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Abstract

The status of Atlantic salmon on the Rocky River was assessed for the year 2000. The 2000 escapement to Rocky River was 381 (277 small and 104 large) salmon which was 131% and 83% of the 1987-91 and 1992- 1999 means, respectively. Egg deposition for Rocky River was 35% of the required conservation egg deposition. The 2000 Rocky River smolt count of 7,616 was below the 1990-99 mean of 9,705 with sea survival to 1SW salmon being 3% which was the same as the 1990-1998 mean and up 61% above 1999.

Résumé

L'évaluation de l'état du stock de saumon atlantique de la rivière Rocky en 2000 a révélé que l'échappée dans ce cours d'eau se chiffrait à 381 saumons (277 petits saumons et 104 gros saumons), soit 131 % et 83 % des moyennes pour 1987-1991 et 1992- 1999, respectivement. La ponte a satisfait 35 % des besoins au titre de la conservation. Le compte de 7 616 smolts pour 2000 se chiffrait sous la moyenne de 9 705 smolts pour 1990-1999 et leur survie en mer jusqu'au stade d'unibermarins se situait à 3 %. Ce niveau, égal à la moyenne pour 1990-1998, est de 61 % plus élevé qu'en 1999.

Introduction

Rocky River, the largest watershed on the Avalon Peninsula, encompasses a drainage area of 296 km² (Porter et al. 1974) and flows to the sea in Salmon Fishing Area (SFA) 9 in the northern most part of St. Mary's Bay (Fig. 1). Historically the Rocky River was inaccessible to anadromous Atlantic salmon and is the site of a colonisation project where a run of anadromous Atlantic salmon was established. Prior to fishway construction in 1987, a natural falls at the mouth of this river, barred entry of anadromous fish to this watershed.

The Rocky River was stocked with unfed fry from a controlled flow spawning channel from 1984 to 1987; unfed fry from 1995 to 1996 from a recirculation incubator; 90 day fingerlings from the latter source in 1995 and adult salmon in 1987. For the stockings from 1984 to 1987, the brood source was Little Salmonier River, a nearby watershed in St. Mary's Bay. For additional detail on stocking activities, refer to Table 4 and (Bourgeois 1998).

The intent of this document is to review the status of Atlantic salmon in the Rocky River watershed in 2000.

Methods

Habitat Determinations

Habitat surveys of Rocky River determined 10,823 units (100m²) of riverine habitat (Table 1) and 2,191 ha of lacustrine habitat Porter et al. (1974) and unpublished stream surveys conducted in the early 1980's.

Biological Characteristics

Biological characteristics used in this document i.e. mean fork length and weight of fish, percent female, and freshwater and sea age are those determined for the Rocky River stock (see Tables 2 and 3). Smolt that were sampled had the following data collected; fork length, whole weight, scale sample and sex (on a sub sample). Adult salmon were scale sampled, weighed and measured.

Management Measures

Management restrictions implemented in 1992 that impacted marine exploitation of salmon were as follows:

1. Moratorium on commercial salmon fishing along the coast of insular Newfoundland.

2. Moratorium on the cod fishery in areas 2J, 3K and 3L implemented on July 15, 1992. In 1998 a limited inshore index cod fishery was permitted in Sept. – Oct. and in 1999 a limited 9,000 t (total allowable catch) fishery was permitted. In 2000 a TAC of 7,000 t was established with season dates of June 26 to July 29 and Sept. 11 to Nov. 30.
3. Moratorium on the cod fishery in SFAs 10-14A implemented in August of 1993 further reduced the by-catch of Atlantic salmon. In 1997 the cod fishery in SFAs 10 and 11 reopened with a TAC of 10,000t: the quota was increased to 20,000 t in 1998 and 30,000 t in 1999.

Since the introduction of anadromous Atlantic salmon Rocky River has not been open for a recreational salmon fishery.

Fecundity

Details of a fecundity study conducted on Rocky River salmon are as follows:

Year	Number of females examined	Number of females examined for egg retention
1994	19	19
1995	30	5

Female salmon (large and small) examined for fecundity were collected throughout the run, held until stripping and were sampled for fork length, whole weight and scale sampled. Fish were manually stripped of their eggs, the eggs fertilised and then counted directly. Fish examined for egg retention were sacrificed and any remaining eggs removed, kept separate, fertilised and then counted directly. Percentage of eggs retained was used to adjust the egg counts of fish that were released alive. All fish were stripped by the same individual throughout the study.

The authors have chosen to utilise a length-based relationship to determine egg deposition as fish length records are less subject to change throughout the season than fish weight records. An analysis of covariance revealed a significant relationship between the fork length of females and number of eggs ($p < 0.05$); but, no significant relationship was found with year. As a result of this analysis fecundity data from the two years were combined. Regression analysis of raw and log transformed data revealed significant relationships for both and provided r^2 values of 0.57 and 0.56, respectively. Figure 2 displays the regression line and equation for the linear regression of total number of eggs on fish length used in the calculation of egg deposition

Conservation Spawning Requirements

The conservation egg requirement was calculated based on 2.40 egg/100m² of fluvial habitat and 368 eggs/ha of standing water (O'Connell and Dempson, 1995).

