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# Assessments of Atlantic salmon stocks of Salmon Fishing Areas 20 and 21, the Southern Upland of Nova Scotia, for 1999. 

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#### Abstract

Assessment of the Atlantic salmon (Salmo salar) stocks of two Salmon Fishing Areas, SFA 20 on the Eastern Shore and SFA21 on the Southern shore of Nova Scotia indicated that returns in 1999 were insufficient to achieve conservation requirement in any index river. Returns to lowacidified index rivers were only $22 \%$ of the adult salmon requirement in the St. Marys River and $48 \%$ of the requirement for the area above Morgans Falls on the LaHave River. Generation-togeneration survival above Morgans Falls for the 1994 egg deposition year-class was again below replacement. Smolt to one-sea-winter survival of stocked hatchery smolts continued a declining trend since 1984 to $0.31 \%$ while survival to two-sea-winter salmon increased marginally to $0.17 \%$. Wild smolt survival back to Morgans Falls decreased to $2.04 \%$. The ratio of wild to hatchery returns for one-sea-winter salmon was 4.8, 5.0 and 6.6 for the 1996 to 1998 smolt classes. Low return rates to low-acidified rivers further constrain enhancement and restoration programs. Hatchery smolt return rates to partially acidified rivers (mean annual pH 4.7 to 5.0 ) has declined to $0.05 \%$ at East River Sheet Harbour and to $0.03 \%$ at Liscomb River. Total salmon count at the Liscomb River fishway was only 25 salmon, and only 33 salmon were counted at East River Sheet Harbour. Tusket River smolt and adult assessment data indicated that the proportion of adult salmon counted in fishways while operating in the assessment mode for a portion of the season was $76.3 \%$. An estimate of 12,408 wild smolts was derived for Tusket River. The high production rate of 48 smolts per escaped salmon indicated that perhaps only the higher pH Carleton River was the origin of the wild smolts. Forecasts to two index rivers indicated a $65 \%$ chance of attaining the conservation requirement above Morgans Falls and a $33 \%$ chance for St. Mary's River in 2000.


## Résumé

Une évaluation des stocks de saumon atlantique (Salmo salar) de deux zones de pêche du saumon, ZPS 20 sur la côte est et ZPS 21 sur la côte sud de la Nouvelle-Écosse, a indiqué que les remontéesen 1999 ne suffisaient pas à combler les besoins de conservation de chacune des rivières-repères Les remontées dans les rivières-repèrespeu acidifiées représentaient seulement $22 \%$ des besoins en saumons adultes dans la rivière St. Marys et $48 \%$ des besoins pour la zone en amont des chutes Morgans, sur la rivière LaHave. Le taux de survie d'une génération à l'autre en amont des chutes Morgans était de nouveau inférieur au remplacement pour la classe d'âge de la ponte de 1994. Le taux de survie des smolts unibermarins est en baisse constante depuis 1984 et s'établit à $0,31 \%$, tandis que celui du saumon dibermarin a légèrement augmenté pour se fixer à $0,17 \%$. Le taux de survie des smolts sauvages revenant aux chutes Morgans a diminué pour s'établir à 2,04 \%. Le rapport entre les remontées d'unibermarins sauvages et d'unibermarins d'élevage était respectivement de 4,8 , de 5 et de 6,6 pour les classes de smolts de 1996 à 1998. Les faibles taux de remontées dans les rivières peu acidifiées ont nui davantage aux programmes de mise en valeur et de rétablissement des stocks. Le taux de remontées des smolts d'élevage dans les rivières partiellement acidifiées ( pH annuel moyen de 4,7 à 5 ) a chuté pour se fixer à $0,05 \%$ dans la rivière East, Sheet Harbour et à $0,03 \%$ dans la rivière Liscomb. Seuls 25 saumons au total ont été dénombrés à la passe migratoire de la rivière Liscomb, et uniquement 33 saumons dans la rivière East, Sheet Harbour. Les données d'évaluation sur les smolts et les adultes de la rivière Tusket ont montré que la proportion de saumons adultes dénombrés dans les passes migratoires pendant le fonctionnement en mode d'évaluation pour une partie de la saison était de $76,3 \%$. Pour cette rivière, on a calculé environ 12408 smolts sauvages. Le taux élevé de production de 48 smolts par évadé a indiqué que les smolts sauvages provenaient peut-être exclusivement de la rivière Carleton, qui présente un pH supérieur. Les prévisions pour 2000 pour deux rivièresrepères ont révélé que la probabilité de combler les besoins de conservation est de $65 \%$ en amont des chutes Morgans, contre $33 \%$ dans la rivière St. Mary's.

## Introduction

Atlantic salmon (Salmo salar) rivers in Maritimes Canada have been grouped by the Department of Fisheries and Oceans (DFO) for management purposes into twenty-three Salmon Fishing Areas (SFA) based on similarities of biological characteristics, catch histories and geographical proximity. In Nova Scotia two of these areas, SFA 20 on the Eastern Shore and SFA 21 on the Southern Shore, almost entirely drain a coastal plain geologically known as the Southern Upland (Roland 1982). The number of rivers in the Southern Upland that historically produced Atlantic salmon is unknown but is thought to have included all accessible habitats. Recent salmon production, as indicated by reported recreational catch, includes about forty rivers in these areas (O'Neil et al. MS1998).

Rivers of the Southern Upland of Nova Scotia generally drain lowland areas of shallow soils and peat bogs underlain by granites and metamorphic rocks lacking in base minerals (Watt 1987). Water is generally organic-acid-stained of lower productivity and, when combined with acid precipitation these conditions can result in toxic conditions for salmon (LaCroix 1985). Interspersed are areas of limestone-rich soils (drumlins) that provide local areas of less acidified water. Difficulties in identifying the locations and quantifying the degree of impact has impeded the derivation of standard conservation requirements for acidified rivers in these areas of mixed geology.

At mean annual pH below 5.1 , salmon production is considered unstable and only remnant populations may persist. Watt (1987), reports fourteen low- or non-acidified salmon rivers in SFA 20 (Gaspereau Brook, West Sheet Harbour, East Sheet Harbour, Port Dufferin, Halfway Brook, Ecum Secum, Quoddy, Moser, Ship Harbour Lake Charlotte, Country Harbour, Saint Mary's, Salmon Guysborough, Musquodoboit and Guysborough rivers) and eight rivers in SFA 21 (Gold, LaHave, Medway, Martins, Meteghan, Mushamush and Petite Riviere). These rivers have a history of Atlantic salmon angling catches and had pH's greater than 5.1.

Two of these rivers, LaHave River above Morgans Falls, Lunenburg County, and St. Mary's River, Guysborough County, were used as indices of the 1999 status of Atlantic salmon in SFA 21 and SFA 20. The count of salmon at Morgans Falls has continued from 1972 and is used to provide in-season forecasts for SFA 20 and 21 (Amiro et al. MS1996; Harvie and Amiro MS1998). These counts are indicative of returns to rivers of SFA20 and 21 (O'Neil et al. MS1998).

On the Southern Upland of Nova Scotia some twenty rivers have salmon stocks that are partially impacted by acidification. Partial impact occurs where the main-stem mean annual pH is 4.7-5.0 and remnant populations of Atlantic salmon may remain in higher pH tributaries. Evidence indicates that water quality in rivers of the Southern Upland of Nova Scotia has deteriorated or at least has not improved since 1986 (Watt MS1997, Watt et al. 1999).

Atlantic salmon are extirpated from fourteen rivers of the Southern Upland of Nova Scotia (Watt 1987 and MS1997). Four of these rivers, East River Sheet Harbour, Mersey River, Clyde River and Jordan River, receive hatchery-reared Atlantic salmon smolts solely to support aboriginal and recreational fisheries.

Three rivers, Liscomb River and Tusket River (partially impacted) and East River Sheet Harbour (re-introduced salmon stock), had operational salmon counting facilities in 1999. The Liscomb River fishway count extends back to 1979 and the East River count periodically back to the 1967. Counts at Tusket River 1979 to 1997 are complete only until July each year. Counts were complete for the entire salmon run of 1998 and 1999. Observations made at these facilities are used to corroborate the counts and forecasts made at Morgans Falls, LaHave River, and to assess the index-river approach.

