FECUNDITY OF BROOK TROUT *(SALVELINUS FONTINALIS)* FROM A COASTAL STREAM IN PRINCE EDWARD ISLAND

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Ovaries from 55 brook trout *(Salvelinus fontinalis)* from the Dunk River, P.E.I., indicated that 80% of those sampled were mature in the third growing season, and would have spawned in November. Only one large trout was mature in its second growing season. Although egg diameter and fork length and egg diameter and age were poorly correlated, the relationships between the number of ova and fork length, fresh weight and ovary weight were linear and highly significant. Egg production for trout longer than 20 cm was greater than that found for in five similar studies in Canada and the United States. Increased egg production in older fish was attributed to their annual migration to the sea where accelerated growth and development enhanced egg production.

Introduction

Information on brook trout *(Salvelinus fontinalis)* inhabiting coastal streams of Prince Edward Island is relatively scarce and, to our knowledge, no reports have been published on the fecundity of trout that run to the sea in the Atlantic Provinces. The objectives of this study were to establish for female brook trout age at maturity, size of mature eggs, fecundity, and relationships between ovary characteristics and body size, in order to compare the results with similar information for other localities in the United States and Canada.

Description of the Study Area

The Dunk River, 46°21'N, 63°36'W, arises from springs and seepage in Queens County, Prince Edward Island, and flows westerly through predominantly agricultural land in southeastern Prince County to Bedeque Bay. The Dunk River is one of the largest rivers in Prince Edward Island, approximately 43 km. Two dams are barriers to upstream movement of migrating fish. For this study, fish were collected from the Lower Dunk River, between Johnston's Bridge and Scales Pond (Fig. 1).

The Lower Dunk River supports a restricted fish fauna with only eight species of fish present. Three of these are salmonids: the brook trout *(Salvelinus fontinalis)*, the rainbow trout *(Salmo gairdneri)*, and the Atlantic salmon *(Salmo salar)*; other species are the smelt *(Osmerus mordax)*, gaspereaux *(Alosa pseudoharengus)*, American eel *(Anquilla rostrata)*, three spined stickleback *(Gasterosteus aculeatus)*, and white perch *(Morone americana)*.