Total Returns

In 2000, as in past years, a trap was installed in the upper most pool of the Rocky River fishway, which enumerated adult salmon from July 4 – Oct. 11.

Spawning Escapement and Egg Deposition

Spawning escapement was calculated from the fishway count less known removals.

Rocky River egg deposition was calculated based on the average number of eggs/cm as derived from the fecundity-length regression. Biological characteristics used in these calculations were derived from the Rocky River stock.

In order to determine the egg deposition in areas where fry stocking occurred, an estimate of egg-to-fry survival of 20% (Sturge, 1968) was used to back-calculate the number of fry released to the equivalent number of naturally spawned eggs. Sturge (1968) gave a range of 10-30% for egg-to-fry survival and indicated that a figure of 20% appeared to be a reasonable value. Parr were back-calculated to eggs by dividing the number of parr stocked by 0.125 (V. Pepper, pers. comm.) based on parr stocking data obtained from Black Brook. Assumptions are that natural egg to fry survival is 20% and that 40% of the wild fry survive to their first fall. Inherent in this calculation is that 80% of fry placed in grow-out cages survive to 90 day fingerlings.

Smolt Enumeration

In 2000, a smolt fence was operated on the Rocky River for the eleventh year. Dates of operation and dates of first and last smolt are listed below:

Year	Dates of Operation	Date of First Smolt	Date of Last Smolt
1990	Apr. 26 - June 8	Apr. 27	June 8
1991	Apr. 23 - June 19	May 1	June 19
1992	Apr. 27 - June 16	Apr. 29	June 15
1993	Apr. 28 - June 14	May 4	June 11
1994	Apr. 29 - June 16	May 1	June 16
1995	May 2 - June 14	May 2	June 14
1996	Apr. 25 - May 22	Apr. 26	May 22

1997	May. 5 - June 23	May 6	June 23
1998	Apr. 24 – June 15	Apr. 26	June 15
1999	Apr. 18 – June 14	Apr. 20	June 14
2000	Apr.20 – June 11	Apr. 20	June 11

Smolt condition was calculated as $K=W \times C/L^3$.

Smolt to adult survival

Smolt to adult survival was calculated based on the portion of virgin 1 SW fish in the escapement i.e. smolts in year i and number of 1SW in year $i + 1$. This was determined by sub sampling the adult run and apportioning the sea ages based on the sub sample.

Results

The use of fixed parameters, such as 2.4 eggs m^2 and 7 smolts/ha of standing water has certain limitations (see O'Connell & Dempson, 1995 for discussion on this topic).

Conservation Egg Deposition

The 2000 freshwater escapement (total returns) of 381 (277 small and 104 large) adults to Rocky River was 131% of the 1987-1991 mean and 83% of the 1992-1999 mean. In 2000 Rocky River achieved 35 % of its conservation egg deposition requirement (Table 4). The percent conservation egg deposition achieved has ranged from 22 to 69 % during the colonisation phase (1983-1987) and 17-56 % in subsequent return years (1988 – present). The means for these two time periods are 44% and 36% respectively. In part the difference in these two means was due to the conversion of the fry stocked from 1983-1987 to eggs as described previously. This conversion took the number of fry produced and back-calculated this figure to eggs which resulted in the egg deposition being larger than the actual number of eggs used.

Smolt Enumeration

In 2000, 7,616 smolt were enumerated. This count (see Table 5) is 78% of the 1990 - 1999 mean smolt count. Smolt counts have ranged from a low of 5,115 in 1993 to a high of 16,900 in 1997, with an overall mean of 9,625. Since the highest smolt count in 1997, the count has dropped annually, and by 2000 it declined by 45%.

The 2000 smolt run was comprised of 10% age 2⁺, 63% age 3⁺, 26% age 4⁺ and 1% age 5⁺ (from the 1994 - 1997 egg depositions) (Table 3). The Rocky River produces predominantly 3⁺ smolt with varying percentages of 2⁺ and 3⁺ year old smolt. Five plus year old smolt are relatively rare.

Rocky River smolt are relatively large smolt, with mean length and weight ranging from 14.9 to 18.9 cm and 32.4 to 58.2 g respectively. The percentage female in the smolt run has ranged from 57.1 to 83.8%.

Smolt-to-Adult Survival

Figure 3 displays smolt-to-adult survival (smolt year) from 1990-1999 which averaged 3% and ranged from 1.79% to 4.2%. In 1999 smolt-to-adult survival increased to 2.9% which still remains below the high recorded for 1996 but is the average for data recorded. The 2000 adult returns were resultant from natural spawning and fry stocking in 1996 to 1998.

Figure 3 also displays the relative condition factor of the outmigrating smolt which revealed one of the highest values observed in 2000. The values from 1997 to 2000 have remained relatively constant 0.890 to 0.891 while the smolt-to-adult survival has ranged from 1.79 to 2.95 during this four year period since 1997.

Figure 4 reveals the relationship between virgin 1SW returns plotted against smolt condition. This figure reveals the relationship between smolt condition and survival to 1SW which again suggests that as smolt condition increases returns of 1SW fish increase.

