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Status of Atlantic Salmon Populations in Middle Barachois Brook and Robinsons River, Newfoundland in 2018

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

Atlantic Salmon (*Salmo salar*) stocks in Middle Barachois Brook and Robinsons River were assessed from visual counts by snorkelers, August 13-17, 2018. A raising factor, ranging from 1.0 to 1.2, was applied to the counts of salmon in each River Section to account for fish not counted (observer efficiency). The adjusted count for each river is an estimate of the total number of spawners. Egg depositions were calculated using mean weights, percent females and fecundity for small (<63 cm) and large (≥63 cm) salmon that had been updated from previous assessments. These updated biological characteristics were also applied to previous estimates of spawning escapements (1996-2008) to obtain revised estimates of egg deposition. The estimated numbers of spawners in Middle Barachois Brook in 2018 are 362 small salmon and 94 large salmon. Of these, 86% were located in seven pools. The total spawners (456) is the lowest number recorded in the 11 years that assessments were conducted (1996-2008), 14% lower than in 2008, and 49% below the average (1996-2008). The estimated egg deposition for Middle Barachois Brook was 39% of the lower Limit Reference Point (LRP) in 2018, the same as estimated for 2008, indicating a serious conservation issue. The estimated numbers of spawners for Robinsons River are 1,099 small salmon and 201 large salmon. Of these, 96% were found in 18 pools. The total number of spawners (1,300) is 36% lower than estimated in 2008, and 11% below the average (1996-2008). The egg deposition in 2018 is 70% of the LRP, and is 23% below the estimated % LPR in 2008. Applying the revised biological characteristics resulted in a 2-11% increase in the estimated egg deposition and % LRP for Middle Barachois Brook (1996-2008); but on Robinsons River the revised estimates resulted in 18-43% decrease in egg deposition and % LRP. The magnitude of these changes in % LRP highlights the importance of using river specific biological characteristics.

INTRODUCTION

Atlantic Salmon stocks in Bay St. George rivers declined in the 1970s (Porter and Chadwick 1983). Reddin and Mullins (1996) assessed the status of the salmon stocks using primarily angling data, and concluded that the spawning population sizes have been below conservation levels for most of the past 30 years. A number of recreational and commercial fisheries management measures were put in place to improve the spawning populations beginning in 1978 (Chadwick et al. 1978; Porter et al. 2002). Although there were some improvements in spawning populations, most stocks remained below their conservation levels (Bay St. George Seven Rivers Atlantic Salmon Conservation Working Group 2004).

Ideally, monitoring of the spawning escapement would be conducted using a fish counting fence or electronic fish counters. However, this is not practical on most Bay St. George rivers, due to very high discharge events and cost. Several rivers in Bay St. George are particularly suitable for enumerating Atlantic Salmon by snorkeling because:

1. There are no ponds or lakes on their main stems that are accessible to Atlantic Salmon;
2. Tributary streams are small and salmon do not usually migrate into the tributaries until fall after water levels have increased;
3. By the end of July most of the Atlantic Salmon have migrated into the rivers from the marine environment;
4. In August, Atlantic Salmon are primarily found in pools due low water levels and high water temperatures (20°C to 25°C); and,
5. Snorkelers can see the bottom of most pools.

Visual counts of salmon using snorkeling survey methodologies have been conducted on five rivers in Bay St. George 1996-2008, except for years when water levels were too high. Similar snorkel surveys have been used to count adult salmon in other Atlantic Provinces (DFO 2001, 2003, and 2012).

Assessments of Salmon stocks in Bay St. George rivers in 2008 concluded that:

> “Although there have been some improvements in the Bay St. George stocks -----the sizes of the stocks are still low, particularly the large salmon component…. Concern is expressed for Middle Barachois Brook, which only received 28% of its required egg deposition.” (DFO 2009a).

In 2018, the Bay St. George South Area Development Association conducted snorkel surveys of Middle Barachois Brook and Robinsons River to assess the status of salmon populations. This document assesses the status of these stocks based on the results of the surveys.

METHODS

SURVEY METHODOLOGY

Atlantic Salmon were visually counted using snorkel survey techniques in Middle Barachois Brook and Robinsons River August 13-17, 2018. The methodology used is described by Porter et al. (2017), and is consistent with methods used by DFO in previous surveys in these rivers (see Porter et al. 2002). A brief description of the methodology is as follows. Each river was divided into Sections (Fig. 1 and 2). The size of each River Section was determined by the distance that could be surveyed in one day (8 to 10 km), and proximity of access roads to the river at the beginning and ending of a Section. The rivers were further sub-divided into Cells, which are the 1 km grids as shown on 1:50,000 topographic maps, and consecutively numbered beginning with one (1) at the mouth of each river (Fig. 3). The purpose of recording the number of salmon in each Cell is for future reference of the locations where salmon are found and assessing the annual variation in distribution of salmon. The River Section and cell numbers are the same as those used by DFO in previous surveys. The river cells in each section are as follows:

Middle Barachois Brook

- Section 1 – Cells 1 to 8
- Section 2 – Cells 8 to 18
- Section 3 – Cells 18 to 28
- Section 4 – Cell 28 to 35
- Section 5 – Cell 35 to 46

Robinsons River

- Section 1 – Cells 1 to 12
- Section 2 – Cells 12 to 21
- Section 3 – Cells 21 to 32
- Section 4 – Cells 32 to 40

A survey crew, comprising of two to seven snorkelers and one or two assistants, was assigned to each River Section. The assistants were responsible for recording the data and assisting snorkelers as required. The number of snorkelers in a crew depended on the width of the pools in each Section. Generally, there would be one snorkeler every 3 m width of the pool. Each river was surveyed beginning with the uppermost Section. On Middle Barachois Brook the survey began at a waterfall in Cell 38 (Section 5); since few salmon are able to surmount the falls. On the last day of the survey, snorkelers surveyed River Cells 38, 39, and 44 above the waterfall to determine if any salmon had surmounted the falls. On Robinsons River the uppermost Section began at a waterfall impassable to salmon.

Snorkelers floated down each river wherever the water was sufficiently deep. However, due to low water levels and high temperatures almost all the salmon were found in pools. The general procedure for surveying a pool was for snorkelers to line up across the upstream end of a pool. Each snorkeler carried a rope approximately 3 m in length with a clip on each end. If the width of a pool required more than two or three snorkelers to visually cover the entire water column across the river, snorkelers would attach the clip of the rope that they were carrying to the rope of the adjacent snorkeler to form a snorkeler alignment rope (SAR). An assistant on each riverbank would hold the end of the SAR keeping the snorkelers in a straight line across the river, and slowly walk downstream to the end of the pool. Snorkelers would all look in the same direction across the river and count the salmon that passed under the rope between adjacent snorkelers. If snorkelers were unsure of the count, the pool would be surveyed a second or third time. Only occasionally did a pool need to be surveyed more than once.

There were two differences in the 2018 survey from previous surveys. One difference was the survey of the pool at the base of the falls on Robinsons River (Section 4). This pool is in a gorge and is too deep for snorkelers to see the bottom. In surveys conducted by DFO from 2001 to 2008, in addition to a SAR across the pool, a 6 m long rope, consisting of 3 m of nylon rope and a 3 m lead line was attached to the SAR at 2.5 m intervals and suspended vertically in the water column. Assistants kept the snorkelers in a straight line and pulled them downstream though the pool. This technique herded the salmon downstream into shallower water near the end of the pool. The salmon then swam upstream under the snorkelers, at which time they were counted. Higher numbers of salmon were counted when this technique was used. In 2018, no vertical lines were suspended in the water column; thus the number of salmon counted in this pool in 2018 was only a partial count.

A second difference was in Section 5, Middle Barachois Brook. In previous years the surveys began in Cell 38 below a waterfall, which is only surmountable by salmon at some water levels. In 2018, Cells 44, 39 and the portion of Cell 38 above the waterfall were also surveyed.

