Assessment of the Status of the Atlantic Salmon Stocks of the LaHave River, Nova Scotia

by

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ABSTRACT

The LaHave River of Lunenburg, Kings, and Annapolis counties, Nova Scotia, has present river escapements comprised of over eighty percent one-seawinter fish. Installation of a fishway at a natural falls in 1969 opened up about 44 percent of the drainage for salmon production. Mean annual recreational salmon catches have increased about 150 percent since 1974 and commercial landings have shown gains as a result of the stocking program and the increased natural production. Correlation of one-seawinter counts at the fishway in year t with multi-seawinter catches in t + 1 in the commercial fishery of Fisheries Statistical Districts 26 and 27 suggests that fishery was a good indicator of stock availability, until new management measures were introduced in the 1981-83 period. Correlations between fishway counts and other data sets indicate the value of the counting facility information base as an indicator of stock abundance.

Estimation of the 1983 spawning escapement by three methods suggests egg deposition was adequate, or close, to the 4.91 million egg target. With existing stock characteristics spawning requirements were calculated to be 497 and 2815 M-SW and 1-SW salmon, respectively.

Predictions of stock abundance in 1984 was made by several methods. The angling fishery should take at least 1700 grilse and salmon under normal water conditions. At present harvest levels, adequate spawning escapements will be achieved and a surplus of 1-SW salmon above spawning requirements should be available for allocation to harvest in the fisheries.

RESUME

Le nombre de saumons qui se sont échappées et ont pu se reproduire dans la rivière LaHave des comtés de Lunenburg, Kings et Annapolis, en Nouvelle-Ecosse, est formé de plus de 80 % de saumons unibermarins (1 hiver en mer). Grâce à une passe migratoire installée à proximité d'une chute naturelle en 1969, jusqu'à environ 44 % du bassin hydrographique a été rendu accessible à la production de saumons. Les prises annuelles moyennes de la pêche récréative ont augmenté d'environ 150 % depuis 1974, et les débarquements commerciaux sont à la hausse, résultat d'un programme de peuplement et d'une production naturelle accrue. La corrélation entre le nombre d'unibermarins observés à la passe migratoire, dans l'année t, et les prises de redibermarins (plusieurs hivers en mer), dans l'année t + 1, par la pêche commerciale dans les districts statistiques 26 et 27 nous permet de croire que, jusqu'à ce que de nouvelles mesures de gestion aient été introduites entre 1981 et 1983, la pêche a été un bon indicateur de l'accessibilité du stock. La corrélation entre les comptages à la passe migratoire et autres données met en évidence la valeur, comme indice d'abondance du stock, des renseignements recueillis à l'installation de comptage.

L'échappement en vue de la reproduction, estimé par trois méthodes, donne à penser que le nombre d'oeufs déposés a été adéquat, approchant la cible de 4,91 millions. On a calculé qu'avec les caractéristiques actuelles du stock, le nombre de saumons requis pour la reproduction est de 497 redibermarins et 2 815 unibermarins.

Des prévisions d'abondance de stock en 1984 ont été établies suivant plusieurs méthodes. La pêche récréative devrait capturer au moins 1 700 madeleineaux et grands saumons dans des conditions d'eau normales. Aux actuels niveaux de pêche, il y aura échappement adéquat, et la pêche devrait se voir attribuer les unibermarins en surplus du nombre requis pour la reproduction.

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INTRODUCTION

The LaHave River is found in Lunenburg, Kings, and Annapolis counties of southwestern Nova Scotia (Fig. 1). The river drains approximately 1670 km^2; and has a meander length of 92 km with an average gradient of 2.64 m/km. The watershed contains 113 lakes having a surface area of 7515 h and has five major tributaries, West Branch, Main Branch, North Branch, Ohio River, and North River (Gray et al. 1984). The basin is 80 percent mixed forest and the underlying bedrock is largely slates covered by an extensive drumlin field which supports some agricultural activity (Cann and Hilchey, 1958). The basin lies in the zone affected by acid precipitation, but Watt (1981) indicates the pH decrease for the LaHave River between 1954-55 and 1979-80 is not statistically significant. Recent water sampling shows some headwater tributaries have water quality which is marginal for good survival of juvenile salmon. A salmon development project has been in operation since a new fishway at Morgan Falls in New Germany began functioning in 1970 providing salmon access to about 44 percent of the drainage. Aspects of the salmon development project in the early years, 1969-73, were described by Gray (1974).

This document summarizes some of the available data bases with reference to the salmon resource, identifies the spawning requirements, reviews the 1983 stock status and forecasts expected salmon returns for 1984.

METHODS

Salmon Landings

The salmon resource of the LaHave River is exploited in recreational and commercial fisheries. Tables 1 and 2 show tabulations of the recreational catches by grilse (1-SW) and salmon (2-SW and older) and by month for the periods of record (Smith, 1981; Redbooks*).

Marshall (MS 1982) reports that interception of fish from several stocks along Nova Scotia's Atlantic coast occurs in several Fisheries Statistical Districts FSD 9-32. Returns from tagged smolts from FSD's 26-28, LaHave River being in FSD 27, suggested about 93 percent by weight of the commercial landings in those three Districts had originated in those districts. A further 20 percent of the landings in FSD's 22, 23, 25 originated from smolts released in FSD's 26-28. Since only 4 percent of the tag returns came from districts westerly of the home rivers in FSD's 26-28 and since the Medway River is the only major salmon stream in FSD 28, west of the LaHave, commercial landings in FSD 26 and 27 are used in this analysis as an index of homewater commercial harvest of LaHave stock. Tables 3-5 summarize commercial salmon catches in these districts as well as for FSD's 22, 23, and 25 for the 1970-83 period (Redbooks).

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*Atlantic Salmon Sport Catch Statistics, Maritime Provinces, annual series beginning 1970. Published by Department of Fisheries and Oceans and its precursors.

Salmon Development Project

In 1969 a fishway was constructed at Morgan Falls when a former dam was removed from atop a 6.5-meter natural barrier. Installation of the fishway added about 50 percent to the nursery area accessible for salmon migration. In 1971, stocking of hatchery-reared salmon began in order to accelerate the development of a self-sustaining salmon population. Table 6 contains a listing of the various juvenile salmon stages that were stocked, 1971-1983. Medway River stock was used initially in the project because of its similarity to the LaHave River stock. However, since 1975 all juvenile releases have been of LaHave origin. All fish which pass Morgan Falls on their upstream migration must pass through a fishway trap where annual counts are made (Table 7).

Biological Characteristics

Biological characteristics of the stock were obtained by sampling the adult run at Morgan Falls. Data on sex ratios, grilse:salmon ratios, age and size composition are summarized in Tables 8-11.

(1) Sex Ratios/Sexing Error/Egg Deposition

Atlantic salmon migrating upstream at Morgan Falls utilize a vertical slot fishway to by-pass the falls and are processed at the fishway trap. At the time of sampling all salmon are sexed externally. Corrections were made to the sexing data for those salmon which entered the trap prior to July 31. Sexing after July 31 was assumed to be accurate since subtle changes in secondary sex characteristics, such as head and jaw configurations, even at this early date were evident to the samplers. This presumption was confirmed by a small grilse sub-sample (N = 10) taken on July 31, 1980 (Table 9).

Calculations to correct for sexing error prior to July 31 each year were based on recaptures of tagged salmon which reentered the fishway trap and hence were sexed at least twice and sometimes 3 or 4 times; some reentered the trap a second time after September 1 when secondary sex characteristics were pronounced. Data from the initial (trap) sexing of tagged broodstock prior to July 31 and sexings of those individual salmon at spawning were also used. Sexing error calculations were divided into two periods, 1973-77 and 1978-81, so that substantial numbers of salmon were available to calculate correction factors. This division would also suggest whether sampler skills may have changed over time.

Stock description	Correction Factor Period I N	Period I (1973-77)	Period II N	Period II (1978-81)
Salmon (MSW) (HR/W) female	114	1.18	123	1.15
Salmon (1SW) (HR/W) female	121	0.74	24	.88

Consequently, all sexed data for wild (W) and hatchery-return (HR) grilse and salmon were adjusted using the following calculations:

Period I: (1973-77)

(1) $FC_2 = FO_2 \times 1.18$, where
FC_2 = correct number of M-SW salmon females
FO_2 = original estimate of M-SW salmon females

(2) MC_2 = total number of M-SW salmon - FC_2 = correct number of M-SW salmon males.

(3) $FC_1 = FO_1 \times 0.74$, where
FC_1 = correct number of 1-SW salmon females
FO_1 = original estimate of 1-SW salmon females

(4) MC_1 = total number of 1-SW salmon - FC_1 = correct number of 1-SW salmon males.