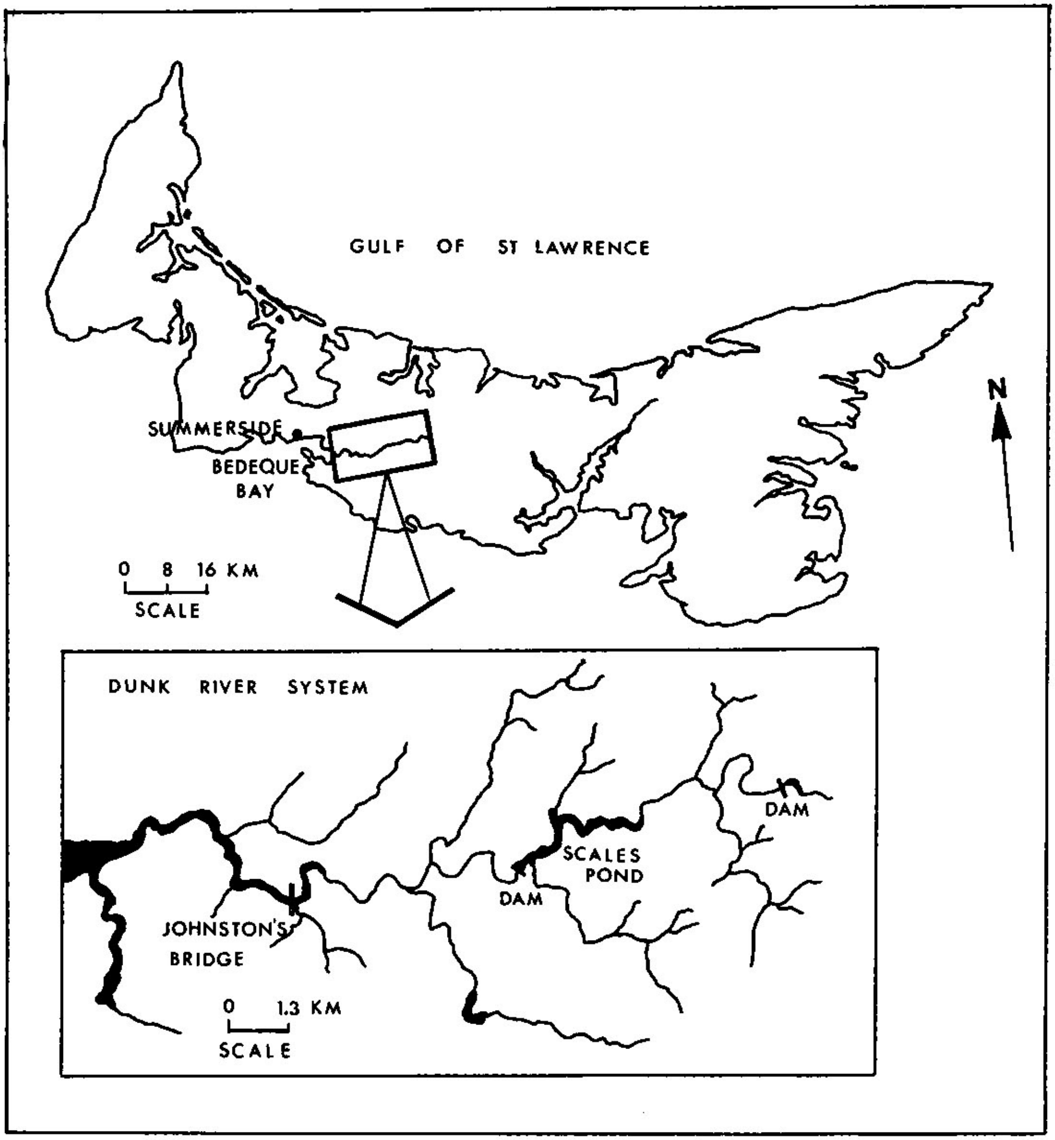

Fig. 1. Location of the Dunk River, Prince Edward Island.

Materials and Methods

Fish Collection and Egg Preservation Female trout were collected immediately before spawning between September 28 and October 25, 1974, using electroshocking and seining methods. All length and weight measurements were to the nearest 0.1 cm and 0.1 g respectively.

After the stage of ovary maturity (Nikolsky 1963) for each trout was determined, the ovaries were removed from the body cavity, wiped dry and weighed to the nearest 0.1 g. Then they were stored in modified Gilson's fluid (Simpson 1951) in separately labelled bottles and allowed to harden for 2-3 months.

Maturity and Egg Diameter Measurements Only ovaries from mature fish were used in egg diameter measurements. Hardened eggs were removed from the ovarian tissue by shaking. Mature eggs were separated using a sieve with a mesh size less than the diameter of the smallest mature egg (2 mm diameter). Diameters of a random sample of 30 eggs from each fish were measured using a stereo-microscope with a calibrated ocular micrometer.

Estimation of Egg Numbers A random subsample of 250 eggs from each mature fish was counted, weighed, and the total number of eggs was estimated from the total weight of eggs of each fish. For trout containing over 1,000 eggs, an average of 3 determinations was used. Estimates were checked for reliability by counting all the eggs from six brook trout. A 0.4% difference was found to exist between egg estimates and actual egg counts when a subsample of 250 eggs was used in the calculation procedure. Egg estimates determined from smaller subsamples were less reliable.

Age Determination A sample of scales was taken from captured trout in the region of the lateral line just below the adipose fin. Four or five non-regenerated scales were cleaned and permanently mounted in a glycerin-gelatin mounting solution. Mounted scales were read and aged by at least two individuals on two different occasions. Year marks or annuli were established on the basis of crowded circuli, irregularity of circuli, "cutting-over" of circuli, and length: frequency histograms of scales (Cooper 1951). No single characteristic was completely reliable so a combination of these features was employed.

