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**Atlantic salmon (Salmo salar L.) target spawning requirements for
the Exploits River and status of the stock 1960-1991**

by

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Abstract

The target egg deposition for the Exploits River is calculated in terms of riverine and lacustrine habitat utilizing 240 eggs/m² of riverine habitat and 7 smolts /ha. of standing water respectively. The egg depositions and percent of target egg achieved are calculated from 1960 to present.

Résumé

On calcule la ponte cible pour les habitats de rivière et les habitats lacustres de la rivière Exploits en se fondant sur 240 oeufs par mètre carré d'habitat de rivière et sur sept saumoneaux par hectare d'eau dormante. On calcule également la ponte et le pourcentage de ponte cible atteint de 1960 à nos jours.

Introduction

The Exploits River is the largest watershed in insular Newfoundland encompassing a drainage area of 11,272 km² (Porter et al. 1974). The river flows in a northeasterly direction entering the sea in SFA 4. Due to natural obstructions, less than 10% of watershed area was available to anadromous Atlantic salmon (Taylor and Bauld, 1973).

The intent of this document is to provide data on required egg deposition and percentage of target egg deposition achieved from 1960 to present.

Background

Since 1957 the Exploits River has been the site of an extensive salmon enhancement program. This work has been conducted in three phases addressing the major sections of the watershed (Fig. 1). The approach taken in this development was to stock previously inaccessible areas with various life stages of Atlantic salmon and to provide upstream passage for adults where necessary. Phase 1, conducted on the lower section (area below Grand Falls) from 1957-1965, included an adult transfer from Rattling Brook (a tributary flowing into the Bay of Exploits) to Great Rattling Brook.

Phase 2 of this development addressed stocking of the tributaries below Red Indian Lake and above Grand Falls, i.e. that area referred to as the middle section. This phase was conducted between 1968-1980. Due to a brood shortage, the approach taken was to stock these tributaries with unfed swim up fry produced in a spawning channel and deep substrate incubators. From 1967-1973, brood stock was collected from Aides Stream a tributary of the Humber River. Since 1974 broodstock has been collected, solely from the Exploits River.

Phase 3 colonization of the upper Exploits, the area above Red Indian Lake, was conducted from 1981-1991. The approach taken here was to stock accessible riverine habitat with unfed swim up fry.

Logging activities which are currently ongoing, including log driving, have impacted much of the watershed. Associated with these activities are two hydro generating facilities at Grand Falls and Bishop Falls. Entrainment, migrational delays, and turbine mortality are not sufficiently studied to assess their impacts on production.

Due to production capabilities of fry, the main stem of the Exploits below Red Indian Lake and all standing waters were not stocked. For complete details on operations up to and including 1981 refer to O'Connell et al. (1983).

Methods

Biological characteristic data

Biological characteristic data used to convert number of eggs into number of adults were obtained from broodstock from Grand Falls and Great Rattling Brook. Mean weight of females, 1.38 kg., was based on 16,272 observations with the sex ratio, 77% female, being derived from 38,955 observations.

Data, used to determine the smolt age, were collected at Bishop Falls over a 7 year period (1981-1988) encompassing 2,700 observations. This revealed that 93.4% of the smolts examined smoltified at ages 3⁺ and 4⁺. The 3⁺ accounted for 53.5% of the total smolts examined.

Fecundity was determined from 253 adult salmon accumulated during 3 years of salmon escapement to Grand Falls (Bourgeois unpubl.). Eggs were stripped manually from the adults, allowed to water harden for 1 hour and were then counted manually. A percentage (varied by year) of these adults was sacrificed to determine the number of eggs retained; this average for retained eggs was used to adjust the counts on fish that were not sacrificed. Two experienced individuals stripped all fish over the 3-year period.

Habitat determinations

Accessible riverine habitat units for the middle and lower Exploits were taken from Mercer (1970). Accessible riverine habitat units for the upper Exploits are from unpublished surveys (helicopter) during 1987-1989. The riverine rearing units for Tulk's Brook and the main stem of the Exploits were determined from map surveys.

The total accessible lacustrine habitat was determined using an Altek graphic digitizer with AC40 controller from 1:50,000 topographic maps.

All accessible riverine and lacustrine habitat was included for the Lower and Middle Exploits. Red Indian Lake, Lloyd's Lake and Mary March Brook were excluded from the Upper Exploits. Red Indian Lake was excluded due to a 22 ft. draw down and Lloyd's Lake was excluded due to its depth and sharp drop off. Mary March Brook was excluded as it is known to freeze to the bottom with the only existing flow moving through the substrate; Joe Globes Brook a tributary of Mary March Brook is included.

Target egg deposition

Target egg requirement was calculated based on 240 egg m² and 7 smolts per ha. of standing water. Smolt production of 7 smolt per ha. was divided by 1.9% to convert this to eggs as per O'Connell et al. (1991).

