Atlantic Salmon (Salmo salar L.) Target Spawning Requirements for Selected Rivers in Salmon Fishing Area 5 (Bonavista Bay), Newfoundland

by

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Abstract

Target spawning requirements in terms of fluvial and lacustrine habitat were derived for selected rivers in Bonavista Bay, Newfoundland. Spawning requirements were calculated from smolt production estimates using an egg-to-smolt survival rate of 1.25% for fluvial habitat and a rate of 1.9% for lacustrine habitat. Smolt production estimates were derived assuming the production of 3 smolts per unit from fluvial parr rearing habitat and 7 smolts per hectare from lacustrine habitat.

Résumé

On a établi les besoins-cibles de reproducteurs des habitats fluviaux et lacustres en se fondant sur diverses rivières de la baie de Bonavista, à Terre-Neuve. Ces besoins ont été calculés d'après la production estimée de saumoneaux fondée sur des taux de survie oeufs-saumoneaux de 1,25 % et 1,9 % respectivement pour les habitats fluviaux et lacustres. Les estimations de production de saumoneaux reposent sur une hypothèse de production de 3 saumoneaux par unité dans les habitats d'élevage de tacons et de 7 saumoneaux par hectare dans les habitats lacustres.

Introduction

In 1990, management measures affecting the commercial fishery for Atlantic salmon in the Newfoundland Region were implemented on a zonal or Salmon Fishing Area (SFA) basis for the first time. In an attempt to increase river escapements, quotas were set in the commercial fishery in each SFA while previous management measures were maintained. Ideally, levels of harvest allocated to user groups should centre around meeting river specific target (preferably optimum) spawning requirements in each SFA. The 1990 commercial quotas were implemented without consideration of spawning requirement information.

Before the status of a particular stock can be determined, the spawning requirement has to be defined. In insular Newfoundland, in addition to utilizing fluvial habitat for rearing, juvenile Atlantic salmon make extensive use of lacustrine habitat (Pepper 1976; O'Connell and Reddin 1983; Chadwick and Green 1985; Pepper et al. 1985; O'Connell 1986; Ryan 1986; O'Connell and Ash 1989; O'Connell et al. 1990; O'Connell and Dempson 1990). In this paper, spawning requirements are determined in terms of both fluvial and lacustrine habitat for the major rivers in Bonavista Bay (SFA 5) (Fig. 1).

Methods

Biological characteristic data

Biological characteristic information used to convert target spawning requirements in terms of eggs to requirements in terms of adults was obtained by sampling recreational catches. Data were available only for Middle brook and Terra Nova River. Mean values for these rivers combined were used as a default for rivers where no biological characteristic data were available.

Fecundity was determined for Middle Brook and Terra Nova River from ovaries collected from salmon caught in the recreational fishery. Ovaries were stored in Gilson's fluid until ovarian tissue had broken down after which time eggs were transferred to 10% formalin. Eggs, which for the most part were in early stages of development, were counted directly. Fecundity for each river (years combined) was expressed as relative fecundity (mean no. of eggs/kg).

Accessible habitat determinations

The total surface area of accessible lacustrine habitat available for each river was determined using a planimeter from 1:50,000 topographic maps (Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa). The amount of classical fluvial parr rearing habitat (Elson 1957) for each system was taken from river survey files. These surveys were conducted from helicopter and on foot.

Target spawning requirements

Smolt production was determined by multiplying the amount of fluvial and lacustrine habitat by production parameter values derived for SFA 5 by O'Connell et al. (1991). These values were 3 smolts/100 m^2 of fluvial habitat and 7 smolts/ha of lacustrine habitat.

Target egg deposition requirements were calculated from smolt production estimates using egg-to-smolt survival rates. For fluvial habitat, a rate of 1.25% was used. This value was derived by dividing 3 smolts per unit by 240 eggs per unit, the egg deposition of Elson (1975) that is currently recommended in eastern Canada. For lacustrine habitat, a value of 1.9% derived for Western Arm Brook (SFA 14) by O'Connell et al. (1991) was used. In Western Arm Brook, an estimated 67% of total smolt production was reported to have come from lacustrine habitat (Chadwick and Green (1985).

