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Spawning potential and spawning requirements of Atlantic salmon in the Miramichi River, New Brunswick

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ABSTRACT

Average fecundities of 1SW (50 cm) and MSW salmon (70 cm) from the Miramichi River were estimated to be 2,552 and 6,374 eggs, respectively, from 256 female samples collected in 1982 and 1983. Egg deposition requirements for the Miramichi, assuming a deposition rate of 2.4 eggs$\cdot$m^{-2}, were calculated to be 132 X 10^6 eggs. Numbers of MSW salmon required to produce these eggs were 23,600 (±1800), with another 22,600 (±1800) 1SW salmon being required to ensure one male spawner for each MSW female.

Historically, 1SW salmon contributed about 30% to the total egg deposition in the Miramichi River (1971 to 1983), which is substantially greater than egg deposition by 1SW fish in the Restigouche (1%) or St. John rivers (2%). However, for estimating target spawners in the Miramichi, relying on MSW salmon for providing eggs has two main advantages: (1) MSW salmon returns can be predicted one year in advance and thus spawning requirements can be taken into account before fishing allocations are made each year, and (2) most MSW salmon are females and their high fecundities mean that less spawning biomass is required to achieve target egg depositions, compared to 1SW salmon.

RESUME

La fertilité moyenne du saumon de la rivière Miramichi a été estimée à 2 552 oeufs, pour le saumon ayant passé un an en mer (50 cm), et à 6 374 oeufs, pour le saumon ayant passé plusieurs années en mer (70 cm), d'après 256 échantillons de femelles recueillis en 1982 et en 1983. On a calculé que la quantité d'oeufs nécessaire serait de 132 x 10^6 pour la rivière Miramichi, si l'on suppose un taux de ponte de 2,4 oeufs.m^{-2}. Pour produire un telle quantité d'oeufs, il fallait 23 600 (± 1 800) saumons ayant passé plusieurs années en mer auxquels s'ajoutent 22 600 (± 1 800) saumons ayant passé un an en mer pour qu'il y ait un géniteur mâle pour chaque femelle ayant passé plusieurs années en mer.

Depuis longtemps, le saumon ayant passé un an en mer intervient pour environ 30 % de la quantité totale d'oeufs pondus dans la rivière Miramichi (de 1971 à 1983). Cette contribution est nettement plus élevée que celle du saumon de même classe dans les rivières Restigouche (1 %) et Saint-Jean (2 %). Cependant, pour estimer le nombre de géniteurs cible dans la rivière Miramichi, le fait de se fier au saumon ayant passé plusieurs années en mer présente deux avantages principaux : 1) le nombre de saumons ayant passé plusieurs années en mer, qui reviennent dans la rivière, peut être prévu un an d'avance, ce qui permet de tenir compte des besoins de frai avant d'établir les prises admissibles pour chaque année; 2) la plupart des saumons ayant passé plus d'un an en mer sont des femelles et, comme elles sont très fertiles, il faut une biomasse de poissons en phase de frai moins élevée que dans le cas du saumon ayant passé un an en mer pour atteindre le niveau de ponte visé.

INTRODUCTION

Atlantic salmon of the Miramichi River usually mature after one (1SW salmon) or two (2SW) winters at sea. Relative abundance of 1SW salmon increased dramatically in the mid 1960's, from 50% to over 80% of the spawning run (Ruggles and Turner 1973); this change was attributed to increased fishing mortality of 2SW salmon. Because of the change in age composition of spawners, the reproductive capacity of Miramichi salmon was reduced.

Spawning potential of Miramichi salmon in recent years (1971 to 1982) was estimated by Randall and Chadwick (1983), assuming a relative fecundity of 1,764 eggs per kilogram for both 1SW and 2SW salmon. This fecundity was based on studies of salmon from other rivers. However, fecundity of Atlantic salmon has been shown to be stock specific (Pope et al. 1961; Glebe et al. 1979), and extrapolating from one population to another may be misleading. Unfortunately, very little information on fecundity of Miramichi salmon has been published. Belding (1940) counted eggs from 163 salmon collected in 1930, but his sample included only 2SW and older salmon, and he did not specify exactly where his fish were collected. Glebe et al. (1979) reported the fecundity of salmon from Rocky Brook, a small tributary of the Southwest Miramichi, but their sample was small (28) and it was also restricted to 2SW salmon.