DATA RECORDED

In each River Section, the assistants consecutively numbered the pools where salmon were observed, beginning with Pool 1 at the beginning of each Section. The information collected at each pool included Pool number, River Cell number, GPS coordinates, numbers of large (≥63 cm) and small (<63 cm) salmon, number of salmon with net marks and scars, underwater visibility, maximum depth of the pool, number of snorkelers, and comments. The count of salmon in each pool was categorized as complete, estimated or partial. A complete count indicated that the snorkelers counted all the salmon in the pool; an estimated count indicated that the snorkelers saw all of the salmon in the pool, but because the salmon were too numerous to count individually or swam by too quickly, the number was estimated; a partial count indicated that the snorkelers could not see the bottom in parts of the pool or the pool was too wide and the crew could not span its entire width; therefore some salmon may have escaped detection.

TRAINING

The day prior to the survey was devoted to training. The entire team met in plenary and reviewed the safety issues related to the survey, procedures and techniques for conducting the survey, data recording, locations where salmon are likely to be seen, and behavior of the salmon. The in-class session was followed by in-river training. All snorkelers and assistants went to White Cliff Pool on Crabbes River and practiced techniques for surveying the pool, counting salmon, and recording information. Photos showing the technique used to survey White Cliff Pool during a training exercise are in Appendix I.

NUMBER OF SPAWNERS

A raising factor was applied to the number of salmon counted in each River Section to account for unobserved salmon. It was assumed that the likelihood of unobserved salmon was the same for small and large salmon. Thus, the same raising factor was applied to both categories. In experimental trails reported by Porter et al (2001 and 2002) snorkelers placed some of the large salmon into the small category, which would result in an underestimate of large salmon and over estimate of small salmon (Porter et al 2017). There was insufficient data available to make adjustments in these surveys.

Unobserved salmon may be due to the possibility that some salmon were in tributaries, and observer efficiency. Factors that affect observer efficiency are: water colour, turbulence, stream width and depth, velocity, light conditions, density of fish, and number and experience of snorkelers (Shardlow et al. 1987; Slaney and Martin 1987; Locke, 1997; Porter et al. 2001, 2017; Orell and Erkinaro 2007). Observation efficiencies will vary with habitat, river, and environmental conditions; thus, one raising factor cannot be applied to all River Sections (Porter et al. 2017). A study conducted by Orell et al (2011) found efficiency of snorkelers in pools was high ranging from 75-100%.

The raising factors used to adjust the counts of salmon in Middle Barachois Brook and Robinsons River were subjectively inferred, based on the river conditions and number of pools with partial counts in each River Section and discussions with snorkelers. The raising factors cannot be standardized due to differing physical conditions of pools, water clarity, and number of snorkelers. The rationale for each raising factor is provided in Appendix II.

The adjusted numbers of salmon are assumed to be the number of spawners in each river. There is no information available on mortalities or additional salmon entering the rivers after the surveys took place. Very few salmon are expected to enter these rivers after the end of July as indicated by local knowledge and angling data (Moores and Tucker 1981) and consistent with run timing for Harrys River, Bay St. George (Mullins et al. 1996).

CONSERVATION SPAWNING REQUIREMENTS, LOWER REFERENCE POINT, AND UPPER STOCK REFERENCE POINT

Conservation spawning requirements for Atlantic Salmon were based on an estimate of the numbers of eggs required for conservation of the stock (O'Connell and Dempson 1995). The egg deposition requirements for Middle Barachois Brook and Robinsons River were calculated by Reddin and Mullins (1996) as 2.1 million and 3.3 million eggs respectively, based on an egg deposition requirement of 2.4 eggs per m^2 of fluvial habitat and 368 eggs per hectare of lacustrine habitat. In 2017, DFO adopted two conservation reference points, a lower Limit Reference Point (LRP) and an Upper Stock Reference Point (USR), for managing Atlantic Salmon stocks (DFO 2018). These two reference points conform to the Precautionary Approach in DFO's Fisheries Decision Making Framework (DFO 2018).

Atlantic Salmon stock status is now assessed based on the proportion of the river-specific LRP and USR achieved. The lower LRP corresponds to the previously defined conservation egg requirement and the USR is defined as 150% of the previously defined conservation egg requirement (DFO 2018). For Middle Barachois Brook the lower LRP is 2.1 million eggs and the USR is 3.2 million eggs; and for Robinsons River the lower LRP is 3.3 million eggs and the USR is 5.0 million eggs.

EGG DEPOSITION AND PERCENT LOWER REFERENCE POINT

Egg depositions for Middle Barachois and Robinsons River were calculated for the adjusted numbers of salmon spawners using the formula:

*Egg deposition = (number of small salmon * mean weight * % females * eggs/kg) + (number of large salmon * mean weight * % females * eggs/kg)*

The values for mean weight, percent females and fecundity are those recommended by Veinott and Cochrane (2011) with the exception of the mean weight of large salmon in Middle Barachois Brook (Table 1). The mean weight of 2.94 kg for large salmon in Middle Barachois Brook is the weight calculated from the data in Appendix 6 of Porter (2000). The mean weight for small salmon in Middle Barachois Brook recommended by Veinott and Cochrane (2011) are the same as in (Porter 2000). However, they recommended using the mean weight (4.18 kg) and percent females (65%) of large salmon sampled in all Bay St. George rivers since 1992 rather than values for mean weight (2.94 kg) and percent females (94%) of the 34 salmon sampled in Middle Barachois Brook in 1998 (Porter 2000). Their rational was that even though the sample size was over 30 salmon, the values in Porter (2000) had not been observed in any other rivers in Bay St. George; and thus they may be inaccurate. Possible reasons given are:

the samples were taken in late August in one section of the river and may not be representative of the entire population; and, the fish were sexed externally. Veinott and Cochrane (2011) erred in rejecting the mean weight of large salmon sampled in 1998. Of the 34 fish sampled, only five weighed more than 3.0 kg. Thus a mean weight of 2.94 kg is more representative of the population of salmon in Middle Barachois Brook, and is used in this assessment. The lower mean weight in Middle Barachois Brook is most likely due to the early run timing (beginning in May) of large salmon entering the river.

The decision to accept or reject the percent (94%) female large salmon in Porter (2000) is problematic. Veinott and Cochrane (2011) rejected it on the bases that the sample may not be representative of the entire population, yet they accepted the values for small salmon from the same sampling. No rationale was given for why one was rejected, and the other not. There is no apparent reason why the percent large salmon is so high in the 1999 sample. The salmon were externally sexed; however, in late August the external sex characteristics should be sufficiently developed to distinguish between a male and female salmon by experienced samplers. Given the uncertainty, it is reasonable to use the lower percent female (65%) for large salmon (Veinott and Cochrane 2011) in the assessment; since, the larger value could over-estimate the egg deposition and lead to inappropriate fisheries management decisions.

The estimated egg depositions were used to calculate the percentage of the lower LRP achieved on Middle Barachois Brook and Robinsons River.

RESULTS AND DISCUSSION

MIDDLE BARACHOIS BROOK

The water level in Middle Barachois Brook during the survey was relatively low with water temperatures ranging from 20°C to 28°C. The underwater visibility was only fair ranging from 2 m to 3 m.

There were 312 small salmon (79%) and 81 large salmon (21%) counted in Middle Barachois Brook (Table 2a). Eighty-five percent of the salmon counted were located in Sections 3 and 4 (Table 2a). No salmon were located in Section 1. Salmon were concentrated in a small number of pools. Only seven pools contained >10 salmon; and these pools contained 86% of all salmon counted. The concentration of salmon in a small number of pools in 2018 is similar to that observed by Porter (2000), and Porter et al (2001 and 2002). In 2018, no salmon were observed upstream of the upper waterfall located in River Cell 38 (Section 5). The number of salmon counted in each River Cell in Middle Barachois Brook is provided in Appendix III. Scars were observed on five salmon.