Results

Age and Size at First Maturity Of 55 female brook trout sampled from the Dunk River, 21 were immature second-year (1^+) and third-year (2^+) trout, while 33 were mature and 1 was reproductive (Table I). Only 6% of the 1^+ trout were mature, while 83% were mature by 2^+ and would have spawned in November. One fish with easily expressed eggs was in the reproductive stage (Nikolsky, 1963) and was excluded from Tables III - VI because of possible egg losses during handling. Trout smaller than 15.0 cm did not contain mature eggs. (Table II). Almost all trout (96%) over 20.0 cm in fork length were mature. Based upon the state of gonad development and field observations in 1974, brook trout spawn in the Dunk River in October, November, and as late as December, with a peak in November.

Table I. Relationship between age and maturity of female brook trout from the Dunk River

Age group	Number immature[a]	Number mature[b]
1^+	16	1
2^+	5	24
3^+	0	7[c]
4^+	0	5

[a] With eggs < 2mm.
[b] With eggs > 2mm.
[c] One reproductive, with some eggs > 4 mm and ovary not intact.

Table II. Relationship between fork length and maturity of female brook trout from the Dunk River. Stages defined on Table I.

Fork length (cm)	Number immature	Number mature
10.0 - 14.9	16	0
15.0 - 19.9	4	10
20.0 - 24.9	1	18[a]
25.0 - 29.9	0	3
30.0 - 34.9	0	2
35.0 - 39.9	0	1

[a] One reproductive (eggs >4mm, ovary not intact).

Maturity Index The mean maturity index or gonad as percent body weight for each age-group is presented in Table III. Values ranged from 6.2 - 24.9 with an overall mean of 14.1. The trout with the maturity index of 6.2 had 77 of 945 eggs less than 2.0 mm in diameter. These small eggs were considered to be atretic. Other fish sampled were sufficiently mature to have reabsorbed all atretic eggs.

Diameter of Mature Eggs The mean diameter of mature eggs varied from 2.78 - 4.92 mm for individual trout aged 1^+ and 4^+ respectively (Table III). The meandiameter of eggs lying loose in the body cavity of one trout in the reproductive stage was 4.33 mm. Vladykov (1956) suggested that eggs<4.00 mm are probably not completely mature; however, Wydoski and Cooper (1966) reported that eggs are mature at 3.35 mm. In this study, most trout older than 2^+ had a mean egg diameter >3.35 mm. Only two fish had egg diameters<3.00 mm and they were 16.8 and 26.4 cm in fork length and were 1^+ and 3^+ respectively.

Table III. Relationship between age, maturity, fork length, body weight, gonad as % body weight, egg size, estimated number of ova per fish, estimated number ova per 100 mm fork length and per 100 g fresh weight for brook trout from the Dunk River

Age group	Number mature	Fork length cm		Body weight g		Gonad as % body wt
		Mean	Range	Mean	Range	
1^+	1	16.8	-----	52.2	-----	7.7
2^+	24	20.3	16.4-23.0	94.4	43.0-145.0	13.5
3^+	6	25.6	21.5-30.1	182.6	106.0-282.3	15.6[a]
4^+	2	34.8	30.4-39.3	527.1	357.5-696.7	20.0

[a] 17.5 if one fish with atretic eggs excluded.

Table III. ctd.

Age group	Diameter of ova mm		Estimated number of ova per		Estimated number of ova per	
	Mean	Range	Mean	Range	100 m fork length	100 g fresh weight
1^+	2.78	-----	290	-----	173	556
2^+	3.63	2.93-4.50	461	210-681	227	488
3^+	3.88	2.91-4.74	860	634-1251	336	471
4^+	4.79	4.66-4.92	1826	1277-2376	525	346

Egg Production The estimated mean number of mature eggs (> 2.0 mm diameter) per fish of different ages is shown in Table III. The estimated mean egg production per 100 mm fork length was greater for older trout but per 100 g body weight was less.

