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Status of the Atlantic Salmon of the LaHave River, Nova Scotia, in 1984 and Forecast of Returns in 1985

by

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Abstract

The LaHave River of southwestern Nova Scotia is an Atlantic Ocean coastal stream with Atlantic salmon spawning runs composed of more than eighty percent one-seawinter fish. A salmon development project initiated in 1978 has substantially increased natural production which has been reflected in increased recreational catches.

Spawning escapement estimates by three methods suggest the 1984 egg deposition exceeded the 4.91 million egg requirement by about 12 percent, but the area above Morgan Falls received excess eggs while the area below Morgan Falls was deficient by about 25 percent.

The combined hatchery-return and wild one-seawinter fish forecast to return in 1984 to the Morgan Falls counting trap was close to the observed number (2295 vs. 2293). The multi-seawinter return was 40 percent higher than forecast, a result of the 1984 Salmon Management Plan which was implemented after the assessment and which decreased removals in the commercial and recreational fisheries.

Predictions of stock abundance in 1985 were made for several stock components and by different methods. Although the forecast total run in 1985 is less than that predicted for 1984, spawning escapements should be adequate if the pattern of removals follows that experienced in 1984.

Résumé

La rivière LaHave coule dans le sud-ouest de la Nouvelle-Ecosse jusqu'à l'océan Atlantique; au temps du frai, des saumons atlantique en remontent le cours, dans plus de 80 % des cas après avoir passé un hiver en mer. En 1978, on a entrepris la réalisation d'un projet de mise en valeur : depuis, la production naturelle s'est considérablement accrue, comme le montre l'augmentation des captures en pêche récréative.

Si l'on en juge d'après la proportion de poissons non capturés en période de frai, estimée suivant trois méthodes différentes, la ponte de 1984 a dépassé de quelque 12 % les 4,91 millions d'oeufs nécessaires, mais en amont des chutes Morgan il y a eu un excès, tandis qu'en aval elle était déficitaire de 25 % environ.

Le nombre de poissons d'élevage et de poissons sauvages restés un hiver en mer qui sont revenus (2 293) en 1984 jusqu'aux installations de comptage des chutes Morgan approchait passablement la quantité prévue (2 295). Le nombre de poissons restés plus d'un hiver en mer qui sont revenus dépassait de 40 % la quantité prévue : cette augmentation est le résultat du plan de gestion de 1984, un programme mis en oeuvre après l'évaluation et en vertu duquel on a réduit les captures dans les pêches commerciales et récréatives.

On a prévu par différentes méthodes l'importance de diverses composantes du stock en 1985. Bien que le retour total prévu en 1985 soit inférieur à la valeur escomptée en 1984, les poissons non capturés en période de frai devraient être suffisamment nombreux si on fait les mêmes captures qu'en 1984.

Introduction

The LaHave River drains into the Atlantic Ocean from southwestern Nova Scotia. Its salmon stocks are among the most valuable in the province, because the annual angling catch of salmon has been in the topmost four rivers for at least a decade. Salmon production was increased substantially by a salmon development project, initiated in 1970, which provided salmon access to a further 44 percent of the drainage. Stocking with cultured fish has been a near-annual occurrence since 1971. The waters of the basin are now deleteriously influenced by acid rain. Cutting and Gray, MS 1984, give more detail about the river basin. Reduced rainfall in the July to November period resulted in lower than normal river flows in 1984.

Methods

Salmon Landings

Exploitation of the LaHave River salmon resource occurs in distant and homewater commercial fisheries and in a recreational fishery. Table 1 contains the nearest homewater commercial catches in salmon and non-salmon gears for 1967-1984, i.e., Fisheries Statistical Districts (FSD) 26 and 27 combined, which are considered to be an index of LaHave stocks. The commercial fishing season in 1984 was shortened to June 18-July 6 from the May 24-July 31 or June 1-July 31 seasons operative since 1981.

Angling catches since 1965 are provided in Table 2. The 1984 catch of 1-SW fish was increased by 111 fish angled during a special extended angling season (September 19-October 15). The special season was implemented to harvest some 1-SW returns from the hatchery-reared smolts specifically stocked in 1983 to return to the lower river areas and to offset the lower angling success experienced in July in 1984 when low discharges created poor angling conditions.

Salmon Development Project

A fishway was constructed in 1969 at a natural falls which prevented access to about 34 percent of the salmon spawning and nursery habitat in the LaHave River drainage (Fig. 1). All fish migrating upstream pass through a fishway monitoring facility where counts have been made annually since 1970 (Table 3). Stocking of hatchery-reared salmon (Table 4) has evolved to a program utilizing mainly one-year smolts. Smolts stocked above Morgan Falls in 1984 were a control group for determining returns of other smolts stocked into the lower basin, as well as being insurance for adequate spawning escapement in the upper basin.

Biological Characteristics

Biological characteristics of the salmon stock were obtained by sampling adults at Morgan Falls for several years.

(1) Sex Ratios

Fish passing the Morgan Falls counting facility are sexed by external examination. Past experience has indicated that sex determinations made after July 31 each year are quite accurate. Corrections are made to the sexing data for those salmon entering the facility before August 1. The correction factors utilized to adjust the number of females were 1.15 and 0.88, for M-SW and 1-SW respectively (Cutting and Gray, MS 1984), except that a factor of 0.40 was used to correct the number of maiden 2-SW males, based on the 45 "males" taken for broodstock in the early period in 1984.