Period II: (1978-81)

The same procedure was used for these data but with different correction factors:

(5) $FC_2 = FO_2 \times 1.15$

(6) $FC_1 = FO_1 \times 0.88$

Sex ratios were calculated by expressing the numbers of females in each age group and stock as a percent of the total number of salmon in each group and stock.

Annual egg depositions upstream from Morgan Falls were calculated from the corrected number of females released from the trap in each sea age-class multiplied by the fecundity value for the mean fork length from annual samples. Separate calculations for wild and for hatchery-return fish were summed.

(2) Grilse:Salmon Ratios

Grilse:salmon ratios were calculated from trap data assuming salmon $<$ 63.0 cm, fork length were grilse or 1-SW salmon (Table 8). This length

delineation was corroborated by data from 841 wild salmon aged between 1973-81 where fewer than 5 salmon (previous grilse spawners) were less than 63 cm, fork length (Gray, pers. comm.).

(3) Size/age Composition

Fork length and weight measurements were determined at the Morgan Falls fishway trap. The number of samples taken each year, 1974-81, for length, weight and age are shown in Tables 10 and 11.

Egg Deposition Requirement/Spawning Requirement

Salmon nursery habitat was classified by Gray et al. (1984) into several types based on stream characteristics and parr abundance. These authors report the river has about 20,460 accessible rearing units (r.u.) of 100 m^2. This rearing habitat is distributed as follows:

			Egg deposition target (millions)
Main river	3,660 r.u.,		
North River	1,220 r.u.		
Ohio River	1,980 r.u.		
Subtotal above Morgan Falls		6,860 r.u.	1.65
Main river	8,650 r.u.		
North Branch	3,430 r.u.		
West Branch	1,520 r.u.		
Subtotal below Morgan Falls		13,600 r.u.	3.26
Total accessible		20,460 r.u.	4.91

A further 540 rearing units are not presently accessible to salmon.

Fecundity data used in this paper were collected in November 1980 and 1981 during normal broodstock spawning operations at Coldbrook and Mersey Fish Culture Stations (Table 12). Egg number was determined by the displacement method (Burrows 1951). The relative fecundity method of Randall and Chadwick (1983) was used to determine mean egg capacity for sea age-classes, except that fork length instead of weight was used.

Though the 25-fish sample of LaHave and Medway broodstock available for the fecundity work had a disproportionately high component of previous spawners (7 of 25) relative to to the spawning runs, a fecundity-length regression was calculated (Fec. = $360.532^{0.03827\ F.\ length}$). This result was compared with a similar regression (Figure 2) calculated for 121 fish from the Saint John River (Fec. = $430.19e^{0.03605\ F.\ length}$) (Marshall and Penney, MS 1983). A statistical comparison indicated no statistical difference ($p \simeq 0.5$) between the regression coefficients.

Because none of the LaHave-Medway fish were smaller than 66.5 cm and because the LaHave-Medway and Saint John regressions were so similar over the 65-85 cm size range, fecundity values for 1-SW LaHave fish were calculated from the Saint John fecundity-length regression. The fecundity values for 2-SW fish were determined from the LaHave-Medway fecundity-length regression.

Estimated mean fecundities were:

1-SW (grilse): 3012 eggs/females of mean fork length
M-SW (salmon): 5818 eggs/females of mean fork length

No adjustment was made to the M-SW class fecundity to account for the occasional 3-SW fish or the small variable component of previous spawners.

Egg deposition and spawner requirements for the LaHave River were calculated from the following data:

Required egg deposition rate = 2.4 eggs/m^2 (Elson 1974)

LaHave River rearing area = 2,046,228 m^2 (Gray et al. 1984)

Female salmon (wild 2-SW maiden)	mean weight	= 4.250 kg	(Table 10)
	mean fork length	= 72.67 cm	(Table 10)
Female grilse (wild 1-SW maiden)	mean weight	= 1.638 kg	(Table 10)
	mean fork length	= 53.98 cm	(Table 10)

Salmon sex ratio (wild M:F)	= 0.27:0.73	(Table 8)
Grilse sex ratio (wild M:F)	= 0.67:0.33	(Table 8)
Grilse/salmon ratio (wild)	= 0.85:0.15	(Table 8)

1983 Escapement Estimates

Because the salmon development project on the LaHave River was oriented toward establishing a population upstream from Morgan Falls, in previously inaccessible habitat, it was difficult to use the Morgan Falls trap site as an index of the total salmon stock during the 1970-1977 period when the stock was expanding. Consequently, alternative methods were used to estimate escapements for the early years.

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. In order to estimate escapements in certain years where extreme low water conditions during specific periods adversely affected angling catches of grilse or salmon or both, a significant regression, $Y = 1.98X - 849.72$, $n = 9$, $r=0.83$, 1973-1977 and 1979-82, $p < 0.01$ of total grilse (HR:W) returning to Morgan Falls (Y) on total grilse (HR;W) angled in the river (X) and mean grilse (t):salmon (t+1) ratios in the river escapement (Table 13) were used for predictions. Mean angler exploitation rates for hatchery-return salmon based on recaptures of grilse and salmon which had been released as tagged hatchery-reared smolts, adjusted upwards 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 (Table 14). Mean angler exploitation rates were used in the calculations for years where data were lacking. Losses due to poaching or 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 trap located in the estuary of the LaHave River in 1983, to estimate the proportion of the total 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. 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 originated from headwater tributaries above Morgan Falls (Table 15). In order to calculate wild salmon escapement, it was assumed that other parts of the LaHave River had the same mean grilse:salmon ratio as the fish at Morgan Falls (Table 13). Losses due to poaching or other mortalities are assumed to be the same as in Method I.

Method III for estimating escapements utilized data on rearing areas and known wild salmon production (Table 7) from the headwaters upstream from Morgan Falls as a proportion of total river nursery habitat. This method assumes that egg deposition per m^2 is similar in the area above Morgan Falls as throughout the rest of the river production area. It also assumes that juvenile production per rearing unit and factors affecting survival are the same throughout the river.

Prediction of 1984 escapement levels

Counts of M-SW and 1-SW salmon expected to return to the Morgan Falls counting facility in 1984 have been forecast on the basis of information collected at the facility since 1973. 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 n and the M-SW count in year n + 1. Method II utilized the estimated return rate, measured by the number of M-SW fish counted at Morgan Falls from the estimated eggs deposited in 1978 (Table 16), applied to the estimated eggs deposited in 1979 to estimate the 1984 M-SW returns. The wild 1-SW returns were estimated using method II above wherein the 1-SW return rate from the 1978 and 1979 mean estimated egg deposition was applied to the 1980 estimated egg deposition to provide the 1984 1-SW returns.

Returns of hatchery-reared 1-SW and M-SW salmon to Morgan Falls were estimated on the basis of 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 17).

The 1984 catch of M-SW salmon in number in the combined commercial fisheries of Statistical Districts 26 and 27 was estimated from the significant

regression of the recorded M-SW salmon catch in FSD 26 and 27 in year n + 1 on the 1-SW count at Morgan Falls in year n for 1973-1980. The estimate of reported catch was adjusted to account for the apparent under-reporting of catches occurring since 1980.

Assuming average angling conditions and no substantial change in angling season, an estimate of the 1984 angling catch was made. The estimates were based on application of 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 1-SW count at Morgan Falls.

RESULTS

Egg Deposition Requirements/Spawning Requirements

Egg deposition per sea-age fish, fecundity, percent female, and salmon/grilse proportion outlined in the methods, was calculated as follows:

Eggs per wild female of mean fork length		Percent female (Table 8)		Proportion in runs (Table 8)	Egg deposition per fish
M-SW: 5818	x	0.73	x	0.15	= 637
1-SW: 3012	x	0.33	x	0.85	= 845
		Total egg deposition per fish			= 1482

The total number of fish required by river section to meet egg deposition requirements can be estimated by: required egg deposition rate x rearing area divided by total egg deposition per fish.

West Branch
= 2.4 x 152,103/1482
= 246

North Branch
= 2.4 342,974/1482
= 555

Main River - Upstream Morgan Falls
= 2.4 x 685,732/1482
= 1110

Main River - Downstream Morgan Falls
= 2.4 x 865,419/1482
= 1401

Basin Total = 3312 fish

From the mean wild grilse:salmon ratio (Table 8), therefore, the mean numbers of salmon and grilse required to meet egg deposition requirements are 497 and 2815, respectively. A shift in the grilse:salmon ratio in the spawning requirement to that observed by Hayes (1953) will require 1136 salmon and 2176 grilse.

1983 Escapements

The grilse and salmon returns in 1983 calculated from Method I are summarized below. These data suggest spawning requirements were essentially met in 1983.

