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Spawning and river escapement requirements for Atlantic salmon of the Saint John River, New Brunswick

by

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Abstract

Numbers of Atlantic salmon required for river escapement and spawning in the Saint John River, N.B., 1972-1982, were based on; a length-fecundity relationship for hatchery-spawned fish, proportions of wild and hatchery 1-SW and 2-SW and older females in the population, an accessible salmon-producing substrate of 28,189,000 m^2, an assumed requirement of 2.4 egg/m^2 for optimal adult production, and a management philosophy that requires only as many wild male 1-SW fish as there are 2-SW and older females unaccompanied by males. The required river escapement of 2-SW and older fish, including 200 for broodstock at the Mactaquac Fish Culture Station, is estimated at 10,314 $\pm$ 623 fish. The required total 1-SW river escapement is 10,549 fish. Of that total, 7,656 1-SW fish are target spawning escapement and 2,893 are associating fish of hatchery origin which are surplus to spawning escapement upon arrival at Mactaquac.

Résumé

Le nombre de saumons atlantiques qui ont dû échapper à la capture en rivière et se reproduire dans la rivière Saint-Jean (N.-B.) entre 1972 et 1982 a été établi à partir : d'une relation longueur-fécondité de poissons de pisciculture; des proportions, dans la population, de saumons femelles unibermarins, dibermarins ou redibermarins sauvages et de pisciculture; d'un substrat propice à la production de saumon, accessible, d'une superficie de 28 189 000 m^2; du nombre estimé de 2,4 oeufs/m^2 requis pour une production optimale d'adultes; et, enfin, d'une philosophie de gestion ne requérant que le même nombre de mâles unibermarins sauvages que de femelles diber ou redibermarines non accompagnées de mâles. On estime à 10 314 $\pm$ 623 le nombre de saumons di ou redibermarins échappant à la capture en rivière requis pour la reproduction. Ce nombre inclut un stock de 200 géniteurs pour l'établissement de pisciculture de Mactaquac. Le nombre total de saumons unibermarins échappant à la capture en rivière et requis pour la reproduction est de 10 549. De ce nombre, 7 656 saumons unibermarins représentent l'échappement cible en vue de la reproduction, et 2 893 poissons de pisciculture, surplus d'échappement au moment de l'arrivée à Mactaquac.

Introduction

The Saint John River, New Brunswick, sustains runs of Atlantic salmon of wild and hatchery origins. To optimize production of self-sustaining stocks of Atlantic salmon it is essential to quantify target spawning requirements. This document presents physical and biological data, methodology and rationale used in arriving at both target spawning requirement and river escapement.

Background

The Saint John River (Fig. 1) has a total drainage area of 54,930 km^2 of which 53 percent is in the Province of New Brunswick. Natural production of Atlantic salmon in the Saint John is currently restricted primarily to those waters within New Brunswick and, more specifically, to those tributaries below Grand Falls. The main stem is characterized (proceeding upstream) by an estuary of 96 km length extending to within 3 km of the Mactaquac hydroelectric dam; Mactaquac headpond of 97 km length; 34 km of free running river below the Beechwood hydroelectric dam; Beechwood headpond of 35 km length, and 30 km of free running river below Grand Falls. Salmon reaching Mactaquac are collected, sorted, and trucked upriver, principally to the Tobique River. Salmon liberated above Mactaquac at Woodstock can, however, ascend Beechwood Dam in a fish lift and the Tobique tributary hydroelectric dam in a fishway.

Loss of Atlantic salmon production to hydroelectric development is currently compensated for by the production of approximately 250,000 smolts/year at the Mactaquac Fish Culture Station (F.C.S.) located 2.5 km below the Mactaquac Dam. Until recently, most smolts have been fin clipped and released directly to the Saint John River from the hatchery. Since 1981, up to 24 percent (49,000) of the smolts have been liberated primarily marked to tributaries downriver of Mactaquac.

Methods

Estimates of the required numbers of salmon for spawning and for river escapement for the Saint John River both above and below Mactaquac dam were based on the analysis of 11 years of data in the general formula

$$P_s = E/m^2 \cdot R_a / \sum_{i=1}^{n} (E/♀_i \cdot p_i ♀ \cdot p_i) \text{ where,}$$

P_s = required number of male and female spawners,

E/m^2 = required number of eggs deposited per m^2,

R_a = accessible rearing area (m^2),

$p♀$ = proportion female,

$i_{1..n}$ = identifiable components of the run, e.g., 1-SW fish of hatchery origin, 1-SW fish of wild origin, 2-SW and older fish of hatchery ------ etc.,

P = proportion total population,

$E/♀$ = number of eggs carried per female.

Fecundity

A length-fecundity relationship of the form $y = ae^{bx}$ was established for 121 spring-, summer-, and fall-run wild salmon ranging 51 to 102 cm fork length collected at Mactaquac F.C.S. for broodstock in 1968, 1969, and 1970. Estimates of eggs/fish were derived by the von Bayer method. The number of eggs taken by artificial spawning was assumed to approximate those extruded in natural spawning (Baum and Meister, 1971).