This study was undertaken to determine the fecundity of 1SW and 2SW salmon in the Miramichi River. The relative importance of 1SW salmon to spawning is identified and compared to other New Brunswick rivers. Numbers of spawners required to attain adequate egg deposition in the Miramichi River are recalculated from Randall and Chadwick (1983), using the new information on fecundity.

METHODS

1. Egg deposition requirements

The required egg deposition rate was assumed to be 2.4 eggs $.m^{-2}$ (Elson 1975). Total area of juvenile salmon rearing habitat was estimated from aerial photographs (Amiro 1983). Egg deposition requirements were calculated as:

(1) Egg requirements = deposition rate X rearing area.

2. Fecundity

Ovaries from 256 salmon were collected from the following locations in 1982 and 1983:

	1982	1983
Miramichi Bay	53	4
Millbank	71	46
Northwest Miramichi	10	27
Southwest Miramichi	16	29
TOTAL	150	106

Samples from Miramichi Bay were from commercial drift net fishermen at Escuminac, and Millbank samples were from the estuarial counting trap. Both Miramichi Bay and Millbank salmon were assumed to be random samples of Miramichi salmon. Ovaries collected from the Northwest Miramichi came from angling mortalities from several locations on the main Northwest and Sevogle rivers; samples from the Southwest Miramichi River came from two angling camps close to the mouth of the tributary, and thus represented random samples of salmon entering this river. Sample sizes from the Northwest and Southwest rivers were kept proportional to the rearing area of each tributary.

Ovaries were collected from June to September each year. Egg samples were placed in Gilson's fluid until ovarian tissue broke down, and then transferred to 10% formalin to harden the eggs. All egg samples were counted in their entirety. Other information recorded for each fish included: fork length (cm), weight (nearest 0.1 kg), sampling location, date, gear and age (from scales).

Fecundity was recorded as total fecundity (total eggs per fish) for each sea-age group. Length-fecundity relationships were calculated after both fork lengths and total fecundity were transformed (natural logarithms); the rationale for using this transformation is discussed by Pope et al. (1961) and Healey and Heard (1984).

3. Biological characteristics

Biological characteristics of spawning salmon entering the Miramichi River from 1971 to 1982 were summarized by Randall and Chadwick (1983). These data were re-examined to estimate fork lengths and proportions at sea age for 2SW and 3SW salmon separately. Also, sex ratios were re-calculated to include both sacrificed salmon (as in Randall and Chadwick 1983), and external sexing of salmon beginning in early August. Similar data for adults sampled in 1983 were added. Sea-ages of salmon in this report are identified as:

1SW = one sea winter
2SW = two sea winter
3SW = three sea winter and older
MSW = two sea winter and older
PS = previous spawner

For calculating long-term means of proportions (sex ratios and proportions-at-age), arcsine transformations (Zar 1974) and weighted means were used.

4. Eggs per fish

Average eggs per fish each year from 1971 to 1983 were calculated as:

(2) Eggs per fish = fecundity X proportion female X proportion at sea age

where fecundity was calculated from length-fecundity relationships (see pg. 6). Eggs per fish were calculated for each sea-age separately and then summed to determine total eggs per fish, regardless of age.

5. Numbers of required spawners

Three methods were used to estimate the number of 1SW and MSW salmon required for spawning in the Miramichi River:

Method 1: This was the method used in previous assessments of Miramichi salmon (Randall and Chadwick 1983), but updated parameter values were used here. Eggs per fish were calculated using equation (2), and fork lengths, sex ratios and proportions at sea age from Millbank (1971 to 1983). Required spawners were calculated by dividing the required eggs by the average eggs per fish, and proportioned into 1SW and MSW salmon based on the average 1SW/MSW ratio at Millbank (1971 to 1983).

Method 2: MSW salmon required for spawning were calculated presuming all eggs came from MSW salmon. Eggs per MSW salmon were calculated as the product of fecundity and proportion females. Numbers of 1SW salmon required were calculated assuming that at least one male spawner was needed for each female MSW spawner.

Method 3: This method assumed egg deposition came from both 1SW and MSW salmon, as in Method 1, but the overall sex ratio at spawning was set at 1:1. Required spawners were calculated using simultaneous equations (see pg. 8) and average (1971 to 1983) biological characteristics as in Method 1.

For all three methods, estimates of required 1SW and MSW spawners were rounded off to the nearest 100 fish. The utility of each method was assessed by estimating the proportion of years (1971 to 1983) that ≧ 90% of target egg deposition would be achieved and by comparing the relative impact on available harvest of each method.