The raising factors used to account for salmon not observed by snorkelers for River Sections in Middle Barachois Brook ranged from 1.0 to 1.20 with an average of 1.16 (Table 2a). The rationale for choosing each raising factor is provided in Appendix II. The adjusted numbers of fish are 362 small salmon and 94 large salmon for a total of 456 salmon (Table 2a). These are considered the total numbers of spawners in 2018.

Estimates of the number of spawners in Middle Barachois Brook 1996-2008 are available from Porter et al. (2002) and DFO (2009b). However, the estimated number of spawners in 2008 in DFO (2009b) had not been adjusted for unobserved fish; whereas, estimates for all other years had been adjusted. In order to make the estimates comparable, the average (1.14) of all raising factors used in previous surveys and in 2018 (Porter 1997 and 2000; Porter and Bourgeois 1998; Porter et al. 2001 and 2002; and DFO unpublished) was applied to the 2008 counts of small and large salmon. The revised numbers of spawners for 2008 are those shown in Table 3 and Figure 4.

The estimated total number (456) of salmon spawners in 2018 is the lowest in the time series (1996-2018) (Table 3, Fig 4). It is 14% lower than the number (529) of spawners in 2008, and 65% lower than the number (1,297) in 2000, and 49% below the average (896) for years 1996-2008. The annual percent large salmon spawners varied from 4% in 1996 and 2008 to 24% in 2002 (Table 3). The low number of spawners in 2018 is consistent with the decline in the salmon stock in Middle Barachois Brook reported in DFO (2009b). However, since there are no estimates of spawning stock size in the nine years between 2008 and 2018, it is not possible to conclude whether the declining trend is continuing.

The estimated egg deposition in Middle Barachois Brook, in 2018, is 818,579 eggs, which is 39% of its LRP (2,100,000 eggs). A revised % LRP achieved in previous surveys, 1996-2008, was calculated using the numbers of small and large salmon in Table 3, and the mean weight, percent females and fecundity used to calculate egg deposition in 2018. In all years except for 2002 the revised estimates are higher (2-11%) than the previous estimates (Table 4, Fig 5.). This is due to the higher fecundity used in the calculations. The lower revised value in 2002 is a result of a higher proportion of large salmon spawners, and the higher percent females for large salmon used in previous assessments.

The 39% LRP achieved in 2018 is 62% lower than the 103% LRP achieved in 2000; but it is the same as the % LRP in 2008 even though the total number of spawners (456) in 2018 is lower than the number (538) of spawners in 2008 (Table 4). This high percent is because there were more large salmon spawners in 2018 than in 2008 (Table 3). The continued low % LRP in Middle Barachois Brook is of concern.

A Working Group, consisting of local residents was established in 2009 to provide options for restoring the salmon stock in Middle Barachois Brook. The Group recognized the low survival of salmon at sea, which negatively affect returns of salmon to all Bay St. George rivers. In addition, they identified habitat changes and illegal fishing as the primary causes for the stock decline in Middle Barachois Brook, and recommended a strategy for stock rebuilding (unpublished). This strategy consisted of four interrelated components:

1. Fisheries management and enforcement;
2. Environment/habitat;
3. Community education and awareness; and
4. Stock assessment and monitoring. This strategy was not carried out.

ROBINSONS RIVER

The water level in Robinsons River during the survey was relatively low and water temperatures ranged from 20°C to 23°C. The underwater visibility was about 2 m. Most of the salmon were observed in pools.

There were 932 small (85%) and 169 large salmon (15%) counted in Robinsons River (Table 2b). Seventy-six percent (76%) of the salmon were counted in River Section 4 and 13% in River Section 3. The number of salmon counted in each River Cell is provided in Appendix IV. There were 18 pools that contained >10 salmon (Table 2b). The number of salmon in these pools accounted for 97% of all salmon observed. The high proportion of the spawners located in River Section 4 is possibly related to the early migration run timing (May-June) of some salmon to Robinsons River, and the high river discharge a couple of weeks prior to the survey. Scars were observed on five salmon. Some of the salmon observed in Section 1 appeared silvery or bright indicating recent entry into the river, possibly during the high discharge event a couple of weeks prior to the survey.

The raising factor used to account for salmon not observed by snorkelers in each River Section ranged from 1.05 to 1.20 with an average of 1.18 (Table 2b). The rationale for the raising factors is in Appendix II. The adjusted numbers of fish are 1,099 small salmon and 201 large salmon for a total of 1,300 salmon (Table 1). These are considered the total numbers of spawners in 2018.

Estimates of the number of small and large salmon spawners in Robinsons River in previous surveys, 1996-2008, are available from Porter et al. (2002) and DFO (2009b). Similar to Middle Barachois Brook, the estimated number of spawners for year 2008 in DFO (2009b) had not been adjusted for unobserved fish, whereas estimates for all other years had been adjusted. In order to make the estimates comparable, the average (1.16) of all raising factors used in previous surveys and in 2018 (Porter 1997 and 2000; Porter and Bourgeois 1998; Porter et al. 2001 and 2002; and DFO unpublished) was applied to the 2008 counts. The revised numbers of spawners are in Table 3 and Figure 6. The annual estimates of spawners are quite variable, ranging from 888 in 1996 to 2,020 in 2008, with an average of 1,468 spawners (1996-2008) (Table 3). The estimated total number (1,300) of salmon spawners in 2018 is 36% lower than the estimate in 2008, and 11% below the average, 1996-2008. The percent large salmon is also quite variable, ranging from 5% in 2008 to 21% in 2002 with an average of 13% (1996-2008) (Table 3).

The estimated egg deposition for Robinsons River in 2018 is 2,304,308, which is 70% of its LRP (3,300,000 eggs). The percent LRP achieved in previous surveys, 1996-2008, was calculated using the numbers of small and large salmon in Table 3, and the mean weight, percent females and fecundity used to calculate egg deposition in 2018 (Table 1). The revised percent LRPs are lower than the previously calculated percent LRPs in all years due to the use of lower mean weights, and lower percent females for large and small salmon (see Table 8 in Veinott and Cochrane 2011). The 70% LRP achieved in 2018 is 23% lower than the 91% LRP in 2008, and 29% lower than the 99% LRP in 2001, which was the highest percentage achieved in the time series (Table 4).

The differences between the previous and the revised percent LRP ranges from 18% to 43%. This large change in % LRP highlights the importance of having reliable river specific biological characteristic data for salmon stocks being assessed.

There is no information available to explain the high annual variability in numbers of spawners or egg deposition.

CONCLUSIONS AND RECOMMENDATIONS

There were an estimated 456 spawners in Middle Barachois Brook in 2018 which is the lowest in the 11 years (1996-2018) that the spawning populations were estimated. The number of spawners in 2018 was 14% lower than in 2008 (the most recent estimate prior to 2018), and 65% below the estimated number of spawners in 2000. The egg deposition in middle Barachois Brook is at a critically low level at 39% of its LRP.

There were an estimated 1,300 Atlantic Salmon spawners in Robinsons River in 2018; which is 36% lower than the number of spawners in 2008 and 11% below the average, 1996-2008. The estimated egg deposition in 2018 is 70% of its LRP. The stock has not achieved its LRP in any of the 11 years assessed (1996-2018). The revised biological characteristic used to estimate the egg depositions in Robinsons River has greatly reduced the estimates of egg depositions and percent LRPs achieved.

There are a number of uncertainties in the assessment. These include:

1. The raising factor, which is used to increase the counts of salmon by snorkelers is subjective; and
2. The biological characteristic may not represent those in the actual populations.

RECOMMENDATIONS

- It is recommended that the mean weight of 2.94 kg for large salmon be used in for estimating egg deposition in Middle Barachois Brook until more sampling has been done.
- Biological characteristics data should be collected on both Middle Barachois Brook and Robinsons River to decrease the uncertainty in the estimates of egg deposition. External sex determination should be evaluated for accuracy.
- Observation efficiency should be better quantified so that the raising factors applied to the counts of salmon would be less subjective.
- Conservation and stock improvement measures (such as, habitat improvement and fish passage) should be undertaken to increase the spawning success in Middle Barachois Brook since the spawning stock is at critically low level and may be declining.
- Research should also be undertaken to better understand why the spawning population in Robinsons River undergoes such wide annual variation.