Eggs/female figures were calculated by solving the length-fecundity relationship for lengths of female 1-SW and 2-SW and older, wild and hatchery fish sorted and sampled at Mactaquac for years where lengths were available. Annual means were used to derive fecundities for years for which there were no data.

Sea-age, place of origin and sex

All fish arriving at Mactaquac were identified as having spent one (< 65 cm) or more (> 65 cm) winters at sea.

All adults of hatchery origin were identifiable by fin clips or tags applied to the smolt before release.

All adults were sexed by external examination. While June and July 1-SW fish in particular were difficult to sex, checks in various years and experience gained from broodstock collections and occasional sacrifices lend confidence to the method.

Proportions for 1-SW and 2-SW and older, hatchery and wild female salmon ($p♀$) distributed above Mactaquac were derived from Ingram (1980; 1983 Unpubl. data). Spawners below Mactaquac were assumed to be of the same sex ratio as wild fish sorted at Mactaquac. The proportion of 1-SW:2-SW and older fish among wild fish spawning below Mactaquac was assumed to be the same as the proportion below the Kingsclear Indian fishery located between the Mactaquac F.C.S. and dam. This proportion was estimated from the summed estimated harvest of 1-SW and 2-SW and older wild salmon by Kingsclear and the count of wild fish at Mactaquac.

Estimates of the Kingsclear catch were based on a synthesis of various reports and exploitation rates determined for hatchery fish from returned tags. The reconstituted proportions of 1-SW fish below Kingsclear showed improved correlation with the proportions of 1-SW fish in the New Brunswick angling statistics for the Nashwaak, Hammond, and Kennebecasis rivers, 1972-1982.

The length-fecundity relationship established for wild salmon was applied to hatchery fish.

Accessible Rearing Area

Estimates of the total accessible rearing area were developed by various personnel and methods over the last 30 years. Methods of estimating area have included measurement of streams by tapes and range finders in both selected areas and sample transects (every 0.8 to 1.6 km), measurement of stream length and widths on topographic maps and aerial photos, and the application of the proportion of salmon-producing habitat determined for the drainage area of a surveyed stream to the drainage area of an unsurveyed stream.

Required egg deposition

An egg deposition of 2.4 eggs/m^2 (Elson, 1975) was assumed to be optimal for adult returns to the Saint John River.

Results

Solution of the length-fecundity relationship $Y_{fec} = 430.19e^{0.03605X}$ length (Fig. 2) for mean annual fork lengths of 1-SW and 2-SW and older wild and hatchery fish provided respective eggs/female values ranging from 2,954 to 4,084; 7,175 to 8,182; 3,246 to 3,857 and 6,874 to 7,795 (Table 1).

Eggs/fish values for wild populations of presumed sea-age and female composition spawning below Mactaquac were calculated for 1972 to 1982 and ranged from 2,219 (1979) to 4,926 (1972) (Table 2). Eggs/fish values for combined hatchery and wild fish distributed above Mactaquac, 1972-1982 ranged from 1,564 (1979) to 4,784 (1972) (Table 3).

The current estimated total salmon production habitat of the Saint John River is 28,189,000 m^2 (App. 1). Of the total, 12,261,000 m^2 (43.5%) are above Mactaquac and 15,928,000 (56.5%) are below Mactaquac. The 11-year mean number of 2-SW and older salmon required to seed the total accessible production area is 10,114 $\pm$ 623 (95% CL) (Table 4). One-sea-winter fish which by virtue of the proportion of 1-SW:2-SW and older fish would have accompanied but contributed 0.4 to 4.8 percent ($\bar{X}_{11yr}$ = 2.1 percent) of eggs below Mactaquac and 1.5 to 11.2 percent ($\bar{X}_{11yr}$ = 4.4 percent) of eggs above Mactaquac averaged 12,214 $\pm$ 4,524 (95% CL) over the same 11 years.

Discussion

From the length-fecundity relationship, Saint John River salmon of 60 and 80 cm fork length would carry an estimated 3,741 and 7,694 eggs respectively. Pope et al. (1961) provide a relationship which indicates that British salmon of the same lengths have fecundities of 3,764 and 7,191 eggs. Fish from Big Salmon River, N.B., carry 3,571 and 9,706 eggs at 60 and 80 cm fork length respectively (Glebe et al. MS 1979). A length-weight relationship for 73 wild females at Mactaquac, 1970, ($\log_e$ Wt = -3,6068 + 2.7857 $\log_e$ length; r^2 = 0.88) indicates that 60 and 80 cm fish weigh 2.4 and 5.4 kg respectively and therefore would yield 1,535 and 1,416 eggs/kg body weight. British salmon weighing 2.0 and 4.7 kg at 60 and 80 cm length (Pope et al. 1961) yield 1,855 and 1,531 eggs/kg respectively.