The relationship of fecundity to fork length, body weight, and ovary weight was examined through regression analysis. The predictive regressions for each set of data are shown in Figures 2, 3,4. Statistics from the analysis of variance for each of these equations (Table IV) indicate that egg number is more closely related to weight than to length, gonad weight or age.

Table IV. Statistics from the analysis of the variance of the regressions of fecundity on age, fork length, body weight and ovary weight of 33 brook trout from the Dunk River

Source of variation		F ratio	Accountable variation in fecundity (%)
Age		66.7***	68
Fork length	(X_1)	263.2***	89
Body weight	(X_2)	476.4***	94
Ovary weight	(X_3)	256.7***	87

*** Significant at 0.1 % level of confidence.

Discussion

According to Wydoski and Cooper (1966) fast growing brook trout are capable of spawning at the end of their first year, but in our sample only one large 1^+ trout was mature by the end of the second growing season. Reports on the maturity of female trout elsewhere suggest that, as in Prince Edward Island, most trout in the wild do not mature until 2^+ (Table V). The exceptional trout in Lawrence Creek, Wisconsin, had greater growth in the first two years of life than in any other locality, apparently leading to their early gonad maturation.

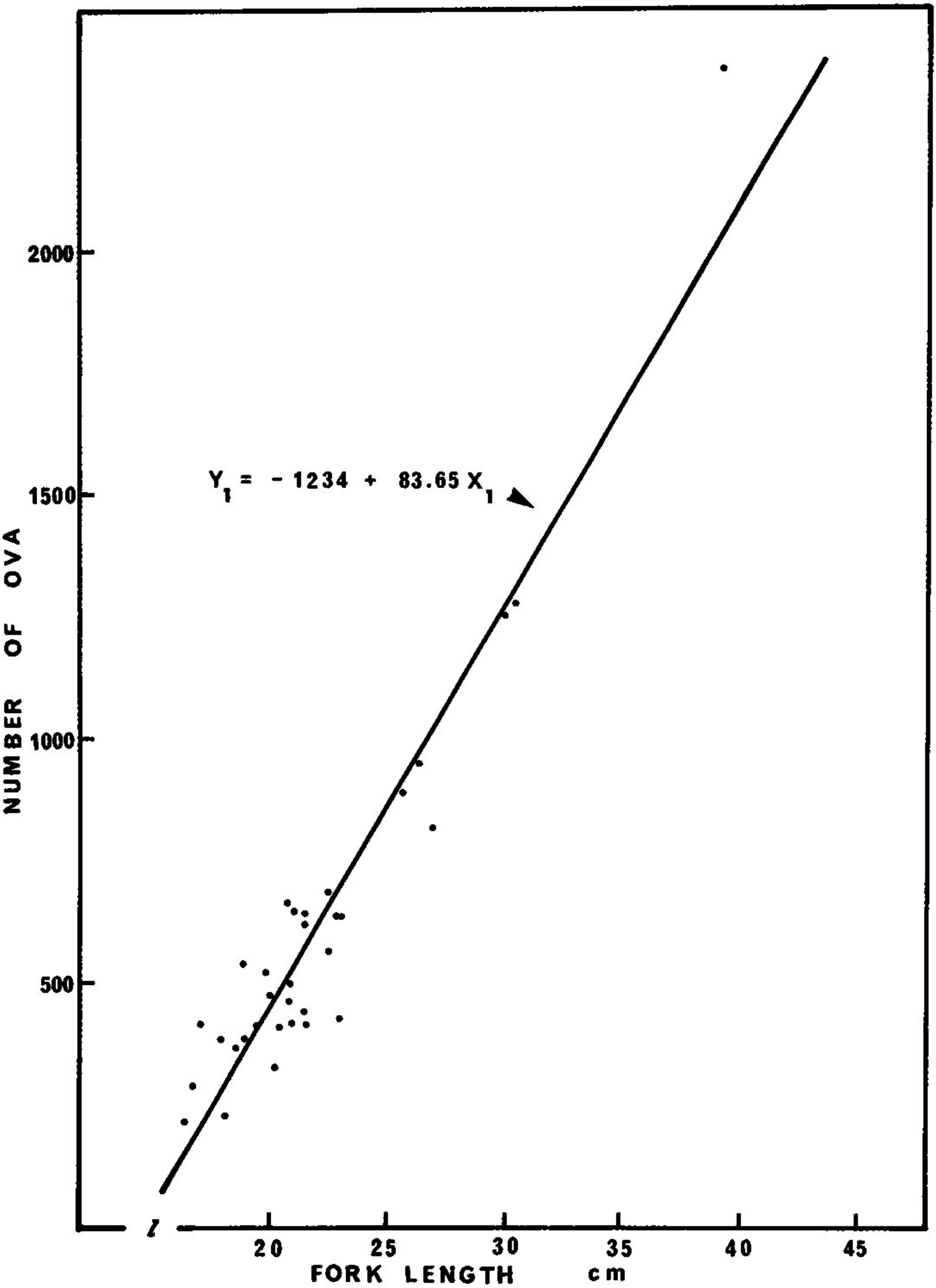

Fig. 2. Scattergram and regression equation for the number of ova and fork length of trout from the Dunk River, P.E.I.