Hydroelectric power facilities or impoundment for domestic water use also impacts some of these rivers including Tusket, Jordan, Mersey, Medway, LaHave, Indian and Northwest (St. Margaret's Bay), Salmon River Lake Major and East River Sheet Harbour rivers. Two rivers included in SFA 22 but containing salmon with biological characteristics more like SFA 20 and 21 rivers are the Annapolis River and the Gaspereau River, which drain into the Bay of Fundy. Both are impounded for hydroelectric power and have fish passage facilities.

## Biological characteristics of SFA20 and SFA21 Atlantic salmon

The majority of Atlantic salmon of SFA 20 and 21 migrates to the sea as two-year smolts and are characterised by returns of mixed age-at-maturity salmon (Anon 1978). Detailed age and size information is collected at Morgans Falls, LaHave River, during population estimates in the St. Mary's River, and during broodstock collections in many rivers of SFA 20 and 21. Based on these data, fish that mature after one winter-at-sea (1sea winter (SW) salmon, small salmon or "grilse") comprise about $70 \%$ of the numbers of fish and are about $60 \%$ female. On average, egg depositions are contributed equally by 1 SW and 2 SW salmon in these rivers (P. G. Amiro unpublished data).

Historically there were exceptions to this generalisation, notably Annapolis River, Tusket River, East River Sheet Harbour and St. Mary's River. Stocks in these rivers were noted for large salmon, some of which were identified to be three-sea-winter salmon (Marshall 1986). Ageing of salmon in the returns to counting facilities and in-river assessments indicates that most stocks now have higher proportions maturing and returning after one sea-winter than previously observed (Anon 1978, O'Neil and Harvie 1995). Incidences of multiple-spawning salmon have increased in some, but not all, rivers.

Length-fecundity equations have been determined for three rivers, LaHave, Medway and St. Mary's (P. G. Amiro unpublished manuscript) and are applied to assessed rivers depending on proximity.

## Conservation Requirements

Operational conservation requirements have been assigned for two low-acidified rivers, LaHave and St. Mary's (Amiro et al. MS1996; O'Neil et al. MS1998). These requirements are equivalent to 1,320 fish for the LaHave River above Morgans Falls and 3,155 fish for the entire St. Mary's River.

Conservation requirements have been deferred for management purposes in four rivers: East River Sheet Harbour, Mersey River, Clyde River and Jordan River, because toxicity due to low pH and/or habitat loss has precluded the ability of these rivers to sustain natural production of salmon.

Although several perfunctory estimates of conservation requirements for SFA 20 and 21 rivers have been postulated (Marshall et al. MS1992, O'Neil et al. MS1998) the remaining rivers of SFA 20 and 21 have no established conservation requirements.

## Fishery

Salmon are classified in two size categories for management purposes. Salmon less than 63.0 cm are termed "small salmon" and salmon equal to or greater than 63.0 cm are termed "large salmon".

In 1999 no licensed commercial fishery for Atlantic salmon took place in SFA 20 or 21.
Based on a forecast for 1999 that indicated a probability of achieving conservation requirement of $83 \%$, and, after consultation with the Zone Management Committees, the recreational salmon fishery opened for hook-and-release angling by artificial fly in SFA 21 and did not open in SFA 20. The June 15 in-season assessment at Morgans Falls, LaHave River, indicated a probability of $88 \%$ attaining the conservation requirement. Based on this in-season forecast, observations at the other salmon counting facilities and, fter consultation with stakeholders, a First Nation food fishery began at Morgans Falls and a recreational retention fishery of one fish per day was initiated in the LaHave River.

First Nation food fishery agreements permitted the harvest of Atlantic salmon in the four acidified rivers of SFA 20 or 21 that were recipient of the stocking of hatchery smolts. Depending on the forecasts and in-season assessments, harvests of hatchery male grilse were conducted at the Morgans Falls fishway in 1999. Harvests at Morgan Falls and in the LaHave River recreational fishery were conducted until the July 6, 1999,assessment. Except for Clyde, Jordan, Mersey and East River Sheet Harbour rivers, all salmon fisheries in SFA 20 and 21 discontinued on July 8, 1999, after the second in-season assessment indicated less than $1 \%$ chance of achieving the conservation requirement. Based on further assessments conducted on July 15 and July 30, no further salmon fisheries were opened in rivers of SFA 20 and 21 in 1999.

## Status- index rivers

Status for all low-acidified rivers in SFA 20 and 21, which are still capable of producing wild Atlantic salmon, is expected to be similar or worse than the index rivers. Dissimilarities in the status of salmon stocks among rivers of these SFAs may be attributed to the levels of acidification and/or habitat loss and to the level of hatchery supplementation.

## St. Mary's River

## Adult salmon

Total escapement to St. Mary's River was estimated by an in-river mark-and-recapture in 1997 (O'Neil et al. MS1998), in 1998, (Marshall et al. MS 1998) and again in 1999.

In 1999, a total of 38 adult salmon was marked at three locations on the West Branch of St. Mary's River on September 21 and 22, 1999. A total of 82 fish was captured and examined at three pools on the West Branch of the St. Mary's River on October 4, 1999. Eight of these fish were previously marked in September. Based on these data the most probable estimate (by sequential Bayesian estimation, Gazey and Staley 19xx) of escapement to the West Branch was 390 fish ( $90 \%$ CL $256-915$ ). The West Branch at $55 \%$ of the total area of the St. Mary's River requires 1,735 salmon of average biological characteristics. Based on the uncertainty of the estimate, there was only a $0.14 \%$ chance that at least 1,735 salmon escaped into the West Branch in 1999.

The salmon conservation requirement for the total St. Mary's River is 3,155 fish. Using the estimate for the West Branch and the proportion of the total salmon habitat found in the West Branch, the total escapement to the St. Mary's River in 1999 was estimated at 709 fish or $22 \%$ of the conservation requirement.

Based on the observed biological characteristics of the 112 fish captured during the mark and recapture population estimate (Table 1.), $79 \%$ of the escapement was first-time-returning (recruit) grilse (matured after one-sea-winter) which were all less than 63 cm . About $15 \%$ of the captured fish, or $63 \%$ of the fish greater than 63 cm , were repeat spawning grilse.

Table 1. Age, spawning history, gender, and lengths of Atlantic salmon captured by seining in the St. Mary's River, Guysborough County, during September and October of 1999.

| Sea age | Number |  | Length (cm) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Mean |  | Max. |  | Min. |  |
|  | Males | Females | Males | Females | Males | Females | Males | Females |
| 1 | 28 | 57 | 55.0 | 54.6 | 59.5 | 59.0 | 51.0 | 50.0 |
| 2 sp 1 | 1 | 12 | 62.2 | 60.1 |  | 63.5 |  | 54.0 |
| $3 \mathrm{sp} \mathrm{1,2}$ | 0 | 4 |  | 67.5 |  | 69.5 |  | 65.5 |
| 2 | 0 | 10 |  | 75.4 |  | 81.0 |  | 70.0 |

The spawning run of fish with these biological characteristics would have contributed about 30\% of the required egg deposition for the St. Mary's River in 1999.

## Juvenile salmon

Densities of juvenile salmon were determined at 15 sample locations by quantitative electrofishing in 1999. These data indicate an average age- $0^{+}$parr density of 13.3, an age- $1^{+}$parr density of 2.6 and age $-2^{+}$density of 1.4 per $100 \mathrm{~m}^{2}$. These numbers of parr are low relative to previous annual means and to Elson's "normal index of abundance", i.e., 29 fry, and 38 total older parr per $100 \mathrm{~m}^{2}$ (Elson 1967). The number of age- $1^{+}$parr resulting from the number of age $-0^{+}$ (fry) the previous year was again low. This result continues a trend since 1993 of low fry to parr survival (Figure 1).

Figure 1. Mean densities of age $-0^{+},-1^{+}$, and $-2^{+}$Atlantic salmon parr determined by electrofishing in 10 to 37 locations of the St. Mary's River. Years of electrofishing and number of locations fished are indicated.

St. Mary's


The West Branch mean total age $-1^{+}$and age- $2^{+}$parr density was 1.75 times greater than that estimated for the East Branch in 1999. The West Branch mean total older parr density (age-1 $1^{+}$and
age $-2^{+}$parr) was $4.98 \pm 4.28$ SD while the East Branch was $2.58 \pm 1.91$ SD. This finding could imply that using the estimated salmon escapement for the West Branch with the proportional habitat method might over-estimate the total escapement to the St. Mary's River.