Method I (1983)	Grilse	Salmon
1. River escapement (W+HR) (Table 18) (See Method II)	3455	782
2. Losses to commercial fisheries (Stat. Dist. 26-27)	56	180
3. Returns to homewaters	3511	962
4. All losses:		
commercial fishery (Table 3)	56	180
angling fishery (Table 1)	130	172
poaching and other mortalities	200	100
Total	386	452
5. Spawning escapement	3125	510
6. Spawning requirements	2815	497
7. Surplus or (deficit)	310	13

Method II for estimating 1983 grilse and salmon returns uses recapture information from salmon tagged at an estuarial trapnet and known fish counts at Morgan Falls. These data suggest that spawning requirements were not met in 1983.

Method II (1983)	Grilse	Salmon
1. River escapement		
Salmon (W) (1124/0.303; 3710/0.854-3710)	3710	634
Salmon (HR) angled (Table 18)	13	29
Salmon (HR) Morgan Falls (Table 7)	31	103
Total	3754	766
2. Losses to commercial fisheries (Stat. Dist. 26/27)	56	180
3. Returns to homewaters	3810	946
4. All losses:		
commercial salmon fishery (Table 4)	45	176
non-salmon commercial gear (Table 5)	11	4
angling fishery (Table 1)	130	172
poaching and other mortalities	200	100
Total	386	452
5. Spawning escapement	3424	494
6. Spawning requirements	2815	497
7. Surplus or (deficit)	609	(3)

It is important to note that even if these escapements calculated from Method II were realized in 1983, if the angling fishery had harvested at the 1981 level and if the commercial fishery is harvesting at higher levels than logbook records indicate, (e.g., 24 percent), no surplus fish would have occurred. Key assumptions are that all "Morgan Falls" fish migrate upstream past that point and that the trapnet sampled stocks proportionally to the drainage areas.

Method III uses rearing area and known adult production above Morgan Falls to derive escapement. The data suggest that spawning escapements were adequate in 1983.

Method III (1983)	Grilse	Salmon
1. River escapement		
Salmon (W) (1124 x 2,046,228/685,732; 210 x 2,046,228/685,732)	3354	627
Salmon (W+HR) angled (Table 1)	130	172
Salmon (HR) Morgan Falls (Table 7)	31	103
Total	3515	902
2. Losses to commercial fisheries (Stat. Dist. 26/27)	56	180
3. Returns to homewaters	3571	1082
4. All losses:		
commercial fisheries	56	180
angling fishery	130	172
poaching and other mortalities	200	100
Total	386	452
5. Spawning escapements	3185	630
6. Spawning requirement	2815	497
7. Surplus or (deficit)	370	133

1984 Catches and Escapements

The count of M-SW fish at Morgan Falls in 1984 was estimated by two methods.

Method I utilized the significant correlation between wild 1-SW counts in year n and the wild M-SW counts in year n + 1. That regression; $Y_{M\text{-}SW} = 20.41 + 0.184X_{1\text{-}SW}$, $p < 0.01$, $r = 0.913$, 1973-1983; estimates a 1984 wild M-SW return to Morgan Falls of 227 fish (172-282, 95% C.L.). Although the hatchery fish correlation is significant almost at the 0.02 level, the 1983 1-SW count was so low that it is outside the range of the prior data set, and thus an estimate is not possible.

Method II utilized data in Table 16. The method of determining egg deposition levels for above Morgan Falls has been described. Adult returns to Morgan Falls are 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 the most current return rate. Use of the 0.012 percent return rate for M-SW fish multiplied by the estimated 1,982,600 eggs deposited in 1979 provides an estimate of 238 M-SW salmon in 1984.

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 and 1979 eggs. This mean observed return rate (0.051 percent) estimates a return of 1963 1-SW fish in 1984 from the estimated 3,849,100 eggs deposited in

1980 above Morgan Falls (Table 16). The return will also include a number of fish which were 3-year old smolts from the 1979 eggs.

Returns of hatchery-reared 1-SW and M-SW salmon to the LaHave in 1984 were estimated from the rates of return to Morgan Falls observed since 1976 from estimated smolt outputs (Table 17). Return rates have averaged as follows:

Smolt year-classes	Sea-age-class	Mean % return	Std. dev.	N
1976-1982	1-SW	1.45	0.53	7
1976-1981	M-SW	0.41	0.20	6

Utilization of these rates estimates that 8 M-SW fish will appear in 1984 at Morgan Falls from the 1982 smolts from the 1981 planting. The 22,761 (28,451 less 20 percent) smolts released above Morgan Falls in 1983 are estimated to result in 332 hatchery-return 1-SW in 1984. A further 617 1-SW fish should be available for spawning in the remainder of the basin from the 42,242 smolts (52,803 less 20 percent) released in 1983 if the pattern of their removals and survival is similar to that for fish returning above Morgan Falls.

The commercial catch of M-SW salmon in FSD's 26 and 27 in number shows a significant correlation with the 1-SW salmon count at Morgan Falls the previous year; $Y = 176.97 + 0.3591X$, $p < 0.01$, $r = 0.8779$, 1973-1980. The regression estimates a 1984 commercial catch of 592 fish (447-737, 95% C.L.). Addition of the data sets for 1981-83 to the above regression quickly destroys the statistical significance. Beginning in 1981 the commercial salmon season opening has been delayed and logbooks have been mandatory in the fishery. Although the recorded catches have decreased, the proportion of the annual catch caught before June 1 has remained fairly constant since the first substantial hatchery-reared M-SW returns began in 1978. The recorded M-SW catches 1981-83 average about 24 percent of the values predicted on the basis of the aforementioned regression:

Year	Predicted catch	Recorded catch	Recorded/predicted
1981	878	287	0.327
1982	1075	161	0.150
1983	687	180	0.262
Totals and mean	2640	628	0.238

Reducing the 592-fish estimate by the estimated rate of reporting, suggests the recorded 1984 M-SW catch in FSD 26-27 will be about 140 fish if similar seasons are fished.

The estimate of the M-SW angling catch in 1984 is based on the estimated angling exploitation rate applied to the estimated river escapement. Removal of M-SW fish at a 22 percent rate from the estimated 1188 wild (see following text) and 10 hatchery-return in the river escapement provides an estimate of angling catch of 264 fish.

The 1984 rod catch of 1-SW fish will have four contributing components: hatchery-return and wild fish from above and from below Morgan Falls.

	1984 estimated returns
Above Morgan Falls	
Wild	1963
Hatchery-return	332
Below Morgan Falls	
Hatchery-return	617
Wild $1963 \times \frac{13,600 \text{ r.u.}}{6,860 \text{ r.u.}}$	3892

If the hatchery-return and wild fish are angled at a 0.293 rate, the 1-SW rod catch contributions by component will be:

	1-SW fish in rod catch
Above Morgan Falls	
Wild	814
Hatchery-return	138
Below Morgan Falls	
Hatchery-return	256
Wild	1613
	2821

This estimate is far higher than any catch on record.

An alternate method of estimating the 1-SW rod catch in 1984 is to use the significant regression of total 1-SW (H,W) rod count on total 1-SW (H,W) count at Morgan Falls. This regression, $Y = 391.5 + 0.4112X$, $r = 0.698$, $n = 12$, $p < 0.02$, 1972-1983, estimates a 1-SW rod catch of 1335 (906-1765, 95% C.L.) in 1984 from the estimated 2295 1-SW fish count forecast for Morgan Falls. This latter estimate is more reasonable based on historical performance of the fishery, but its attainment will, as always, depend on possible fishery restrictions and on suitable climatic conditions for successful angling. A further 136 fish must be added for the angling catch from the hatchery smolts stocked below Morgan Falls in 1983.

River escapement of 1188 (790-1787, 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 18) $\text{Loge}_{\text{M-SW}\hat{}} = -2.8754 + 1.2146 \text{ Loge}_{\text{1-SW}}$, $r = 0.745$ $n = 10$, 1973-83, $p > 0.01$, Y converted from geometric mean to arithmetic mean per Ricker, 1975, p. 274-275).

In summary, the numbers of LaHave fish counts and harvests estimated for 1984 are as follows:

1984 Summary	1-SW	2-SW
River escapement (W + H)	6804	1198*
Losses to commercial fisheries (FSD 26-27)	80 (est.)	592
Returns to home waters	6884	1790
All harvests and losses		
Commercial fishery (FSD 26-27)	80	592
Angling fishery	1471	264
Poaching and other mortalities	200	100
Subtotal	1751	956
Spawning escapement	5133	834
Spawning requirements	2815	497
Surplus or (deficit)	2318	337

*Use of the 1977-78 survival rate (0.017) from the 1979 eggs (4,045,700) suggests a wild M-SW river return of 688 fish which would result in a 52-fish deficit for spawning.

It is important to note the shift in grilse:salmon ratios in the LaHave River since the 1950's. Hayes (1953) reported a grilse:salmon ratio of 0.657:0.343; this compares with a higher number of grilse in the present wild population (mean = 0.85:0.15). In spite of greater numbers of grilse, during the past eleven years, the proportion of eggs deposited by multiseawinter salmon has averaged 55 percent (14.08 std. dev.)