RESULTS

1. Rearing area

Amiro (1983) estimated the area of juvenile salmon habitat in the Miramichi River to be about 55 x 10^6 m^2. Total area is subdivided by major tributary below:

	Area	%
Northwest Miramichi	16,788,400	31
Southwest Miramichi	36,657,900	67
Main Miramichi (below confluence)	1,158,800	2
TOTAL	54,605,100	

Egg deposition requirements were estimated to be 132 x 10^6 eggs (equation (1) and assuming 2.4 eggs m^{-2}).

2. Fecundity

Sea-age composition and location of female salmon collected for estimating fecundity are indicated below:

Location	Number of fish 1SW	2SW	3SW	PS	Total
1982					
Miramichi Bay	1	51	1		53
Millbank	44	24		3	71
Northwest	9			1	10
Southwest	8	7		1	16
Subtotal	62	82	1	5	150

1983					
Miramichi Bay		4			4
Millbank	20	24		2	46
Northwest	10	16		1	27
Southwest		26		3	29
Subtotal	30	70		6	106
TOTAL	92	152	1	11	256

In both years, the majority of 1SW samples came from Millbank. Fewer samples in 1983 reflected the poor returns of 1SW salmon to the river in that year, compared to 1982 (Randall and Schofield 1983). During both years, it was difficult to get female 1SW salmon from the Southwest Miramichi; anglers reported less than 5% of 1SW fish were female, compared to 30 to 50% of 1SW fish in the Northwest Miramichi. Of the total 152 2SW fish sampled in 1982 and 1983, most came from Miramichi Bay and Millbank (68%). Of the remainder, 33 and 67% came from the Northwest and Southwest tributaries, respectively.

Slopes of length-fecundity relationships for 1SW and MSW salmon were significantly different ($P < 0.05$). For MSW salmon, there was no difference in the slopes or intercepts between 1982 and 1983. Intercepts of 1SW salmon were different ($P < 0.01$), however, indicating fecundity was greater for a given length in 1983 than in 1982. Slopes of 1SW salmon length-fecundity relationships between years were not significantly different.

Regression statistics for the length-fecundity relationships of 1SW and MSW salmon were (Figure 1):

Sea age	n	slope	intercept	r	F	P
1SW	92	3.1718	-4.5636	0.45	23.16	< 0.001
MSW	164	1.4132	2.7560	0.39	29.42	< 0.001

These equations gave total fecundities of 2,552 and 6,374 eggs for 1SW (50 cm) and MSW salmon (70 cm), respectively (Table 1).

3. Biological characteristics

During the period 1971 to 1983, 1SW, 2SW and 3SW salmon entering the Miramichi River averaged 52.1, 72.8 and 79.9 cm in length, respectively (Table 2). Proportion of females for each sea-age respectively were 0.25, 0.88 and 0.64. Of the total spawning run, 1SW salmon were usually the most abundant (average 76%), followed by 2SW (22%) and 3SW salmon (2%) (Table 3). For 2SW and 3SW salmon combined (i.e. MSW salmon), mean fork length was 73.4 cm, proportion females was 0.86 and proportion at sea-age was 0.24.

On average (1971 to 1983), 1.5% of 2SW salmon and 88.3% of 3SW were previous spawners. For estimating eggs per fish (Section 4), no distinction was made between virgin or previously spawned fish.

4. Eggs per fish

Average eggs per spawner during 1971 to 1983 (Table 4) was 2,006 (±460). Proportional contribution by each sea-age group was as follows:

	Proportion of total eggs	
	Average	Range
1SW	30	(8-67)
2SW	64	(30-88)
3SW	6	(2-14)

5. Spawning requirements

Method 1:

Average eggs per fish, as given above, indicated the following required spawners:

Required spawners	=	$132 \times 10^6/2{,}006^{\pm 460}$
	=	65,803 (53,528 - 85,382)
Required MSW salmon	=	15,800 (12,800 - 20,500)
Required 1SW salmon	=	50,000 (40,700 - 64,900)

Method 2:

Eggs per fish calculated assuming all eggs came from MSW salmon indicated approximately 23,600 (±1800) MSW salmon are required for spawning (Table 5).