(2) Size

All fish processed at Morgan Falls are weighed and measured for fork length. These data form the basis for the mean lengths and weights of the wild and hatchery-return components by sea age-class.

(3) Grilse/Salmon Ratios

The Morgan Falls counting facility has provided sea-age ratios, based on the assumption that fish under 63.0 cm were grilse; i.e., 1-SW salmon (Table 3). The wild grilse/salmon ratio in 1984 was 5.3:1 as compared to the 1973-1983 pooled average of 5.4:1. The grilse/salmon ratio for hatchery-return fish in 1984 is meaningless because of differing smolt stocking rates in 1982 and 1983, but the 1973-1983 pooled average ratio is 3.8:1. Note the wild ratio in 1984 was presumably influenced toward the salmon side by the 1984 Management Plan which presumably reduced exploitation of those sea age-classes and increased their escapement.

(4) Fecundity

Fecundity values were determined using the fecundity-length regressions in Cutting and Gray, MS 1984. The two regressions used were:

For 1-SW fish: $Fec.= 360.532e^{0.03827FL}$

For M-SW fish: $Fec.= 430.19e^{0.03605FL}$

An attempt to refine the LaHave fecundity data base in 1984 failed due to a technical problem.

Estimated mean fecundities for the 1984 wild run were:

1-SW (grilse): 2790 eggs/female of mean fork length of 53.47 cm

M-SW (salmon): 5781 eggs/female of mean fork length of 72.07 cm

(5) Spawning Requirements

The spawning target of 1-SW and M-SW spawners for 1984 was adjusted from the general target of 2815 1-SW fish and 497 M-SW fish (Cutting and Gray, MS 1984) by reflecting the mean size, sex ratios, and grilse/salmon ratio seen in the 1984 spawning run. The 1984 target number of fish was that number required to meet a 2.4 egg$\cdot m^{-2}$ egg deposition level.

Egg depositions were calculated using the corrected number of females in the 1-SW and M-SW sea age-classes multiplied by the fecundity value for the mean fork length. Separate calculations for wild and hatchery-return fish were summed.

1984 Escapement Estimates

The counting facility at Morgan Falls monitors fish movements for only the upper main river. Thus, estimates of escapement for the entire basin must be developed by construction. The 1984 escapement for the entire river was estimated by three methods.

Method I used angler exploitation rates for hatchery-return grilse and salmon, trap counts at Morgan Falls, angling catch statistics, and mean angler exploitation rate of wild grilse and salmon. Mean angler exploitation rates for hatchery-return salmon, based on recaptures of grilse and salmon which had been released as tagged hatchery-reared smolts and adjusted upward to account for 30 percent non-reporting, were 29.3 percent for 1 sea-winter compared to 22.0 percent for 2 sea-winter and older hatchery-return salmon (Cutting and Gray, MS 1984). These exploitation rates were also used for wild stocks. Losses due to poaching and other mortalities were assumed to be 200 grilse and 100 salmon.

Method II used tag recapture data collected from grilse and salmon captured, tagged, and released from a trapnet located in the estuary of the LaHave River estuary in 1983 to estimate the proportion of the total LaHave stock represented by production above Morgan Falls. Since trap counts are available at Morgan Falls, estimates of total river escapement could be calculated. However, only a few, wild salmon, hatchery-return salmon and hatchery-return grilse were tagged, so only data from wild grilse were used in the analyses. Recapture rate was adjusted for an estimated 30 percent delayed mortality of tagged fish. From this analysis, 30.3 percent of the total escapement of wild grilse reached headwaters above Morgan Falls. In order to calculate wild salmon escapement, it was assumed that other parts of the LaHave River had the same grilse:salmon ratio as the fish at Morgan Falls. Poaching or losses and other mortalities are assumed the same as in Method I.

Method III for estimating wild escapements utilized data on rearing areas and known wild salmon production from the headwaters upstream from Morgan Falls as a proportion of total river nursery habitat. Egg deposition per m^2, juvenile production per rearing unit, and factors affecting survival are assumed to be similar throughout the river.

Prediction of 1985 escapement levels

Counts of M-SW and 1-SW salmon expected to return to the Morgan Falls counting facility in 1985 have been forecast on the basis of information collected at the facility during 1973-1983. M-SW wild returns were estimated by two methods. Method I estimated the M-SW returns from the significant correlation between the 1-SW count in year t and the M-SW count in year t + 1. Method II utilized the estimated mean return rate, measured by the number of M-SW fish counted at Morgan Falls from the estimated eggs deposited in 1978 and 1979 (Table 7) applied to the estimated eggs deposited in 1980, to estimate the 1985 M-SW returns.

The wild 1-SW returns were estimated using Method II above wherein the 1-SW mean return rate from the 1978, 1979 and 1980 estimated egg depositions was applied to the 1981 estimated egg deposition to provide the 1985 1-SW returns.