## Forecasts of returns to St. Mary's River for year 2000.

Outlook for the St. Mary's River in 1999 was based on the previous five-year mean of estimated escapements and indicated only a $33 \%$ chance that returns would be greater than the conservation requirement. Using a similar model to forecast returns in year 2000, based on estimated returns for 1995-1999, forecasts about 1,600 returns or about a $5 \%$ chance of achieving the required egg deposition without in-river exploitation.

## LaHave River above Morgans Falls

## Fishery

The Aboriginal fishery harvested 42 male hatchery grilse at the fishway between June 16 and July 8, 1999.

A preliminary estimate of the recreational fishery harvest was 7 grilse less than 63 cm between June 16 and July 8, 1999. Releases in the recreational fishery were 49 grilse less than 63 cm and 27 salmon equal to or greater than 63 cm between May 10 and July 8, 1999.

## Adult salmon counts

The Morgans Falls fishway trap was operated from May 3 to November 5, 1999. Based on the age, size (Table 2.) a total of 435 female salmon was required and only 199 escaped to spawn after removals were accounted (Table 3). The 1999 total count of salmon at Morgans Falls fishway indicated $48 \%$ of the requirement of 1,320 fish or $68 \%$ of the egg requirement above Morgans Falls were achieved (Figure 2). After broodstock removals and without accounting for non-return fall back, the 1999 potential egg deposition to the river above Morgans Falls was at $55 \%$ of the egg deposition requirement.

LaHave at Morgans Falls


Figure 2. Counts of Atlantic salmon at Morgans Falls fishway identified by smolt origin, 1973 to 1999.

Table 2. Age and size composition of wild and hatchery adult Atlantic salmon sampled at Morgans Falls on the LaHave River, May to November, 1999. Age is shown as years to smolt (fresh), post-smolt years (sea) and ages at previous spawning (s1,s2).

| Age |  |  | Fork Length (cm) |  |  |  |  | Weight (kg) |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Origin Fresh | Sea | s1 s2 | Number | Mean | Min. | Max. | Std. dev. | Number | Mean | Min. | Max. | Std. dev. |
| Wild |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 | 1 |  | 2 | 57.1 | 56.4 | 57.8 | 0.7 | 2 | 2.0 | 1.9 | 2.0 | 0.1 |
| 2 | 1 |  | 126 | 55.6 | 50.0 | 62.5 | 2.5 | 126 | 1.9 | 1.2 | 2.9 | 0.3 |
| 3 | 1 |  | 14 | 57.3 | 54.0 | 63.0 | 2.6 | 14 | 2.2 | 1.7 | 2.8 | 0.3 |
| 4 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| 2 | 2 |  | 6 | 75.4 | 72.7 | 77.0 | 1.4 | 6 | 5.0 | 4.1 | 6.0 | 0.6 |
| 3 | 2 |  | 72 | 74.1 | 65.0 | 84.0 | 2.8 | 72 | 5.0 | 3.0 | 6.9 | 0.8 |
| 2 | 2 | 1 | 8 | 61.5 | 60.3 | 64.2 | 1.3 | 8 | 2.5 | 2.1 | 2.7 | 0.2 |
| 0 | 3 | 1 |  |  |  |  |  |  |  |  |  |  |
| 2 | 3 | 1 | 5 | 77.4 | 74.3 | 82.0 | 2.8 | 5 | 6.1 | 4.5 | 8.0 | 1.2 |
| 3 | 3 | 1 | 1 | 79.3 | 79.3 | 79.3 | 0.0 | 1 | 6.5 | 6.5 | 6.5 | 0.0 |
| 2 | 3 | 2 |  |  |  |  |  |  |  |  |  |  |
| 2 | 4 | 2 | 1 | 94.0 | 94.0 | 94.0 | 0.0 | 1 | 10.5 | 10.5 | 10.5 | 0.0 |
| 2 | 5 | 13 | 1 | 86.5 | 86.5 | 86.5 | 0.0 | 1 | 8.6 | 8.6 | 8.6 | 0.0 |
| Hatchery |  |  |  |  |  |  |  |  |  |  |  |  |
| 0 | 1 |  | 1 | 56.5 | 56.5 | 56.5 | 0.0 | 1 | 2.0 | 2.0 | 2.0 | 0.0 |
| 1 | 1 |  | 33 | 56.7 | 51.0 | 63.0 | 3.3 | 33 | 2.1 | 1.5 | 2.7 | 0.3 |
| 2 | 1 |  | 4 | 55.9 | 53.3 | 58.0 | 1.7 | 4 | 2.1 | 1.8 | 2.3 | 0.2 |
| 1 | 2 | 1 | 1 | 64.7 | 64.7 | 64.7 | 0.0 | 1 | 3.1 | 3.1 | 3.1 | 0.0 |
| 1 | 2 |  | 35 | 73.9 | 68.8 | 78.3 | 2.3 | 35 | 4.6 | 3.6 | 6.8 | 0.7 |
| 2 | 2 |  | 2 | 75.4 | 74.3 | 76.4 | 1.1 | 2 | 5.1 | 4.9 | 5.2 | 0.2 |
| 1 | 3 | 1 | 2 | 77.1 | 74.9 | 79.4 | 2.3 | 2 | 5.4 | 3.7 | 7.1 | 1.7 |
| 1 | 3 |  | 1 | 85.5 | 85.5 | 85.5 | 0.0 | 1 | 7.1 | 7.1 | 7.1 | 0.0 |
| 0 | 4 | 2 | 1 | 95.3 | 95.3 | 95.3 | 0.0 | 1 | 8.8 | 8.8 | 8.8 | 0.0 |
| 1 | 4 | 2 | 1 | 87.0 | 87.0 | 87.0 | 0.0 | 1 | 8.3 | 8.3 | 8.3 | 0.0 |

Table 3. Spawning escapement relative to requirements based on numbers of Atlantic salmon counted and aged at Morgan Falls fishway in 1999, removals, size-at-sea-age, fecundity, contribution to egg deposition and required adult salmon. Spawning requirements are based on $1.96 \times 10^{6}$ eggs that at 1,482 eggs per fish is equivalent to 1,320 fish.

| Origin Post-smolt age | Gender | Number at age | Prop. | Broodstock removals | Angling+ Native harvest above | Mean length females (cm) | Mean fecundity (eggs) | Eggs contributed | Percent cont. to egg dep. | Required female spawners |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Wild |  |  |  |  |  |  |  |  |  |  |
| One-sea-winter | Female | 130 | 0.22 | 21 | 0 | 55.6 | 3,342 | 363,874 | 33.8 | 198 |
|  | Male | 188 | 0.32 | 29 | 0 | 55.9 |  |  |  |  |
| Multi-sea-winter | Female | 73 | 0.12 | 19 | 0 | 74.1 | 6,529 | 353,309 | 32.8 | 98 |
|  | Male | 14 | 0.02 | 6 | 0 | 71.3 |  |  |  |  |
| Hatchery |  |  |  |  |  |  |  |  |  |  |
| One-sea-winter | Female | 50 | 0.09 | 4 | 0 | 55.9 | 3,378 | 155,754 | 14.5 | 84 |
|  | Male | 86 | 0.15 | 2 | (42) | 57.0 |  |  |  |  |
| Multi-sea-winter | Female | 38 | 0.06 | 8 | 0 | 75.2 | 6,794 | 202,867 | 18.9 | 54 |
|  | Male | 6 | 0.01 | 3 | 0 | 73.7 |  |  |  |  |
| Totals |  | 585 | 1.00 | 92 | (42) |  | 5,011 | 1,075,804 | 100 |  |
| Escaped female spawners Required female spawners = Surplus (Deficit) = |  | 291 |  | 92 | 0 |  |  |  |  | 199 |
|  |  |  |  |  |  |  |  |  |  | 435 |
|  |  |  |  |  |  |  |  |  |  | (236) |

This year was the sixth consecutive that escapement of salmon above Morgans Falls on the LaHave River, before adjustment for non-return fall back, was at or below the operational conservation requirement. However, parr densities have remained average to better than average (Figure 3).


Figure 3. Average density ( $100 \mathrm{~m}^{2}$ ) of age $-1^{+}$and age- $2^{+}$Atlantic salmon parr determined by electrofishing above and below Morgans Falls, LaHave River, 1979 to 1999.