Elson (1975) suggests that both 1-SW and 2-SW and older Miramichi River salmon yield 1,764 eggs/kg (800 eggs/lb). One sea-winter and 2-SW and older salmon returning to the Saint John average an estimated 2.2 and 5.2 kg body weight, and approximately 1,580 and 1,410 eggs/kg respectively. Hence, despite their large size, Saint John River salmon do not yield as many eggs as would be expected using Elson (1975) values.

Selection of the 2.4 eggs/m^2 value as optimum spawning requirement for the Saint John River is in relative accordance with the suggested minimal value of 2.0 eggs/m^2 (CAFSAC, 1980 Unpubl. data). It allows for: possible underestimation of the total production area (e.g., exclusion of 7.6 X 10^6 m^2 main stem above Mactaquac); concern about the reluctance of fish of hatchery origin to seek prime spawning substrate (e.g., 64 percent of hatchery, relative to 41 percent of wild 2-SW and older fish ascended Beechwood dam 1976-1982 (Ingram; 1983 Unpubl. data)); and fall-back of hatchery and some wild fish from headwater and headpond release sites to less desirable spawning substrate.

Watt and Penney (1980), using "total potential" (as opposed to "actual") adult returns from estimated egg depositions in the Tobique River 1967-1972, anticipated that maximum smolt production on the Saint John (Tobique) might be met with an egg deposition of 1.5-2.0 eggs/m^2. A 4-year update and revision of base information (Watt and Penney, op. cit) on estimated egg deposition so as to coincide with methodology and data base of this paper and on total potential returns to Mactaquac, appear in Table 5. Unlike the original straight line 6-point plot (Fig. 6; Watt & Penney (1980)) these ten-and eight-point relationships between potential egg deposition and 1-SW and 2-SW and older fish, both separate and combined (Fig. 3), provide little evidence for the selection of a value different than 2.4 eggs/m^2.

If we accept that 2.4 eggs/m^2 remains a viable objective in maximizing adult returns to the entire Saint John, the 11-year mean of 10,114 ± 623 2-SW and older salmon would on average be an adequate 2-SW and older target spawning escapement. This estimate includes a small proportion of fish of hatchery origin (principally females) which, because they are retained at Mactaquac until dates proximate to the spawning event, are considered to be the equivalent of wild fish. An additional 200 2-SW and older fish are used as broodstock at Mactquac, bringing the total 2-SW and older requirement to 10,314 ± 623 fish.

The 12,214 ± 4,524 1-SW fish, which would on average accompany the 2-SW and older spawning requirement, contribute less than 5 percent on average of the total egg requirement and are therefore of little consequence in meeting target egg deposition. The management philosophy that recognizes the need to make 1-SW males available for improved chances of servicing 2-SW and older females unaccompanied by males and the need for a broad genetic diversity among progeny suggests that the required spawning escapement of 1-SW fish should be that number which would provide sufficient wild 1-SW males to approximate a 1:1 male:female sex ratio in the total spawning population. Moreover, because of the general abundance of 1-SW fish at Mactaquac, the concerns about the contribution of hatchery fish to spawning, and the incapacity to retain 1-SW fish at Mactaquac until spawning time, 1-SW fish of hatchery origin are included in required river escapement but excluded from target spawning requirement.

An approximation of the total 1-SW requirement can be calculated as follows:

Relationship to Mactaquac	No. 2-SW and older fish unaccomp. by males	No. 1-SW fish to provide equal males	No. 1-SW fish to provide wild males
Below	5,718[1] (0.869[2]-0.131[3]) = 4,220	4,220/0.952[4] = 4,433	4,433
Above	4,396[1] (0.849[2]-0.151[3]) = 3,068	3,068/0.952[4] = 3,223	3,223/0.527[5] = 6,116
TOTAL	7,288	7,656	10,549

[1]Table 4
[2]11-yr mean prop. females (arcsin transf.)
[3]11-yr mean prop. males (arcsin transf.)
[4]11-yr mean prop males (arcsin transf.)
[5]11-yr mean prop. wild (arcsin transf.)

The required total 1-SW river escapement is 10,549 of which 7,656 are target spawning escapement and 2,893 (10,549-7,656) are hatchery fish surplus to spawning escapement upon arrival at Mactaquac.

The identified target spawning requirement and river escapement will necessarily need upward revision if additional rearing area in the Saint John River basin is developed for salmon usage.

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Table 1. Mean estimated fecundity of wild and hatchery 1-SW and 2-SW and older female salmon at Mactaquac, Saint John River, 1972-1982. Sample size in parentheses.