Target spawning requirements in terms of adults were calculated only for specimens < 63 cm in length. The calculation was as follows:

$$\text{No. of grilse} = \frac{\text{Target no. of eggs}}{\text{Relative fecundity X Mean weight X \% female}}$$

Most of these fish were virgin grilse with some repeat spawning grilse. Egg deposition from large salmon (>= 63 cm) was considered as a buffer to estimates of spawning requirements. These fish generally constitute less than 10% of total runs to the rivers in SFA 5, and are predominantly repeat spawning grilse.

In the case of Terra Nova River, target spawning requirements were calculated for the area above the lower fishway, excluding the area above Mollyguajeck Falls.

Results

Estimated smolt production in terms of fluvial and lacustrine habitats and total smolt production for the major rivers in Bonavista Bay are presented in Table 1. Also shown for each river is the ratio of the amount of lacustrine to fluvial habitat and the percentage of total smolt production coming from lacustrine habitat. The proportion of smolt production from lacustrine habitat in Indian Bay, Traverse, Middle, Northwest, and Salmon (76-86%) was more than double that estimated for Gambo and Southwest (28-29%) with Terra Nova being intermediate (49%).

Corresponding spawning requirements in terms of eggs and adults are shown in Table 2. Pertinent biological characteristic data are also shown. Total spawning requirements in terms of adults ranged from 299 (Salmon Brook) to 3,917 (Gambo River).

Discussion

The use of fixed parameters such as 3 smolts/unit of fluvial habitat and 6 smolts/ha of lacustrine habitat to calculate smolt production for all rivers in SFA 5 has limitations in that there could be inter-river as well as inter-annual variation in such parameters. The same is true for the value of 240 eggs per unit used to calculate the egg-to-smolt survival of 1.25% for fluvial habitat. The egg-to-smolt survival value of 1.9% chosen for lacustrine habitat was calculated for Western Arm Brook (O'Connell et al. (1991) which has a modal smolt age of 4+ years (Chadwick et al. 1978). The dominant smolt age for rivers in Bonavista Bay is 3+ years. With one less year spent in freshwater, egg-to-smolt survival could be higher in these rivers than in Western Arm Brook and hence spawning requirements in terms of lacustrine habitat could be overestimated. The value of 1.25% for fluvial habitat is similar to one used by Symons (1979) for 3+ smolts with 'medium' survival. However, if this value is too high for Newfoundland rivers then spawning requirements could be underestimated.

Chadwick and Green (1985) reported conductivity and hardness values for Western Arm Brook that were quite higher than those observed for rivers in SFA 5 (Porter et al. 1974). Compared to rivers in SFA 5, any advantage in productive capacity accruing to Western Arm Brook as a result of water chemistry could be offset by its shorter growing season as evidenced indirectly by its older smolts.

Ideally, stream production should be defined in terms of different types of fluvial habitat. In the present analysis, smolt production (based on complete counts) was defined in terms of the amount of classical parr rearing habitat available, the relative proportion of which could be quite variable among rivers, thus confounding estimates. Expressing lacustrine production in terms of total lake surface area as opposed to production from different lentic habitats poses similar problems and as well, variability in morphometric parameters affecting production are important considerations (O'Connell and Ash 1989; O'Connell et al. 1990; O'Connell and Dempson 1990).

The phenomenon of atresia has been reported to occur in Atlantic salmon in the Soviet Union (Melnikova 1964) and in France (Prouzet et al. 1984). Recently there is evidence to show that it can occur to varying degrees in insular Newfoundland (O'Connell and Dempson, unpublished data). Fecundity values therefore have to be regarded as potential values. Since target spawning requirement calculations were based on eggs in early stages of development, the occurrence of atresia in a given year on a particular river would increase the number of spawners required.