## Smolt-to-adult return survival

## - Hatchery smolts

Return rate of hatchery smolts to Morgans Falls has continued a declining trend ( $p=0.001$ ) since 1984. Return rate of 1998 hatchery smolts as 1SW fish in 1999 decreased to $0.31 \%$ from the $0.87 \%$ experienced in 1998. Returns of 2SW hatchery salmon in 1999 (1997 smolt class) increased to $0.17 \%$ from the $0.14 \%$ value in 1998 (1996 smolt class)(Figure 4).

## LaHave at Morgans Falls



Figure 4. Return rates of Atlantic salmon hatchery-raised smolts released at or above Morgans Falls in the LaHave River, 1972 to 1998.

## -Wild smolts

Annual populations of wild smolts have been estimated at the Morgan Falls Power (MFP) facility across from the Morgans Falls fishway since 1996. Known numbers of hatchery-grown smolts are marked and released above Morgans Falls and smolts are captured in the assessment facility below the deflector louvers at the power station. Smolts are counted independent of the operating state of the plant. In 1999 a total 2,700 tagged smolts was released above MFP. A total of 3,799 smolts was examined at MFP of which 782 tagged smolts were recaptured. These data indicated a most probable population of $10,420\left(9,760-11,060,5^{\text {th }}\right.$ and $95^{\text {th }}$ percentiles) wild smolts in 1999. This number was a decrease from 1998 and from previous years (Figure 5).

## Wild smolt estimates Morgans Falls



Figure 5. Number of wild smolts and $90 \%$ confidence intervals as estimated at the Morgans Falls Power by-pass canal by mark-and-recapture technique for smolts migrating from above Morgans Falls, LaHave River, 1996 to 1999.


Figure 6. Return rates of wild and hatchery smolts to Morgans Falls after one-sea-winter.
Wild smolt return rate to Morgans Falls for 1998 wild smolts returning as 1SW salmon in 1999 was $2.04 \%$, down from $4.33 \%$ observed for the 1997 smolts class (Figure 6).

Returns of wild 1SW salmon and hatchery 1SW salmon provide comparative estimates of return rates for wild and hatchery smolts. This result is because all tagged hatchery smolts were stocked 2.0 km above Morgans Falls and all marked hatchery smolts were stocked in the top pool of the fishway. No parr have been stocked above MF since 1994. The ratio of wild to hatchery return rate to the 1SW stage was 4.8 for the 1996 smolt class, 5.0 for the 1997 smolt class and 6.6 for the 1998 smolt class. The ratio to the 2SW stage was 1.9 for the 1996 smolt class and 3.1 for the 1997 smolt class.

## Stock and recruitment - Above Morgans Falls, LaHave River

Returns of salmon to LaHave River above Morgans Falls, an area minimally impacted by acidification, have been monitored and aged since 1973. Recruitment is essentially complete after five years, allowing current assessment of the 1994-egg deposition class in 1999. The natural log of the number of recruits for each spawner $\mathrm{Ln}(\mathrm{r} / \mathrm{s})$, a measure of generation-togeneration survival, has been below population replacement since 1985 and is indicative of a population in decline (Figure 7). Spawners that contributed to recruitment since 1985 have been both high and low, (Figure 8 and 9 ) yet recruitment has been less than replacement, i.e., $\mathrm{Ln}(\mathrm{r} / \mathrm{s})$ $<1$ (Figure 7).


Figure 7. Natural logarithim of the number of recruits from all subsequent years per the number of spawning salmon in that year plotted against the number of spawning salmon.

Ln(r/s) vs Year


Figure 8. Natural logarithim of the number of recruits from all subsequent years per the number of spawning salmon in that year plotted against the year of the spawning run.


Figure 9. Numbers of salmon counted at Morgans Falls, 1970 to 1999.

## Forecasts - LaHave River

Forecast counts to Morgans Falls fishway have been made since 1983. Forecasts are provided for each age-at-maturity (1SW and MSW) and origin (wild and hatchery) classes. MSW (mostly 2SW recruits) are forecast from 1SW counts the previous year. These forecasts are sibling models or first to second recruit models. Hatchery-origin 1SW counts are forecast from known stocking numbers and average or recent return rates. Wild 1SW counts are forecast from annual average counts or from estimated wild smolt output and their various associated return rates. In 1998, three groups of models were shown: A) Long term model averages for the data sets. B) Short term, past five-year averages, for 1SW returns. C) Use of the previous year's return rates for wild and hatchery grilse and the 1999 estimates of wild and hatchery smolts (Table 2).

Although the total count of fish returning in 1999 was not outside the combined $90 \%$ CL of Models A, the forecast of hatchery grilse was significantly overestimated by a factor of 4.34. The 1999 forecast of wild MSW count, while not outside the $90 \%$ CL was also an overestimate by 1.87 times. These observations are consistent with the trend in $\operatorname{Ln}(\mathrm{r} / \mathrm{s})$ and indicate a declining trend in marine survival. This trend is not captured in long-term Models A. Models B better capture this downturn. Models C attempt to utilise all of the information at hand and the most recent observed return rates. Variance for return rates used in Models C is that derived from the most recent five (hatchery) and three (wild) year observations.

Because Models B performed better in 1999 and because Models B capture some of the present epoch of low marine survival, it is the recommended model for risk analysis for the year 2000 counts. The models need amendment in order to reflect the higher variation of in-river exploitation during recent years as well as better account for recent survival trends in the data.

Based on Models B, there is a $65 \%$ chance of counting the required egg deposition of $1.96 \times 10^{6}$ eggs above Morgans Falls in year 2000 without in-river exploitation. This forecast does not account for non-return fall back (fish that ascend the fishway but fall back down river), which has been estimated between 30 and $40 \%$ by two different methods on three occasions.

Table 4. Numbers of Atlantic salmon by stock origin and sea-age composition of returns to the Morgans Falls fishway, LaHave River, 1970 - 1999, forecasts for 2000, and comparison of counts in 1999 with forecasts made for 1999.

B) Using 5yr. means for wild grilse and 5yr return rates for hatchery grilse.

| 2000 Forecast | $\mathbf{3 1 7}$ | $\mathbf{4 2}$ | $\mathbf{5 3 1}$ | $\mathbf{9 6}$ | 848 | $\mathbf{1 3 8}$ | $\mathbf{9 8 6}$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
|  |  |  |  |  |  |  |  |
| Upper $95^{\text {th }}$ percentile | 724 | 168 | 979 | 317 | 1,703 | 485 | 2,188 |
| Lower $5^{\text {th }}$ percentile | 0 | 7 | 82 | 15 | 82 | 22 | 104 |

C) Using count of wild and hatchery smolts and 1999 return rates for grilse.

| 2000Forecast | 125 | 42 | 213 | 96 | 338 | 138 | 476 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Upper $95{ }^{\text {th }}$ percentile | 532 | 168 | 226 | 317 | 758 | 485 | 1,243 |
| Lower 5"'percentile | 0 | 6 | 200 | 15 | 200 | 21 | 221 |
| Rates and population estimates used: Hatchery smolt 1998 |  |  | Hatchery smolt return (\%) |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Hatchery smolt out= 40,484 |  |  |  |  | 0.310 |  |  |
|  |  |  |  |  | 0.783 |  | 1.634 |
|  |  |  | Average 1994-98= std. dev. = |  | 0.471 |  | 1.070 |
| Wild smolt estimate 1999 |  |  | Wild smolt return (\%) |  |  |  |  |
| Mode | 10,420 |  | Mode 199 | 999 | 2.0385 |  |  |
| 5th | 9,760 |  |  | 5th | 1.9157 |  |  |
| 95th | 11,060 |  |  | 95th | 2.1670 |  |  |
|  |  |  | 1999 |  | 2.0439 |  |  |

## North Branch - LaHave River

A counting trap in the fishway at Indian Falls on the North Branch LaHave River was operated from May 31 to November 10, 1999 the first time a counting trap has been operational at this location since 1983. The fishway provides access above a 4.9 m falls that is known to be at least a partial barrier to salmon. All fish that entered the trap at Indian Falls were marked by a lower caudal fin hole punch.

| Sea age | Number |  |  |  | Mean length cm. |  | Max. length cm. |  | Min. length cm. |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | males |  | females |  |  |  |  |  |  |  |
|  | H | W | H | W | males | females | males | females | males | males |
| 0 | 0 | 0 | 0 | 1 |  | 30.0 |  |  |  |  |
| 1 | 17 | 54 | 4 | 34 | 57.4 | 56.6 | 63.5 | 63.0 | 51.8 | 50.0 |
| 2 | 0 | 3 | 3 | 14 | 73.5 | 76.0 | 74.0 | 80.0 | 73.1 | 72.0 |
| 3 sp .1 | 0 | 0 | 0 | 1 |  | 78.0 |  |  |  |  |

Unknown ages: 3 H males large, 2 W males large, 4 W males small, 1 W female large, 1 W female small

Totals of 24 hatchery and 107 wild salmon were counted in 1999. This count does not included 42 repeat ascending fish. Included in this number were three grilse previously marked with an upper caudal fin punch at Morgans Falls in 1999. No fish marked at Indian Falls were observed at Morgans Falls fishway in 1999. Also included in the 1999 count at Indian Falls was one tagged grilse known to have been released in New Germany Lake, above Morgans Falls, in 1998.

