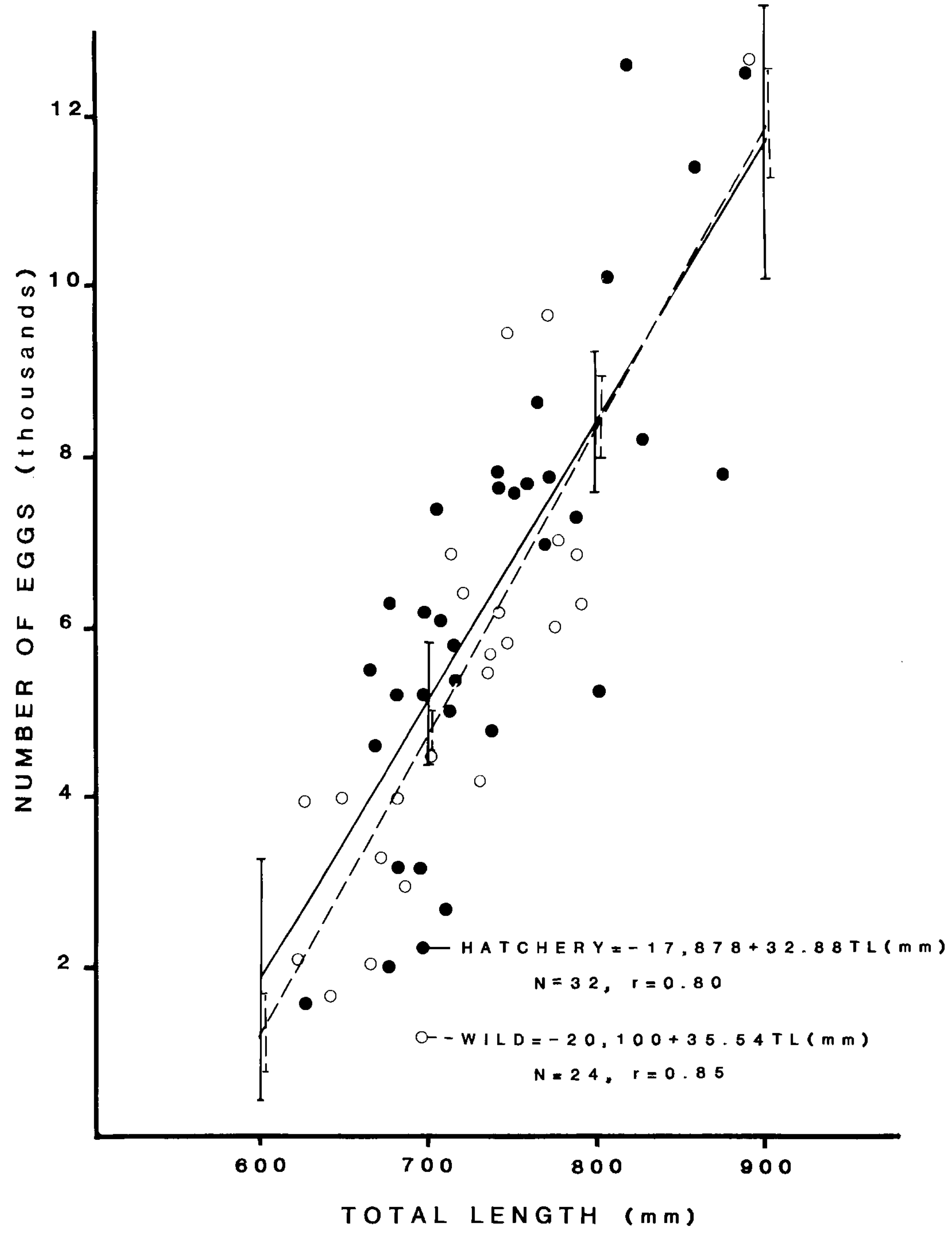

Figure 1. Relationships between fecundity (number of eggs) and total length (mm) for hatchery (x——x) and wild (o——o) lake trout from the Keweenaw Point to Munising area of Lake Superior. Vertical lines are 95% confidence limits.