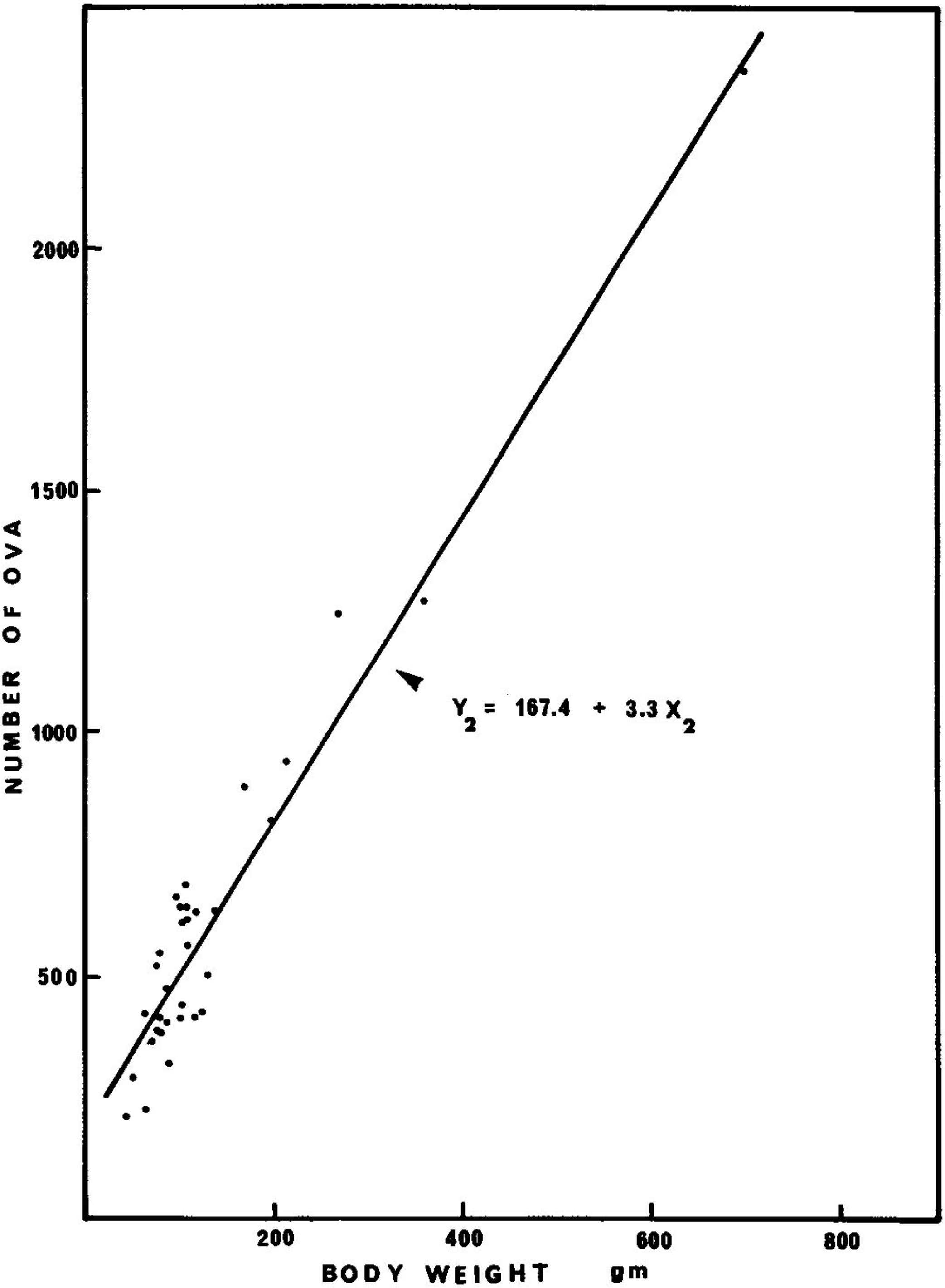

Fig. 3. Scattergram and regression equation for the number of ova and fresh weight of trout from the Dunk River, P.E.I.