Two recapture attempts were conducted above Indian Falls, September 24 and October 22, 1999. On the first sampling date only, the pool where the Sherbrooke River crosses the FortiesDalhousie highway above Sherbrooke Lake was seined. No salmon were caught or observed at this location. On each sampling date the river between Sherbrooke Lake and the outlet of Texas Lake was fished using an electrofishing boat. On September 24 one marked grilse was captured. On October 22 seven marked grilse were captured. No salmon (by sea-age or size) were captured on either of these sampling ocasions although two salmon were observed but not captured.

These data indicate that the count of grilse made at the trap in the indian Falls fishway can be considered a complete count of grilse (<63cm) passing Indian Falls. The same certainty was not established for fish $\geq 63 \mathrm{~cm}$. Salmon were observed jumping at the falls in 1999, and have been previously been observed jumping at the falls.

## Musquodoboit River

In 1999 electrofishing for juvenile salmon abundance was conducted at twelve etablished locations in the Musquodoboit River (Figure 10). Densities at these locations remained moderate to high. The Musquodoboit has excellent water quality for salmon, although, ideal habitat for juvenile salmon is limited in comparison to higher gradient rivers. The Musquodoboit has been stocked with Musquodoboit stock smolts and juveniles since 1983.


Figure 10. Densities (per $100 \mathrm{~m}^{2}$ of Atlantic salmon parr age- $0^{+}, 1^{+}$and $2^{+}$determined at 12 to 29 locations in the Musquodoboit River 1988-1993, 1996 and 1999.

Returns to Musquodoboit River are not monitored other than through recreational fishery lisence stub returns and through observations made while conducting broodstock collections. In 1999 all salmon captured during broodstock collection were retained. This sample indicated 13 wild and two hatchery fish in the collection.

| Sea age, origin | Number |  | Length (cm) |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Mean |  | Max. |  | Min. |  |
|  | Males | Females | Males | Females | Males | Females | Males | Females |
| 1, wild | 5 | 0 | 59.2 |  | 61.0 |  | 57.0 |  |
| 1, hatchery | 1 | 0 | 59.0 |  |  |  |  |  |
| 2, wild | 0 | 8 |  | 78.1 |  | 81.0 |  | 71.5 |
| 2, hatchery | 1 | 0 | 79.0 |  |  |  |  |  |

A final 18 rod days of effort and 15 small and 13 large salmon released were estimated for the June 18 to July 8 season on the Musquodoboit River.

## Sackville River

A counting trap in the Cox Fishway at Heffler's Mill was operated from May 18 until November 1, 1999. Including fish removed for broodstock, 22 large salmon and 70 grilse were counted at the trap in 1999.

Forty-one fish were marked and released at the fishway. A total of 24 fish was seined and examined for marks above and below the fishway on October 14 and October 31, 1999. Only one marked fish was recaptured. No reasonable mark and recapture estimate can be derived from
only one recapture. Therefore a minimum population of salmon in the system is the 92 fish counted at the fishway and plus the 23 unmarked fish observed during the seining.

Stock and origin components in the run:

| Large Salmon |  |  |  | Grilse |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Male |  | Female |  | Male |  | Female |  |
| Wild | Hatchery | Wild | Hatchery | Wild | Hatchery | Wild | Hatchery |
| 2 | 3 | 4 | 13 | 12 | 34 | 14 | 10 |

Trap data and the records of broodstock transfers to the hatchery show a discrepancy. Some additional fish (up to 14) may have passed through the trap but are unaccounted.

## Ecum Secum River

Ecum Secum River, a low-acidified river, contained sufficient juvenile salmon to enable the derivation of a quantitative density estimate in 1999. One location, site 5, located at the Newchester Road on the main river, was fished in 1999. In comparison to densities determined in 1983 and 1998 (Cameron and Gray 1979, O'Neil et al. MS1998), the density of age-0 ${ }^{+}$parr increased and the density of older parr decreased.

| Location site | Age $0^{+} / 100 \mathrm{~m}^{2}$ |  |  | Older parr / $100 \mathrm{~m}^{2}$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1983 | 1998 | 1999 | 1978 | 1998 | 1999 |
| 1 | 4.9 |  |  | 1.2 |  |  |
| 2 | 4.9 |  |  | 6.5 |  |  |
| 3 | 10.4 |  |  | 9.0 |  |  |
| 4 | 1.8 |  |  | 11.8 |  |  |
| 5 | 0.4 | 3.3 | 14.4 | 17.5 | 10.3 | 6.4 |

## Partially-Acidified Rivers of SFA 20 and SFA 21

## Liscomb River

Returns to the Liscomb River fishway numbered only 25 fish in 1999 (Figure 11). Wild salmon less than 63.0 cm numbered 9 fish, or $36 \%$ of the count.


Figure 11. Count of Atlantic salmon by origin at the Liscomb Falls fishway, 1979 to 1999.
Survival of hatchery-origin salmon has declined severely and was only $0.03 \%$ to grilse return in 1999. Delayed mortality of stocked smolts attributed to pH shock is suspected, and falling pH (i.e., increased acidity) of the Liscomb River may be the primary cause. Therefore, hatchery supplementation as a mitigation technique for acidification is less effective now in lowpH impacted rivers than when stocking programs began. This effect may be seen in comparison of 1SW return rates for hatchery smolts stocked in LaHave River, a low acid-impacted river, and the Liscomb River, a partially acid-impacted river.

Hatchery 1SW return rates


Figure 12. Percent return of hatchery one-sea-winter Atlantic salmon stocked as smots at or above Morgans Falls fishway, LaHave River and to the Liscomb River fishway for smolts stocked 1978 to 1998.

## West River Sheet Harbour

Juvenile salmon surveys conducted on the West River, Sheet Harbour, in 1999 continue an intermittent data record back to 1966. No significant increase was noted in the population of age$1^{+}$parr above or below a 500 m section of the river, which was overlain with limestone rubble in 1996 in order to buffer low pH episodes. In 1999 parr densities increased in both treatment and control locations. Based on the continuing low densities, the declining trend and low abundance of salmon returns to all rivers in the SFA, returns in year 2000 are not expected to be greater than the conservation requirement.

## Tusket River

The Tusket River is a hydropower-developed drainage. A diversion dam and powerhouse dam at Tusket Falls, Yarmouth County, creates the Lake Vaughn headpond just above the head of tidal influence. Fishways at both facilities provide upstream access for diadromous fishes. Counts and collection of salmon broodstock have been made at these fishways since 1979. The completeness of these counts is unknown because the fishways were annually open to migration before and after collections were complete and when water levels were low. In 1998 the operating season for these counts was extended to cover the assumed migration season of diadromous fishes known to have been present in the river system. All salmon ascending the fishways in 1998 and 1999 were marked with a caudal fin punch.

In 1999 the downstream passage facility at the powerhouse was modified to sample fish. These samples were examined for marks and tags. Both kelts and smolts were caught and examined. A total of 1,992 tagged hatchery smolts was released on April 21, 1999, to the Carleton River, a higher-pH tributary above Lake Vaughn.

## Adult salmon

The count of salmon at the fishways and released to Lake Vaughn in 1998 was 267. A total of 156 kelts was examined in the downstream passage trap from April 8 to May 18, 1999, of which 119 were previously caudal fin pinched. These data indicate that the sampling traps in the fishways in 1998 caught about $76.3 \%$ of the population above Lake Vaughn.

The total count of salmon released above the fishways in 1999 was 142 fish.