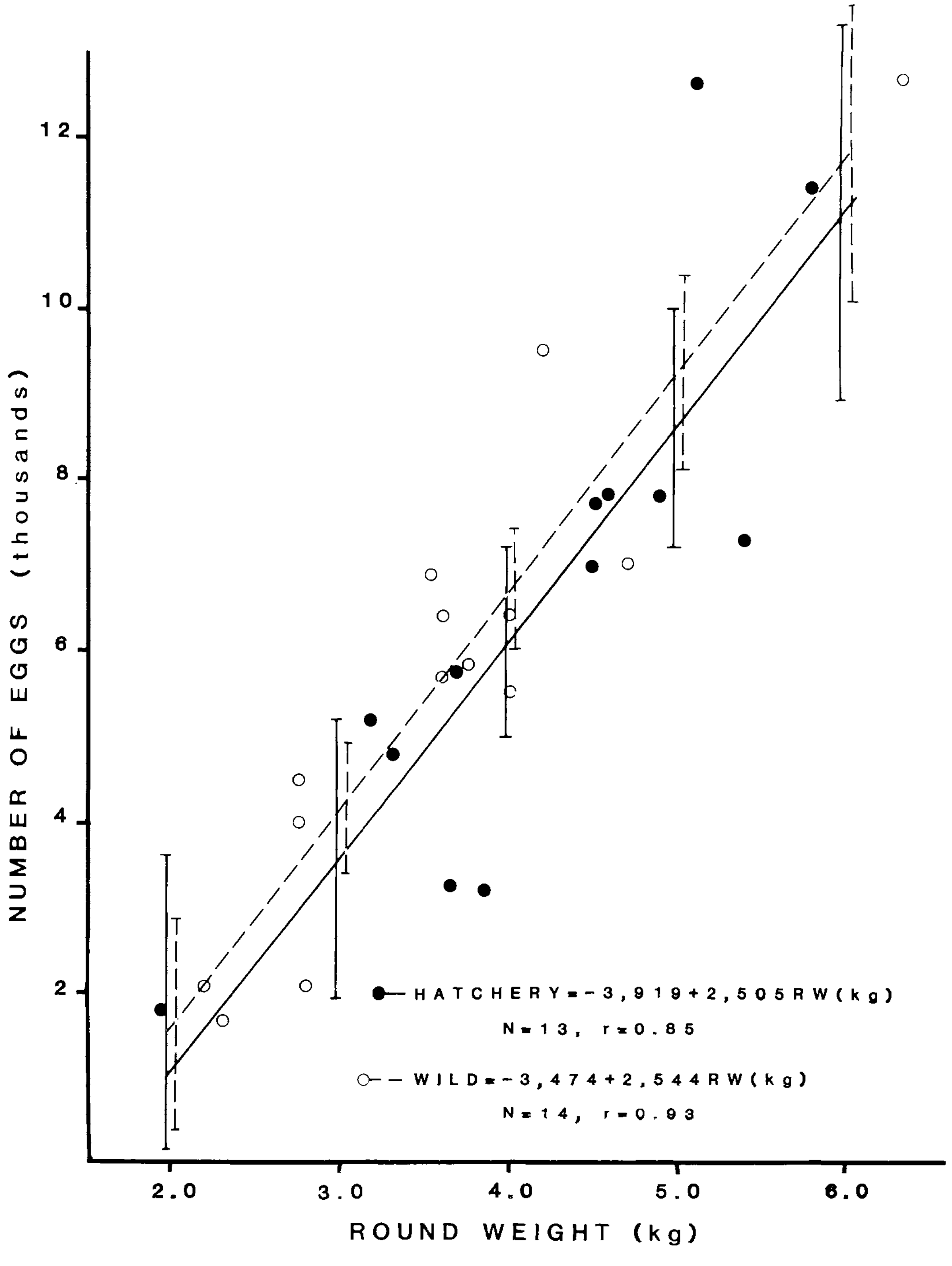

Figure 2. Relationships between fecundity (number of eggs) and round weight (kg) for hatchery (x——x) and wild (o——o) lake trout from the Keweenaw Point to Munising area of Lake Superior. Vertical lines are 95% confidence limits.

Table 1. Size and fecundity parameters (±95% confidence limits) of hatchery and wild lake trout, Keweenaw Point to Munising, Lake Superior, 1977–1983.

Origin and number	Total length (mm)		Round weight (kg)[1]		Egg number		Eggs/ kg[1]	Egg diameter (mm)
	Average	Range	Average	Range	Average	Range		
Hatchery 32	741 ±23	623–889	4.2 ±0.6	1.9–5.8	6,477 ±968	1,798– 12,662	1,508 ±274	5.10 ±0.13
Wild 24	722 ±26	623–892	3.6 ±0.6	2.2–6.4	5,561 ±1,086	1,726– 12,650	1,431 ±262	5.16 ±0.10

[1] Round weight and eggs per kg of body weight from 13 hatchery and 14 wild trout.

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