Egg-to-Smolt survival

Table 6 provides insight into the egg/fry-to-smolt survival on the Rocky River. At present it appears that egg-to-smolt survival was increasing up to 1992 and since 1993 it has declined below the high of 1.62% achieved in 1992. Figure 5 displays the relationship between egg deposition and egg-to-smolt survival which has a negative slope (Note: regression is not significant). With the exception of 1995, the last year of data, all post moratorium points were above the regression line. This may seem to indicate a return to egg-to-smolt survival figures that were encountered in the pre-moratorium years. In 1987 a fry to smolt survival of 1.6% was achieved based on three year classes. This value is based upon stocked fry and for the limited data available suggests that stocked fry perform well in terms of their survival to smolts.

Predicted adult returns

Predictions in terms of virgin grilse returns in year $X + 1$ from smolts in year X have been made since 1994 for Rocky River and are listed in the text table below. Predictions were made based on the range of smolt-to-adult survivals observed prior to the prediction.

Year	Prediction	Observed
2001	136-316 virgin grilse	

2000	152-351 virgin grilse	249 virgin grilse.
1999	268-511 virgin grilse	218 virgin grilse
1998	410-740 virgin grilse	370 virgin grilse
1997	300-496 virgin grilse	353 virgin grilse
1996	189-323 virgin grilse	314 virgin grilse
1995	234-318 virgin grilse	324 virgin grilse

Discussion

The colonisation of Rocky River with anadromous salmon by all accounts has been quite successful. The method utilised to calculate conservation egg deposition for the stocking phase was to back calculate the number of fry stocked to eggs by dividing by 20%. If this calculation was completed using the number of fry as a surrogate for the number of eggs then the Rocky River egg deposition for the colonisation phase (i.e. 44%) would be much lower and an increase in egg deposition after the colonisation phase would be evident. The comparison of the egg deposition in the colonisation phase and subsequent returns is like comparing apples to oranges. The latter protocol was one that was adopted for the Exploits River enhancement where millions of fry were stocked. The work of (O'Connell and Bourgeois, 1987) has shown that subsequent returns from fry stocking are in part dependent on the density at which the fry were stocked. The stocking density for the Rocky River watershed was very low. Also the presence of landlocked salmon and brown trout (*Salmo trutta* L.) in the Rocky River watershed may be slowing the growth of the anadromous stock.

The Rocky River requires approximately 880 small salmon to meet its conservation egg deposition or based on the average smolt production, a smolt-to-adult survival rate of 9% would achieve conservation egg deposition based on 1SW returns. To date repeat spawners have accounted on average for approximately 30% of the returns to the Rocky River and taking this into account a smolt-to-adult survival of 6.5% plus repeat spawners would achieve conservation egg deposition for the watershed. It would appear that the limiting factor controlling the returns to Rocky River is sea survival of smolts as opposed to sea survival of repeat spawners. In fact the repeat spawning portion of the run is critical for stock development/maintenance.

In an effort to better understand the freshwater phase of production a redd distribution survey was conducted in 1999 which revealed redds in all tributaries that were considered to be productive habitat. Certain intermittent tributaries which were omitted from the habitat calculations were devoid of redds.

The Rocky River, a third order stream, produces predominantly 3⁺ smolt with average percentages since 1988 being 9.5%, 69.5% 19.0% and 1.5% for 2⁺ 3⁺ 4⁺ and 5⁺ aged smolts respectively. These smolt average 17.1 cm in length and 46.8 g which when compared to other Newfoundland stocks are relatively large, which would be expected to survive well at sea. However the Rocky River smolts generally have the lowest sea survival of the Newfoundland stocks where smolts and adults are monitored (DFO,

2001). Subsequent adult returns since 1990 are on average 57 cm in length and 2.2 kg in weight which are large on average, with a number 1SW fish exceeding 63cm in length.

References

- Bourgeois, C. E. 1998. Assessment of the introduction (1984-1987) of Atlantic salmon (*Salmo salar* L.) into the Rocky River and stock status 1984-1995. In I. G. Cowyx (ed.) Stocking and Introduction of Fish. Fishing News Books 456pp.
- DFO. 2001. Newfoundland & Labrador Atlantic Salmon Stock Status for 2000. Stock Status Report D2-01. 19p.
- O'Connell, M.F., and C. E. Bourgeois. 1987. Atlantic salmon enhancement in the Exploits River, Newfoundland, 1957-1984. N. Amer. J. Fish. Manag. 7:207-214.
- O'Connell, M. F., and J. B. Dempson. 1995. Target spawning requirements for Atlantic salmon, *Salmo salar* L., in Newfoundland Rivers. Fisheries Management and Ecology. 2:161-170.
- Porter, T. R., L. G. Riche, and G. R. Traverse. 1974. Catalogue of rivers in insular Newfoundland. Vol. D. Resource Development Branch, Newfoundland Region. Data Record Series No. NEW/D-74-9: 353p.
- Sturge, C. C. 1968. Production studies of the young stages of Atlantic salmon (*Salmo salar* L.) in an experimental area of Indian River, Notre Dame Bay, Newfoundland. M.Sc. Thesis, Dept. Biology, Memorial University of Newfoundland. 134p.