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REFERENCES CITED

Bay St. George Seven Rivers Atlantic Salmon Working Group. 2004. Bay St. George Seven Rivers Atlantic Salmon conservation/recovery strategy. Final Report. i + 60 p.

Chadwick, E.M.P., Porter, R. and D. Reddin. 1978. Atlantic Salmon management program, Newfoundland and Labrador, 1978. Atl. Salmon J. 1978(1): 9-15.

DFO. 2001. Proceedings of the Atlantic Salmon Stock Assessment Peer Review for the Maritime Provinces for 2000. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2001/039.

DFO. 2003. Atlantic Salmon Maritime Provinces Overview for 2002. DFO Science Stock Status Rept. 2003/026

DFO. 2009a. Stock Assessment of Newfoundland and Labrador Atlantic Salmon – 2008. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/063.

DFO. 2009b. Proceedings of the Newfoundland and Labrador Region Salmonid Stock Assessment Meeting; November 6-7, 2008. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2009/026.

DFO. 2012. Stock Status of Atlantic Salmon (Salmo salar) in DFO Gulf Region (Salmon Fishing Areas 15 to 18). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/040.

DFO. 2018. Stock Assessment of Newfoundland and Labrador Atlantic Salmon – 2017. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/034. (Erratum: September 2018)

Locke, A. 1997. Precision of diving and canoe-based visual estimates of Atlantic Salmon (*Salmo salar*) abundance. Fish. Res. 29: 283-287.

Moores, B.R., and R.J. Tucker. 1981. Angling catch and effort data in the Atlantic salmon recreational fishery, Newfoundland and Labrador, 1980. Can. Data Rep. Fish. Aquat. Sci. 260: xiv+85p.

Mullins, C.C., Downer, D.F., and S.L. Lowe. 1996. The status of the Atlantic salmon stock on Harry's River/Pinchgut Brook, Newfoundland, 1995. DFO Atlantic Fish. Res. Doc. 96/68.

O'Connell, M.F., and J.B. Dempson. 1995. Target spawning requirements for Atlantic Salmon, *Salmo salar* L., in Newfoundland rivers. Fish. Manage. Ecol. 2: 161-170.

Orell, P., and J. Erkinaro. 2007. Snorkelling as a method of assessing spawning stock of Atlantic Salmon, *Salmo salar.* Fish. Manage. Ecol. 14: 199-208.

Orell, P., Erkinaro, J., and P. Karppinen. 2011. Accuracy of snorkelling counts in assessing spawning stock of Atlantic salmon, *Salmo salar,* verified by radio-tagging and underwater video monitoring. Fish. Manage. Ecol. 18: 392-399.

Porter, T.R. 1997. Status of Atlantic Salmon (*Salmo salar* L.) Populations in Crabbes, Robinsons and Middle Barachois Rivers, Bay St. George, Newfoundland, 1996. DFO Can. Sci. Advis. Sec. Res. Doc. 97/43.

Porter, T.R. 2000. Status of Atlantic Salmon (*Salmo salar* L.) populations in Crabbes and Robinsons rivers, and Middle Barachois, Fischells, and Flat Bay Brooks, Newfoundland, 1999. DFO Can. Sci. Advis. Sec. Res. Doc. 2000/042.

Porter, T.R., and C.E. Bourgeois. 1998. Stock status of Atlantic Salmon (*Salmo salar* L.) in Crabbes, Robinsons and Middle Barachois Rivers, Bay St. George, Newfoundland, 1997. DFO Can. Sci. Advis. Sec. Res. Doc. 98/112.

Porter, T.R., and E.M.P Chadwick. 1983. Assessment of Atlantic Salmon stocks in Statistical Area K and L, western Newfoundland, 1982. CAFSAC Res. Doc. 83/87.

Porter, T.R., Clarke, G., and J. Murray. 2001. Status of Atlantic Salmon (*Salmo salar* L.) Populations in Crabbes and Robinsons Rivers, and Middle Barachois, Fischells, and Flat Bay Brooks, Newfoundland, 2000. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/037

Porter, T.R., Clarke, G., and J. Murray. 2002. Status of Atlantic Salmon (*Salmo salar* L.) Populations in Crabbes and Robinsons rivers, and Middle Barachois, Fischells, and Flat Bay brooks, Newfoundland, 2001. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/029

Porter, T.R., Clarke, G., and J. Murray. 2017. Underwater Visual Survey Methodology used to Count Atlantic Salmon (*Salmo salar*) in Rivers in St. Georges Bay, Newfoundland. DFO Can. Tech. Rept. Fish. Aquat. Sci. 3126: iv+ 51 p.

Reddin, D.G., and C.C. Mullins. 1996. Status of Atlantic Salmon (*Salmo salar* L.) stocks in eleven rivers in Bay St. George (SFA 13) Newfoundland, 1994. DFO Atl. Fish. Res. Doc. 96/86.

Shardlow, T., Hilborn, R., and D. Lightly. 1987. Components analysis of instream escapement methods for Pacific salmon (*Oncorhynchus* spp.). Can. J. Fish. Aquat. Sci. 44: 1031-1037.

Slaney, P.A., and A.D. Martin. 1987. Accuracy of underwater census of trout populations in a large stream in British Columbia. N. Am. J. Fish. Mange. 7:117-122.

Veinott, G., and N. Cochrane. 2011. New Estimates of Whole Weight, Percent Females and Fecundity for use in Determination of Conservation Status of Atlantic Salmon (*Salmo salar*) in Assessed Rivers in Bay St. George Area (SFA 13). DFO Can. Sci. Advis. Sec. Res. Doc. 2011/006. iv + 9 p.

TABLES

Table 1. Biological characteristics used to estimate the egg deposition in Middle Barachois Brook and Robinsons River in 2018.

River	Small Salmon			Large Salmon		
	Wt (kg)	% Females	Eggs/kg	Wt (kg)	% Females	Eggs/kg
M Barachois Bk	1.46	54	1,880	2.94	65	1,570
Robinsons R	1.49	47	1,880	4.18	65	1,570

Table 2a. Number of small and large salmon counted in Middle Barachois Brook, August 2018.

River	# pools	Unadjusted Count		Raising	Adjusted Count			Percent of Total	Percent
Section	**>10 fish**	**Small**	**Large**	**Factor**	**Small**	**Large**	**Total**	**-**	**Large**
1	0	0	0	1.00	0	0	0	0	-
2	0	14	3	1.10	15	3	19	4	17.6
3	4	155	44	1.20	186	53	239	52	22.1
4	2	109	28	1.10	120	31	151	33	20.4
5	1	34	6	1.20	41	7	48	11	15.0
TOTAL	**7**	**312**	**81**	**1.16**	**362**	**94**	**456**	**-**	**20.6**

Table 2b. Number of small and large salmon counted in Robinsons River, August 2018.

River	# pools	Unadjusted Count		Raising	Adjusted Count			Percent of Total	Percent
Section	**>10 fish**	**Small**	**Large**	**Factor**	**Small**	**Large**	**Total**	**-**	**Large**
1	1	85	9	1.10	94	10	103	8	9.6
2	1	28	2	1.05	29	2	32	2	6.7
3	6	139	13	1.15	160	15	175	13	8.6
4	10	680	145	1.20	816	174	990	76	17.6
TOTAL	**18**	**932**	**169**	**1.18**	**1,099**	**201**	**1,300**	**-**	**15.5**

Table 3. Adjusted numbers[1] of Atlantic Salmon spawners and per cent large salmon in Middle Barachois and Robinsons River 1996-2018.