Returns of hatchery-reared 1-SW and M-SW salmon to Morgan Falls were estimated on the basis of mean rates of adult return of the estimated smolt outputs since 1976 when the Mersey Fish Culture Station assumed the LaHave River major stocking responsibility (Table 5).

The 1984 catch of M-SW salmon in number in the combined commercial fisheries of Statistical Districts 26 and 27 was originally estimated from the significant regression of the recorded M-SW salmon catch in FSD 26 and 27 in year t + 1 on the 1-SW count at Morgan Falls in year t for 1973-1980. That estimate of catch was adjusted to account for the apparent under-reporting of catches occurring since 1980. In view of the fishing season change in 1984, however, the catch was reduced. The 1985 catch is assumed equal to the declared 1984 commercial catch.

If average angling conditions and no substantial change in angling season are assumed, an estimate of the 1985 angling catch can be made based on application of the estimated mean angling exploitation rates to the estimated returns of wild and hatchery-reared fish. A second estimate of the 1-SW angling catch used the significant regression of total 1-SW rod catch on total estimated 1-SW count at Morgan Falls.

Results

1984 Egg Deposition Relative to Spawning Requirement

The spawning requirement is based on the quantity of spawning and rearing habitat, on fecundity, on sex ratios, on grilse/salmon ratios (Table 6), and on an assumed minimal egg deposition density of 2.4 eggs$\cdot m^{-2}$.

The target spawning escapement for 1984 was determined from these data:

Required egg deposition rate = 2.4 eggs·m^{-2} (Elson 1974)

LaHave River rearing area = 2,046,230 m^2 (Cutting and Gray, MS 1984)

Female salmon (wild 2-SW maiden) mean weight = 3.79 kg
mean fork length = 72.1 cm

Female grilse (wild 1-SW maiden) mean weight = 1.58 kg
mean fork length = 53.5 cm

Salmon sex ratio (wild M:F) = 0.31:0.69 (Table 6)
Grilse sex ratio (wild M:F) = 0.70:0.30 (Table 6)
Grilse/salmon ratio (wild) = 0.84:0.16 (Table 6)

The egg deposition per fish for 1984 is 1341 eggs, as compared to 1482 eggs in a calculation based on average stock values for 1973-1983. Thus, the required spawning requirement for the average situation, i.e., 3312 fish, will necessarily increase to 3660 fish for 1984. At the 1984 wild grilse:salmon ratio, the number of grilse and salmon required to meet spawning requirements in 1984 are 3074 and 586, respectively, for the 4.91 million egg deposition needed for the entire drainage.

The egg deposition requirement for the area above Morgan Falls is 1.65 million. The egg deposition achieved was about 1.82 million eggs, without correction for illicit removals or natural mortalities but with correction for broodstock removals.

1984 Escapements

A comparison of the catches and counts observed in 1984 with the values forecast may prove useful.

		Hatchery return		Wild		Total	
		Obs.	For.	Obs.	For.	Obs.	For.
Morgan Falls count:	1-SW	250	332	2043	1963	2293	2295
Morgan Falls count:	M-SW	36	8	384	227-238	420	235-246
Angling catch:	1-SW	-	-	-	-	753	1471
Angling catch:	M-SW	-	-	-	-	213	264
Commercial catch:	M-SW	-	-	-	-	82	140
River escapement:	M-SW	-	-	-	-	968	1188

The fisheries management regulations designed to reduce the harvest of M-SW fish seem to have achieved their goal, resulting in additional escapement of M-SW fish. The estimated LaHave River escapement of M-SW fish is probably an underestimate because the unclear status of the hook-and-release provision in the angling fishery most likely reduced the salmon angling exploitation rate below the "usual" value of 0.22. Such an impact would raise the river escapement estimate for M-SW fish.

The 1-SW and M-SW returns in 1984 calculated from Method I are summarized below.

Method I (1984)		Grilse	Salmon
River Escapement (W + HR)(Table 8)		4554	968
Losses to commercial fisheries (Stat. Dist. 26-27)		145	82
Returns to homewaters	Total	4699	1050
All losses:			
commercial fishery (Table 1)		145	82
angling fishery (Table 2)		753	93[a]
poaching and other mortalities		200	100
	Total	1098	275
Spawning escapement		3601	775
Spawning requirements		3074	586
Surplus or (deficit)		527	189

[a]80 retained plus 10 percent mortality of 133 released.

Method II for estimating 1984 1-SW and M-SW returns uses recapture information from the estuarial trap net releases in 1983 as those appeared at Morgan Falls. Low river discharge lasting from late July into November in 1985 may have slowed the normal angling success rates. As well, there was a decrease in fishing effort with a 25 percent drop in salmon angling license sales in Nova Scotia.

Method II (1984)		Grilse	Salmon
River Escapement			
Salmon (W) (2043/0.303; 6590 (384)/2043		6590	1239
Salmon (W) angled (Table 8)		456	203
Salmon (HR) angled (Table 8)		297	10
Salmon (HR) Morgan Falls		250	36
	Total	7593	1488
Losses to commercial fisheries (Stat. Dist. 26-27)		145	82
Returns to homewaters	Total	7738	1570
All losses:			
commercial salmon fishery (Table 1)		140	82
non-salmon commercial gear (Table 1)		5	0
angling fishery (footnote Method I)		753	93
poaching and other mortalities		200	100
	Total	1098	275
Spawning escapement		6640	1295
Spawning requirements		3074	586
Surplus or (deficit)		3566	709

Method III used rearing area and known adult production above Morgan Falls to derive escapement.