Target spawning requirements

Target spawning requirements in terms of adults were calculated as follows;

$$\text{no. of adults} = \frac{\text{target no. of eggs}}{\text{relative fecundity} \times \text{mean weight} \times \% \text{ female}}$$

$$= \frac{\text{target no. of eggs}}{(1593 \text{ eggs/kg.}) \times 1.38 \text{ kg.} \times 77\%}$$

Egg to fry survival

In order to calculate the egg deposition in areas where stocking occurred, an estimate of egg to fry survival of 20% (Sturge, 1968) was used. The no. of

fry released was back calculated to indicate the egg equivalent to produce those fry. 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.

Spawning escapement

Spawning escapement was calculated by subtracting angling counts from fishway counts without inclusion of an estimate for poaching and disease.

Results and Discussion

Tables 1, 2 and 3 detail the accessible rearing area, the required number of spawners, and target egg deposition respectively by section for the Exploits River. The use of fixed parameters such as 240 eggs m² and 7 smolts per ha. of standing water has certain limitations (see O'Connell and Dempson, 1991 for discussion on this topic).

LOWER EXPLOITS

The lower Exploits did not receive any fry stocking up to 1987 and for the purposes of this paper is considered wild. Table 4 details the number of spawners and subsequent egg deposition and % target egg deposition achieved for the lower Exploits by year. This can be further broken down into Great Rattling Brook and the various other tributaries within the Lower Exploits. As can be seen from Table 4, there was no escapement to Great Rattling Brook above Camp 1 fishway prior to enhancement activities.

During the colonization phase of Great Rattling Brook (1957 -1964), the watershed area received between 5 - 31% of its required egg deposition or an average of 12.8% of target egg per year. From Table 4 it is apparent that percentage of target egg achieved rose in the mid 1970's and has fluctuated around the 50% level since.

Beginning with the smolt output in 1988, returns to Great Rattling Brook have declined. A possible explanation is the drought conditions experienced in 1987 combined with poor smolt survival. Poor smolt survival was documented on the Conne River in 1988 and 1989 (Dempson, 1990).

With respect to the tributaries within the lower Exploits, other than Great Rattling Brook, the authors are not confident in the figures as poaching is considered to be a serious problem in this area. The figures for percentage of target egg achieved in this area are calculated by adding angling within the area, the counts at Grand Falls and Camp 1, and subtracting this figure from the number released at Bishop Falls. This results in poached fish being included in the escapement to the tributaries in the Lower Exploits other than Great Rattling Brook. It is unknown if these poached fish would be destined for Great Rattling Brook, Grand Falls, or for the tributaries of the Lower Exploits other than Great Rattling Brook.

MIDDLE EXPLOITS

The Middle Exploits stocking was conducted from 1968-1980 and encompassed most of the tributaries of the middle Exploits excluding the main stem. Due to limitations in the no. of fry produced, not all of the riverine habitat was stocked and no standing water was stocked. Table 5 details the egg deposition for this area as well as % of target egg achieved. The main stem of the Middle Exploits is to be stocked in the next five year phase (Phase 4) commencing in 1992.

In considering the area stocked, the required no. of spawners to meet target egg is 11,301 adults. Returns from this phase to Grand Falls fishway ranged from 2219-5024 with an average of 3,339 adults. These figures represent escapement after all fisheries. Spawning escapement averaged 30% of the required no. of adults to meet target egg. If the Middle Exploits returns develop, as did Great Rattling Brook, it is conceivable that target egg will be met in the mid 1990's for the areas stocked in the second phase. It should be noted that escapements to the middle Exploits since 1980 have been used as brood for the upper Exploits.

UPPER EXPLOITS

Colonization of the upper Exploits habitat with swim-up fry began in 1981. Rather than stock the entire area, a management decision was made to test stock Lloyd's River and to assess the effectiveness of this approach in terms of smolt migration through Red Indian Lake. This test stocking commenced in 1981 and was assessed in 1984. The results of this assessment were positive. It was shown that smolts did migrate through Red Indian Lake. Table 6 details the percentage of target egg that the Upper Exploits received from the various stockings. Data on the return rate of adults from these stockings are available only for 1991 as there was either no fishway present at Red Indian Lake or all adults were removed at Grand Falls fishway.

The egg deposition figures for the middle and upper Exploits for 1991 will be updated upon completion of the fry releases this spring. Realizing that the lower and middle Exploits took several generations to increase their percentage of target egg deposition, it is not anticipated that the Upper Exploits will achieve target egg deposition in the near future. Of interest is the fact that the original brood sources for the Lower and Middle Exploits were not of Exploits origin. The brood source for the Upper Exploits is of Exploits origin and may result in a higher return rate of adults.

