NB Salmon Council – Reasons for Support of CAST's Smolt-to-Adult-Supplementation Project

The following explains in detail why we support a continuation of the Coalition for Atlantic Salmon Tomorrow's (CAST's) Smolt-to-Adult Supplementation (SAS) program on the Northwest / Little Southwest Miramichi River systems.

We, the New Brunswick Salmon Council (NBSC) have grave concerns about the progressively decreasing wild Atlantic salmon population of the greater Miramichi system, particularly of the sub-populations of the Northwest (NW) and Little Southwest (LSW) Miramichi drainages.

The NBSC Fisheries Committee has compiled, reviewed and interpreted the data from the Atlantic Salmon Federation (ASF), the Department of Fisheries and Oceans (DFO) and the NB Department of Energy and Resource Development (NBDERD) on striped bass populations, wild Atlantic salmon returns and smolt survival. According to documents provided by DFO in January 2019 to the Recreational Fisheries Advisory Committee, the number of eggs deposited by spawning salmon was below the Limit Reference Point of the Precautionary Approach on the NW/LSW Miramichi River composite in 2018. Low egg deposition resulting from year-over-year declines in wild Atlantic salmon returns has also occurred for several years prior to this. Despite DFO's opinion to the contrary, it is the NBSC's strongly supported belief that predation by the huge proliferation of striped bass spawning in the Northwest Miramichi estuary that is the major contributor to this rapid decline. The decline in salmon and grilse returns is illustrated in Figure 1. (Extensive evidence for the role of striped bass in the decline in salmon returns is provided in Appendix A.) In the estuary and high seas, the increased striped bass population acts cumulatively with other mortality factors such as seals, and harvests by humans to increase post-smolt mortality thus resulting in the decreasing egg deposition trends that we now see.

Atlantic Salmon Federation (ASF)-led research (Chaput et. al., 2018) has determined that, from 2013 to 2017 inclusively, Northwest Miramichi post-smolt (smolt) mortality, just within the Miramichi estuary (i.e. between the head-of-tide and Portage Island at the mouth of Miramichi Bay) has averaged 63%. Mortality within the estuary was only 29% from 2003 to 2008. (Please refer to Appendix A for information on these numbers.) Additionally, there is anecdotal evidence that striped bass are also preying heavily on juvenile salmon parr and brook trout in the upland reaches of the drainage, as well as on vital forage species such as smelt.

If the spawning population of bass continues to remain above 100,000, the downward trend in (largely female) multi-sea-winter salmon (MSWs) suggests that resulting egg deposition will rapidly decline. Figure 1, which depicts annual MSW and grilse counts at the salmon protection barrier on the Northwest Miramichi, also demonstrates the rapid response of grilse returns to changes in annual bass densities, changes that MSWs are somewhat buffered from because of repeat spawning. Keep in mind also that recent barrier counts are augmented in comparison with previous years because of Catch & Release in the angling fishery and decreased harvest in the First Nations' Food, Social, and Ceremonial fisheries.

This information indicates that the wild Atlantic salmon are rapidly descending to numbers at which the Northwest and Little Southwest Miramichi sub-populations may start to exhibit depressed population phenomenon, commonly called "the Extinction Vortex". At these levels, DFO would be tempted to do what they have done in the past – i.e. river closure as evidenced by the Nashwaak, Tobique, and Hammond rivers within the greater St. John River (Wolastoq) system. These closures have had little-to-no success in rebuilding populations.