Year	M. Barachois Brook				Robinsons River			
	Small	Large	Total	% Large	Small	Large	Total	% Large
1996	805	36	841	4	768	120	888	14
1997	1,044	182	1,226	15	1,017	172	1,189	14
1999	560	66	626	11	1,399	200	1,599	13
2000	1,142	155	1,297	12	1,293	316	1,609	20
2001	934	141	1,075	13	1,776	219	1,995	11
2002	515	160	675	24	758	198	956	21
2003	733	101	834	12	1,066	173	1,239	14
2004	1,078	96	1,174	8	1,811	159	1,970	8
2005	590	97	687	14	1,114	98	1,212	8
2008[1]	508	21	529	4	1,909	111	2,020	5
2018	362	94	456	21	1,099	201	1,300	15
Mean 1996-2008	791	106	896	12	1,291	177	1,468	13

[1] Numbers of spawners for 1996 and 1997 are from Porter et al (2002). Spawners from 1999 to 2008 are from DFO (2009b). In these references the numbers of spawners had been adjusted to account for unobserved salmon except in 2008. Therefore, a raising factor of 1.16 was applied to the spawners in Middle Barachois Bk and a raising factor of 1.18 was applied to spawners in Robinsons R for 2008.

Table 4. Revised egg deposition and previous (Prev) and revised (Revis) % LRP in Middle Barachois Brook and Robinsons River 1996-2018.

Year	Middle Barachois Brook			Robinsons River		
	Revised Eggs	Prev % LPR	Revis % LRP	Revised Eggs	Prev % LPR	Revis % LRP
1996	1,301,174	52	62	1,523,004	67	46
1997	2,093,458	95	100	2,072,644	91	63
1999	1,028,045	43	49	2,695,011	118	82
2000	2,164,698	95	103	3,050,275	135	92
2001	1,807,405	80	86	3,272,404	142	99
2002	1,243,372	61	59	1,842,562	82	56
2003	1,389,474	61	66	2,141,422	94	65
2004	1,885,829	79	90	3,062,542	132	93
2005	1,165,519	52	56	1,884,690	81	57
2008	815,959	28	39	2,986,812	110	91
2018	818,579	-	39	2,304,308	-	70

Year	Middle Barachois Brook			Robinsons River		
	Revised Eggs	Prev % LPR	Revis % LRP	Revised Eggs	Prev % LPR	Revis % LRP
Mean 1996-2008	1,489,493	65	71	2,453,137	105	74

FIGURES

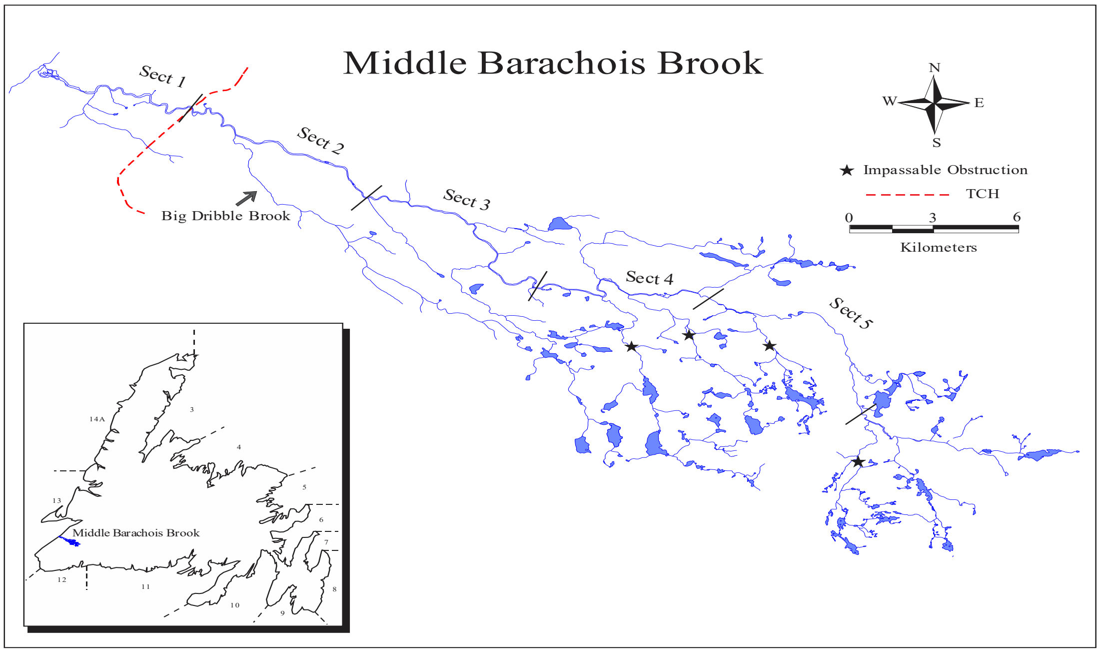

Figure 1. Map of Middle Barachois Brook showing River Sections used in snorkel surveys.

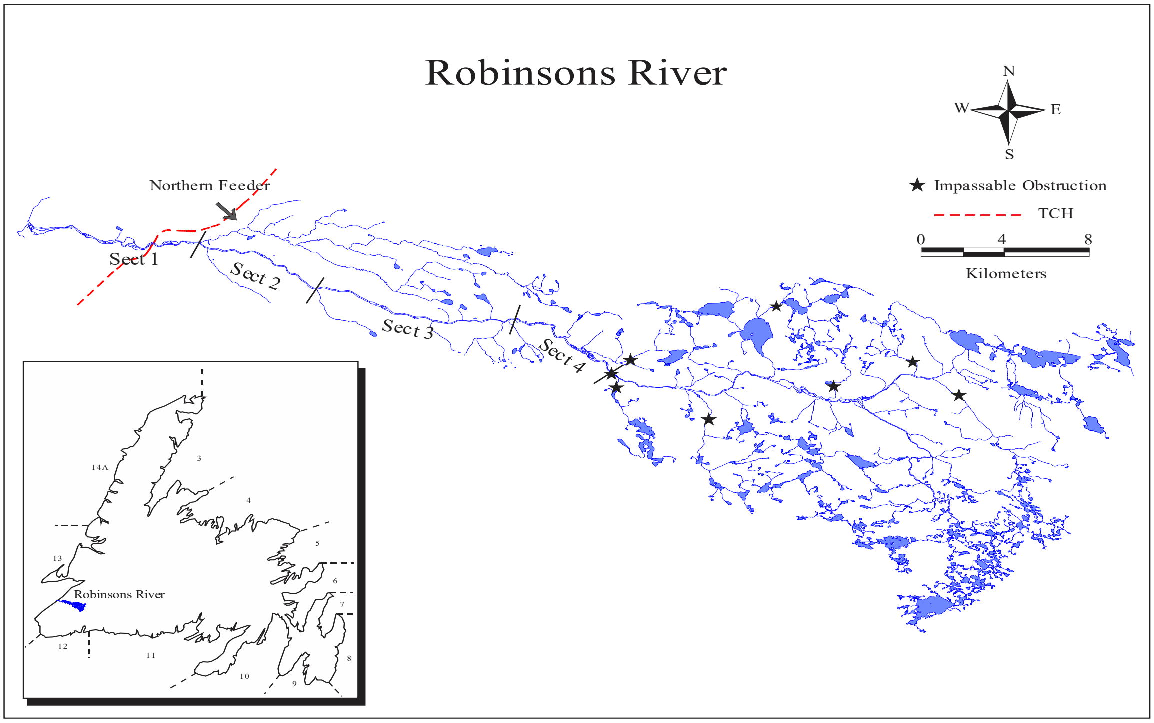

Figure 2. Map of Robinsons River showing River Sections used in snorkel surveys.