The fry stocking densities prior to 1976 averaged 42 fry per unit or 210 eggs per unit. Post 1976 stocking densities have ranged between 75 - 100 fry per unit or 375 - 500 fry per unit. For discussion on these stocking densities see O'Connell and Bourgeois (1987).

While the figures used in this document are the best available, refinement of estimates of available rearing area is required due to habitat damage. Also required is research into smolt losses due to hydro electric facilities; refinement of these figures likely will change the target egg deposition.

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Table 1. Rearing area available on the Exploits River by section.

Tributary	Riverine	Lacustrine
Lower Section		
	(100 m ²)	(ha ²)
Jumpers Brook	1,913	214
Great Rattling Brook	34,694	5,738
Three Brooks	5,297	154
Little Rattling Brook	4,120	368
Greenwoods Brook	1,600	40
Stoney Brook	9,928	401
TOTAL	57,552	6,915
Middle Section		
Lemottes Brook	31	300
Rushy Brook	523	224
Tom Joe Brook	177	0
Pamehoc Brook ¹	1,441	367
Noel Paul's Brook	19,443	3,773
Badger Brook ¹	18,851	12,745
Little Red Indian Brook	2,333	387
Harpoon Brook ¹	4,406	3,382
Main Stem ²	187,668	0
TOTAL	234,873	21,178
Upper Section		
Victoria River	13,171	3,244
Lloyd's River	36,699	1,668
Shanadithit Brook	2,598	0
Mary March Brook ³	0	0
Buchans Brook ⁴	1,471	120
Joe Globes Brook	1,254	633
Tulk's Brook	244	0
TOTAL	55,437	5,665
GRAND TOTAL	347,862	33,758

¹ These rivers have been affected to varying degrees by logging activities.

² These rearing units were determined from a map survey.

³ Winter flows in this system are extremely low and are limiting (river is known to freeze to gravel i.e. only flows are through the gravel).

⁴ Only the East Branches of this system are included due to water control and drying up of river bed.

Table 2. No. spawners required on the Exploits River by section.

Tributary	Riverine	Lacustrine	Total
Lower Section			
Jumpers Brook	271	47	318
Great Rattling Brook	4,920	1,249	6,169
Three Brooks	751	34	785
Little Rattling Brook	584	80	664
Greenwoods Brook	227	9	236
Stoney Brook	1,407	87	1,494
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TOTAL	8,160	1,506	9,666
Middle Section			
Lemottes Brook	4	65	69
Rushy Brook	74	49	123
Tom Joe Brook	25	0	25
Pamehoc Brook	204	80	284
Noel Paul's Brook	2,757	821	3,578
Badger Brook	2,673	2,774	5,447
Little Red Indian Brook	330	84	414
Harpoon Brook	625	736	1,361
Main Stem	26,612	0	26,612
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TOTAL	33,304	4,609	37,913
Upper Section			
Victoria River	1,868	702	2,570
Lloyd's River	5,204	363	5,567
Shanadithit Brook	368	0	368
Buchans Brook	209	26	235
Mary March Brook	0	0	0
Joe Globes Brook	178	138	316
Tulk's Brook	35	0	35
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TOTAL	7,862	1,229	9,091
GRAND TOTAL	49,326	7,344	56,670

Table 3. Target egg deposition required on the Exploits by section and habitat.

Tributary	Target Egg Riverine	Target Egg Lacustrine	Total Target Egg
Lower Section			
Little Rattling Brook	988800	135579	1124379
Three Brooks	1271280	56737	1328017
Jumpers Brook	459120	78842	537962
Great Rattling Brook	8326560	2114000	10440560
Greenwoods Brook	384000	14737	398737
Stoney Brook	2382720	147737	2530457
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TOTAL	13812480	2547632	16360112
Middle Section			
Lemottes Brook	7440	110526	117966
Rushy Brook	125520	82526	208046
Tom Joe Brook	42480	0	42480
Pamehoc Brook	345840	135211	481051
Noel Paul's Brook	4666320	1390053	6056373
Badger Brook	4524240	4695526	9219766
Lt. Red Indian Brook	559920	142579	702499
Harpoon Brook	1057440	1246000	2303440
Main Stem	45040320	0	45040320
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TOTAL	56369520	7802421	64171941
Upper Section			
Victoria River	3161040	1187789	4348829
Shanadithit Brook	623520	0	623520
Buchans Brook	353040	44211	397251
Joe Globes Brook	300960	233211	534171
Tulk's Brook	58560	0	58560
Lloyd's River	8807760	614526	9422286
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TOTAL	13304880	2079737	15384617
GRAND TOTAL	83486880	12429790	95916670

Table 4. Details of egg deposition, Lower Exploits.