Year	Eggs/Female 1-SW Wild	Eggs/Female 1-SW Hatchery	Eggs/Female 2-SW and older Wild	Eggs/Female 2-SW and older Hatchery
1972	3513 (24)	3642[1]	7175 (147)	7462[1]
1973	2954 (31)	3642[1]	7491 (173)	7462[1]
1974	3495 (7)	3642[1]	8182 (156)	7462[1]
1975	3238 (185)	3246 (393)	7677 (5560)	7503 (1360)
1976	3692 (21)	3684 (67)	7441 (744)	6874 (255)
1977	3492 (15)	3648 (42)	7551 (825)	7360 (398)
1978	3676 (16)	3857 (23)	7775 (694)	7795 (406)
1979	3368 (58)	3620 (24)	8018 (250)	7741 (218)
1980	3891 (84)	3834 (143)	7548 (755)	7445 (437)
1981	3233 (24)	3604 (16)	7455 (387)	7514 (275)
1982	4084 (25)	3642[1]	7390 (168)	7462[1]

[1]mean of 7 values, 1975-81.

Table 2. Numbers of eggs/1-SW and 2-SW and older salmon spawning below Mactaquac as estimated from the product of numbers of eggs/female salmon, proportion of females in each sea-age and proportion of 1-SW and 2-SW and older fish, 1972-1982.

Year	Sea-age	No. eggs/ female (E/♀i)[1]	Proportion female (p_i♀)	Proportion pop'n (p_i)	Eggs/fish by sea-age
1972	1-SW	3513	.115	.140	57
	2^+-SW	7175	.789	.860	4869
	Total				4926
1973	1-SW	2954	.139	.439	180
	2^+-SW	7491	.847	.561	3559
	Total				3739
1974	1-SW	3495	.095	.410	136
	2^+-SW	8182	.883	.590	4263
	Total				4399
1975	1-SW	3238	.040	.469	61
	2^+-SW	7677	.891	.531	3632
	Total				3693
1976	1-SW	3692	.010	.483	18
	2^+-SW	7441	.753	.517	2897
	Total				2915
1977	1-SW	3492	.020	.264	18
	2^+-SW	7551	.892	.736	4957
	Total				4975
1978	1-SW	3676	.033	.285	35
	2^+-SW	7775	.882	.715	4903
	Total				4938
1979	1-SW	3368	.032	.701	76
	2^+-SW	8018	.894	.299	2143
	Total				2219
1980	1-SW	3891	.045	.436	76
	2^+-SW	7548	.873	.564	3716
	Total				3792
1981	1-SW	3233	.022	.611	43
	2^+-SW	7455	.896	.389	2598
	Total				2641
1982	1-SW	4084	.051	.524	109
	2^+-SW	7390	.921	.476	3240
	Total				3349

[1]Table 1.

Table 3. Numbers of eggs/1-SW and 2-SW and older salmon spawning above Mactaquac as estimated from the product of numbers of eggs/female salmon, proportion of females in each sea-age, and proportion of 1-SW and 2-SW and older fish, 1972-1982.

Year	Stock	Sea-age	No. eggs/ female (E/♀i)[1]	Proportion female (p_i♀)	Proportion pop'n (p_i)	Eggs/fish by sea-age
1972	Wild	1-SW	3513	.115	.126	51
		2^+-SW	7175	.789	.772	4370
	Hatchery	1-SW	3642	.203	.031	23
		2^+-SW	7462	.642	.071	340
		Total				4784
1973	Wild	1-SW	2954	.139	.297	122
		2^+-SW	7491	.847	.374	2373
	Hatchery	1-SW	3642	.213	.276	214
		2^+-SW	7462	.764	.053	302
		Total				3011
1974	Wild	1-SW	3495	.095	.250	83
		2^+-SW	8182	.883	.350	2529
	Hatchery	1-SW	3642	.192	.274	192
		2^+SW	7462	.800	.126	752
		Total				3556
1975	Wild	1-SW	3238	.040	.302	39
		2^+-SW	7677	.891	.326	2230
	Hatchery	1-SW	3246	.081	.282	74
		2^+-SW	7503	.813	.090	549
		Total				2892
1976	Wild	1-SW	3692	.010	.317	12
		2^+-SW	7441	.753	.256	1434
	Hatchery	1-SW	3684	.036	.359	48
		2^+-SW	6874	.787	.068	368
		Total				1862
1977	Wild	1-SW	3492	.020	.187	13
		2^+-SW	7551	.892	.382	2573
	Hatchery	1-SW	3648	.032	.329	38
		2^+-SW	7360	.808	.102	607
		Total				3231
1978	Wild	1-SW	3676	.033	.174	21
		2^+-SW	7775	.882	.328	2249
	Hatchery	1-SW	3857	.034	.290	38
		2^+-SW	7795	.804	.208	1304
		Total				3612
1979	Wild	1-SW	3368	.032	.500	54
		2^+-SW	8018	.894	.154	1104
	Hatchery	1-SW	3620	.032	.282	33
		2^+-SW	7741	.753	.064	373
		Total				1564

Table 3. (Continued)

Year	Stock	Sea-age	No. eggs/female ($E/♀i$)[1]	Proportion female ($p_i♀$)	Proportion pop'n (pi)	Eggs/fish by sea-age
1980	Wild	1-SW	3891	.045	.279	49
		2^+-SW	7548	.873	.299	1970
	Hatchery	1-SW	3834	.066	.356	90
		2^+-SW	7445	.753	.066	370
		Total				2479
1981	Wild	1-SW	3233	.022	.391	28
		2^+-SW	7455	.896	.202	1349
	Hatchery	1-SW	3604	.044	.323	51
		2^+-SW	7514	.815	.084	514
		Total				1942
1982	Wild	1-SW	4084	.051	.438	91
		2^+-SW	7390	.921	.242	1647
	Hatchery	1-SW	3642	.050	.256	47
		2^+-SW	7462	.786	.064	375
		Total				2160

[1]Table 1.