Figure 13. Combined counts of Atlantic salmon summed by size class (grilse $<63.0 \mathrm{~cm}$ and salmon $\geq 63.0 \mathrm{~cm}$ ) and origin of smolt (wild and hatchery) at two fishways of the Tusket River, Yarmouth Co. Nova Scotia, 1979 to 1999.

## Smolts

A total of 1,992-tagged hatchery smolts was released in the Carleton River in 1999. Of the 1,501 smolts examined at the downstream by-pass in 1999, 82 were tagged and 1,419 were not tagged. Of the 1,419 smolts without tags, 908 or $64 \%$ were adipose fin clipped and therefore derived from hatchery fall fingerling releases. Because not all fall fingerlings were marked before release in 1997, potentially contributing to age $-3^{+}$smolt in 1999, the proportion of wild smolts in the untagged population is uncertain. A sample of 41 smolts with adipose fins intact was collected in the by-pass in 1999. Scale reading indicated all sampled smolts with an adipose fin intact were of wild origin.

| Ages |  |  |  |
| :---: | :---: | :---: | :---: |
| $1+$ | $2+$ | $3+$ | Total |
| 1 | 34 | 6 | 41 |

The above data were used to derive a 1999 modal estimate of 34,458 smolts ( $90 \%$ CL 28,758 37,458 ) not including the tagged smolt release. Of these, an estimated 12,408 had the adipose fin intact and are most likely wild origin smolts. The estimated salmon production area of the Tusket River is $66,764 \times 10^{2} \mathrm{~m}^{2}$, without accounting for pH . The resulting wild smolt production rate for the entire Tusket River above Lake Vaughn in 1999 was 0.186 smolts $\mathrm{m}^{-2}$. The 1996 spawning escapement that contributed $83 \%$ of these smolts was 258 adult salmon. These data indicate an approximate production rate of 48 smolts per escaped fish.

## Salmon River Digby

Three locations were electrofished in 1999. These locations were previously electrofished in 1978 (Cameron and Gray 1979). The data indicate declines in densities from 1978 to 1999.

| Location site | Age $0^{+} / 100 \mathrm{~m}^{2}$ |  | Older parr / $100 \mathrm{~m}^{2}$ |  | Catch per 5min <br> Age- $0^{+}$Older |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |
|  | 1978 | 1999 | 1978 | 1999 | 1999 | 1999 |
| Indian River |  |  |  |  |  |  |
| 3 (wild) | 1.4 | 3.5 | 20.2 | 0.9 |  |  |
| 3 (hatchery) |  |  |  | 1.1 |  |  |
| Main River |  |  |  |  |  |  |
| 5 | 17.1 |  | 1.4 |  | 0.0 | 5.0 |
| 7 | 0.0 |  | 0.0 |  | 0.0 | 0.0 |

## Other partially acidified rivers of SFA 20 and 21

Electrofishing spot checks were conducted in 1999 on six partially impacted rivers of SFA 20. No wild-origin parr were found in five of these rivers and only a remnant population remains in the Salmon River Port Dufferin.

| River | Location | Age-0 ${ }^{+}$ | Older parr |
| :--- | :--- | :---: | :---: |
| Tangier | Mooseland | 0 | 0 |
| Taylor Bay Brook | above hwy.7 | 0 | 0 |
| Salmon R. Port Dufferin | Fourth L. Stills | 1 | 1 |
| Gaspereaux Brook | hwy. 7 | 0 | 0 |
| Gegogan Brook | hwy. 7 | 0 | 0 |
| Liscomb River | below fishway | 0 | 5 hatchery |

## Acid-Impacted Rivers with Fisheries Dependent on Stocking

Some rivers can no longer support the production of salmon because of inadequate fish passage, flooding of habitat and acidification. The East River Sheet Harbour, Mersey River, Clyde River and Jordan River receive hatchery smolts placed below barriers and sometimes directly into salt or brackish water to provide adult returns for harvest. Because of low pH there is little natural production possible in these rivers, and therefore no present-day operational conservation requirements are in place. All fish in excess of the broodstock requirements for these stocks have been allocated for exploitation.

## Clyde River

Aboriginal or First Nations fisheries reported no effort for 1999. The reported recreational fishery effort was 233 rod-days. The harvest by the recreational fishery was 7 grilse and 2 salmon were reported released (Appendix).

## Jordan River

No fishery reported any effort for the Jordan River in 1999 (Appendix).

## Mersey River

In 1999 a count of salmon ascending the Cowie Falls fishway on the Mersey River observed only one grilse ascending the fishway. The number of salmon harvested below the fishway is unknown. The estimated recreational catch was four grilse (Appendix).

## East River Sheet Harbour

Counts at the Ruth Falls fishway increased to 33 grilse and 3 salmon from a total of 9 fish in 1998. The 1SW return rate of hatchery smolts increased from $0.03 \%$ in 1998 to $0.05 \%$ in 1999. As was the case in 1998, all fish were retained for broodstock in 1999. As a result of the declining return of ERSH smolts, relative to returns to non-acid-stressed rivers, an experiment to examine the effect of pre-release treated-water acclimation of smolts was begun on ERSH smolts stocked in 1999.

Table 5. Numbers of smolts release, numbers counted at the fishway, return rate and destiny of Atlantic salmon captured at Ruth Falls fishway, East River Sheet Harbour, 1992 - 1999.

| Year | Smolts released year i | Number of fish counted at fishway ${ }^{\text {a }}$ |  |  |  |  |  | Return rate in percent |  | Distribution of returns |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  | Broodstock | Released 15 Mile Stream | Free swim | Food fishery |
|  |  | Hatchery |  | Wild |  | Total |  |  |  |  |  | $\begin{gathered} \hline 1 \mathrm{SW} \\ \operatorname{yr}(\mathrm{i}+1) \end{gathered}$ | $\begin{array}{r} 2 S W \\ \operatorname{yr}(\mathrm{i}+2) \end{array}$ |
|  |  | 1SW | MSW | 1SW | MSW | 1SW | MSW |  |  |  |  |  |  |
| 1992 | 26,977 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1993 | 26,900 |  |  |  |  |  |  |  |  |  |  |  |  |
| 1994 | 26,700 | 85 | 3 | 17 | 2 | 102 | 5 | 0.32 | 0.01 | 57 | 24 | 11 | 15 |
| 1995 | 36,890 | 96 | 4 | 27 | 2 | 123 | 6 | 0.36 | 0.02 | 57 | 40 | 12 | 18 |
| $1996{ }^{\text {b }}$ | 18,700 | 135 | 16 | 11 | 1 | 146 | 17 | 0.37 | 0.06 | 77 | 59 | 14 | 13 |
| $1997{ }^{\text {c }}$ | 25,740 | 14 | 1 | 4 | 1 | 18 | 2 | 0.07 | 0.00 | 20 | 0 | 0 | 0 |
| $1998{ }^{\text {c }}$ | 33,756 | 7 | 1 | 1 | 0 | 8 | 1 | 0.03 | 0.01 | 7 | 0 | 2 | 0 |
| $1999{ }^{\text {cd }}$ | 22,020 | 16 | 2 | 15 | 0 | 31 | 2 | 0.05 | 0.01 | 33 | 0 | 1 | 0 |

a. The barrier dam is passable under high water conditions so these counts are not complete.
b. The barrier dam fish lift was only operated for part of the 1996 run; most fish were captured at the Ruth Falls diversion dam fishway which is located 4 km above the head of tide and above the majority of the angling fishery which harvested grilse. Preliminary angler reports indicate a harvest of 21 grilse; applying the proportion hatchery fish noted at the fishway (0.92) results in 19 hatchery grilse harvested so $135+19=154$, a reconstructed return of 154 fish and a revised return rate of $0.42 \%$. c. All the trapping was done at Ruth Falls diversion dam.
d. In addition to these numbers there was also one grilse that came from a fall fingerling stocking in 1994.

## Management Considerations

Reduced performance of the stocks in low or non-acidified rivers has resulted in management actions in SFA 20 and 21 to decrease in-river exploitation through reductions in recreational fisheries seasons, daily catch limits and early closure of Aboriginal people's fisheries. Based on the status and recent performance of the wild salmon stock above Morgans Falls, LaHave River, and estimates of returns to St. Mary's River, non- or low-acidified rivers are not expected to achieve operational conservation requirements in 2000.