Method III (1984)		Grilse	Salmon
River escapement			
Salmon (W) (2043 x 2,046,228/685,732; 384 x 2,046,228/685,732)		6096	1146
Salmon (W + HR) angled (Table 2)		753	213
Salmon (HR) Morgan Falls (Table 3)		250	36
	Total	7099	1395
Losses to commercial fisheries (Stat. Dist. 26-27)		145	82
Returns to homewaters	Total	7244	1477
All losses:			
commercial fisheries		145	82
angling fishery (footnote Method I)		753	93
poaching and other mortalities		200	100
	Total	1098	275
Spawning escapements		6146	1202
Spawning requirements		3074	586
Surplus or (deficit)		3072	616

1985 Catches and Escapements

The count of M-SW fish at Morgan Falls for 1985 was estimated by two methods.

Method I utilized the significant regression between wild 1-SW counts in year t and the wild M-SW counts in year t + 1. That regression; $Y_{M-SW} = 23.12 + 0.202X_{1-SW}$, p 0.001, r = 0.885, 1973-1984; estimates a 1985 wild M-SW return to Morgan Falls of 436 fish (311-561, 95% C.L.). The similar regression for hatchery-return M-SW fish; $Y_{M-SW} = -15.59 + 0.29X_{1-SW}$, p= 0.021, r= 0.713, 1973-1983; estimates a 1985 M-SW hatchery-return of 57 fish (0-173, 95% C.L.).

Method II utilized data in Table 7. The method of determining egg deposition levels for above Morgan Falls has been described. Wild adult returns to Morgan Falls can be tabulated in relation to their proper brood year. Because there seems to have been a reduced rate of adult return beginning with the 1978 eggs, it was felt preferable to use those most current return rates. Use of the mean 1978-1979 return rate, 0.013, multiplied by the estimated 3,849,100 eggs deposited in 1980 provides an estimate of 500 M-SW salmon in 1985.

The count of wild 1-SW fish at Morgan Falls is estimated on a similar basis to Method II; that is, on the adult return rates experienced with the 1978, 1979, and 1980 estimated egg depositions. This mean observed rate (0.049 percent) estimates a return of 2128 1-SW fish in 1985 from the estimated 4,341,900 eggs deposited in 1981 above Morgan Falls (Table 7). The return will include a further small number of fish which were 3-year-old smolts from the 1980 eggs.

Returns of hatchery-reared 1-SW and M-SW salmon to the LaHave River in 1985 were estimated from the rates of return to Morgan Falls observed since 1976 from estimated smolt outputs (Table 5). Return rates have averaged as follows:

Smolt year-classes	Sea-age-class	Mean % return	Std. dev.	N
1976-1983	1-SW	1.41	0.51	8
1976-1981	M-SW	0.41	0.20	6

Utilization of these rates estimates that 93 M-SW fish will appear in 1985 at Morgan Falls from the 22,761 smolts arising from smolts stocked in 1983. The estimated 14,276 smolts (80 percent of 15,000 plus 20 percent of 28,451) released above Morgan Falls and migrating to sea in 1984 will result in about 201 hatchery-return 1-SW fish there in 1985. A further 169 1-SW fish and 173 M-SW fish should be available for spawning in the remainder of the basin from the 52,803 smolts stocked in 1983 and the 12,000 smolts in 1984 if their pattern of survival, migration, and removal is similar to that for fish returning above Morgan Falls.

Presentation of a numerical forecast for the commercial catch of M-SW fish in FSD's 26 and 27 is not possible. Although there is a significant correlation between the commercial M-SW catch and the 1-SW count at Morgan Falls the prior year for 1973-1980, changes in the commercial fishery season and in the statistics reporting have invalidated the regression for the period since 1980.

River escapement of 751 (593-952, 95% C.L.) wild M-SW fish is forecast on the basis of the ln-ln regression of total M-SW returns in year t + 1 on total 1-SW returns in year t (Table 8), Log e_{M-SW} = -2.5833 + 1.1884 log e_{1-SW}, r = 0.837, n = 11, 1973-1984, p=0.001, (Y converted from geometric mean to arithmetic mean per Ricker, 1975, p. 274-275).

Estimate of the 1-SW angling catch in 1985 was determined from the regression of total 1-SW (HR + W) angling count on total 1-SW (HR + W) counts at Morgan Falls in the same year. This regression; Y_{ROD} = 426.31 + 0.345 X_{MF}, r = 0.629, n = 13, 1972-1984, p=0.021; estimates a 1-SW rod catch of 1230 (829 -1631), 95% C.L.) in 1985 from the estimated 2329 1-SW fish count forecast for Morgan Falls. Attainment of the catch will depend on average fishing effort in 1985 and on suitable climatic conditions for successful angling.