Table 4. Estimated number of 1-SW and 2-SW and older salmon[1] required to seed accessible production areas[2] below and above Mactaquac on the Saint John River at 2.4 eggs/m^2.

	Number spawners					
	Below Mactaquac		Above Mactaquac		Total Saint John River	
Year	1-SW	2^+-SW	1-SW	2^+-SW	1-SW	2^+-SW
1972	1,086	6,674	966	5,185	2,052	11,859
1973	4,488	5,736	5,600	4,173	10,088	9,909
1974	3,536	5,127	4,336	3,939	7,872	9,066
1975	4,855	5,497	5,942	4,233	10,797	9,730
1976	6,334	6,780	10,683	5,120	17,017	11,900
1977	2,029	5,655	4,699	4,408	6,728	10,063
1978	2,206	5,535	3,780	4,367	5,986	9,902
1979	12,076	5,151	14,713	4,102	26,789	9,253
1980	4,395	5,686	7,538	4,333	11,933	10,019
1981	8,844	5,631	10,819	4,334	19,663	9,965
1982	5,981	5,433	9,455	4,169	15,436	9,602
X	5,075	5,718	7,139	4,396	12,214	10,114
95% CL	2,148	361	2,653	267	4,524	623

[1]Calculated as: $\frac{1}{\text{total eggs/fish}^{a}}$ x area x 2.4 x proportion pop'n

[2]Area: below Mactaquac = 15,928,00m^2; above Mactaquac = 12,261,000 m^2.

[a]Tables 2 and 3; right-hand columns.

Table 5. Estimated numbers of spawners and eggs deposited in the Tobique River, 1967-1976, and estimated total potential numbers of 1-SW and 2^{+}-SW progeny returning to Mactaquac.

	No. spawners					Total potential returns to Mactaquac		
	1-SW		2^{+}-SW		Eggs/			
Year	Wild	Hatch.	Wild	Hatch.	m^2	1-SW	2^{+}-SW	Total
1967	302	0	149	0	0.108	963	2884	3847
1968	305	0	61	0	0.057	558	1006	1564
1969	1594	0	589	0	0.436	3279	6605	9884
1970	1873	0	925	0	0.609	5649	8286	13935
1971	757	0	1155	0	0.712	4885	5926	10811
1972	215	42	1969	155	1.308	6968	8932	15900
1973	885	605	1062	118	0.865	2343	2909	5252
1974	1828	1823	2648	808	2.694	3944	5915	9859
1975	3780	2893	3941	1075	3.682	9088	8280	17368
1976	3812	3764	3314	733	2.454	5872	4725	10597