The three methods for calculating the adequacy of spawning escapement in 1983 produced the following surplus or (deficit) results:

	Grilse	Salmon
Method I	310	13
Method II	609	(3)
Method III	370	133

Each method suggests a surplus of 1-SW fish. Although sufficient egg deposition was available in 1983, too large a proportion was provided by 1-SW fish, relative to the longer-term 1-SW:M-SW ratio observed in the spawning runs.

DISCUSSSION

Randall and Chadwick (MS 1983) have examined some of the variables associated with calculations of spawning escapement. Fecundity has been shown to be quite variable even within a specific stock and sea-age group of salmon (Baum and Meister 1971). At least two studies suggest fecundity is different between river stocks (Pope et al. 1961; Glebe et al. 1979) and unpublished data by one of the present authors has shown possible differences in fecundity between the LaHave and Liscomb river stocks in Nova Scotia. It is important that future calculations of egg deposition requirements should be based on more-extensive fecundity data from the LaHave stock.

Egg deposition requirements have been met above Morgan Falls since 1978 (Table 16), but spawning requirements in the remainder of the LaHave River may not have been met in certain years (Table 18). This problem was partially

alleviated in 1980 by transplanting surplus spawners from Morgan Falls to the North and West branches of the river. Adult transplantation is one option which should be considered to alleviate under-escapement in the lower basin or in the North or West branches of the LaHave if spawning surpluses materialize at Morgan Falls.

Adult recruits to the spawning escapement at Morgan Falls in 1982 and 1983 declined substantially from levels observed earlier and egg to 1-SW and to M-SW salmon returns were correspondingly reduced (Table 16). Although preliminary, the data appear to suggest that an egg deposition of 1.5-1.7 million eggs or 2.2-2.5 eggs/m^2 may be adequate for this area. Egg depositions greater than 2.4 eggs/m^2 as suggested by Elson (1975) or estimated for the LaHave River by Hayes (1953) (2.45 eggs/m^2) may in fact reduce survival and adult yields. Loss of spawners from the broodstock sanctuary above Morgan Falls due to illegal poaching activity may also be a possible contributor to reduced returns beginning in 1982-83.

Over-escapements have been released above Morgan Falls as part of a program to determine an adequate spawning escapement above Morgan Falls, when all habitats are considered. Adult returns and correspondingly survival data will provide useful knowledge in view of the fact that spawning requirements may vary between rivers.

Hayes (1953) reported river adult salmon returns of 2,097 and 1,291 in 1950 and 1951, respectively. He suggested that in certain years the river stock could be as high as 3,100 salmon and grilse. If it is assumed that adequate spawning escapements (2,925,000 eggs) provided a return of 2,097 salmon and grilse from the accessible portion of the LaHave River at that time (1,270,210 m^2), the comparable production from the 2,046,228 m^2 presently accessible to salmon would be 3,378 salmon and grilse provided that the egg-to-adult return to the river has remained constant and that a total egg deposition of 4,911,000 is distributed in the entire river. By the same methodology, if other accessible habitats such as pools, stillwaters and flats are considered, both in 1950 and at present, estimated current annual river escapement could be approximately 3,950 salmon and grilse.

Based on Hayes' egg deposition estimate and the adult return in 1950 of 1,548 grilse and 549 salmon, egg-to-adult return to the river was 0.0529 percent for grilse and 0.0188 percent for salmon. Morgan Falls data show similar rates. An egg deposition of 1,825,200 in 1978 resulted in a total river return of 1,122 grilse in 1982 and 269 salmon in 1983. Morgan Falls counts of wild grilse and salmon were corrected for freshwater age and the number of wild grilse and salmon taken in the angling fishery were calculated using current angling exploitation rates. Therefore, the egg-to-adult return to the river was 0.0615 percent for grilse and 0.0147 percent for salmon - not greatly different from Hayes' data. While significant changes have occurred in distant and homewater harvests since the 1950's, the return rate from eggs seems similar. If these egg-to-river-return rates are valid for grilse and salmon, a potential annual river escapement of 3,742 salmon and grilse might be expected from an egg deposition of 2.4 eggs/m^2 or 4,911,000 eggs deposited in the entire basin. If other habitats such as pools, stillwaters and flats play a role in production, potential river escapement could be higher.

Lastly, if it is assumed that the lower basin, North and West branches have maintained their capacity to escape 2,100 salmon and grilse annually since the 1950's and annual wild river escapement from above Morgan Falls is added, another estimate of present river escapement can be made. By this method, potential annual escapement back to the river is estimated to range from 3700-4300 salmon and grilse, adding the mean annual escapement (1614) or the highest annual escapement (2168) since 1980 above Morgan Falls.

To summarize, if home and distant commercial fisheries remain unchanged and adequate spawning escapements are maintained, potential annual escapement back to the river is expected to be 3400-4300 wild salmon and grilse. In certain years Hayes (1953) reported higher returns of roughly 1,000 additional salmon and grilse. Occasionally the stock might be expected to reach over 5,000 wild salmon and grilse. However, until the role which other habitats such as pools, stillwaters, flats or lakes play in salmon production is understood in the LaHave River, this conservative river escapement estimate may prove useful.

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Table 1. LaHave River, monthly Atlantic salmon sport catches, 1970-1983.

Year	Monthly Sport Catch												Total		Total	
	May		June		July		August		September		October					
	1 SW	MSW	1 SW	MSW	1 SW	MSW	1 SW	MSW	1 SW	MSW	1 SW	MSW	1 SW	MSW	Fish	Effort
1970	0	16	282	59	141	5	71	7	63	6	———		557	93	650	2712
71	0	17	159	75	29	2	135	20	88	5	———		411	119	530	2150
72	0	6	83	74	201	10	22	3	0	0	———		306	93	399	2388
73	0	4	265	79	264	21	65	3	10	0	———		604	107	711	2490
74	0	4	445	77	237	8	39	0	129	3	———		850	92	942	5240
75	0	42	442	178	42	1	10	2	87	1	———		581	224	805	2723
76	0	22	170	47	725	36	55	0	62	5	———		1012	110	1122	6865
77	0	31	1144	180	217	14	107	7	0	0	———		1468	232	1700	9855
78	2	108	143	54	30	5	0	0	0	0	———		175	167	342	4504
79	2	23	641	66	460	11	259	7	3	0	———		1365	107	1472	5505
80	15	184	766	265	464	66	28	5	0	0	———		1273	520	1793	10,554
81	8	185	934	241	695	16	0	0	0	0	———		1637	442	2079	16,447
82	———		425	152	360	28	———						785	180	965	14,450
83	0	36	87	120	43	16	———						130	172	302	5,435

N.B. Lines indicate whole months when the river was closed to angling.

Table 2. Recreational catch of Atlantic salmon, LaHave River, 1951-83.

Year	Annual Sport Catch						Fishing Effort (Rod-Days)
	MSW Salmon		1SW Salmon		Total Salmon		
	No.	Kg	No.	Kg	No.	Kg	
1951					379	1347.6	715
1952					357	1368.0	784
1953					608	2157.3	1,920
1954					402	1719.1	1,725
1955					94	309.8	759
1956					289	978.4	1,112
1957					118	370.6	952
1958					807	2469.8	2,265
1959					639	2060.2	2,005
1960					81	253.6	1,347
1961					646	1511.8	4,695
1962					546	1629.8	5,582
1963					200	729.8	4,917
1964					589	1231.5	2,407
1965	18	91.2	64	112.9	82	204.1	1,059
1966	187	848.2	216	377.4	403	1225.6	1,842
1967	150	694.0	267	487.6	417	1181.6	2,125
1968	74	355.2	133	240.4	207	595.6	1,626
1969	50	282.6	95	172.4	145	455.0	1,248
1970	93	413.2	557	1010.6	650	1423.8	2,712
1971	119	520.3	411	745.7	530	1266.0	2,150
1972	93	377.4	306	555.2	399	932.6	2,388
1973	107	455.0	604	1096.8	711	1551.8	2,490
1974	92	374.2	850	1542.2	942	1916.4	5,240
1975	224	1016.5	581	1054.1	805	2070.6	2,723
1976	110	496.2	1012	1836.1	1122	2332.3	6,865
1977	232	1075.0	1468	2663.5	1700	3738.5	9,855
1978	167	821.9	175	317.5	342	1139.4	4,504
1979	107	482.6	1365	2476.6	1472	2959.2	5,505
1980	520	2312.4	1273	2309.7	1793	4622.1	10,554
1981	442	2004.9	1637	2970.1	2079	4975.0	16,417
1982	180	853.0	785	1424.0	965	2277.0	14,450
1983	172	819.0	130	236.0	302	1055.0	5,435

Table 3. Commercial salmon landings of Fisheries Statistical Districts 22-27 as an index of landings from the LaHave River located in FSD 27, 1967-1983.