In summary, the numbers of LaHave fish counts and harvests estimated for 1985 are:

1985 Summary Forecast			1-SW	M-SW
	1-SW	M-SW		
River escapement (W)	8.102 million eggs x 0.049%	751	5491	1017
	x 1.29 (for angling correction)			
(H)	201 + 169	93+173		
Losses to commercial fisheries (FSD 26 & 27)(1984 level)			145	82
Returns to home waters		Total	5636	1099
All homewater harvests and losses				
Commercial fishery (FSD 26 & 27)(1984 level)			145	82
Angling fishery (M-SW: 0.1 mortality of a 0.22 catch that is released)			1230	22
Poaching and other mortalities			200	100
		Subtotal	-1575	-204
Available spawning escapement			4061	895
Requirement for spawners (average)			-2815	-497
Additional to spawning requirement			1246	398

Discussion

Fecundity continues to play an important role in salmon stock assessments. The biological basis for the fecundity values for the LaHave River stocks is quite limited. Additional effort should be made to refine fecundity values, particularly for the 1-SW fish which form a significant component of the annual egg depositions.

The three methods of calculating the adequacy of the LaHave River spawning escapement in 1984 suggest surplus spawners, between 500 and 3600 for 1-SW fish and 200 to 700 for M-SW fish. Although the egg deposition shows a 5 percent increase over the level in 1983, the 1-SW fish continue to provide too large a proportion, relative to the longer term 1-SW:M-SW ratios observed in the spawning runs.

The egg requirement for the area above Morgan Falls is 1.65 million, at a deposition rate of 2.4 eggs$\cdot m^{-2}$. This threshold level has been exceeded with regularity since 1977 (Table 7). No adjustment has been made for possible poaching activity which may have removed a portion of the egg potential. The rates of return since 1977 seem to suggest a plateau at a level much lower than those seen prior to 1978. The 1-SW wild returns in 1985 will provide insight into the case where the egg density exceeds our current minimal requirement by more than 2.5 times.

References

Cameron, J.D. 1985. Atlantic salmon stock composition for river escapements and broodstock collections, and juvenile salmon stocking for selected Nova Scotia rivers. Can. Data Rept. Fish. Aquat. Serv., in preparation.

Cutting, R.E., and R.W. Gray. MS 1984. Assessment of the status of the Atlantic salmon stocks of the LaHave River, Nova Scotia. CAFSAC Res. Doc. 84/40, 44 p.

Elson, P.F. 1974. Impact of recent economic growth and industrial development on the ecology of Northwest Miramichi Atlantic salmon (Salmo salar). J. Fish. Res. Bd. Canada 31:521-544.

R.W. Gray, and J.D. Cameron. 1980. Juvenile Atlantic salmon stocking in several Nova Scotia and southern New Brunswick salmon streams, 1971-79. Can. Data Rept. Fish. Aquat. Sci. No. 202, 47 p.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish population. Fish. Res. Bd. Bull. 191, 382 p.

Table 1. Commercial salmon catches in numbers of fish in the salmon and non-salmon gears in Fisheries Statistical Districts 26 and 27 combined, 1967-1984, presented as an index of LaHave River salmon catches.

Year	Salmon gear		Non-salmon gear		Total
	1-SW	M-SW	1-SW	M-SW	
1967					1443
1968					345
1969					527
1970	6	178	23	31	238
1971	27	120	79	10	236
1972	62	139	89	15	305
1973	0	202	5	11	218
1974	33	136	17	58	244
1975	40	297	13	37	387
1976	129	449	59	65	702
1977	21	214	182	293	710
1978	30	384	89	80	583
1979	81	324	54	11	470
1980	114	961	91	8	1174
1981	87	286	8	1	382
1982	74	137	16	24	251
1983	45	176	11	4	236
1984	140	82	5	0	227

Table 2. Recreational catch of Atlantic salmon, LaHave River, Nova Scotia, 1965-84.

Year	Annual Sport Catch			Fishing Effort (Rod-days)
	M-SW Salmon No.	1-SW Salmon No.	Total Salmon No.	
1965	18	64	82	1,059
1966	187	216	403	1,842
1967	150	267	417	2,125
1968	74	133	207	1,626
1969	50	95	145	1,248
1970	93	557	650	2,712
1971	119	411	530	2,150
1972	93	306	399	2,388
1973	107	604	711	2,490
1974	92	850	942	5,240
1975	224	581	805	2,723
1976	110	1012	1122	6,865
1977	232	1468	1700	9,855
1978	167	175	342	4,504
1979	107	1365	1472	5,505
1980	520	1273	1793	10,554
1981	442	1637	2079	16,417
1982	180	785	965	14,450
1983	172	130	302	5,435
1984	213[a]	753[b]	966	5,240

[a]Estimated on the basis of voluntary license stub returns. Eighty salmon were estimated to have been retained and 133 released.

[b]Of these, 111 were angled in an extended season in September and October.

Table 3. Stock origins and sea-age composition of salmon returns to the Morgan Falls fishway, 1970-1984.