The calculations of target spawning requirements presented in the foregoing assume that the locations of spawning substrate and nursery areas are such that under natural mechanisms of distribution, juveniles will have access to all the specified fluvial and lacustrine habitat. This condition will likely be met to varying degrees on different rivers.

Landlocked salmon populations are known to occur in several of the rivers in Bonavista Bay. These parr may interact with anadromous parr and reduce anadromous smolt production per unit area.

Until the parameter values used in the present analysis can be updated for rivers in SFA 5, target spawning requirements calculated from them serve as reasonable standards against which to evaluate stock status.

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Table 1. Accessible fluvial and lacustrine habitat and estimated smolt production for various rivers in SFA 5, Bonavista Bay, Newfoundland. Lacustrine (L) habitat is expressed in hectares while fluvial (F) habitat is expressed as the number of classical parr rearing units (a unit = 100 m^2). The ratio L/F is expressed in terms of m^2.

River	Habitat area		Ratio L/F	Estimated smolt production[1]			
	L	F		L	F	Total	% L
Indian Bay	9,878	3,861	255.8	69,146	11,583	80,729	86
Traverse	4,389	2,639	166.3	30,723	7,917	38,640	80
Middle	4,636	2,640	175.6	32,452	7,920	40,372	80
Gambo	4,768	28,940	16.5	33,376	86,820	120,196	28
Terra Nova[2]	5,954	14,499	41.1	41,678	43,497	85,175	49
Northwest	8,489	3,944	215.2	59,423	11,832	71,255	83
Salmon	1,223	892	137.1	8,561	2,676	11,237	76
Southwest	590	3,415	17.3	4,130	10,245	14,375	29

[1]Estimated assuming the production of 3 smolts/unit of classical fluvial parr rearing habitat and 7 smolts/hectare of lacustrine habitat (O'Connell et al. 1991).

[2]Accessible area above lower fishway, does not include area above Mollyguajeck Falls.

Table 2. Target Spawning requirements for various rivers in SFA 5, Bonavista Bay, Newfoundland expressed in terms of lacustrine (L) and fluvial (F) habitats and total requirements. Also included are pertinent biological characteristic data. Numbers of fish are in parentheses.

River	Relative fecundity (eggs/kg)	$\bar{X}$ ± SD Weight of females (kg)	% Females	Spawning Requirements (No.) Eggs ($X10^6$) L	Eggs ($X10^6$) F	Eggs ($X10^6$) Total	Adults L	Adults F	Adults Total
Indian Bay[1]	1,886 (287)	1.55 ± 0.38 (519)	76	3.639	0.927	4.566	1,638	417	2,055
Traverse[1]	1,886 (287)	1.55 ± 0.38 (519)	76	1.617	0.633	2.250	728	285	1,013
Middle	1,941 (221)	1.51 ± 0.39 (274)	79	1.708	0.634	2.342	738	274	1,012
Gambo[1]	1,886 (287)	1.55 ± 0.38 (519)	76	1.757	6.946	8.703	791	3,126	3,917
Terra Nova[2]	1,713 (66)	1.59 ± 0.36 (245)	74	2.194	3.480	5.674	1,088	1,726	2,814
Northwest[1]	1,886 (287)	1.55 ± 0.38 (519)	76	3.127	0.947	4.074	1,408	426	1,834
Salmon[1]	1,886 (287)	1.55 ± 0.38 (519)	76	0.451	0.214	0.665	203	96	299
Southwest[1]	1,886 (287)	1.55 ± 0.38 (519)	76	0.217	0.820	1.037	98	369	467

[1]Default: data for Middle Brook and Terra Nova River combined used in spawning requirement calculations.

[2]Calculations are for the area above the lower fishway, excluding the area above Mollyguajeck Falls.