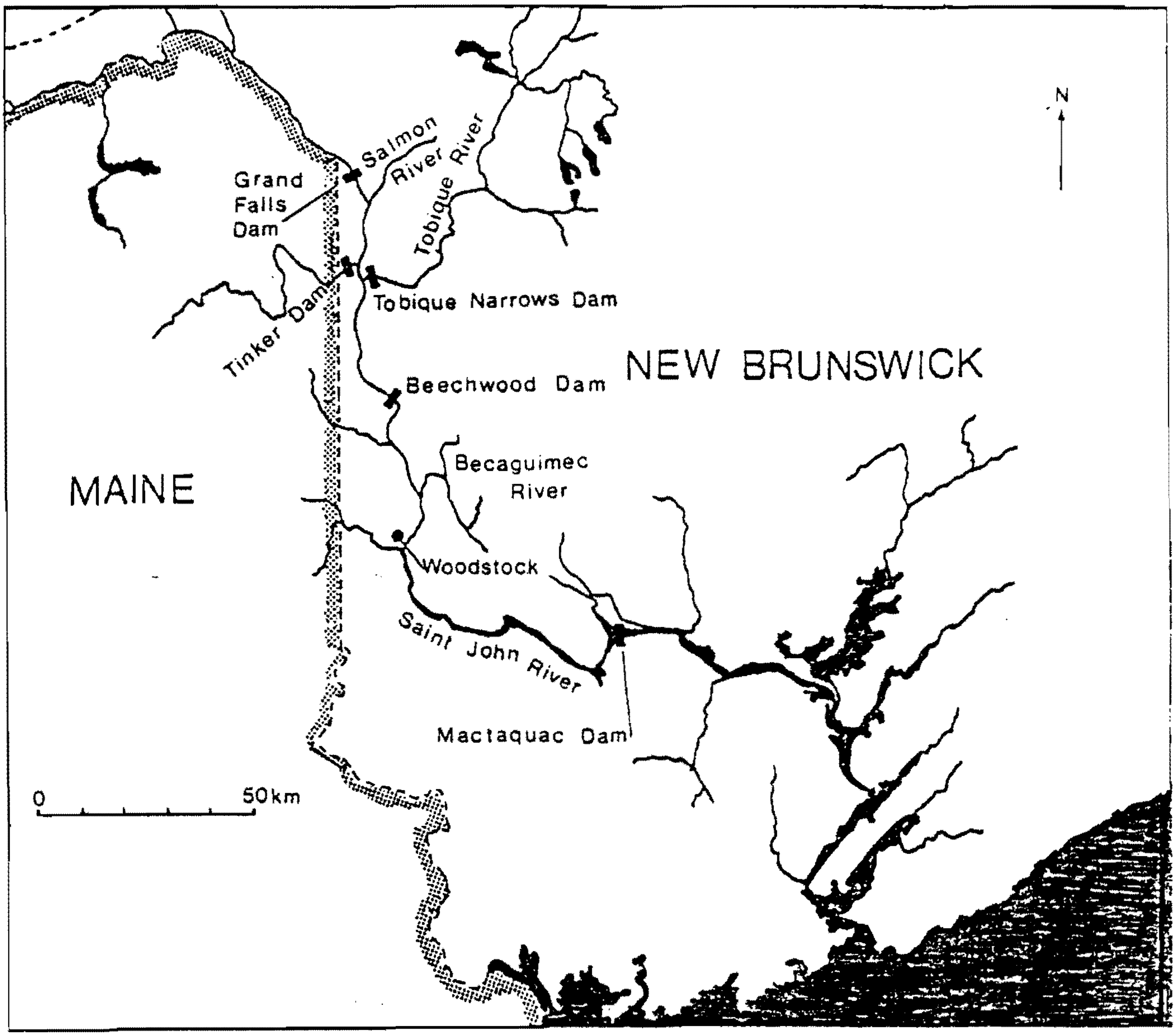

FIG. 1. Saint John River system map, indicating positions of dams and some major tributaries.