Sixteen rivers in SFA 20 and 21 were stocked with hatchery smolts or parr in 1999 (Table 6).
Table 6. Distribution of hatchery stocked Atlantic salmon smolts and fall fingerlings to rivers of SFAs 20 and 21 during 1999.

| River | $\begin{gathered} \mathrm{pH} \\ \text { Category } \end{gathered}$ | Origin of stock | Number of Smolt | Percent of SFA | Number of parr |
| :---: | :---: | :---: | :---: | :---: | :---: |
| SFA 21 |  |  |  |  |  |
| Clyde | 1 | La Have | 11,552 | 5 |  |
| Jordan | 1 | La Have | 4,980 | 2 |  |
| Jordan | 1 | Medway | 0 | 0 |  |
| Mersey | 2 | La Have | 9,960 | 4 |  |
| Sackville | 2 | La Have | 0 | 0 |  |
| Sackville | 2 | Sackville | 20,516 | 9 | 26,599 |
| Tusket | 2 | Tusket | 45,457 | 19 | 28,292 |
| Gold | 3 | Gold | 16,432 | 7 |  |
| La Have | 3 | La Have | 45,637 | 19 | 85,273 |
| Medway | 3 | Medway | 41,640 | 17 | 24,854 |
| Salmon River - Digby | 3 | Salmon River | 7,032 | 3 | 14,292 |
| Meteghan | 4 | Tusket | 0 |  | 14,100 |
| Mushamush | 4 | La Have | 9,545 | 4 | 12,900 |
| Petite | 4 | La Have | 10,804 | 5 | 12,900 |
| Bear River |  | Tusket | 15,504 | 6 |  |
| SFA 21 Total |  |  | 239,059 |  | 219,210 |
| SFA 20 |  |  |  |  |  |
| East R. Sheet Hbr. | 2 | East River | 22,020 | 23 | 4,364 |
| Liscomb | 2 | Liscomb | 56,066 | 58 | 23,197 |
| Musquodobit | 4 | Musquodobit | 18.953 | 20 | 28.030 |
| SFA 20 Total |  |  | 97,039 |  | 51,227 |
|  |  |  | 336,098 |  |  |

The St. Mary's and LaHave rivers are representatives of low acid-impacted rivers. Returns to the St. Mary's River in 1999 were again insufficient to achieve the conservation requirement, and are unlikely to be sufficient in year 2000 ( $5 \%$ chance). Also, the conservation requirement was not met on the LaHave River (above Morgans Falls) for the third year in a row and may be achieved in year 2000 ( $65 \%$ chance). The continued trend of low return of hatchery smolts as grilse reduces the expectation that rivers enhanced through hatchery supplementation will have returns in excess of their requirements in year 2000.

The Liscomb River is representative of a partially acidified river. Returns to the Liscomb have shown an almost total loss of wild salmon and a severe decline in the survival of stocked hatchery salmon. Hatchery supplementation as a mitigation technique for acidification is now less effective in these rivers than when stocking programs began. For this reason, despite substantial hatchery smolt stocking in 1998, and 1999, conservation requirements are not likely to be met in 2000 in the Liscomb River or other partially acidified rivers (e.g., Medway, Gold) receiving hatchery supplementation.

Acid-impacted rivers wholly dependent on stocking include the East River Sheet Harbour, Mersey, Clyde and Jordan rivers. Because these rivers are no longer capable of supporting wild salmon production, they have no active conservation requirement. They do, however, offer the potential to provide broodstock to maintain their programs. Considering the low escapements to donor-stock rivers, the self-sufficiency of these programs needs to be considered. The decline in hatchery return rates to all rivers in SFA 20 and 21 and especially to rivers with low pH , indicates that returns in 2000 are not likely to be much greater than broodstock requirements.

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Appendix 1. Atlantic salmon recreational fishing season openings and closings for 1999 in salmon Fishing Area 20

| River | SFA | Open | Closed |
| :--- | :---: | :---: | :---: |
| Chezzetcook | 20 | 1-Jan | 1-Jan closed |
| Clam Harbour | 20 | 24-Jun | 8-Jul Hook \& release |
| Cole Harbour | 20 | 1-Jan | 1-Jan closed |
| Country Harbour | 20 | 24-Jun | 8-Jul Hook \& release |
| East: Sheet Harbour | 20 | 1-Jun | 30-Sep |
| Ecum Secum | 20 | 18-Jun | 8-Jul Hook \& release |
| Gaspereau: Brook | 20 | 1-Jan | 1-Jan closed |
| Gegogan | 20 | 18-Jun | 8-Jul Hook \& release |
| Guysborough | 20 | 1-Jan | 1-Jan closed |
| Halfway Brook | 20 | 1-Jan | 1-Jan closed |
| Isaac's Harbour | 20 | 1-Jan | 1-Jan closed |
| Kirby | 20 | 1-Jan | 1-Jan closed |
| Larry's | 20 | 1-Jan | 1-Jan closed |
| Lawrencetown Lake (Salmon | 20 | 1-Jan | 1-Jan closed |
| Liscomb | 20 | 18-Jun | 8-Jul Hook \& release |
| Little Salmon | Lake Major) | 20 | 1-Jan |
| Moser 1-Jan closed |  |  |  |
| Musquodoboit | 20 | 1-Jan | 1-Jan closed |
| Necum Teuch | (Smith Bro | 20 | 18-Jun |
| New Harbour | 20 | 1-Jul Hook \& release | 1-Jan closed |
| Port Dufferin | 20 | 1-Jan | 1-Jan closed |
| Quoddy | 20 | 1-Jan | 1-Jan closed |
| Rocky Run Porters L. | 20 | 1-Jan | 1-Jan closed |
| Saint Francis | 20 | 1-Jan | 1-Jan closed |
| Saint Mary's | 20 | 1-Jan | 1-Jan closed |
| Salmon: Guysborough Co. | 20 | 18-Jun | 8-Jul Hook \& release |
| Salmon: Halifax Co. | 20 | 18-Jun | 8-Jul Hook \& release |
| Ship Hbr.L.Charlotte | 20 | 1-Jan | 1-Jan closed |
| Tangier | 20 | 18-Jun | 8-Jul Hook \& release |
| Taylor Bay Brook | 20 | 1-Jan | 1-Jan closed |
| Three Fathom Harbour Brook | 20 | 1-Jan | 1-Jan closed |
| West Sheet Harbour | 20 | 1-Jan | 1-Jan closed |
| Porters Lake (East Brook) | 20 | 1-Jan | 1-Jan closed |

Appendix 2. Atlantic salmon recreational fishing season openings and closings for 1999 in Salmon Fishing Area 21.

| River | SFA | Open | Closed $\quad$ Comments |
| :--- | ---: | ---: | ---: |
| Barrington | 21 | 1-Jan | 1-Jan closed |
| Broad | 21 | 1-Jan | 1-Jan closed |
| Clyde | 21 | 10-May | 30-Sep |
| East: Lunenburg Co. | 21 | 1-Jan | 1-Jan closed |
| Gold | 21 | 1-Jan | 1-Jan closed |
| Ingram | 21 | 1-Jan | 1-Jan closed |
| Jordan | 21 | 10-May | 30-Sep |
| LaHave | 21 | 10-May | 8-Jul Hook \& release until June 18 |
| Martins | 21 | 1-Jan | 1-Jan closed |
| Medway | 21 | 1-Jan | 1-Jan closed |
| Mersey | 21 | 10-May | 30-Sep |
| Middle: Lunenburg Co. | 21 | 1-Jan | 1-Jan closed |
| Mushamush | 21 | 18-Jun | 8-Jul daily limit 1 |
| Nine Mile | 21 | 1-Jan | 1-Jan closed |
| Petite Riviere | 21 | 1-Jan | 1-Jan closed |
| Roseway | 21 | 1-Jan | 1-Jan closed |
| Salmon: Digby Co. | 21 | 18-Jun | 8-Jul daily limit 1 |
| Sissiboo | 21 | 1-Jan | 1-Jan closed |
| Tusket | 21 | 18-Jun | 8-Jul daily limit 1 |
| Sackville | 21 | 1-Jan | 1-Jan closed |
| Meteghan | 21 | 1-Jan | 1-Jan closed |

Appendix 3. Atlantic salmon sportcatch and effort for Scotia-Fundy Region rivers, 1999 and 1998, contrasted with mean catches, 1994-98.