Fish. Stat. Dist.	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
By weight in kilograms																	
22	6384	4566	4593	1300	1276	2321	2224	3034	8886	2314	7815	8287	5141	18623	2511	3523	2056
23	7949	1516	1558	685	1157	891	1001	1599	2496	800	2707	1265	301	2926	3271	3166	672
25	2331	473	375	285	383	496	769	3098	2033	1277	4978	2271	878	1312	415	594	919
26	1966	694	1170	598	634	601	485	539	444	678	1341	309	130	246	63	200	91
27	2402	752	743	400	137	366	541	423	1156	1946	1335	2021	1618	4622	1324	734	938
Total	21032	8001	8439	3268	3587	4675	5020	8693	15015	7015	18176	14153	8068	27729	7584	8217	4676
By number by sea age-class																	
One-seawinter:																	
22				100	166	198	91	448	746	37	1606	1369	1753	5841	264	376	233
23				96	626	34	244	320	559	6	648	154	72	303	478	284	340
25				68	106	40	116	285	431	380	78	312	264	347	19	105	150
26				18	99	139	5	21	1	68	133	25	24	68	26	59	35
27				11	7	42	0	29	52	120	70	94	111	137	69	31	21
		Sub-Total		293	1004	453	456	1103	1789	611	2535	1954	2224	6696	856	855	779

Table 3. (Cont'd)

Fish. Stat. Dist.	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Multi-seawinter:																	
22				249	217	324	448	495	1255	372	1093	1279	437	1264	473	645	208
23				113	131	184	125	227	322	60	334	217	40	513	534	585	18
25				37	37	94	125	574	280	133	1069	379	90	190	84	90	140
26				125	102	90	100	112	98	123	244	59	19	29	4	21	6
27				84	28	64	122	82	236	391	266	411	316	940	283	140	174
		Sub-Total		608	515	756	920	1490	2191	1079	3006	2345	902	2936	1378	1481	546
Combined sea age-classes:																	
22	1607	873	1055	349	383	522	539	943	2001	409	2699	2648	2190	7105	737	1021	441
23	1980	386	382	209	757	218	369	547	881	66	982	371	112	816	1012	869	358
25	554	143	123	105	143	134	241	859	711	513	1147	691	354	537	103	195	290
26	898	185	339	143	201	229	105	133	99	191	377	84	43	97	30	80	52
27	545	160	188	95	35	106	122	111	288	511	336	505	427	1077	352	171	195
Total	5584	1747	2087	901	1519	1209	1376	2593	3980	1690	5541	4299	3126	9632	2234	2336	1336

Table 4 . Commercial salmon landings of Fisheries Statistical Districts 22-23, 25-27, licensed salmon gear only, 1970-1983.

Fish. Stat. Dist.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
By weight in kilograms														
22	957	1175	1695	1822	2699	4829	1392	3354	3382	759	6078	1099	2498	1221
23	291	146	5	79	522	964	238	440	372	66	305	96	102	37
25	91	44	295	159	339	105	13	220	362	49	173	74	93	66
26	520	455	438	468	378	444	365	45	46	81	152	63	109	91
27	294	133	300	520	294	965	1889	984	1788	1526	4512	1305	670	814
Total	2153	1953	2733	3048	4232	7307	3897	5043	5950	2481	11220	2637	3472	2229
By number by sea age-class														
One-seawinter:														
22	74	163	191	91	402	370	8	496	0	58	136	60	249	151
23	5	18	0	1	80	0	3	0	0	4	0	0	2	0
25	0	0	4	14	48	18	0	8	6	3	0	0	2	0
26	1	20	36	0	13	1	9	4	3	24	35	26	51	35
27	5	7	26	0	20	39	120	17	27	57	79	61	23	10
Sub-Total	85	208	257	106	563	428	140	525	36	146	250	147	327	196

Table 4 (Cont'd).

Fish. Stat. Dist.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Multi-seawinter:														
22	183	196	191	369	439	904	305	545	718	146	574	292	468	203
23	63	25	1	17	84	196	52	78	83	13	62	20	17	8
25	20	6	64	30	56	16	4	46	78	10	38	16	20	10
26	115	93	83	91	79	98	77	8	9	8	21	4	4	6
27	63	27	56	111	57	199	372	206	375	316	940	282	133	170
Sub-Total	444	347	389	618	715	1413	810	883	1263	493	1635	614	642	397
Combined sea age-classes														
22	257	359	382	460	841	1274	313	1042	718	204	710	352	717	354
23	68	43	1	18	164	196	55	89	83	17	62	20	19	8
25	20	6	68	44	104	34	4	54	84	13	38	16	22	10
26	116	113	119	91	92	99	86	12	12	32	56	30	55	41
27	68	34	82	111	77	238	492	226	402	373	1061	343	156	180
Total	529	555	652	724	1278	1841	950	1423	1299	639	1927	761	969	593

Table 5 . Commercial salmon landings of Fisheries Statistical Districts 22-23, 25-27, non-salmon licensed gear only, 1970-1983.

Fish. Stat. Dist.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
By weight in kilograms														
22	343	101	626	402	335	4057	922	4461	4905	4382	12545	1412	1025	835
23	394	1011	886	922	1077	1532	562	2267	893	235	2621	3175	3268	635
25	194	339	201	610	2759	1928	1264	4758	1909	829	1139	341	501	853
26	78	179	163	17	161	0	313	1296	263	49	94	0	91	0
27	106	4	66	21	129	191	57	351	234	92	110	19	64	33
Total	1115	1634	1942	1972	4461	7708	3118	13133	8204	5587	16509	4947	4949	2356
By number by sea age-class														
One-seawinter:														
22	26	3	7	0	46	1376	29	1110	1369	1695	5705	204	127	85
23	91	608	34	243	240	559	3	648	154	68	303	478	282	340
25	68	106	36	102	237	413	380	70	306	261	347	19	103	150
26	17	79	73	5	8	0	59	129	22	0	33	0	8	0
27	6	0	16	0	9	13	0	53	67	54	58	8	8	11
Sub-Total	208	796	166	350	540	2361	471	2010	1918	2078	6446	709	528	586

Table 5.(Cont'd).

Fish. Stat. Dist.	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Multi-seawinter:														
22	66	21	133	79	56	351	67	547	543	291	701	231	177	10
23	51	106	183	108	143	116	8	245	134	27	459	514	568	10
25	17	37	30	95	518	264	129	1017	301	80	152	68	70	130
26	10	9	7	2	33	0	46	236	50	11	8	0	17	0
27	21	1	8	9	25	37	19	57	30	0	0	1	7	4
Sub-Total	165	174	361	293	775	768	269	2102	1058	409	1320	814	839	154
Combined sea age-classes:														
22	92	24	140	79	102	1727	96	1657	1912	1986	6406	435	304	95
23	142	714	217	351	383	675	11	893	288	95	762	992	850	350
25	85	143	66	197	755	677	509	1087	607	341	499	87	173	280
26	27	88	80	7	41	0	105	365	72	11	41	0	25	0
27	27	1	24	9	34	50	19	110	97	54	58	9	15	15
Total	373	970	527	643	1315	3129	740	4112	2976	2487	7766	1523	1367	740

Table 6. 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				28,451
Total	92,269	130,226	13,963	399,808	107,606	68,580	32,851	690,883

[1] All hatchery reared juvenile salmon have 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 7. Stock origin of yearly salmon returns to the Morgan Falls fishway, 1970-1983.

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

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

Table 8. Sex ratio and salmon:grilse ratio of hatchery-return and wild Atlantic salmon recorded at the Morgan Falls trap 1973-1983. 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	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	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
Unweighted mean (S.D.)		69 (7.0)	25 (24.5)		25 (3.7)	75 (24.5)		73 (8.8)	15 (8.0)		33 (8.4)	85(7

[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 (1984, in preparation).

Table 9. Data collected from live 1 sea-winter salmon compared to data from the same fish sampled post-mortem, July 31, 1980.

Sample Number	Live			Post-Mortem		
	Sex	Fork length (cm)	Weight (kg)	Sex	Fork length (cm)	Weight (kg)
1	M	55.2	1.530	M	55.5	1.525
2	M	56.2	1.950	M	56.9	1.850
3	M	53.4	1.650	M	54.0	1.600
4	M	57.3	1.800	M	57.0	1.925
5	F	57.2	2.000	F	57.7	2.000
6	F	55.4	1.900	F	55.9	1.900
7	M	53.2	1.400	M	53.0	1.450
8	F	54.3	1.700	F	54.2	1.750
9	M	55.0	1.750	M	55.0	1.675
10	M	56.7	1.825	M	57.3	1.825
Mean		55.4	1.750		55.6	1.750
SD		1.47	0.1875		1.59	0.1826

Table 10.

Size characteristics in relation to age and stock origin of Atlantic Salmon released above Morgan Falls for natural spawning, 1974-76.