Assuming 1 male spawner for each MSW female spawner, the numbers of 1SW salmon required were 22,600 (±1800)

Of the 22,600 1SW salmon required, 5,650 would be female. Given the average fecundity of 1SW females of 2,908 eggs (see below), these fish would produce 16.4×10^6 eggs, surplus to the 132×10^6 eggs produced by MSW salmon.

	Fork length	Fecundity	Proportion female	Eggs per fish
MSW	73.4	6,816	0.86	5,862
1SW	52.1	2,908	0.25	727

Method 3:

If MSW = number of MSW salmon required, given that each has 5,862 eggs on average

1SW = number of 1SW salmon required; each has 727 eggs

(3) then $MSW (5,862) + 1SW (727) = 132 \times 10^6$ eggs

Assuming a 1:1 sex ratio at spawning, and given average sex ratios for 1SW and MSW salmon as shown in the previous section

then

$$\text{males} = \text{females}$$

$$(0.14)\ MSW + (0.75)\ 1SW = (0.86)\ MSW + (0.25)\ 1SW$$

(4) $$MSW = (0.69)\ 1SW$$

Solving with (4) in (3):

$$1SW\ (0.69)\ (5,862) + 1SW\ (727) = 132 \times 10^6$$

$$1SW = 27,663$$

$$= 27,700$$

$$MSW = 0.69\ (27,663)$$

$$19,100$$

Results of the three methods are compared in Table 6. Both Methods 2 and 3 significantly increased available harvest to the fishery compared to Method 1, and Method 2 indicated target deposition would be achieved with 23,600 MSW and 22,600 1SW spawners in most years (92% from 1971 to 1983).

DISCUSSION

Fecundity of Miramichi River salmon based on ovaries collected in 1982 and 1983 is compared to other salmon populations in Table 1. Fecundity of both 1SW (fork length 50 cm) and 2SW salmon (fork length of 70 cm) were within the ranges found elsewhere. Average relative fecundity was 2,035 and 1,636 eggs per kilogram for 1SW and 2SW fish, respectively. The assumed relative fecundity of 1,764 eggs per kilogram in previous assessments (Randall and Chadwick 1983) therefore overestimated the reproductive potential of MSW spawners, but underestimated 1SW spawners.

Contribution to total egg deposition by 1SW fish in the Miramichi is considerably greater than in the Restigouche and St. John Rivers (Randall 1984; Marshall and Penney 1983); this is primarily because of the greater proportion of female 1SW fish in the Miramichi:

	fecundity (50 cm)	proportion female	proportion of total spawners	proportion of total egg deposition
Miramichi	2,552	0.25	0.76	0.30
Restigouche	2,913	0.02	0.39	0.01
St. John (below Mactaguac)	2,609	0.05	0.43	0.02

However, the majority of eggs come from MSW salmon in all three rivers. Age 3SW and older salmon are rare in the Miramichi and contribute only 6% of the total egg deposition. In contrast, 3SW salmon contribute 49% of the egg deposition in the Restigouche River (Randall 1984).

The difference in the reproductive potential of 1SW and MSW salmon in the Miramichi River is considerable: it takes eight 1SW fish to produce as many eggs as one MSW salmon. This difference was apparent when the three methods of estimating spawning requirements were compared (Table 6). Methods 2 and 3 rely more on MSW salmon for egg deposition and thus fewer numbers and biomass of spawners are required to achieve the target egg deposition. Of the three methods, Method 2 is the most desirable because, in addition to requiring less spawning biomass, it also ensures that target deposition will be met in most years (92%). Method 2 indicates that 23,600 MSW and 22,600 1SW salmon are required for spawning.

In addition to the above advantages, there are other reasons why MSW salmon are more desirable as spawners than 1SW salmon:

(1) Paloheimo and Elson (1974) found a significant correlation between MSW salmon at Curventon (Northwest Miramichi) and subsequent small parr densities, but there was no correlation between 1SW fish and parr during the same period (1951 to 1971). Similar results were found using more recent data on angling landings (as an index of spawners) and parr densities from all tributaries (Chadwick and Randall 1986). These results emphasize the importance of MSW spawners.

(2) As mentioned earlier, MSW salmon were historically proportionally more abundant in the spawning run of the Miramichi River (Ruggles and Turner 1973). The apparent relative importance of 1SW spawners is probably exceptionally high in recent years because of selective fishing mortality of large salmon. Historically 1SW fish were not as important for egg deposition.