Table 1: Rearing area and conservation egg deposition for the Rocky River watershed..

	Riverine habitat (m ²)	Lacustrine habitat (ha)	Conservation egg deposition
Rocky River	10,823	2,191	3,404,730

Table 2. Biological characteristics of Rocky River adults.

Year	No. Sampled	% Female	No. 2 Sea Winter Virgin	Mean Length(cm)	Mean Weight(kg)	% Repeat Spawners	Freshwater Age			
							2 ⁺	3 ⁺	4 ⁺	5 ⁺
1990	21	N/A	0	57.1	2.2	14	6	72	16	6
1991	32	N/A	0	56.9	2.2	9	15	58	27	0
1992	24	N/A	0	58.0	2.4	17	18	55	27	0
1993	32	N/A	0	56.5	2.2	13	3	69	24	3
1994	68	79	0	56.9	2.0	31	16	72	12	0
1995	111	86	1	56.0	2.0	22	14	77	9	0
1996	18	N/A	0	54.9	2.0	17	6	61	33	0
1997	41	N/A	1	59.6	2.5	34	13	85	2	0
1998	38	N/A	1	57.5	2.3	26	3	90	5	2
1999	32	N/A	0	57.1	2.3	41	20	44	36	0
2000	22	N/A	0	56.3	2.1	18	-	-	-	-

Table 3 . Biological characteristics of Rocky River smolt.

Year	No. Sampled	% Female	Mean Length(cm)	Mean Weight(g)	Percentage at various Freshwater Ages				
					2 ⁺	3 ⁺	4 ⁺	5 ⁺	6 ⁺
1988	28	57.1	17.5	54.5	0	64	36	0	0
1989	28	N/A	14.9	32.4	18	67	11	4	0
1990	101	84.2	17.3	46.5	1	66	29	4	0
1991	146	86.3	17.0	43.2	16	70	13	1	0
1992	71	78.9	17.0	44.7	1	76	21	2	0
1993	88	71.6	18.9	58.2	13	57	24	6	0
1994	160	83.8	17.0	45.1	2	66	29	3	0
1995	124	77.4	17.0	44.8	16	77	7	0	0
1996	203	83.4	16.7	44.1	7	82	10	0	1
1997	110	75.5	17.2	46.3	11	76	13	0	0
Finclip	116	56.3	17.5	49.1	100	0	0	0	0
1998	119	55.7	17.0	44.1	27	62	9	2	0
Finclip	90	55.0	18.1	54.2	0	100	0	0	0
1999	193	77.6	17.3	50.8	1	79	19	1	0
Finclip	3	?	18.7	61.0	0	0	100	0	0
2000	379	77.4	17.9	54.7	10	63	26	1	0

Table 4. Details of egg deposition Rocky River.

Year	Fry Stocked	Parr Stocked	Adults Stocked	Adult Count			Broodstock	Total Eggs	% Conservation Egg
				Total	Small	Large			
1983	0		0				0	1,538,875	45
1984	307775		0				0	2,172,500	64
1985	434500		0				0	970,000	29
1986	194000		0				0	1,998,225	59
1987	399645		140	81	80	1	0	743,595	22
1988	0		0	319	313	6	0	1,011,527	30
1989	0		0	177	168	9	0	561,255	17
1990	0		0	418	401	17	0	1,359,420	40
1991	0		0	227	211	16	0	730,874	22
1992	0		0	283	237	46	0	961,811	28
1993	0		0	364	292	72	0	1,148,320	34
1994	0		0	177	158	19	62	857,862	25
1995	50,000	31,983	0	424	385	39	76	1,918,012	56
1996	162,231	0	0	401	356	45	0	1,163,295	34
1997	0	0	0	524	435	89	0	1,917,225	56
1998	0	0	0	553	423	130	0	1,834,473	54
1999	0	0	0	404	327	77	0	1,340,193	39
2000	0	0	0	381	277	104	0	1,191,401	35

-The 1998 biocharacteristics for Rocky River egg deposition are the same as those used for 1996.

Table 5. Details of smolt enumeration Rocky River 1990-1999.

Year	Smolt Count	Smolt Released	% Smolt-to-1SWAdult Survival
1990	8287	8287	2.47
1991	7732	7732	2.93
1992	7813	7813	3.49
1993	5115*	5115	2.30
1994	9781	9781	3.39
1995	7577	7577	4.15
1996	14,261*	13,057	2.8
1997	16,900*	16,900	2.19
1998	12,163*	12,163	1.79
1999	8,625*	8,436	2.95
2000	7,616	7,262	

* Smolt count is an estimate due to fence washout

Table 6. Details of egg/fry to smolt survival for Rocky River.