Year	No. fry released G.R.B.	No. Spawners G.R.B.	No. Spawners Others	Total Eggs G.R.B.	Total Eggs Other	% Target Egg G.R.B.	% Target Egg Other	% Target Egg Total
1957	0	610	*	1032401	*	10	*	*
1958	0	786	*	1330274	*	13	*	*
1959	0	329	*	556819	*	5	*	*
1960	0	771	892	1304887	1509674	12	28	18
1961	0	624	577	1056095	976549	10	18	13
1962	0	1212	*	2051262	*	20	*	*
1963	0	577	691	976549	1169490	9	22	14
1964	0	1886	*	3191980	*	31	*	*
1965	0	777	594	1315041	1005321	13	19	15
1966	0	1412	+228	2389754	385881	23	7	18
1967	0	1204	829	2037722	1403049	20	26	22
1968	0	2021	*	3420462	*	33	*	*
1969	0	1182	272	2000488	460349	19	9	16
1970	0	1222	*	2068186	*	20	*	*
1971	0	1163	66	1968331	111702	19	2	13
1972	0	729	114	1233803	192940	12	4	9
1973	0	*	*	0	*	*	*	*
1974	0	*	2647	0	4479942	*	83	*
1975	0	4601	4225	7787008	7150644	75	133	94
1976	0	1910	983	3232599	1663688	31	31	31
1977	0	3632	1396	6147015	2360982	59	44	54
1978	0	2139	671	3620172	1135641	36	21	30
1979	0	3109	2334	5261858	3950202	50	73	58
1980	0	4611	*	7803933	*	75	*	*
1981	0	4741	+560	8023953	947778	77	18	57
1982	0	2877	2258	4869207	3821575	47	71	55
1983	0	3252	*	5503880	*	53	*	*
1984	0	6178	5679	10456018	9611480	100	179	127
1985	0	5952	3712	10073522	6282412	96	117	103
1986	0	2742	3026	5616360	5121384	54	95	68
1987	195127	230	3236	4744161	5476801	45	102	65
1988	870979	896	+1900	6469514	3215674	62	60	61
1989	990614	46	2574	3215478	4356392	31	81	48
1990	627525	11	2313	3483172	3914660	33	73	47
1991	692911	1086	1993	1838012	3373073	18	63	33

* Indicates no data

+ Indicates incomplete data (i.e. partial count)

Table 5. Details of egg deposition, Middle Exploits

Year	No. of Fry released	Spawners released	Natural Egg Deposition	Egg Equivalents	Total Eggs	% Target Egg Achieved
1967	0	0	0	768600	768600	1.20
1968	153720	0	0	841700	841700	1.31
1969	168340	0	0	1644600	1644600	2.56
1970	328920	0	0	1479730	1479730	2.31
1971	295946	0	0	1612530	1612530	2.51
1972	322506	0	0	2053445	2053445	3.20
1973	410689	0	0	1779000	1779000	2.77
1974	355800	31	88491	1063050	1151541	1.79
1975	212610	20	57091	6463125	6520216	10.16
1976	1292625	25	71364	6733930	6805294	10.60
1977	1346786	26	74218	6832050	6906268	10.76
1978	1366410	32	91345	3628785	3720130	5.80
1979	725757	220	628000	9352470	9980470	15.55
1980	1870494	1842	5258073	4513470	9771543	15.23
1981	902694	2588	7387564	3941270	11328834	17.65
1982	788254	1229	3508236	1926610	5434846	8.47
1983	385322	810	2312182	3960965	6273147	9.78
1984	792193	3525	10062273	2539510	12601783	19.64
1985	507902	2981	8509400	2558670	11068070	17.25
1986	511734	0	0	5333120	5333120	8.31
1987	1066624	80	228364	5243995	5472359	8.53
1988	1048799	5	14273	7854460	7868733	12.26
1989	1570892	0	0	8758425	8758425	13.65
1990	1751685	0	0	7436240	7436240	11.59
1991	1487248	243	693655	0	842091	1.31

Table 6. Details of egg deposition Upper Exploits

Year	No. Fry Released	Natural Spawning	Egg Equivalents	% Target egg Deposition
1975	0	0	952665	6.19
1976	190533	0	892390	5.80
1977	178478	0	155580	1.01
1978	31116	0	0	0.00
1979	0	0	0	0.00
1980	0	0	3326500	21.62
1981	665300	0	4460735	28.99
1982	892147	0	2041055	13.27
1983	408211	0	1992570	12.95
1984	398514	0	4403050	28.62
1985	880610	0	8189350	53.23
1986	1637870	0	11078265	72.01
1987	2215653	0	14895245	96.82
1988	2979049	0	19275305	125.29
1989	3855061	0	18345255	119.24
1990	3669051	0	13471645	87.57
1991	2694329	0	14047	0.00