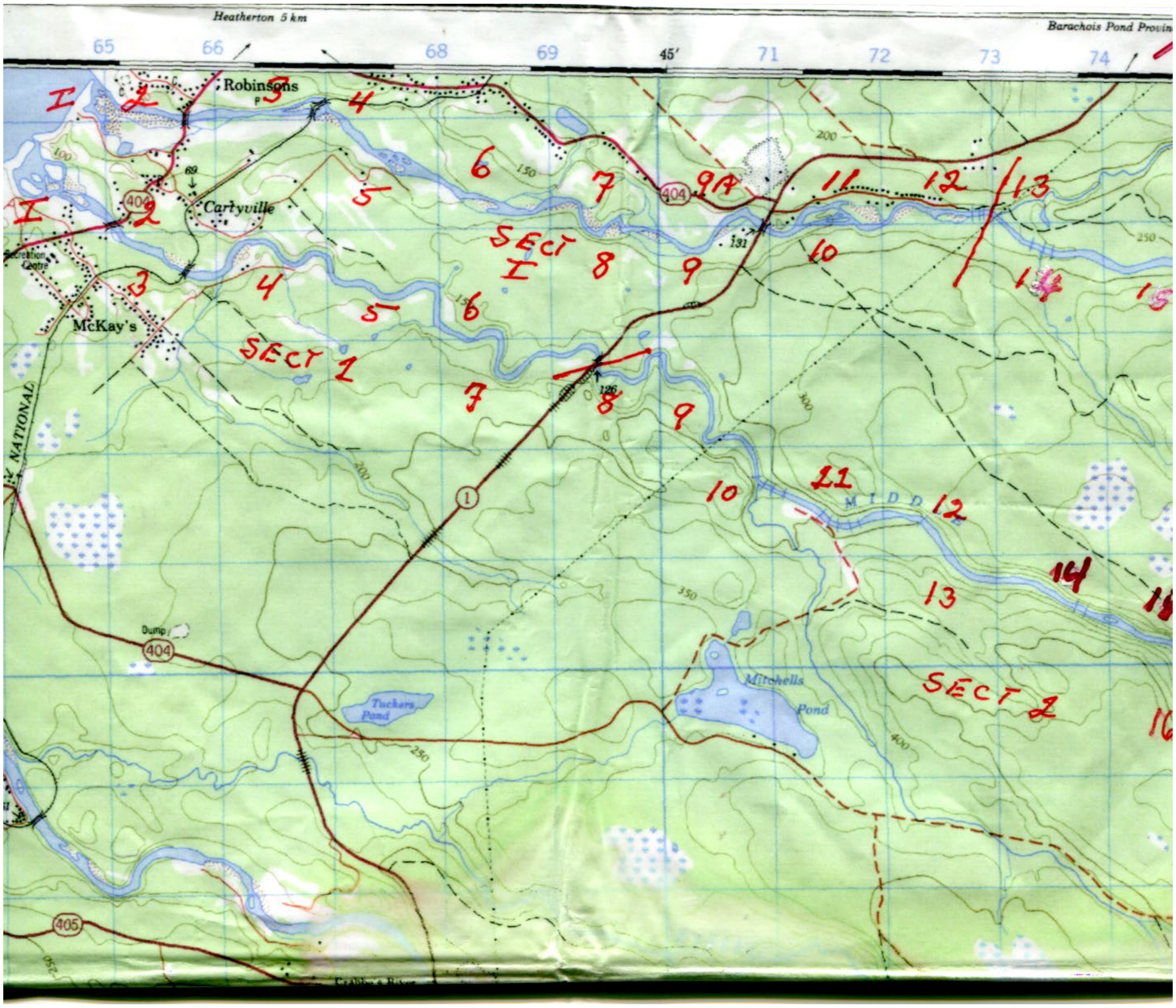

Figure 3. Map showing River Cells on lower portion of Middle Barachois Brook and Robinsons River.

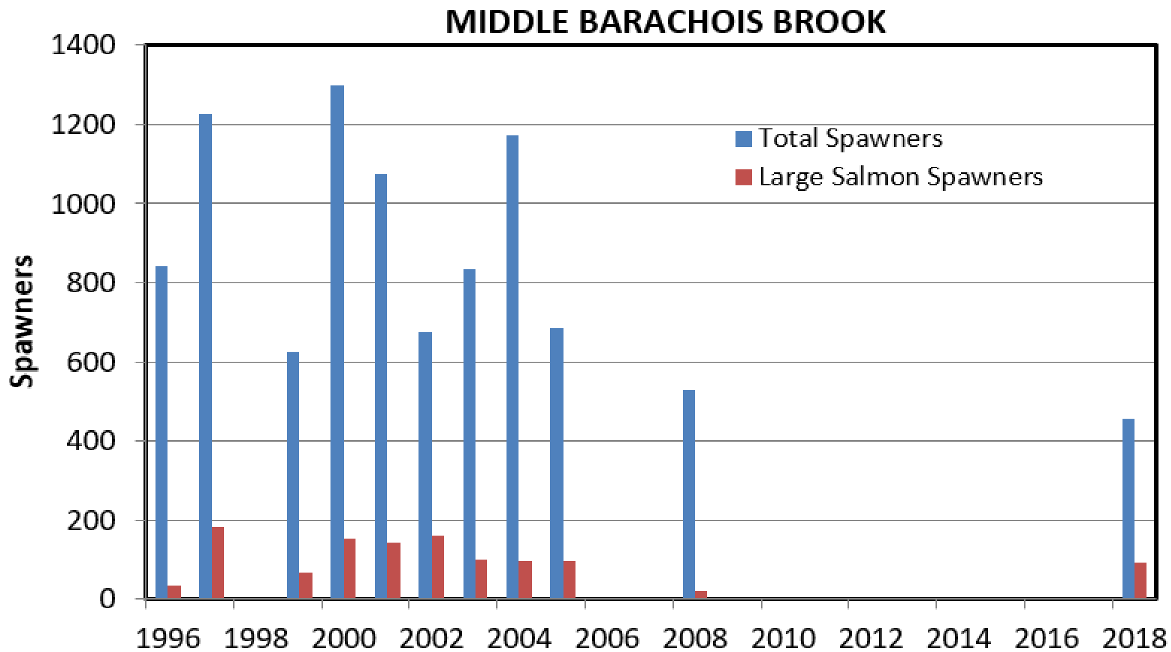

Figure 4. The adjusted total numbers of Atlantic Salmon spawners and numbers of large salmon spawners in Middle Barachois Brook, 1996-2018.

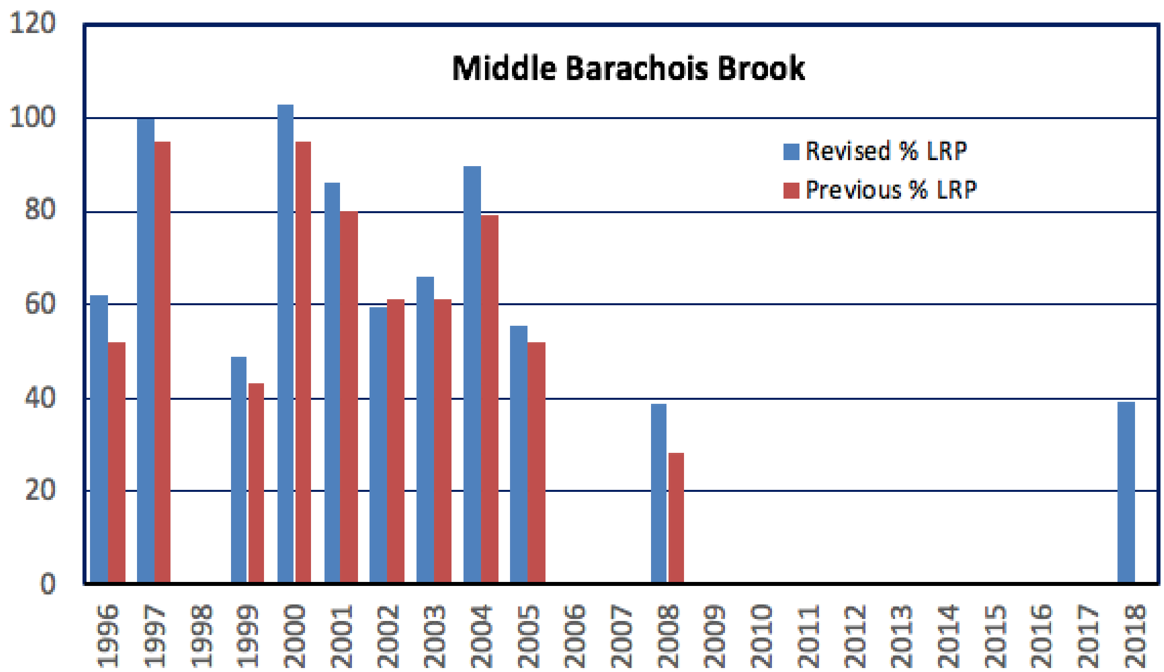

Figure 5. Revised and previous egg deposition as a percent of the LR) for Middle Barachois Brook 1996-2018. Numbers above the bars are the percentages.