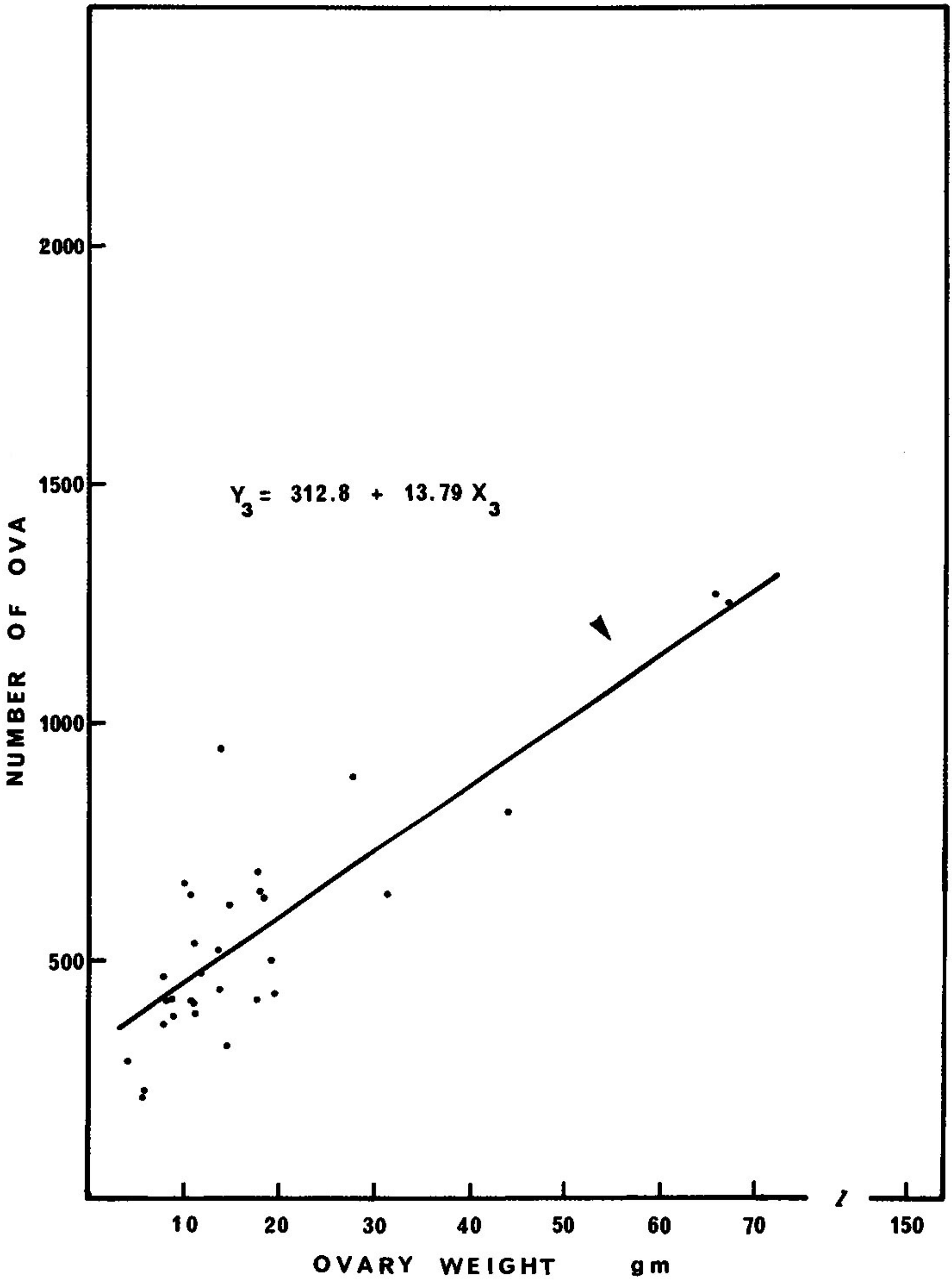

Fig. 4. Scattergram and regression equation for the number of ova and ovary weight of trout from the Dunk River, P.E.I.

Table V. A comparison of the percentage of mature female brook trout in each age-group for 5 areas. Numbers in parenthesis represent the mean fork length for each age-group

	Percentage Mature for:				
Age-group	Wyoming Beaver Ponds (Allen 1956)	Wisconsin Lawrence Creek (McFadden 1961)	Pennsylvania Lingle Stream (Wydoski 1966)	Quebec Matamek Lake (Saunders & Power 1970)	P.E.I. Present Study (1974)
0^+	0 (6.3)	0 (9.8)	0 (7.1)	0	0
1^+	6 (10.8)	83 (18.8)	10 (10.4)	17 (9.6)	6 (16.8)
2^+	82 (15.0)	100 (23.4)	42 (13.1)	68 (12.2)	83 (20.3)
3^+	100 (18.4)	100 (29.5)	100(16.2)	96 (17.2)	100 (25.6)
4^+	—	100 (34.4)	—	99 (20.7)	100 (34.8)
5^+	—	—	—	100 (24.8)	—

The mechanism responsible for early gonad maturation remains unknown, but may depend on some alteration in the functional maturation of the hypothalamic mechanism (Scharrer 1959). In fast growing trout functional maturation of the hypothalamic mechanism may be hastened by the presence of some endogenous factor(s) associated with growth. Alternatively an endogenous growth factor together with the hypothalamic releasing factor acting synergistically to increase the release of gonadotrophins from the pituitary, thereby augmenting gonad maturation may be responsible.

The relative weight of the mature ovary, the "maturity index" of Vladykov, (1956), varies for different populations. In Pennsylvanian streams only 10% of the total weight of the mature fish was gonad (Wydoski and Cooper 1966). In Quebec (Vladykov 1956) the ovary weight averaged 13.6% of the body weight and never exceeded 20%, while in this study, the mean value was 14.1% and was more than 20% in older trout. This suggests that older trout in Prince Edward Island produce a greater mass of eggs per mass of body weight than trout elsewhere.