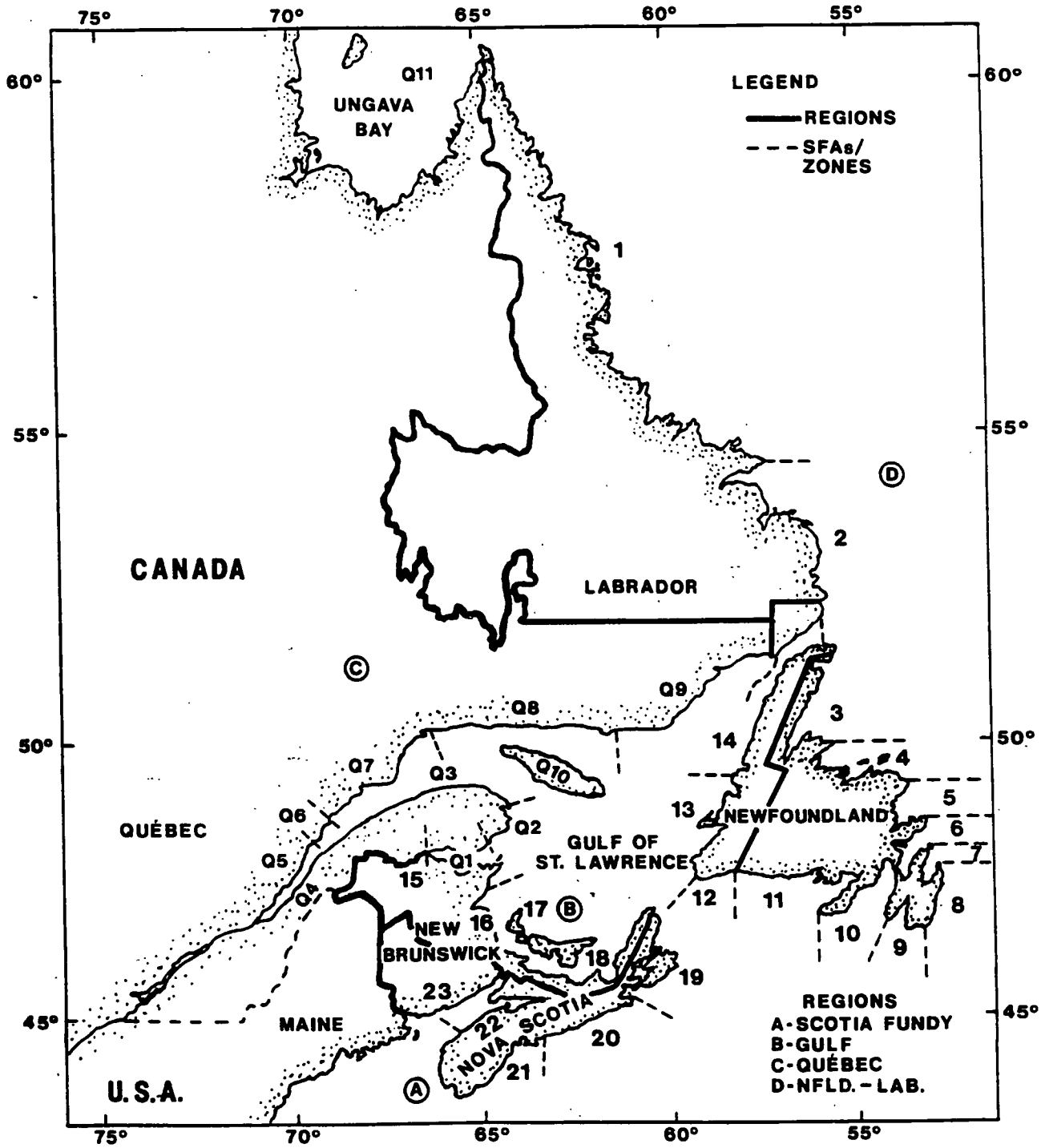

Fig. 1. Map of Atlantic Provinces of Canada showing Salmon Fishing Areas (SFAs) 1-23, Salmon Management Zones of Quebec (Qs) 1-11, and regional boundaries. The Newfoundland Region is comprised of SFAs 1-11.