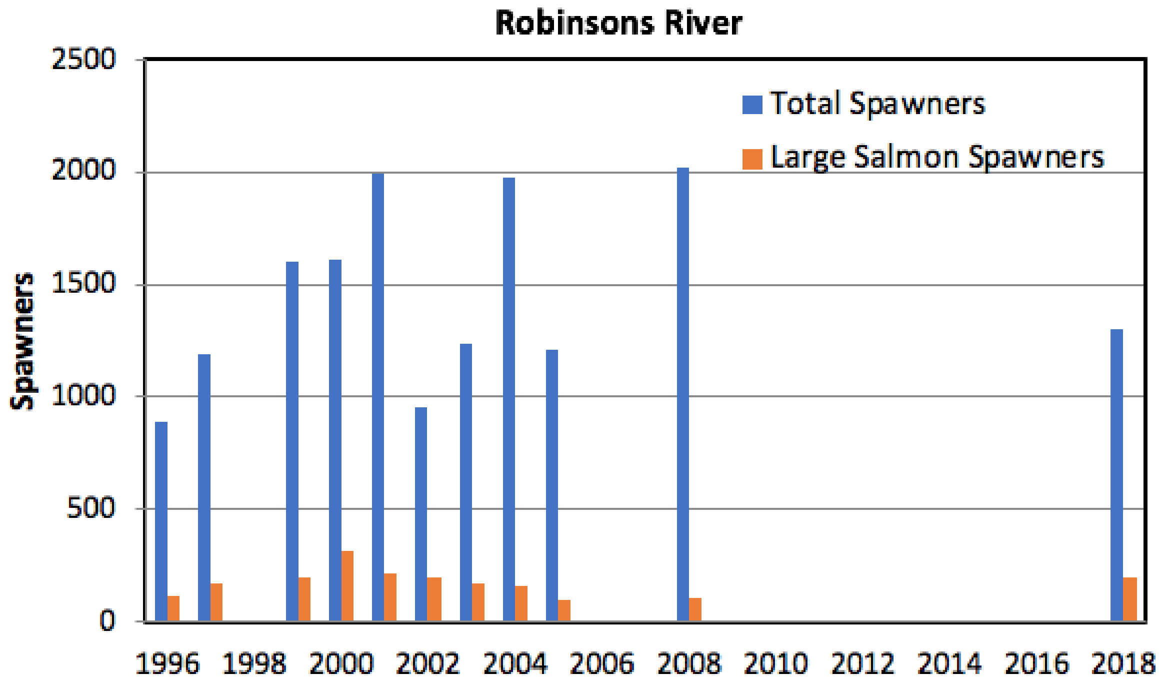

Figure 6. The adjusted total numbers of Atlantic Salmon spawners and numbers of large salmon spawners in Robinsons River, 1996-2018.

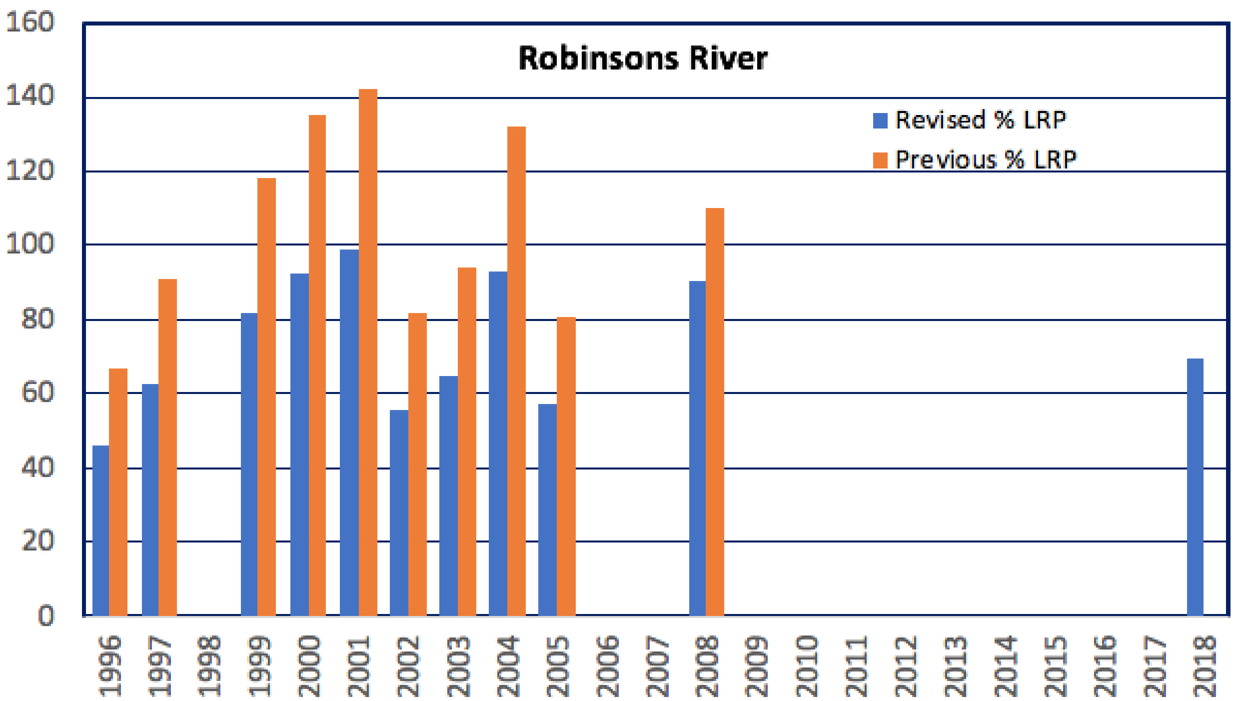

Figure 7. Revised and previous egg deposition as a percent of the LRP for Robinsons River 1996-2018.

APPENDIX I – TRAINING EXERCISE AT WHITE CLIFF POOL, CRABBES RIVER

Figure 1. Snorkelers and assistants preparing to survey pool.

Figure 2. Snorkelers lined up along a SAR counting Atlantic Salmon.

Figure 3. Snorkeler holding a SAR looking to the right, and can view the bottom and the snorkeler to the right.