Year	Hatchery		Wild		Total		
	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Combined
1970	-	-	2	4	2	4	6
1971	-	-	3	-	3	-	3
1972	-	-	10	2	10	2	12
1973	147	11	11	7	158	18	176
1974	314	25	40	2	354	27	381
1975	503	71	39	5	542	76	618
1976	523[1]	104	199	24	722	128	850
1977	974	83[1]	289	25	1,263	108	1,371
1978	553	208	285	66	838	274	1,112
1979	1,079	99	857	67	1,936	166	2,102
1980	335	515	1,618	287	1,953	802	2,755
1981	1,180	215	1,814	354	2,994	569	3,563
1982	627	230	793	258	1,420	488	1,908
1983	31	103	1,124	210	1,155	313	1,468
1984	250	36	2,043	384	2,293	420	2,713

[1]Data include 1-SW salmon returns (1976) and 2-SW salmon returns (1977) from fall fingerlings released in 1973.

Table 4. Number of hatchery-reared juvenile salmon released at different locations upstream from Morgan Falls, 1971-83 (1, 2).

Year of release	Juvenile Stage at Release						Total release
	0+ Parr	1+ Parr		1+ Smolt		2+ Smolt		
		released	tagged	released	tagged	released	tagged	
1971		9,440		4,892	4,892			14,332
1972		6,790		8,400	8,400	6,450	5,000	21,640
1973	51,643[1]	43,133		9,166	4,970	18,526	7,971	122,468
1974		5,235		17,118	9,958	14,435	5,890	36,788
1975		18,883	13,963					18,883
1976		11,454		40,678	10,000	5,772	3,994	57,904
1977		28,183		95,204	20,000	7,371	4,000	130,758
1978		7,108		73,236	23,400			80,344
1979	30,000			33,910	8,000			63,910
1980	10,626[3]			63,226	9,995	16,026	5,996	89,878
1981				25,527	7,991			25,527
1982								0
1983				28,451	0			28,451
1984	33,000 fry			15,000	9,000			48,000

[1]All hatchery-reared juvenile salmon had an excised adipose fin except underyearling parr released in 1973.

[2]Summarized from Gray and Cameron (1980).

[3]Released as unmarked fry from streamside incubator in late May 1980.

Table 5. Summary of distribution of hatchery-reared juvenile salmon above Morgan Falls in the LaHave River, number of adult returns counted, and calculated return rates based on adult counts, 1976-1984.

Year of release	Juvenile stage	Number released	Estimated smolt output[1]	Adult returns to trap			Estimated return rate to trap (%)		
				1-SW	M-SW	Total	to 1-SW	to M-SW	Total
1976	1+ Parr	11,454							
	1+ Smolt	40,678							
	2+ Smolt	5,772	45,867	974	208	1,182	2.12	0.45	2.58
1977	1+ Parr	28,183							
	1+ Smolt	95,204							
	2+ Smolt	7,371	91,370	553	99	652	0.61	0.11	0.71
1978	1+ Parr	7,108							
	1+ Smolt	73,236	77,478	1,079	515	1,594	1.39	0.66	2.06
1979	0+ Parr	30,000							
	1+ Smolt	33,910	35,830	335	215	550	0.93	0.60	1.54
1980	Fry	10,626							
	1+ Smolt	63,226							
	2+ Smolt	16,026	69,320	1,180	230	1,410	1.70	0.33	2.03
1981	1+ Smolt	25,527	32,680	627	103	730	1.92	0.32	2.23
1982	None	0	2,042	31	36	67	1.52	1.76	3.28
1983	1+ Smolt	28,451	22,761	250	N.A.	N.A.	1.10	N.A.	N.A.
1984	1+ Smolt	15,000	14,276						
1985	2+ Smolt		1,200						

[1]Assumptions: 0+ parr to 1+ smolt survival is 60%; 1+ parr to 2+ smolt survival is 40%, 20% of 1+ smolts since 1976 do not migrate in year of stocking. Smolt output is the total of the age age 1^+ and 2^+ smolts that were estimated.

Mean return rates:	(1976-1983)	1.41	
	Std. dev.	0.51	
	(1976-1981)[2]		0.41
	Std. dev.		0.202

[2] Return rate for M-SW fish in 1984 was not included in calculations of mean rate because of a very high proportion of previous spawners.

Table 6. Sex ratio and salmon:grilse ratio of hatchery-return and wild Atlantic salmon recorded at the Morgan Falls trap 1973-1984. Data are corrected for sexing error prior to July 31 each year.

Year	Hatchery Returns						Wild					
	Salmon			Grilse			Salmon			Grilse		
	n	% F	% S	n	% F	% G	n	% F	% S	n	% F	% G
1973[2]	12	66	6	177	28	94	9	78	32	19	53	68
1974	25	76	7	314	24	93	2	-	5	40	27	95
1975	71	59	12	503	25	88	5	86	11	39	40	89
1976	104[1]	64	17	523[1]	22	83	24	56	11	199	23	89
1977	83[1]	72	8	974	25	92	25	81	8	289	33	92
1978	208	79	27	553	30	73	67	66	20	275	34	80
1979	99	74	9	1,079	28	91	67	81	7	857	36	93
1980	515	59	61	335	26	39	287	69	15	1,618	29	85
1981[2]	215	67	15	1,180	22	85	354	73	16	1,814	30	84
1982[2]	230	77	27	627	30	73	258	71	25	793	24	75
1983[2]	100	71	81	24	19	19	213	68	16	1,129	34	84
1984	36	83	13	250	16	87	384	69	16	2,043	30	84
Unweighted mean (S.D.)		71 (7.7)	24 (23.6)		25 (4.3)	76 (23.6)		73 (8.0)	15 (8.0)		33 (8.0)	85 (7.8)

[1]Data include 1-SW salmon returns (1976) and 2-SW salmon returns (1977) from fall fingerlings released in 1973.