|  | 1999 Preliminary |  |  |  | 1998 |  |  |  | 1994-1998 means |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Grilse |  | Salmon |  | Grilse |  | Salmon |  |  | Grilse |  |  | Salm |  | Effor |  |
| River | retained | released | released | Effort | retained | released | released | Effort | retained | 95\% C.I. | released | 95\% C.I. | released | 95\% C.I. | roddays | 95\% C.I. |


| Salmon Fishing Area 20 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Clam Harbour |  |  |  |  |  |  |  |  |  | N/A |  | N/A |  | N/A |  | N/A |
| Cole Harbour |  |  |  |  |  |  |  |  | 0 | N/A | 0 | N/A | 0 | N/A | 1 | N/A |
| Country Harbour |  |  |  |  |  |  |  |  | 7 | N/A | 5 | 5 | 3 | N/A | 70 | N/A |
| East: Sheet Harbour |  |  |  |  | 0 | 0 | 0 | 7 | 6 | 15 | 1 | 4 | 0 | 1 | 93 | 134 |
| Ecum Secum |  |  |  |  |  |  |  |  | 8 | 14 | 10 | 14 | 2 | 3 | 195 | 136 |
| Gaspereau Brook |  |  |  |  |  |  |  |  | 0 | N/A | 0 | 0 | 0 | N/A | 4 | N/A |
| Guysborough |  |  |  |  |  |  |  |  | 1 | N/A | 0 | 0 | 2 | N/A | 10 | N/A |
| Halfway Brook |  |  |  |  |  |  |  |  | 1 | N/A | 0 | N/A | 0 | N/A | 13 | N/A |
| Isaac's Harbour |  |  |  |  |  |  |  |  | 1 | N/A | 1 | 1 | 0 | N/A | 17 | N/A |
| Kirby |  |  |  |  |  |  |  |  | 1 | N/A | 0 | N/A | 0 | N/A | 1 | N/A |
| Larry's |  |  |  |  |  |  |  |  |  | N/A |  | N/A |  | N/A |  | N/A |
| Lawrencetown Lake |  |  |  |  |  |  |  |  | 0 | N/A | 1 | 1 | 0 | N/A | 6 | N/A |
| Liscomb |  |  |  |  |  |  |  |  | 9 | 14 | 6 | 6 | 1 | 1 | 157 | 201 |
| Little Salmon |  |  |  |  |  |  |  |  | 0 | N/A | 11 | N/A | 7 | N/A | 65 | N/A |
| Moser |  |  |  |  |  |  |  |  | 20 | 46 | 19 | 22 | 0 | 0 | 265 | 357 |
| Musquodoboit | 0 | 2 | 2 | 4 | 0 | 13 | 9 | 29 | 34 | 60 | 57 | 105 | 62 | 64 | 711 | 921 |
| Necum Teuch |  |  |  |  |  |  |  |  |  | N/A |  | N/A |  | N/A |  | N/A |
| New Harbour |  |  |  |  |  |  |  |  | 10 | 16 | 3 | 3 | 0 | 0 | 78 | 99 |
| Port Dufferin |  |  |  |  |  |  |  |  | 5 | N/A | 1 | 1 | 0 | N/A | 59 | N/A |
| Porters Lake (East Brook) |  |  |  |  |  |  |  |  | 0 | N/A |  | N/A |  | N/A |  | N/A |
| Quoddy |  |  |  |  |  |  |  |  | 0 | N/A |  | N/A |  | N/A |  | N/A |
| Rocky Run Porters Lake |  |  |  |  |  |  |  |  | 0 | N/A |  | N/A |  | N/A |  | N/A |
| Saint Francis |  |  |  |  |  |  |  |  | 0 | N/A |  | N/A |  | N/A |  | N/A |
| Saint Mary's | 0 | 0 | 0 | 2 | 0 | 20 | 3 | 16 | 83 | 216 | 176 | 290 | 75 | 93 | 1296 | 1760 |
| Salmon: Guysborough Co. | 0 | 0 | 2 | 22 | 0 | 0 | 0 | 0 | 61 | 125 | 130 | 82 | 89 | 72 | 754 | 922 |
| Salmon: Halifax Co. |  |  |  |  |  |  |  |  | 1 | N/A | 0 | N/A | 0 | N/A | 7 | N/A |
| Ship Harbour Lake Charlotte |  |  |  |  |  |  |  |  | 4 | 10 | 1 | 3 | 1 | 3 | 116 | 183 |
| Tangier |  |  |  |  |  |  |  |  | 0 | N/A | 0 | 0 | 0 | N/A | 3 | N/A |
| West Sheet Harbour |  |  |  |  | 0 | 1 | 0 | 1 | 0 | 0 | 6 | 12 | 0 | 1 | 19 | 36 |
| Totals | 0 | 2 | 4 | 28 | 0 | 34 | 12 | 53 | 219 |  | 379 |  | 215 |  | 3490 |  |

Appendix 4. Preliminary Atlantic salmon sportcatch and effort for SFA 21 rivers, 1998 and 1997, contrasted with mean catches, 1993-97.

| River | 1999 Preliminary |  |  |  | 1998 |  |  |  | 1994-1998 means |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Grilse |  | $\frac{\text { Salmon }}{\text { released }}$ | Effort | $\begin{array}{r} \text { Grilse } \\ \hline \text { retained } \end{array}$ | released | $\frac{\text { Salmon }}{\text { released }}$ | Effort | Grilse |  |  |  | Salmon |  | Effort |  |
|  | retained | released |  |  |  |  |  |  | retained | 95\% C.I. | released | 95\% C.I. | released | 95\% C.I. | roddays | 95\% C.I. |
| Broad |  |  |  |  |  |  |  |  |  | N/A |  | N/A |  | N/A |  | N/A |
| Clyde | 7 | 0 | 2 | 233 |  | 30 | 5 | 360 | 22 | 18 | 5 | 7 | 7 | 5 | 500 | 253 |
| East: Lunenburg Co. |  |  |  |  |  |  |  |  | 0 | 0 | 0 | 1 | 1 | 1 | 14 | 29 |
| Gold |  |  |  |  |  |  |  |  | 115 | 87 | 18 | 17 | 35 | 36 | 1127 | 648 |
| Ingram |  |  |  |  |  |  |  |  | 3 | 3 | 2 | 3 | 5 | 10 | 121 | 117 |
| Jordan |  |  |  |  |  | 0 | 0 | 3 | 0 | 0 | 0 | N/A | 0 | 0 | 2 | 2 |
| LaHave | 7 | 49 | 27 | 226 |  |  |  |  | 536 | 564 | 143 | 197 | 216 | 124 | 5676 | 3362 |
| Martins |  |  |  |  |  |  |  |  |  | N/A |  | N/A |  | N/A |  | N/A |
| Medway |  |  |  |  |  |  |  |  | 176 | 251 | 17 | 22 | 53 | 34 | 2447 | 1258 |
| Mersey | 4 | 0 | 0 | 4 |  | 3 | 0 | 428 | 3 | 3 | 0 | 2 | 2 | 3 | 488 | 466 |
| Meteghan |  |  |  |  |  |  |  |  | 1 | N/A | 8 | 6 | 4 | N/A | 74 | N/A |
| Middle: Lunenburg Co |  |  |  |  |  |  |  |  | 5 | 7 | 3 | 2 | 0 | 1 | 25 | 28 |
| Mushamush | 0 | 0 | 0 | 2 |  |  |  |  | 9 | 11 | 1 | 2 | 1 | 1 | 78 | 111 |
| Nine Mile |  |  |  |  |  |  |  |  |  | N/A |  | N/A |  | N/A |  | N/A |
| Petite Riviere | 2 | 0 | 0 | 22 |  |  |  |  | 47 | 52 | 9 | 13 | 15 | 5 | 499 | 228 |
| Sackville |  |  |  |  |  | 03 | 0 | 15 | 17 | 26 | 20 | 48 | 3 | 8 | 345 | 452 |
| Salmon: Digby Co. |  |  |  |  |  |  |  |  | 30 | 51 | 3 | 6 | 15 | 28 | 258 | 293 |
| Tusket | 9 | 2 | 0 | 54 |  |  |  |  | 47 | 55 | 13 | 14 | 28 | 25 | 680 | 373 |
| Totals | 29 | 51 | 29 | 541 |  | 6 | 5 | 806 | 816 |  | 196 |  | 308 |  | 10117 |  |