Year	egg to smolt survival (%)	fry to smolt survival (%)	Smolt classes
1985		0.08	5 ⁺
1986		1.3	4 ⁺ , 5 ⁺
1987		1.6	3 ⁺ , 4 ⁺ , 5 ⁺
1987	1.00		2 ⁺ , 3 ⁺ , 4 ⁺ , 5 ⁺
1988	0.86		2 ⁺ , 3 ⁺ , 4 ⁺ , 5 ⁺
1989	1.04		2 ⁺ , 3 ⁺ , 4 ⁺ , 5 ⁺
1990	0.57		2 ⁺ , 3 ⁺ , 4 ⁺ , 5 ⁺
1991	1.02		2 ⁺ , 3 ⁺ , 4 ⁺ , 5 ⁺
1992	1.62		2 ⁺ , 3 ⁺ , 4 ⁺ , 5 ⁺
1993	1.28		2 ⁺ , 3 ⁺ , 4 ⁺ , 5 ⁺
1994	1.32		2 ⁺ , 3 ⁺ , 4 ⁺ , 5 ⁺
1995	0.62		2 ⁺ , 3 ⁺ , 4 ⁺
1996	0.42		2 ⁺ , 3 ⁺
1997	0.04		2 ⁺

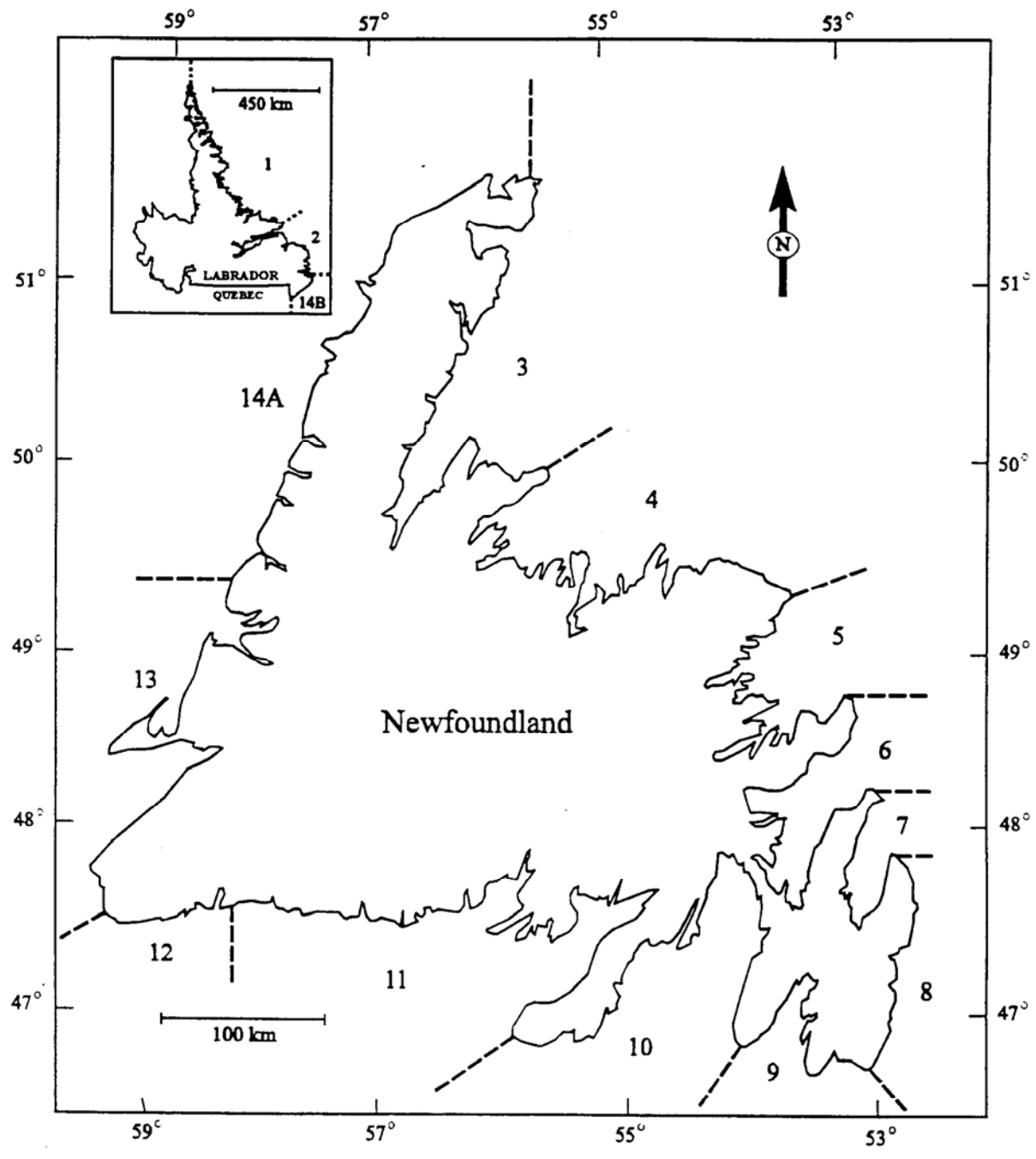


Fig. 1. Map showing the 14 Salmon Fishing Areas of the Newfoundland Region.