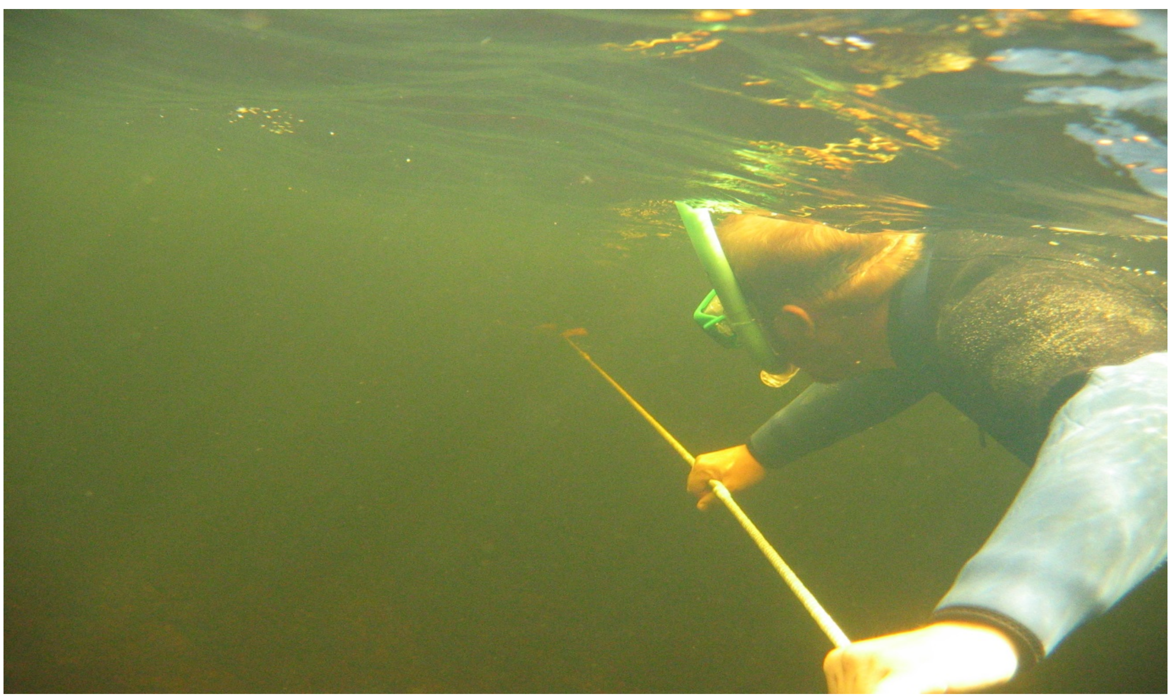

Figure 4. Snorkeler holding a SAR looking to the right, and can view the bottom and the snorkeler to the right.

APPENDIX II – RATIONALE

Rationale for choosing the raising factors used to adjust the numbers of salmon counted in the snorkeling survey on Middle Barachois Brook and Robinsons River, August 2018 to account for salmon that were not observed by snorkelers. The raising factors are subjectively inferred from the river conditions, number of pools with partial counts in each River Section and discussions with snorkelers. The raising factors cannot be standardized due to differing physical conditions of pools, water clarity, and number of snorkelers.

Middle Barachois Brook:

Section 1: Raising Factor – 1.00

No salmon observed. All pools were surveyed. Water level was low and visibility was fair.

Section 2: Raising Factor – 1.10

Salmon were only found in three pools. Water level was low and visibility was fair (2-3 m). One small tributary flows into this section.

Section 3: Raising Factor – 1.20

A partial count was obtained in three of seven pools; all other pools had complete counts. Visibility was poor, approximately 1-3 m. There were five snorkelers and two pools should have had additional snorkelers. Sands Pool was difficult to survey due to its depth and configuration. There may be some salmon in tributaries.

Section 4: Raising Factor – 1.10

All salmon were in five pools. The visibility was only fair (~2m). There were complete counts in all pools where salmon were seen; however in a couple of pools no salmon were seen but the pools were wide, deep and visibility was low. There may have been some salmon missed in tributaries.

Section 5: Raising Factor – 1.20

Salmon were observed in two pools; one of which was too deep to ensure a complete count. Also, there were a couple of deep dark pools, in which there may have been salmon; but no salmon were seen. Only a portion of Section 5 was surveyed.

Robinson's River:

Section 1 Raising Factor – 1.10

Majority of fish was seen in one of four pools. A partial count was made in pool and visibility was fair. There may have been a few fish missed in tributaries.

Section 2: Raising Factor – 1.05

Salmon were only counted in one pool. Visibility was only fair.

Section 3: Raising Factor – 1.15

There was a partial count in three of nine pools. Some salmon were in runs and among boulders, which made detection difficult. Some salmon were in runs with large boulders, which made counting salmon difficult.

Section 4: Raising Factor – 1.20

Counts were considered partial in one of seven pools and were estimated in two pools. The large pool at the base of the falls was too deep to see the bottom. Unlike previous years (2001-2008) no suspended lead-lines were used to crowd salmon towards the shallow downstream end of the pool. The application of this technique appeared to result in a larger count of salmon. Therefore a raising factor of 1.20 was used in 2018.

APPENDIX III – NUMBER OF LARGE AND SMALL ATLANTIC SALMON, BY POOL AND SECTION

Counted on Middle Barachois Brook August 14-17, 2018

Section	Cell	Pool	No. of Snorkelers	Count[1] Accuracy	Large Salmon	Small Salmon	Pool Total Lg+Sm	Section Total Large	Section Total Small	Section Total Lg+Sm
5	44, 39	-	2	C	0	0	0	-	-	-
5	38	1	3	P	6	30	36	-	-	-
5	37	2	3	C	0	4	4	**6**	**34**	**40**
4	35	1	3	C	0	5	5	-	-	-
4	34	2	3	C	0	4	4	-	-	-
4	32	3	3	C	2	19	21	-	-	-
4	31	4	1	C	1	3	4	-	-	-
4	30	5	3	C	25	78	103	**28**	**109**	**137**
3	28	1	8	P	11	58	69	-	-	-
3	26	-	1	C	0	1	1	-	-	-
3	25	2	5	C	2	27	29	-	-	-
3	25	3	5	NR	0	7	7	-	-	-
3	25	4	5	C	30	45	75	-	-	-
3	23	5	5	P	0	16	16	-	-	-
3	22	6	NR	NR	1	1	2	**44**	**155**	**199**
2	18	1	4	P	0	1	1	-	-	-
2	15	2	4	C	1	8	9	-	-	-
2	11	3	4	C	0	1	1	-	-	-
2	10	4	2	C	2	4	6	**3**	**14**	**17**
1	8-1	-	3	C	0	0	0	**0**	**0**	**0**
-	-	-	-	-	-	-	**Total**	**81**	**312**	**393**

[1] c= Complete count; e = Estimated count; p= Partial count; NR = Not recorded

APPENDIX IV – NUMBER OF LARGE AND SMALL ATLANTIC SALMON, BY POOL AND SECTION

Counted on Robinsons River, August 14-25, 2018

Section	Cell	Pool	Number of Snorkelers	Count[1] Accuracy	Large Salmon	Small Salmon	Pool Total Lg+Sm	Section Total Large	Section Total Small	Section Total Lg+Sm
4	40	1	7	P	2	22	24	-	-	-
4	38	2	7	C	3	9	12	-	-	-
4	37	3	7	C	0	97	97	-	-	-
4	36	4	7	C	2	18	20	-	-	-
4	36	5	7	C	0	2	2	-	-	-
4	36	6	7	C	0	3	3	-	-	-
4	36	7	7	C	16	23	39	-	-	-
4	36	8	7	C	3	26	29	-	-	-
4	35	9	7	C	0	4	4	-	-	-
4	34	10	7	C	0	19	19	-	-	-
4	34	11	7	C	5	89	94	-	-	-
4	33	12	7	E	30	100	130	-	-	-
4	32	13	7	E	84	268	352	**145**	**680**	**825**
3	31	1	1	C	0	2	2	-	-	-
3	31	2	3	C	0	5	5	-	-	-
3	31	3	3	C	0	1	1	-	-	-
3	31	4	3	C	2	25	27	-	-	-
3	29	5	3	C	3	33	36	-	-	-
3	27	6	3	C	1	4	5	-	-	-
3	27	7	4	P	1	13	14	-	-	-
3	25	8	4	P	0	28	28	-	-	-
3	25	9	3	C	5	13	18	-	-	-
3	21		2	C	1	15	16	**13**	**139**	**152**
2	14	1	2	C	2	28	30	**2**	**28**	**30**
1	12	1	3	C	9	71	80	-	-	-
1	12	2	3	C	0	8	8	-	-	-
1	9	3	3	C	0	1	1	-	-	-
1	6	4	3	P	0	5	5	**9**	**85**	**94**
-	-	-	-	-	-	-	**Total**	**169**	**932**	**1,101**

[1] c= Complete count; e = Estimated count; p= Partial count