(3) MSW salmon can be predicted one year in advance in the Miramichi River, but 1SW salmon cannot (Randall et al. 1985). From a management standpoint, therefore, relying on MSW salmon for egg deposition makes good sense. Given the predicted MSW returns each year, management plans developed before the fishery begins can take into account spawning requirements before fishing allocations are decided.

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Table 1. Comparison of fecundity of Atlantic salmon in the Miramichi River with populations from other rivers in New Brunswick and elsewhere.

River	Reference	Total fecundity 50 cm	70 cm	90 cm	Sample size
Miramichi	This paper	2,552	6,374		256
Restigouche	Randall (1984)		6,406	11,541	91
St. John	Marshall and Penney (1983)	2,609	5,365	11,034	121
Big Salmon	Glebe et al. (1979)	2,473	6,722		28
2; Maine	Baum and Meister (1971)		6,641	12,630	164
6; Scotland	Pope et al. (1961)	2,422	5,314	9,554	402

Table 2. Mean fork lengths (FL, cm) and sex ratios of 1SW and MSW salmon sampled at Millbank, 1971 to 1983. (Sample sizes given in parenthesis.)

Year	1SW FL	1SW % female	2SW FL	2SW % female	3SW FL	3SW % female
1971	51.1 (250)	11 (73)	70.7 (298)	(88)[1] (0)	75.7 (20)	(64)[1] (0)
1972	52.0 (686)	22 (268)	70.7 (480)	73 (167)	79.0 (31)	69 (13)
1973	53.7 (742)	17 (616)	73.6 (687)	84 (467)	79.9 (31)	40 (25)
1974	52.5 (1,390)	30 (603)	74.0 (588)	88 (343)	81.4 (56)	54 (37)
1975	51.4 (1,026)	27 (478)	73.9 (303)	90 (230)	82.2 (36)	70 (27)
1976	51.9 (988)	24 (435)	74.2 (174)	91 (117)	81.9 (22)	50 (14)
1977	51.9 (421)	23 (202)	72.7 (484)	93 (356)	77.4 (33)	71 (21)
1978	51.6 (387)	37 (174)	73.7 (246)	90 (326)	80.2 (42)	82 (97)
1979	51.8 (728)	27 (402)	72.5 (75)	91 (46)	81.2 (26)	83 (12)
1980	52.0 (593)	19 (290)	73.3 (311)	95 (202)	83.0 (21)	38 (13)
1981	51.4 (605)	25 (219)	71.4 (40)	73 (26)	75.4 (14)	20 (5)
1982	52.7 (321)	30 (207)	71.5 (202)	84 (167)	79.3 (40)	37 (35)
1983	52.0 (214)	29 (72)	71.6 (63)	79 (29)	77.3 (12)	67 (3)
Mean	52.1 cm	25%	72.8 cm	88%	79.9 cm	64%

[1] Sex ratios of MSW salmon in 1971 were assumed to be average (1972 to 1983).

Table 3. Sea-age composition of salmon captured at Millbank, 1971 to 1983.

	1SW		2SW			3SW and older		
Year	Number	%	Number	%	(% of salmon)	Number	%	(% of salmon)
1971	1,962	83	375	16	94	24	1	6
1972	2,543	69	1,082	29	94	69	2	6
1973	2,450	68	1,087	30	96	45	1	4
1974	4,038	69	1,630	28	91	161	3	9
1975	3,548	75	1,075	23	89	133	3	11
1976	4,939	84	839	14	89	104	2	11
1977	1,505	44	1,818	53	94	116	3	6
1978	1,268	65	589	30	85	104	5	15
1979	2,500	89	235	8	74	83	3	26
1980	2,139	66	1,027	32	94	66	2	6
1981	2,174	92	147	6	74	52	2	26
1982	2,665	87	343	11	84	65	2	16
1983	810	77	206	20	84	39	3	16
Mean		76%		22%			2%	

Table 4. Estimated numbers of eggs per fish for Miramichi 1SW and MSW salmon, and the variables used to estimate these values, 1971 to 1983. Mean fork lengths (FL), sex ratios and proportions-at-age from Tables 3 and 4; eggs per female calculated from the length-fecundity relationships previously described.