Egg number at maturation is determined by the amount of follicular atresia. Vladykov (1956) recognized this in speckled trout from Quebec Lakes and reported that follicular atresia may be as great as 40%. Follicular atresia in rainbow trout according to Scott (1962) is increased by food shortage or intraspecific competition. These conclusions were further supported by Bagenal's (1969) fecundity experiments on brown trout.

Only one trout in this study possessed atretic eggs. The general lack of atretic eggs suggests that river conditions favored high productivity. Water chemical analysis for nitrate-N (0.4-3.1 ppm), phosphate (0.01-2.0 ppm), potassium (1.1-3.2 ppm), calcium (14.0-30.0 ppm), magnesium (3.0-13.0 ppm), alkalinity (40-80 mg/1 $CaCO^3$), pH (7.2-7.8), conductivity (102-209 μMHO/cm), and the number of bottom organisms/m^2 (range 2692-5930) during the summer months support this suggestion (unpublished data).

Egg size was only weakly correlated with age or fork length of females in this study. Wydoski and Cooper (1966) also noted little correlation between these parameters. Scott (1962) working with rainbow trout observed similar differences in egg size at maturity. He concluded that mean egg size was genetically determined, following Svardson (1949) who maintained that low intraspecific competition for food and space, would select for increased egg production and smaller egg size. On the other hand, populations with high egg production would create high intraspecific competition among fry, favoring a decreased production of larger eggs in maturing females. Larger eggs produce larger fry that are more robust and more able to survive in highly competitive environments.

Table VI. Comparison of fecundity and egg size for brook trout from Quebec and Prince Edward Island

Fork length (cm)	Quebec[a] Fecundity	Quebec[a] Egg diameter (mm)	P.E.I. Fecundity	P.E.I. Egg diameter (mm)
14.4	109	3.52	—	—
19.4	193	4.19	355	3.45
21.4	271	4.22	564	3.67
24.4	356	4.32	774	3.89
27.4	426	4.16	1024	4.14

[a]Data from Vladakov (1956 p. 819)

In spite of the above reasoning, egg size does not appear to be as greatly influenced by environmental conditions or heredity as is fecundity. There is very little difference in the diameter of eggs for fish of the same size from Quebec and Prince Edward Island (Table VI). The number of eggs produced by trout from Prince Edward Island, however, was generally more than double that of Quebec. Data on fecundity in other regions are summarized in Table VII. The slow growing fish of the infertile Pennsylvania streams and Quebec Lakes have a lower fecundity than do trout from the very fertile streams of Michigan and Wisconsin. The fertility of the Dunk River is probably intermediate between the two groups of fertile and infertile waters. As a result, it is not surprising to find that smaller trout produce intermediate numbers of eggs, (fewer eggs than trout from Michigan or Wisconsin but more eggs than trout from Quebec or Pennsylvania). Early growth and maturation of trout in Prince Edward Island may be further slowed by cooler water conditions and by a generally shorter growing season than elsewhere. However,

Table VII. Comparison of the fecundity of brook trout for five areas

Fork length (cm)	Quebec[a] (Vladykov 1956)	Wyoming[a] (Allen 1956)	Michigan[a] (Cooper 1953)	Wisconsin[a] (McFadden 1961)	P.E.I. (Present Study)
14.4	100	195	215	268	—
19.0	200	349	430	476	355
21.5	300	432	550	591	564
24.0	400	516	670	707	774
27.0	500	616	830	857	1024

[a]Data from McFadden (1961, p. 35).

these limitations are overcome for older and larger trout by movements to the sea. Scale analysis indicated that trout older than 2^+ had spent some time in the estuary. Annual migrations of 2^+ and older fish from the Lower Dunk River to the estuary occur regularly in late winter and early spring. While little is known about their movements in the estuary, their growth during this phase is greatly accelerated and they return to the river in June and July in a very fattened condition. Undoubtedly, fat and protein accumulated during the marine phase is employed in the unusually high egg production in older trout from Prince Edward Island.

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