[2]Data base from Cameron (1985, in preparation).

Table 7. Egg deposition of wild and hatchery-return fish and resultant 1-SW and M-SW salmon returns to Morgan Falls, 1973-1984. Percent survival of eggs to observed adult returns in parentheses. Egg depositions are adjusted for broodstock removals for fish culture purposes or for transfers.

Year	Egg deposition (year t)	No. of wild salmon returns* 1-SW (t + 4)	M-SW (t + 5)	Total returns
1973	105,200	312 (0.297)	67 (0.064)	379 (0.360)
1974	215,200	332 (0.154)	71 (0.033)	403 (0.187)
1975	548,000	920 (0.168)	288 (0.053)	1208 (0.220)
1976	704,700	1634 (0.232)	353 (0.050)	1987 (0.282)
1977	1,170,200	1730 (0.148)	257 (0.022)	1987 (0.170)
1978	1,825,200	832 (0.046)	210 (0.012)	1042 (0.057)
1979	1,982,600	1078 (0.054)	274 (0.014)	1352 (0.068)
1980	3,849,100	1816 (0.047)		
1981	4,341,900			
1982	2,908,000			
1983	2,129,500			
1984	1,943,300			

*Data adjusted to reflect freshwater age composition of the returns.

Table 8. Estimates of salmon in the wild river escapement, total river escapement, and egg depositions in the LaHave River, 1973-84.

	ANGLING FISHERY				MORGAN FALLS				RIVER ESCAPEMENT		TOTAL RIVER ESCAPEMENT			ESTIMATED EGG DEPOSITION[11] x 10^3				
	Hatchery Return[1]		Wild[2]		Hatchery Return[3]		Wild[3]		Salmon (W)[4]		Salmon (HR+W)[5]			Above M. Falls		Rest of Basin		
Year	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Total	Grilse	Salmon	Grilse	Salmon	Year Total
(Column)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1973	61	3	543	104	147	11	11	7	1853	473	2061	487	2548	52.0	53.2	2067.4	1643.3	3815.9
1974	130	7	720	85	314	25	40	2	2457	386	2901	418	3319	203.3	11.9	1375.9	1235.5	2826.6
1975[6]	208	20	373	204	503	71	39	5	1273 (1689)[9]	927	2400	1018	3418	422.3	125.7	1607.5	3638.0	5793.5
1976	217	29	795	81	523	104	199	24	2713	368	3453	501	3954	495.1	209.6	1200.2	857.2	2762.1
1977	440	23	1028	209	974	83	289	25	3509	950	4923	1056	5979	909.7	260.5	2133.3	3365.0	6668.5
1978[7]	104	56	71	111	553	208	285	66	242 (1120)[10]	505 (1124)[10]	1777	1388	3165	774.4	1050.8	711.9	3845.8	6382.9
1979[8]	568	28	797	79	1079	99	857	67	2720	359	4367	486	4853	1657.9	324.7	1099.6	963.5	4045.7
1980	78	92	1195	428	335	515	1618	287	4078	1945	4491	2552	7043	1441.2	2407.9	1109.6	4962.1	9920.8
1981	489	121	1148	321	1180	215	1814	354	3918	1459	5587	1795	7382	2482.6	1859.3	429.2	3330.9	8102.0
1982	260	65	525	115	627	230	793	258	1791	523 (1255)[10]	2678	1550	4228	1131.0	1777.0	340.9	3663.6	6912.5
1983	13	29	117	143	31	103	1124	210	399 (3411)[9]	650	3455	782	4237	1160.9	968.6	2207.5	1132.1	5469.1
1984	297[12]	10	456	203	250	36	2043	384	2215 (3543)[9]	922	4554	968	5522	1821.9	1271.8	1079.7	1335.4	5508.8