		LaHave(W)						LaHave(HR)					
Age		Fork Length (cm)			Weight (kg)			Fork Length (cm)			Weight (kg)		
F.S.	N	Mean	S.D.	Range	Mean	S.D.	Range	N	Mean	S.D.	Range	Mean	S.D.	Range
1974													
1.1								3	55.1	1.94	53.4-57.2	1.889	0.2850	1.587-2.154
2.1	8	54.0	1.67	52.1-57.2	1.687	0.2670	1.361-2.041	120	54.7	2.76	48.6-65.4	1.889	0.2690	1.247-2.490
3.1	2	53.3	5.44	49.5-57.2	1.587	0.3200	1.361-1.814							
-.1								17	54.6	3.27	50.8-64.8	1.805	0.3400	1.361-2.490
1975														
1.1								14	52.1	2.57	48.6-55.8	1.516	0.2990	1.275-2.069
2.1	3	57.0	1.68	55.2-58.5	1.947	0.1630	1.758-2.041	42	54.5	3.33	49.3-64.7	1.735	0.3660	1.219-3.090
3.1	4	55.5	2.59	52.3-58.0	1.765	0.1410	1.616-1.899							
-.1	2	51.9	0.35	51.7-52.2	1.432	0.3420	1.190-1.673	11	55.4	3.13	51.5-62.5	1.857	0.3950	1.133-2.264
1.2								2	72.5	2.76	70.6-74.5	3.912	0.4020	3.628-4.196
2.2	5	73.0	1.85	70.4-75.4	4.093	0.2870	3.742-4.365	14	73.2	4.79	65.0-80.2	4.082	0.9680	3.174-5.528
-.2								5	74.9	2.57	73.5-79.5	4.632	0.5440	4.139-5.669
1976														
1.1								1	54.0			1.247		
2.1	49	54.3	1.79	50.4-58.2	1.620	0.2400	1.077-2.125	5	54.8	1.68	53.2-56.7	1.802	0.3060	1.474-2.097
3.1														
-.1	11	53.9	2.59	49.7-57.4	1.564	0.1990	1.247-1.871							
1.2														
2.2	1	68.0			3.287			3	72.7	1.47	71.0-73.6	3.987	0.2560	3.742-4.252
-.2								3	79.8	3.04	76.5-82.5	6.010	0.8910	4.989-6.633
3.2.1								1	78.5			5.443		

Table 10 (Cont'd).

- Size characteristics in relation to age and stock origin of Atlantic Salmon released above Morgan Falls for natural spawning, 1977-78.

Age		LaHave(W)						LaHave(HR)					
		Fork Length (cm)			Weight (kg)			Fork Length (cm)			Weight (kg)		
F.S.	N	Mean	S.D.	Range	Mean	S.D.	Range	N	Mean	S.D.	Range	Mean	S.D.	Range
1977													
1.1								26	54.5	3.05	48.1-61.0	1.744	0.2990	1.247-2.377
2.1	60	53.4	3.08	44.6-58.5	1.673	0.2670	0.907-2.264	16	52.6	2.75	47.7-55.0	1.563	0.2200	1.247-2.264
-.1								2	51.9	4.88	48.5-55.4	1.545	0.2600	1.361-1.729
1.2								1	69.5			3.457		
2.2	11	72.6	3.73	65.3-75.5	4.257	0.5020	3.174-4.847	1	76.3			5.273		
-.2								1	75.0			4.706		
2.3.1								1	77.7			5.897		
2.3.2								2	81.9	3.61	79.5-84.5	6.081	1.1830	5.244-6.917
3.2.1	1	65.2			3.174									
3.4.2	1	87.5			6.576									
1978													
1.1								22	53.7	2.37	49.5-57.7	1.595	0.2220	1.161-2.069
2.1	25	52.6	2.36	48.2-58.8	1.459	0.1640	1.048-1.927	6	54.4	2.83	50.5-58.0	1.720	0.1960	1.531-2.069
3.1	3	56.4	0.60	55.8-57.0	1.757	0.2840	1.474-2.041							
1.2								33	74.8	2.75	68.8-79.4	4.623	0.7000	3.259-5.897
2.2	10	73.7	2.50	70.3-77.2	4.845	0.6720	3.628-5.783	1	74.3			4.989		
-.2	1	74.5			4.989			1	79.0			5.329		
1.3.1								1	82.8			5.811		
1.4.2								1	85.4			7.199		
2.3.1	7	79.4	2.61	74.8-82.5	5.443	0.7940	4.189-6.237							
2.4.2								1	85.5			7.824		
-.3.1	1	77.2			5.669									
-.4.2								1	87.5			6.990		
-.4	1	87.6			10.064									

Table 10 (Cont'd).

- Size characteristics in relation to age and stock origin of Atlantic Salmon released above Morgan Falls for natural spawning, 1979.

		LaHave(W)						LaHave(HR)					
Age		Fork Length (cm)			Weight (kg)			Fork Length (cm)			Weight (kg)		
F.S.	N	Mean	S.D.	Range	Mean	S.D.	Range	N	Mean	S.D.	Range	Mean	S.D.	Range
1979													
1.1								74	52.2	2.45	46.8-56.8	1.485	0.2000	1.133-1.87
2.1	72	52.6	2.52	45.5-57.6	1.597	0.2400	1.077-2.264	19	53.5	2.10	49.0-57.8	1.584	0.1360	1.361-1.75
3.1	10	52.4	1.62	50.2-54.5	1.551	0.2050	1.133-1.814							
-.1	1	55.5			1.673			4	53.5	2.74	51.5-57.5	1.488	0.2080	1.303-1.78
1.2								7	72.2	4.01	66.0-77.6	4.021	0.9600	2.892-5.64
2.2	13	71.4	2.84	67.5-76.8	3.672	0.4640	2.920-4.280	2	74.0	1.41	73.0-75.0	4.649	0.4820	4.308-4.98
3.2	3	72.6	4.38	69.6-77.6	4.044	0.5240	3.714-4.649							
-.2	1	70.6			3.748									
1.3.1	1	75.5			5.160									
2.3.1	3	73.7	2.67	71.6-76.7	4.516	0.2150	4.365-4.762							
2.4.1.2	1	73.8			4.082									
2.4.1.3	1	83.4			5.782									

Table 10 (Cont'd).

Size characteristics in relation to age and stock origin of Atlantic Salmon released above Morgan Falls for natural spawning, 1980-81.

		LaHave(W)						LaHave(HR)					
Age		Fork Length (cm)			Weight (kg)			Fork Length (cm)			Weight (kg)		
F.S.	N	Mean	S.D.	Range	Mean	S.D.	Range	N	Mean	S.D.	Range	Mean	S.D.	Range
1980													
1.1								2	51.6	0.21	51.7-52.0	1.330	0.0400	1.300-1.360
2.1	134	54.1	2.40	46.9-60.5	1.690	0.2500	1.090-2.625	1	52.6			1.500		
3.1	5	54.4	1.70	52.1-56.7	1.770	0.1500	1.610-1.980							
1.2								7	71.5	3.00	67.6-77.4	3.840	0.730	2.550-4.770
2.2	80	72.8	2.90	67.1-79.9	4.290	0.7200	2.650-6.410							
2.1.2	2	61.8	3.70	59.2-64.4	2.210	0.2700	2.025-2.400							
2.1.3	4	80.5	2.70	77.2-83.5	5.780	0.7100	4.815-6.450							
2.2.4	4	88.6	3.05	84.2-91.2	8.760	1.3300	6.875-9.850							
2.1.3.4	1	79.5			4.900									
2.1.3.5	2	89.3	2.19	87.8-90.9	7.730	0.3700	7.465-7.985							
1981														
1.1								74	54.2	2.70	45.8-59.4	1.550	0.2600	0.900-2.100
2.1	240	54.4	2.60	48.0-62.4	1.630	0.2700	1.000-2.575	9	55.6	2.50	51.5-59.7	1.700	0.3200	1.125-2.200
3.1	30	55.0	2.10	51.0-58.6	1.680	0.2900	1.050-2.275							
1.2								32	72.7	3.40	63.4-80.3	4.150	0.6800	2.575-5.700
1.3								6	88.1	3.90	77.4-92.7	7.930	1.4300	7.200-9.675
2.2								3	70.2	7.00	62.6-76.4	3.660	1.4100	2.425-5.200
2.3								1	90.4			7.940		
1.1.3								3	78.3	2.60	75.5-80.7	5.140	0.1100	5.025-5.250
1.2.3								2	79.4	2.80	77.4-81.4	4.090	0.4700	3.760-4.425
1.2.4								2	85.2	0.07	85.2-85.3	6.350	0.7800	5.800-6.900
2.1.2	12	62.0	3.00	57.2-67.0	2.330	0.2900	1.850-2.900	1	67.0			3.000		
2.1.3	12	73.5	3.00	69.2-78.0	4.370	0.6000	3.700-5.560							
2.2.3								2	75.7	6.40	71.2-80.2	4.050	1.3400	3.100-5.000
2.2.4	1	86.7			8.200									
3.1.2	2	60.5	0.42	60.2-60.8	2.330	0.1100	2.250-2.400							

Table 11. Age composition of Atlantic salmon sampled at the Morgan Falls' fishway trap, 1974-83. Numbers in parentheses are percentages of the total number of fish sampled each year. Data for 1982 and 1983 are from Cameron, 1984.