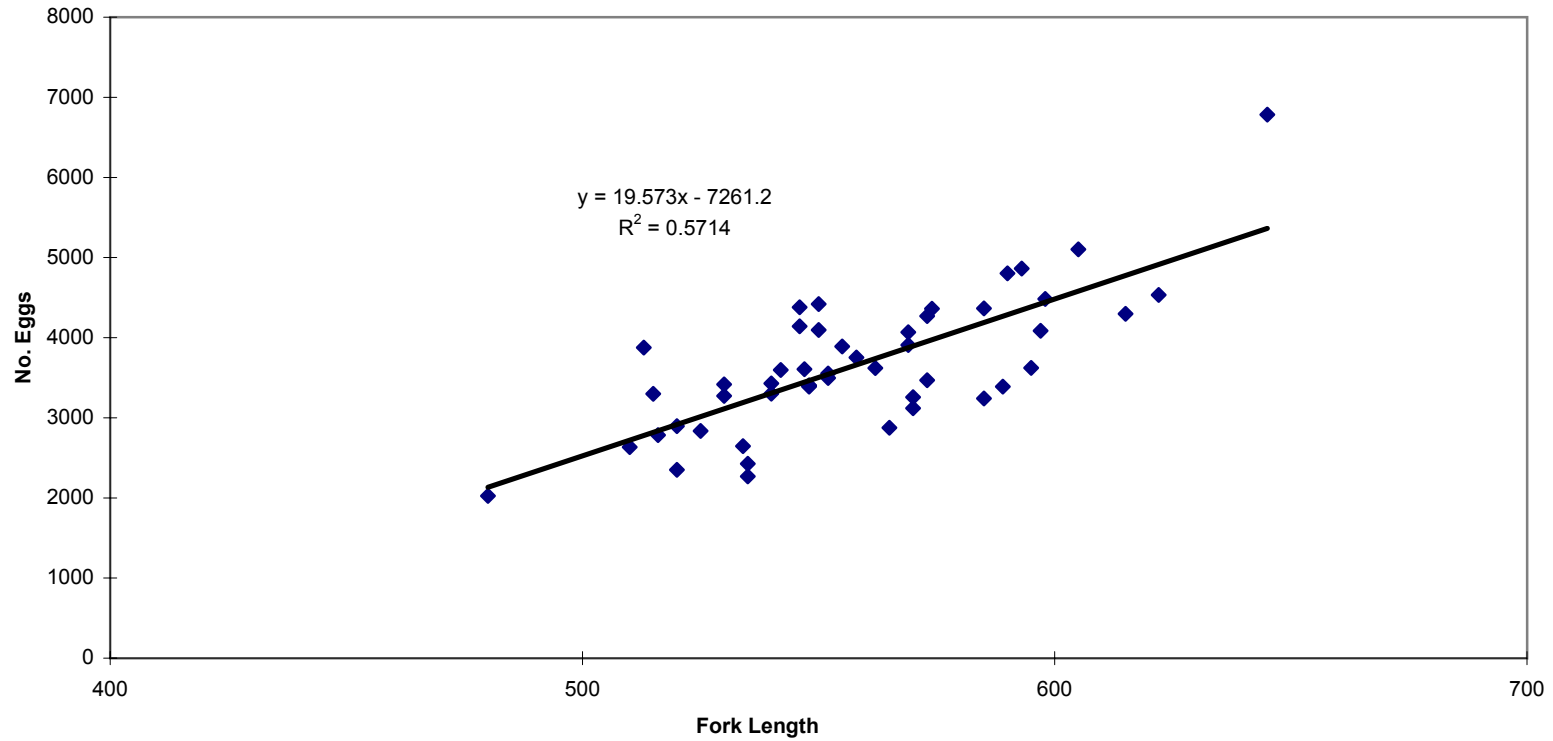


Figure 2. Fecundity relationship for Rocky River salmon.