1. Based on yearly exploitation rates of hatchery grilse and salmon, or on mean exploitation rates of 0.293 and 0.220 for grilse and salmon respectively.
   Thus: $\frac{\text{Fishway count HR Grilse}}{1.000-0.293}$ - Fishway counts HR Grilse = number of HR Grilse angled
2. Total annual angling catch of grilse minus Column 1 = Column 3 (wild grilse). Total annual angling catch of salmon minus Column 2 = Column 4 (wild salmon).
3. Fish trap count at Morgan Falls.
4. Based on angling exploitations at 0.293 (1-SW) and 0.220 (M-SW) divided into angling catch = river escapement.
5. Total river escapement of grilse = Column 1+5+9 = Column 11; total river escapement of salmon = Column 2+6+10 = Column 12.
6. Low water conditions in July, Aug., and Sept. adversely influenced 1-SW angling catch but not M-SW salmon catch in June.
7. Failure of the 1977 smolt year-class; low water conditions in June, July, Aug., Sept. adversely influenced 1-SW and M-SW angling catches in 1978.
8. Failure of the 1977 smolt year-class adversely affected the M-SW returns in 1979.
9. Estimated from regression $Y_{MFcount1\text{-}SW} = 1.98\ X_{1SWangling} - 849.72$ (1973-'77, 1979-'82), minus HR grilse Column 1 0.293.
10. Estimated from mean ratios of grilse (time t) to salmon (t+1) (1973-1982) of 3.121G:1S.
11. Egg deposition : Grilse (Columns 14 and 16); annual mean fork length in Fec. $430.19^{0.03605FL}$ times % F times no. of fish.
    : Salmon (Columns 15 and 17); annual mean fork length in Fec = $360.532^{0.03827FL}$ times % F times no. of fish.
    Estimated deposition from broodstock collections has been removed.
    No adjustment for instream losses to poaching or mortalities. Morgan Falls counts determine numbers of spawners there. Lower basin grilse = Columns 11 - (1+3+5+7). Lower basin salmon = Columns 12 - (2+4+6+8).
12. The HR component was enhanced by an estimated 657 fish which should have returned from smolts stocked below Morgan Falls in 1983 if their performance was similar to the group stocked above Morgan Falls ($\frac{52803}{28451}$ x (250 + 104)). That component would also have provided 193 grilse included in the angling catches.

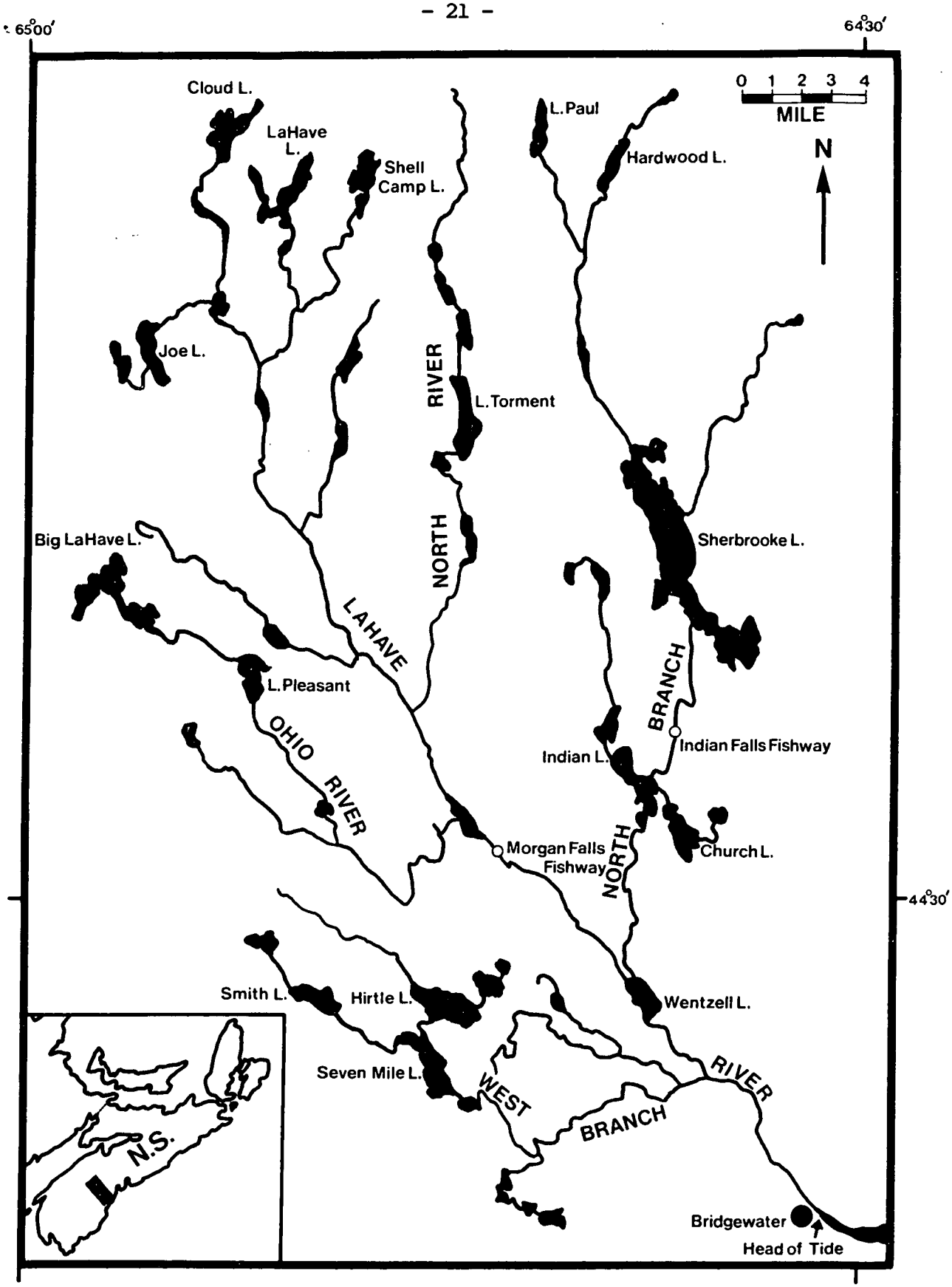

Fig. 1. The LaHave River drainage, Nova Scotia.