Stock Origin		Age Composition (F:S)											
		Virgin Spawners										Previous Spawners	
Year	Number Sampled	1.1	2.1	3.1	_.1	1.2	2.2	3.2	_.2	1.3	2.3	Consecutive	Alternate
1974	175												
LaHave (W)			8(4.6)	2(1.1)									
LaHave (HR)		3(1.7)	139(79.4)		19(10.9)		3(1.7)		1(0.6)				
1975	152												
LaHave (W)			6(3.9)	4(2.6)	2(1.3)		33(21.7)						3(2.0)
LaHave (HR)		20(13.2)	45(29.6)		11(7.2)	2(1.3)	21(13.8)		5(3.3)				
1976	126												
LaHave (W)			49(38.9)		11(8.7)		8(6.3)		1(0.8)			2(1.6)	
LaHave (HR)		1(0.8)	5(4.0)			17(13.5)	22(17.5)		10(7.9)				
1977	127												
LaHave (W)			62(48.8)				11(8.7)		1(0.8)			3(2.4)	2(1.6)
LaHave (HR)		26(20.5)	16(12.6)		2(1.6)	1(0.8)	1(0.8)	1(0.8)	2(1.6)				
1978	182												
LaHave (W)			26(14.3)	3(1.6)			22(12.1)		2(1.1)				15(8.2)
LaHave (HR)		29(15.9)	9(4.9)			56(30.8)	9(4.9)		2(1.1)			1(0.5)	8(4.4)
1979	258												
LaHave (W)			72(27.9)	10(3.9)	1(0.4)		13(5.0)	3(1.2)	1(0.4)			2(0.8)	4(1.6)
LaHave (HR)		75(29.1)	19(7.4)		4(1.5)	30(11.6)	2(0.8)	2(0.8)	5(1.9)			1(0.4)	14(5.4)
1980	278												
LaHave(W)			136(48.9)	6(2.2)			80(28.8)					5(1.8)	8(2.9)
LaHave(HR)		2(0.7)	1(0.3)			34(12.2)						4(1.4)	2(0.7)
1981	474												
LaHave(W)			241(50.8)	30(6.3)			11(2.3)					18(3.8)	17(3.6)
LaHave(HR)		74(15.6)	9(1.9)			45(9.5)	6(1.3)			9(1.9)	1(0.2)	8(1.7)	5(1.1)
1982	160												
LaHave(W)			40(25.0)	2(1.3)			30(18.8)	1(0.6)				9(5.6)	23(14.4)
LaHave(HR)		19(11.9)	7(4.4)			13(8.1)	1(0.6)					5(3.1)	10(6.3)
1983	393												
LaHave(W)			190(48.3)	2(0.5)			81(20.6)					8(2.0)	47(12.0)
LaHave(HR)			6(1.5)			31(7.9)	2(0.5)					9(2.3)	17(4.3)

Table 12. LaHave salmon data used for making mean fecundity estimates for 2 sea-winter virgin and previous spawners.

Stock Origin	Age	Fork Length (cm)	Weight (kg)	Fecundity	Egg Diameter (mm)	Eggs/kg
LaHave HR	1.2	72.5	4.250	6199	5.62	1458
LaHave HR	1.2	77.7	5.010	5833	5.86	1164
LaHave HR	1.2	78.3	------	8129	5.36	----
LaHave HR	1.2	76.8	6.075	7767	5.65	1278
LaHave HR	1.2.3[1]	91.0	------	12634	5.70	----
LaHave W	2.2	73.4	4.425	6400	----	1446
LaHave W	2.2	75.0	4.685	7198	5.21	1536
LaHave W	2.2	76.5	5.135	10051	5.52	1957
LaHave W	2.2.3[1]	92.5	10.300	12657	—	1228
Medway HR	1.2	66.5	------	3895	6.26	----
Medway HR	1.2	72.1	------	5025	6.11	----
Medway HR	1.2	74.2	------	5697	6.21	----
Medway HR	1.2	75.7	------	7456	5.74	----
Medway W	2.2	68.1	------	4160	6.34	----
Medway W	2.2	70.1	------	5292	6.44	----
Medway W	2.2	71.1	------	5404	6.38	----
Medway W	2.2	74.7	------	7527	6.30	----
Medway W	2.2	76.5	------	5724	6.17	----
Medway W	2.2	76.7	------	8816	6.01	----
Medway W	2.2	76.7	------	6324	6.50	----
Medway W	2.2.3[1]	90.4	------	11288	6.72	----
Medway W	2.2.3[1]	90.9	------	13760	6.81	----
Medway W	2.2.3[1]	91.7	------	11220	6.17	----
Medway W	2.2.3[1]	93.5	------	10175	6.47	----
Medway W	2.2.3[1]	95.3	------	13020	6.50	----

1. Previous spawners.

Table 13. Wild grilse (t): salmon (T + 1) ratios calculated from river escapement data from Table 18.

Year	Estimated river escapement		
	Number of grilse (t)	Number of salmon (t + 1)	Grilse/Salmon ratio
1973	1853	386	4.801
74	2457	927	2.650
75	1689	368	4.590
76	2713	950	2.856
77*			
78*			
79	2720	1945	1.398
80	4078	1459	2.795
81*			
82	1791	650	2.755
Means	(weighted) 2.588		(unweighted) 3.121
Standard deviation			1.189

*Data for years 1977, 1978, and 1981 were not used because one or the other of the data pair was atypical due to water conditions or sea survival.

Table 14. Angling fishery exploitation rates of hatchery-return salmon derived from tag recaptures of hatchery-reared salmon released upstream from Morgan Falls as smolts. Exploitation rate in parentheses.

Year of Return	TAG RECAPTURES: 1-Sea-winter				TAG RECAPTURES: 2 Sea-winter & older			
	Angling		Morgan Falls	Total	Angling		Morgan Falls	Total
	Obs.	Adj.*			Obs.	Adj.*		
1977	40	57(.311)	126	183				
1978	2	3(.158)	16	19	7	10(.213)	37	47
1979	13	19(.345)	36	55				
1980	5	7(.189)	30	37	5	7(.152)	39	46
1981					6	9(.360)	16	25
Mean (weighted)		(29.3)				(22.0)		

* Adjusted upwards to account for 30% non-reporting of tags.

Table 15. Recapture information for salmon tagged and released at an estuarial trap located at the mouth of the LaHave River, 1983.

Stock description	NUMBER OF SALMON: Estuarial trap	Recaptures	
	Tagged	Angling fishery	Morgan Falls	Indian Falls
Salmon (HR)	4		1	
Grilse (HR)	4		3	
Salmon (W)	5		2	
Grilse (W)	170	3	36	4

Table 16. Egg deposition of wild and hatchery-return fish and resultant 1-SW and M-SW salmon returns to Morgan Falls, 1973-1983. 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	1112 (0.056)		
1980	3,849,100			
1981	4,341,900			
1982	2,908,000			
1983	2,129,500			

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

Table 17. Summary of distributions 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, 1971-1983.

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
1971	1+ Parr	9,440							
	1+ Smolt	4,892	4,892	9	9	18	0.18	0.18	0.37
1972	1+ Parr	6,790							
	1+ Smolt	8,400							
	2+ Smolt	6,450	18,626	147	25	172	0.79	0.13	0.92
1973	0+ Parr	51,643							
	1+ Parr	43,133							
	1+ Smolt	9,166							
	2+ Smolt	18,526	30,408	314	71	385	1.03	0.23	1.27
1974	1+ Parr	5,235							
	1+ Smolt	17,118							
	2+ Smolt	14,435	48,806	503	104	607	1.03	0.21	1.24
1975	1+ Parr	18,883	12,394	523	36	559	4.22	0.29	4.51
1976	1+ Parr	11,454							
	1+ Smolt	40,678							
	2+ Smolt	5,772	45,867	974	208	1182	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	1079	515	1594	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	1+ Smolt	63,226							
	2+ Smolt	16,026	69,320	1180	230	1410	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	N.A.	N.A.	1.52	N.A.	N.A.
1983	1+ Smolt	28,451	22,761						
1984	2+ Smolt		2,276						
			Mean return rates:		(1976-1982)		1.45		
					Std. dev.		0.53		
					(1976-1981)			0.41	
					Std. dev.			0.20	

[1]Assumptions: 0+ parr to 1+ smolt survival is 60%; 1+ parr to 2+ smolt survival is 40%, 20% of 1+ smolt since 1976 do not migrate in year of stocking.