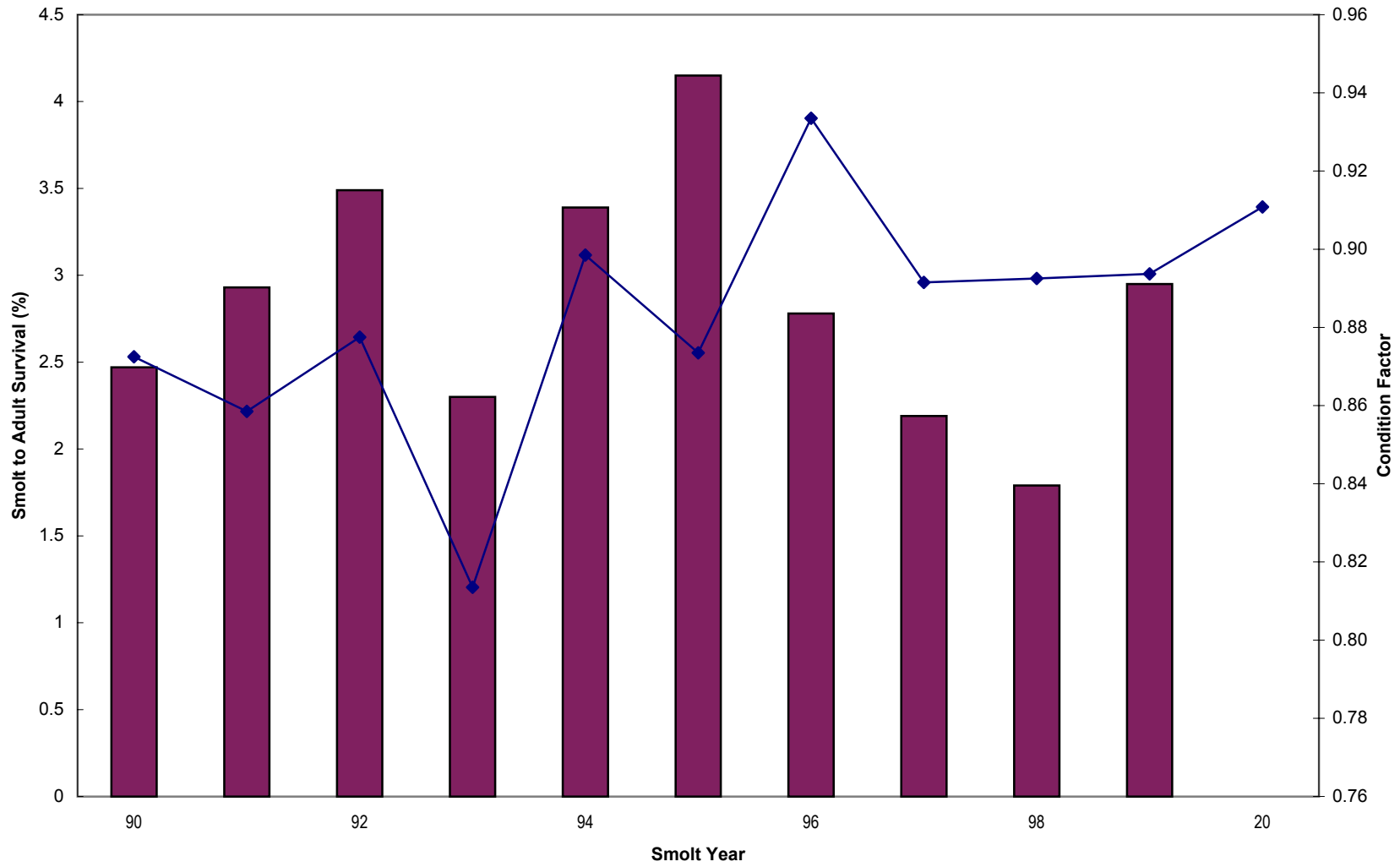


Figure 3. Smolt-to-adult (1SW) survival and relative condition factor of Rocky River smolt.