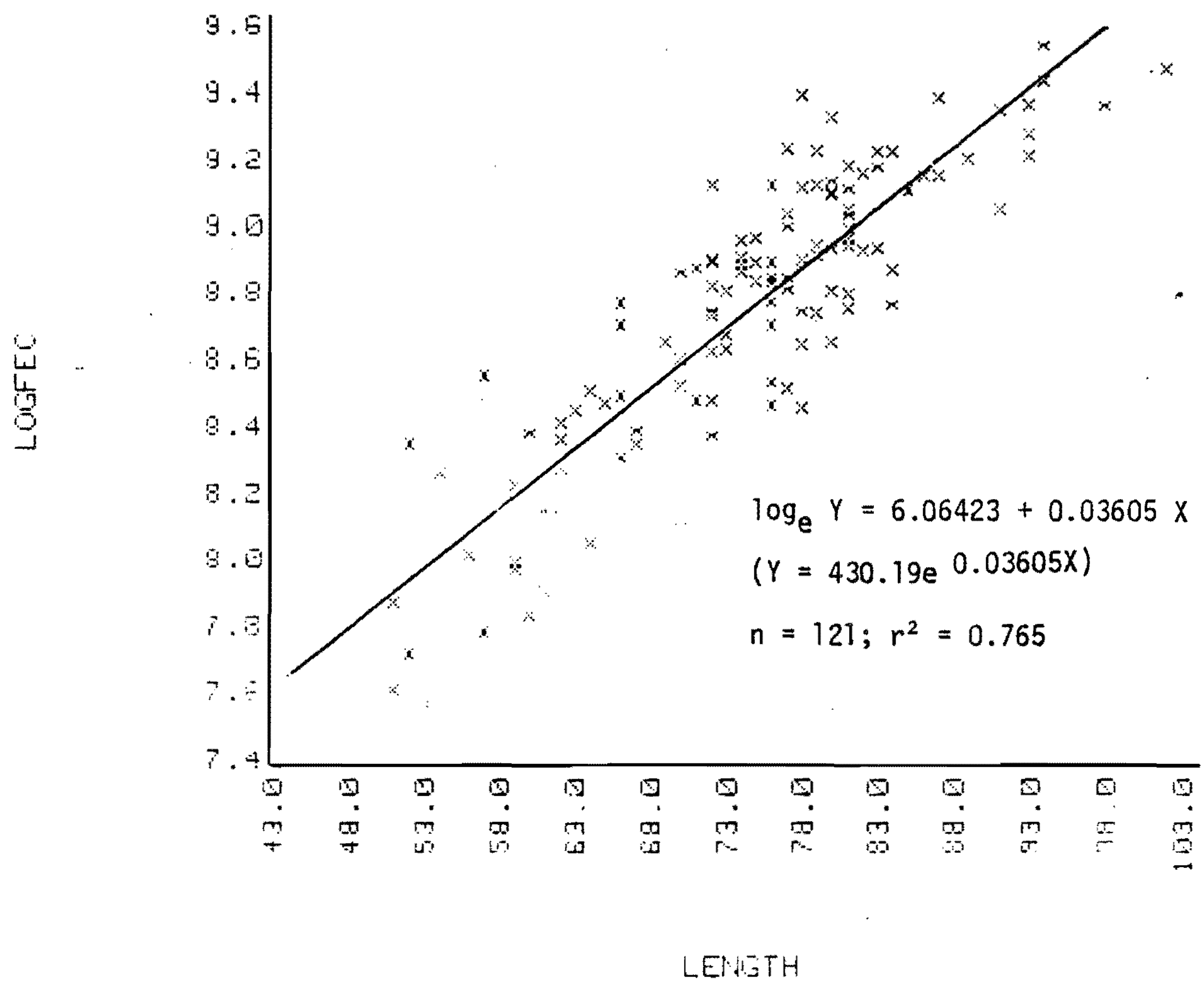

FIG. 2. Relationship between female fork length (cm) and fecundity of 121 wild salmon captured at Mactaquac, Saint John River, 1968, 1969 and 1970.

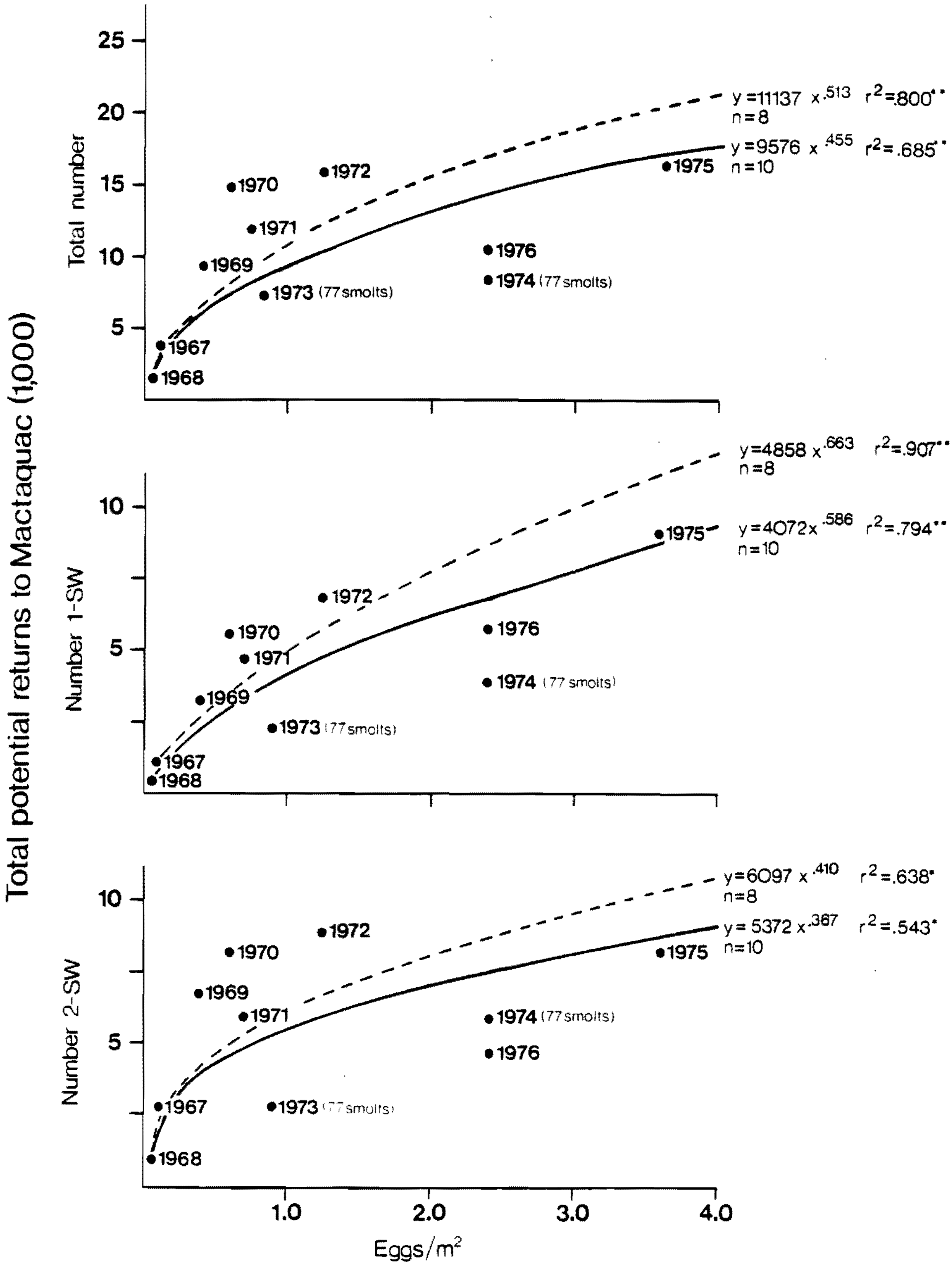

Fig. 3. Relationship between total potential returns to Mactaquac of wild 1-SW and 2-SW and older salmon, both separately and combined, resulting from estimated egg depositions in the Tobique River, 1967-1976. (Broken lines exclude egg depositions for 1973 and 1974 contributory to the 1977 smolt-class.)