Table 18. Estimates of salmon in the wild river escapement, total river escapement, and egg depositions in the LaHave River, 1973-83.

	ANGLING FISHERY				MORGAN FALLS				RIVER ESCAPEMENT		TOTAL RIVER ESCAPEMENT			ESTIMATED EGG DEPOSITION[11] $\times 10^3$				
	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	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]	2254	1053	3307	774.4	1050.8	755.1	3796.7	6377.0
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	1176	3854	1131.0	1777.0	340.9	3605.7	6854.6
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

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.

$$\text{Thus: } \frac{\text{Fishway count HR Grilse}}{1.000-0.293} - \text{Fishway counts HR Grilse} = \text{number of HR Grilse angled}$$

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 $Y_{MFcount1-SW} = 1.98\ X_{1SWangling} - 849.72$ (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 (Table 13).
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).

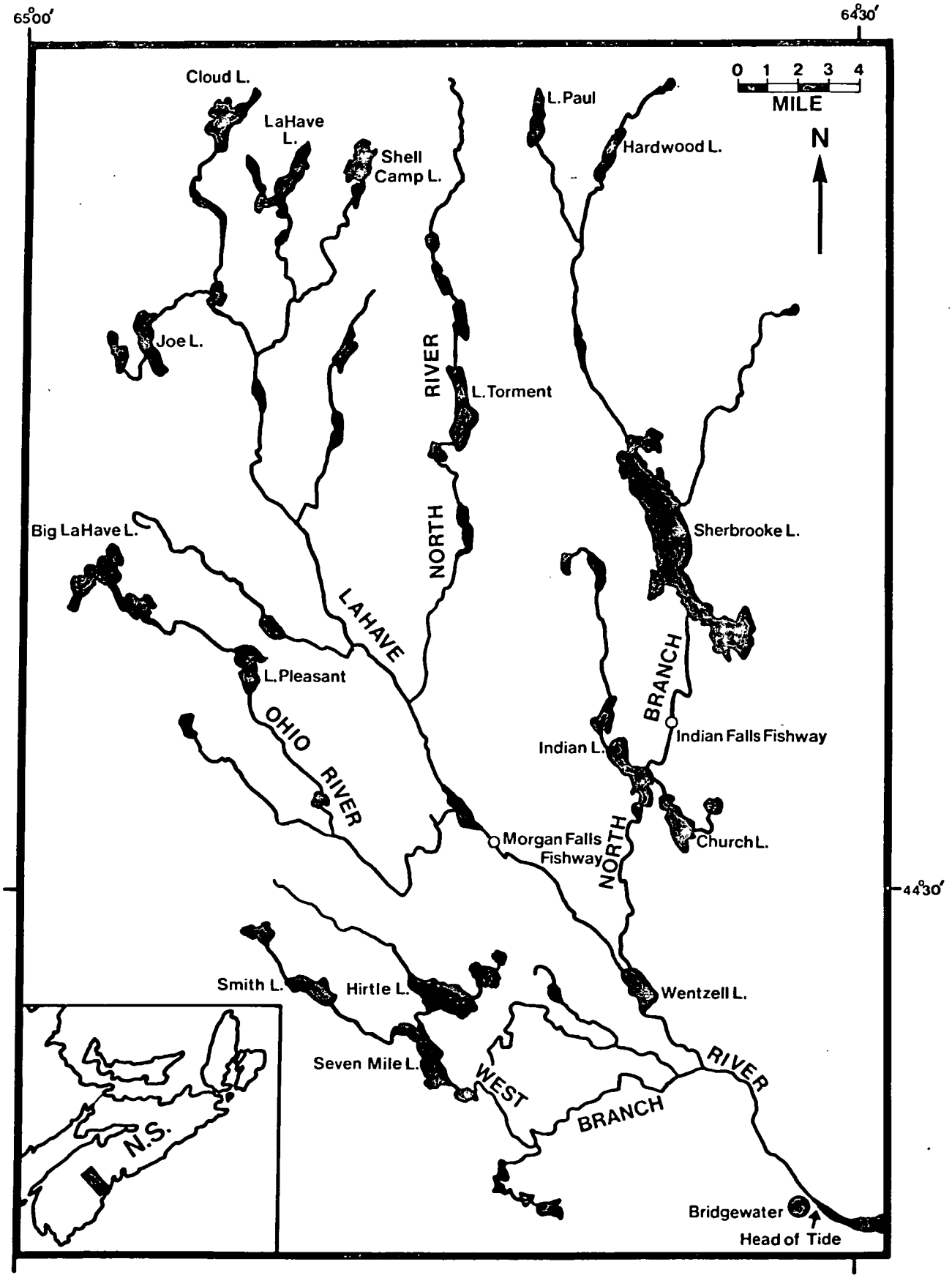

Fig. 1. The LaHave River drainage, Nova Scotia.

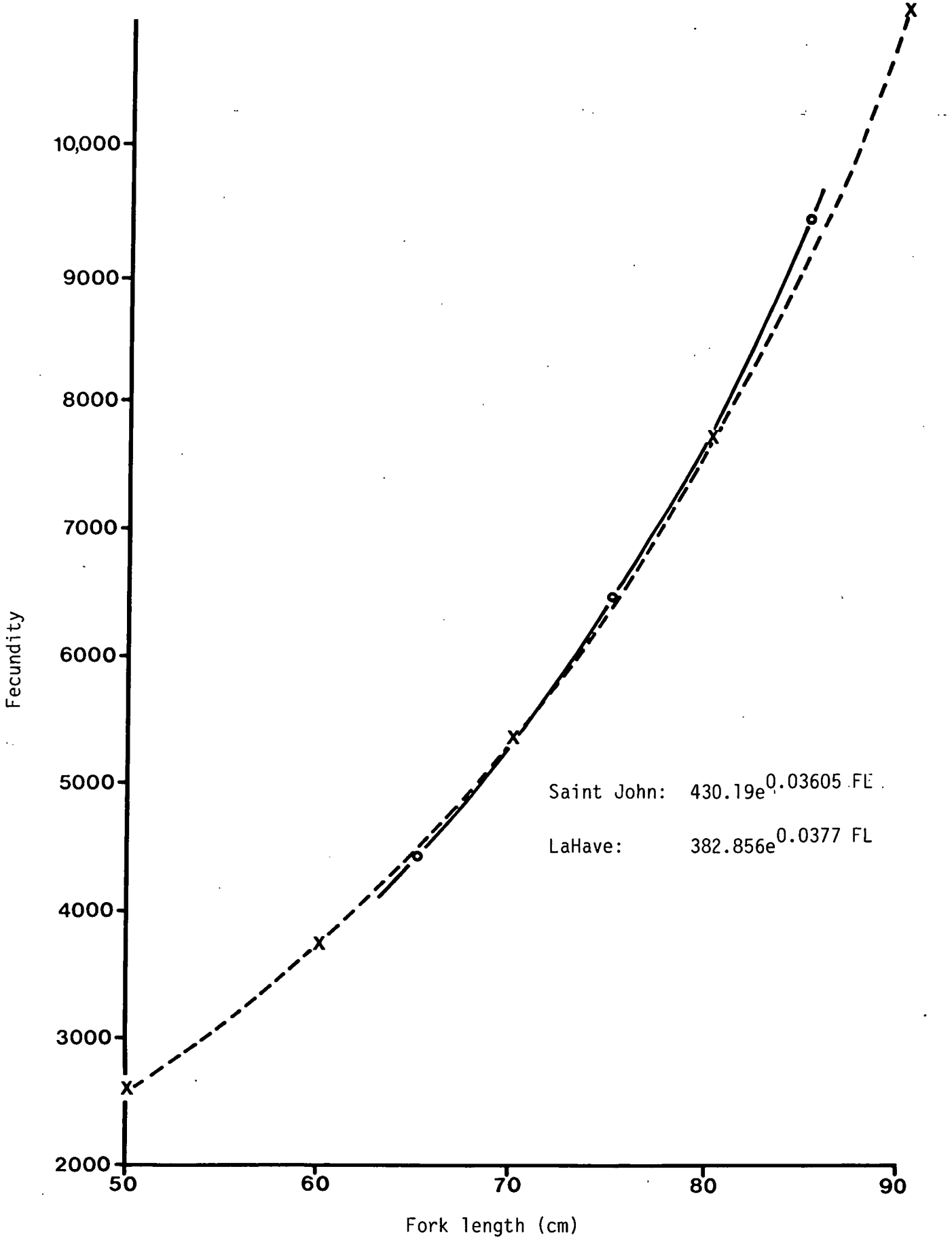

Fig. 2. Comparison of fecundities of Saint John (--) and LaHave (——) salmon stocks.