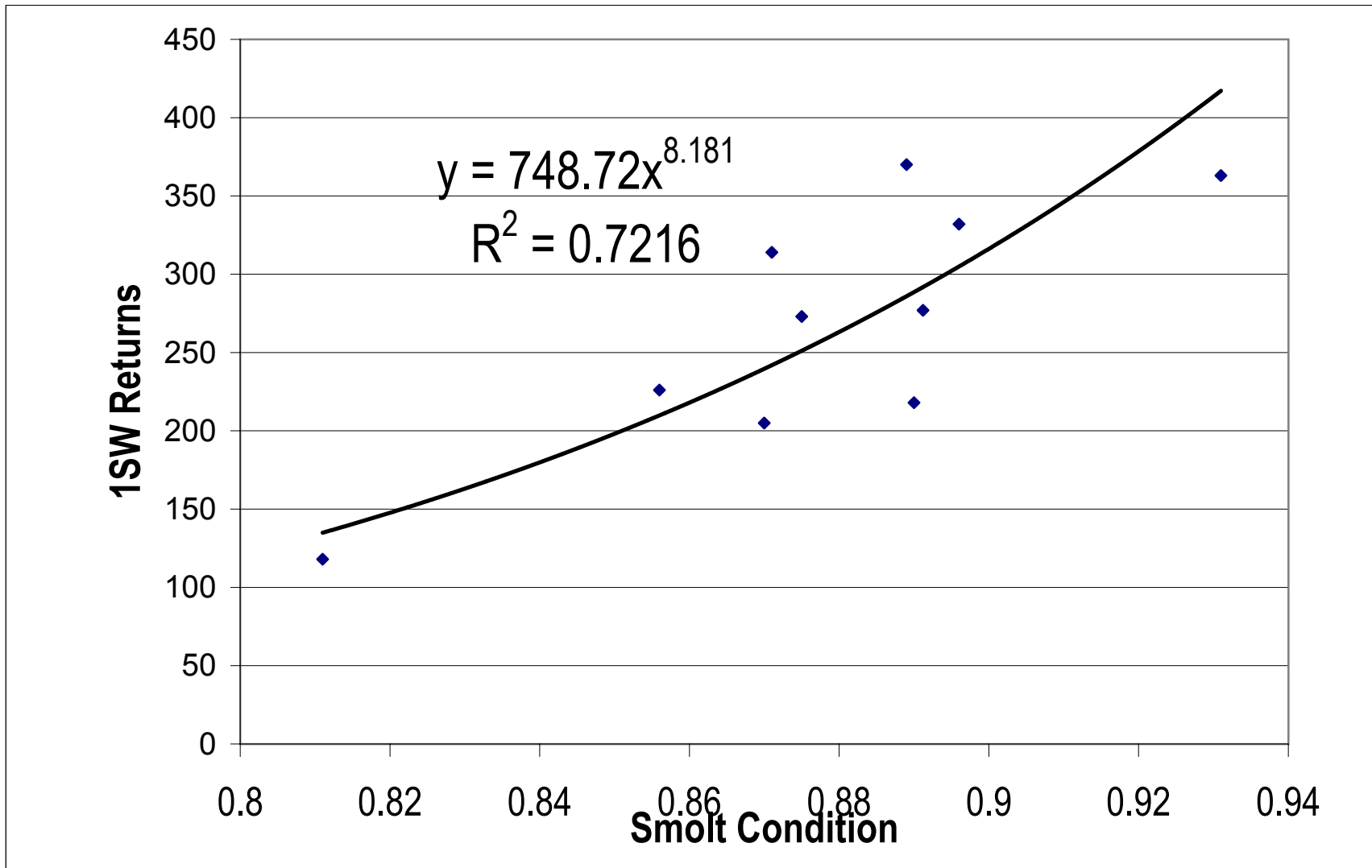


Figure 4. Smolt condition in year X versus 1 SW returns in year X+1 for 1990-1991.

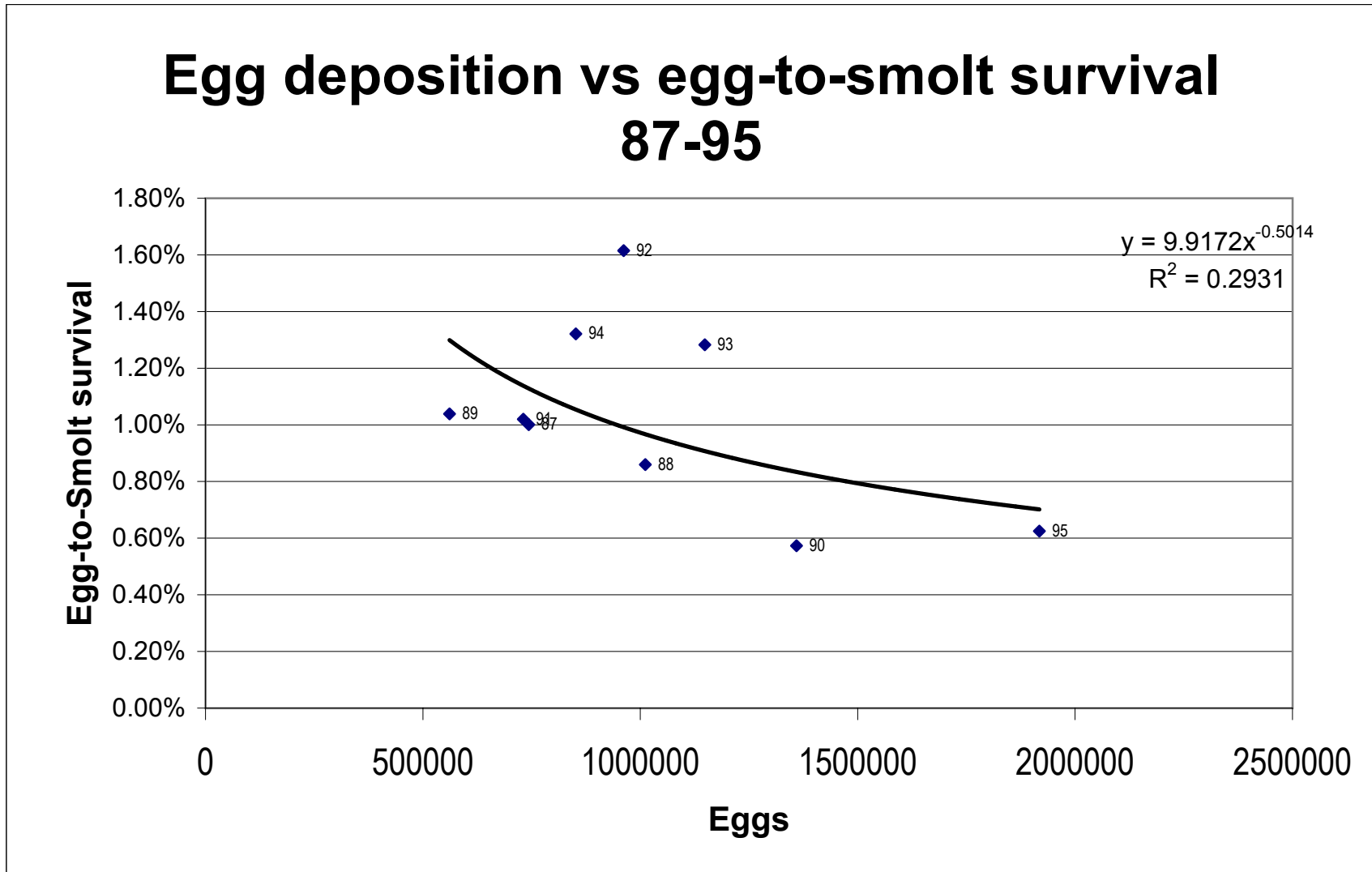


Figure 5. Power regression of egg deposition versus egg-to-smolt survival for the 1987-1995 year classes.