Year	Age-group	FL	Eggs/ female	Proportion female	Proportion-at-age	Eggs/ fish	Percent of total eggs
1971	1SW	51.1	2,734	0.11	0.83	250	21
	2SW	70.7	6,464	0.88	0.16	910	75
	3SW	75.7	7,120	0.64	0.01	46	4
						1,206	
1972	1SW	52.0	2,890	0.22	0.69	439	23
	2SW	70.7	6,464	0.73	0.29	1,368	72
	3SW	79.0	7,562	0.69	0.02	104	5
						1,911	
1973	1SW	53.7	3,200	0.17	0.68	370	17
	2SW	73.6	6,842	0.84	0.30	1,724	81
	3SW	79.9	7,684	0.40	0.01	31	2
						2,125	

Table 4; Continued

Year	Age-group	FL	Eggs/ female	Proportion female	Proportion-at-age	Eggs/ fish	Percent of total eggs
1974	1SW	52.5	2,979	0.30	0.69	617	25
	2SW	74.0	6,895	0.88	0.28	1,699	70
	3SW	81.4	7,889	0.54	0.03	128	5
						2,444	
1975	1SW	51.4	2,785	0.27	0.74	556	26
	2SW	73.9	6,882	0.90	0.23	1,425	66
	3SW	82.2	7,999	0.70	0.03	168	8
						2,149	
1976	1SW	51.9	2,872	0.24	0.84	579	38
	2SW	74.2	6,921	0.91	0.14	882	57
	3SW	81.9	7,957	0.50	0.02	80	5
						1,541	
1977	1SW	51.9	2,872	0.23	0.44	291	8
	2SW	72.7	6,724	0.93	0.53	3,314	88
	3SW	77.4	7,347	0.71	0.03	156	4
						3,761	
1978	1SW	51.6	2,820	0.37	0.65	678	24
	2SW	73.7	6,855	0.90	0.30	1,851	65
	3SW	80.2	7,725	0.82	0.05	317	11
						2,846	
1979	1SW	51.8	2,855	0.27	0.89	686	50
	2SW	72.5	6,698	0.91	0.08	488	36
	3SW	81.2	7,861	0.83	0.03	196	14
						1,370	
1980	1SW	52.0	2,890	0.19	0.66	362	15
	2SW	73.3	6,803	0.95	0.32	2,068	83
	3SW	83.0	8,109	0.38	0.02	62	2
						2,492	
1981	1SW	51.4	2,785	0.25	0.92	641	67
	2SW	71.4	6,555	0.73	0.06	287	30
	3SW	75.4	7,080	0.20	0.02	28	3
						956	
1982	1SW	52.7	3,015	0.30	0.87	787	54
	2SW	71.5	6,568	0.84	0.11	607	42
	3SW	79.3	7,603	0.37	0.02	56	4
						1,450	
1983	1SW	52.0	2,890	0.29	0.77	645	35
	2SW	71.6	6,581	0.79	0.20	1,040	57
	3SW	77.3	7,333	0.67	0.03	147	8
						1,832	

Table 5. Estimated numbers of eggs per salmon (MSW) and the numbers of salmon required for spawning, 1971 to 1983. Required spawners are calculated assuming an egg deposition requirement of 132,000,000 eggs.

Year	F.L.	Eggs/female	Proportion Female	Eggs/salmon	Required Spawners
1971	71.0	6,503	(0.86)[1]	5,593	23,601
1972	71.2	6,529	0.73	4,766	27,696
1973	73.9	6,882	0.82	5,643	23,392
1974	74.6	6,974	0.85	5,928	22,267
1975	74.8	7,000	0.88	6,160	21,429
1976	75.1	7,040	0.87	6,125	21,551
1977	73.0	6,763	0.92	6,222	21,215
1978	74.7	6,987	0.88	6,149	21,467
1979	74.7	6,987	0.89	6,218	21,229
1980	73.9	6,882	0.92	6,331	20,850
1981	72.4	6,685	0.64	4,278	30,856
1982	72.8	6,737	0.76	5,120	25,781
1983	72.5	6,698	0.78	5,224	25,268
				Mean	23,584
				95% C.L.	(±1839)

[1] proportion of female salmon in 1971 was assumed to be average (1972-1983).

Table 6. Comparison of three methods for estimating required numbers of 1SW and MSW spawners in the Miramichi River. The three methods are described in the text. Harvest (kilograms) was calculated assuming a mean weight of 4.5 and 1.6 kg for MSW and 1SW salmon, respectively.