Appendix I. Accessible salmon production habitat (both spawning and rearing) above and below Mactaquac on the Saint John River, New Brunswick.

ABOVE MACTAQUAC		AREA (m^2)
1.	Tobique River. Qualitative field survey (Smith and Ingram, 1955). Quantitative stream production area values determined by Ingram (pers. comm.) in 1960 and 1961.	9,442,000
2.	Main Stem of Saint John River from Grand Falls to Beechwood Dam (not including Beechwood Headpond). This area is not considered to support natural spawning, but may serve as a rearing area for emigrating or stocked juvenile salmon. Quantitative field survey in 1976 and 1977 (Francis, 1984) revealed 3,464,000 m^2 of potential salmon habitat.	-
3.	Salmon River (Grand Falls). Field survey work in 1976 and 1977 incomplete. Production area = drainage area (567 km^2) x prod. area factor of 0.2183 percent determined for Tobique River.	1,238,000
4.	Little River. This stream considered to contribute relatively little to salmon production. No value assigned.	0
5.	Muniac Stream. This stream considered to contribute little salmon production. No value assigned.	0
7.	Main Stem of Saint John River from Beechwood Dam to Mactaquac Dam (not including Mactaquac Headpond). This area is not considered to support natural spawning but may serve as a rearing area for emigrating or stocked juvenile salmon. Quantitative field survey in 1976 and 1977 (Francis, 1984) and aerial photo measurements suggested 4,132,000 m^2 of potential salmon habitat.	-
8.	Shikatehawk River. Field survey in 1972 (J.R. Semple, pers. comm.)	344,000
9.	Becaguimec River. Quantitative field survey in 1976 and 1977 (Francis, 1984).	1,122,000
10.	Main Nackawic River. Field survey in 1972 (J.R. Semple, pers. comm.)	115,000
11.	Mactaquac River. This stream considered to contribute little to salmon production. No value assigned.	0
12.	Presquile River. (International) Qualitative stream survey report (Warner, 1964). Current fish passage provisions and river quality unknown. No value included for salmon production area.	0

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ABOVE MACTAQUAC (Cont'd) AREA (m^2)

13.	Meduxnekeag River. (International) Qualitative stream survey report (Warner, 1967). Current fish passage provisions and river quality unknown. No value included for salmon production area.	0
14.	Eel River. This stream considered to contribute little to salmon production. No value assigned.	0
15.	Shogomoc River. This stream considered to contribute little to salmon production. No value assigned.	0
16.	Pokiok River. This stream considered to contribute little to salmon production.	0
	TOTAL ABOVE MACTAQUAC (Not including an estimated 7,596,000 m^2 of potential rearing habitat in the main Saint John).	12,261,000

BELOW MACTAQUAC

17.	Keswick River.	Quantitative field survey (Smith, 1956a).	789,000
18.	Nashwaaksis Stream.	This stream considered to contribute little to salmon production. No value assigned.	0
19.	Nashwaak River.	Quantitative field survey (Smith, 1956b).	4,938,000
20	Grand Lake drainage.		
	Portabello Creek	- No information/value assigned.	0
	Noonan Brook	- No information/value assigned.	0
	Burpee Mill Stream	- No information/value assigned.	0
	Little River	- Hooper et al. (1977).	293,000
	Newcastle Creek	- No information/value assigned	0
	Gaspereau River	- Hooper et al. (1977) and T. Pettigrew (pers. comm.)	1,004,000
	Salmon River	- Hooper et al. (1977); field survey (Smith, 1953).	401,000
	Coal Creek	- No information/value assigned.	0
	Cumberland Bay	- No information/value assigned.	0
	Youngs Cove	- No information/value assigned.	0
21.	Canaan River.	Qualitative field survey (Smith and Ingram, 1954). Production area = drainage area (668 km^2) x prod. area factor of 0.1732 percent determined for Keswick River.	1,157,000
22.	Belleisle Creek.	No information/value assigned.	0
23.	Kennebecasis River.	Quantitative field survey in 1976 and 1977 (Francis, 1984).	4,191,000

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BELOW MACTAQUAC (Cont'd)	AREA (m^2)
24. Hammond River. Quantitative field survey in 1976 and 1977 (Francis, 1984).	2,648,000
25. Oromocto River. This stream considered to contribute little to salmon production. No value assigned.	0
26. Nerepis River. Production area = drainage area (293 km^2) x prod. area factor of 0.1732 percent determined for Keswick River.	507,000
TOTAL BELOW MACTAQUAC	15,928,000
TOTAL SAINT JOHN (exclusive of main stem)	28,189,000

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