Required spawners	Method 1	Method 2	Method 3
Required spawners			
MSW	15,800	23,600	19,100
1SW	50,000	22,600	27,700
% of eggs from:			
MSW	72%	89%	85%
1SW	28%	11%	15%
Percent of years (1971-1983) when ≥ 90% of target deposition would be achieved with target spawners	69%	92%	77%
Increase in available harvest compared to Method 1:			
Numbers	-	19,600	19,000
Kilograms	-	8,740	20,830

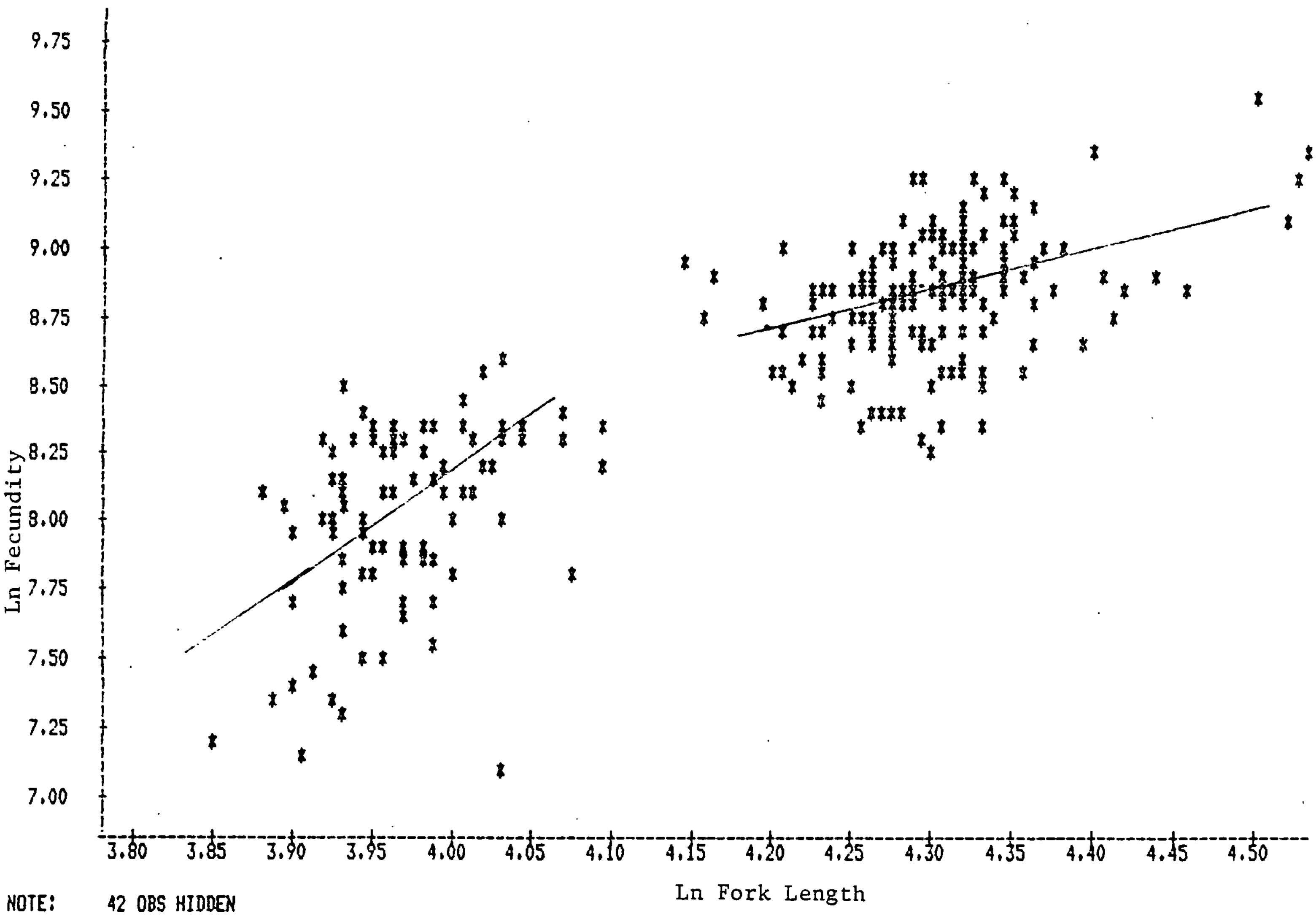

Figure 1. Length-fecundity relationship for 1SW and MSW salmon in the Miramichi River. Regression equations given in text.