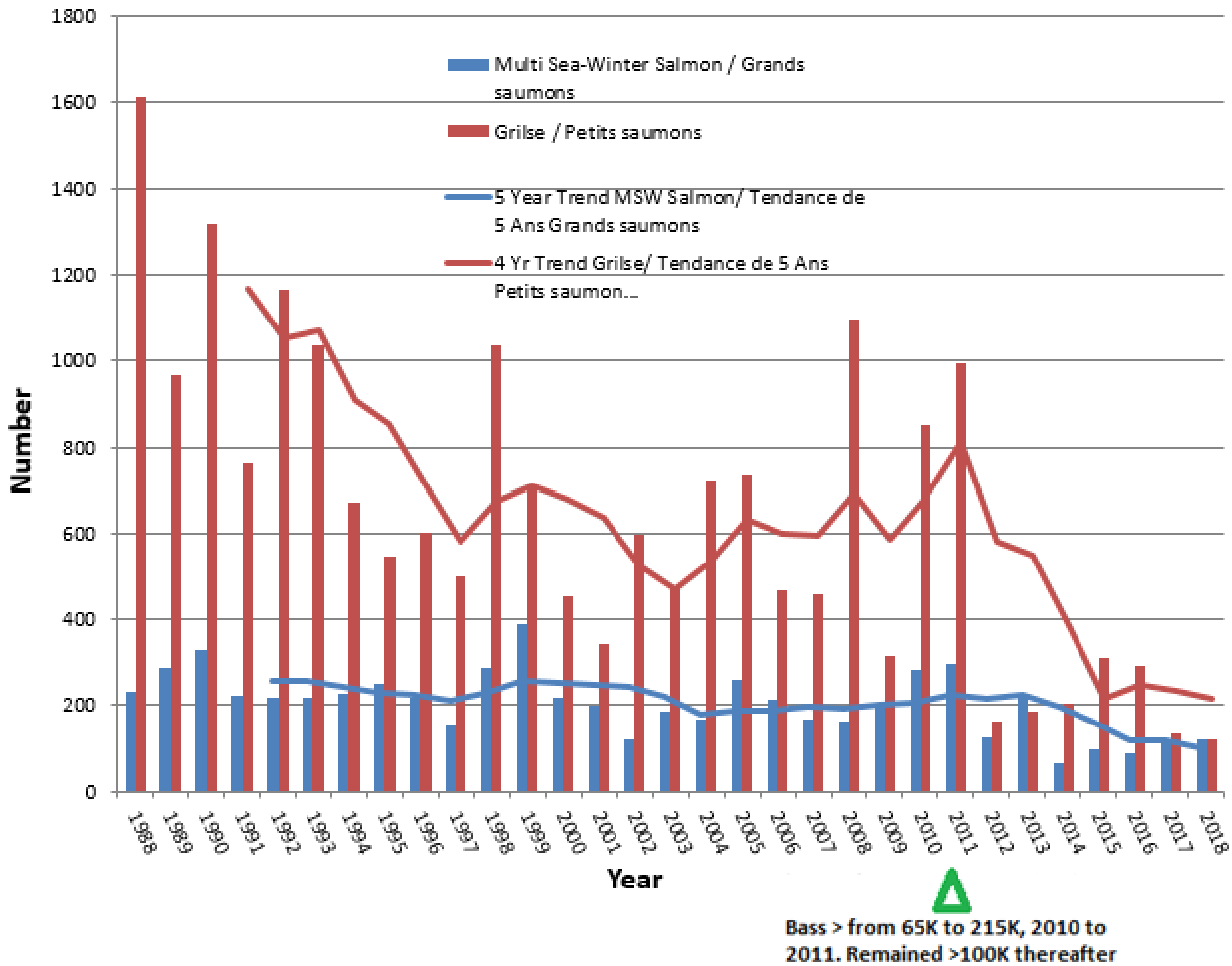

Figure 1. Northwest Miramichi Salmon Protection Barrier Counts for MSWs and Grilse

Smolt-to-adult-supplementation programs take juvenile salmon (smolts) during their May migration to the ocean and grow them to adult size in hatchery tanks. When the fish are mature, they are released where they were captured, and the fish spawn naturally by depositing eggs into the gravel of the stream bottom (egg deposition). The NB Salmon Council (NBSC) has a policy supporting the existing SAS Program that has been initiated on the NW/LSW drainage composite. Since the program has undergone a largely positive peer review, we are now inquiring why DFO and organizations such as the ASF do not support it as well. In a Feb. 6, 2019 CBC story by Connell Smith: "Higgs takes Miramichi salmon-stocking proposal to prime minister" the Minister of Fisheries and Oceans, Jonathan Wilkinson, expressed "concerns related to science and to the role of First Nations that haven't been addressed by CAST." The following is our argument as to why we disagree with Minister Wilkinson.

The peer review of the SAS program was conducted in 2018, and a report on its conclusions was published in a DFO report series (DFO, 2018). The CAST SAS program is comprised of four components, culminating in large-scale introduction of wild-exposed hatchery-produced adult salmon to the Northwest and Little Southwest rivers (Program 4). The peer review explored the potential benefits and risks of the overall SAS program and proposed mitigations to address the risks. There were few risks identified that were associated with the first three stages of the program. The peer review highlighted four potential benefits of Program 4 (SAS) including:

"*Opportunity to explore a proactive approach to population restoration, where the targeted population has declined from historical levels but* ***is not yet at immediate risk of extinction***."

As stated in the peer review, the following are the potential risks associated with Program 4 of the project. They are copied verbatim from the peer review report:

1. *Risk of transferring disease or pathogens, both from wild to captivity and captivity to wild;*
2. *Risks to the wild population increases as the proportion of SAS to wild fish (ratio) increases;*
3. *Risks to the wild population increases as the geographic footprint of the experiment increases will only be justified if the experiment has a reasonable probability of attaining its objectives;*
4. *Risk of obtaining a smaller genetic component of the population to support SAS releases if smolts are collected from a localized area (not broadly distributing sampling in time and space); the proposal addresses this risk by planning for multiple collection areas distributed spatially and temporally; and,*
5. *Risk of …. an increase in inbreeding and a reduction in total effective population size in a combined captive-wild system, which arises when a few captive parents produce a large proportion of offspring that spawn in the wild; this risk is also addressed in the smolt collection protocols in the proposal.*

Mitigation actions recommended to address the risks involved with the proposed program, again verbatim from the published review, were:

1. *Institute a Board to monitor results of the experiment and make adaptive recommendations on program activities on an annual basis, based on pre-agreed triggers and decision points;*
2. *Conduct detailed scans for diseases and pathogens to reduce the risk of transferring these from the wild to captivity and vice versa, based on representative samples of incoming smolts and SAS adults for release;*
3. *Examine the genomics of healthy and diseased or dead fish, particularly the genomics of fish from captive cohorts that experienced high mortality before release, to identify any genetic correlates of disease susceptibility;*
4. *Adjust the ratio of SAS releases to wild spawners annually such that SAS inputs do not exceed returns of wild fish;*
5. *Conduct the experiment on a smaller scale, for example, only in one sub-basin;*
6. *Alternate the years of SAS releases if conducting the experiment in two sub- basins;*
7. *Continue modelling to explore risks and optimize parameters of supplementation; and,*
8. *Increase sampling efforts to improve statistical power of experiments*

The recommended mitigations are easy to implement, and it is the NBSC's understanding that the proponent has volunteered to do so, and included two in its proposal (See Risks 4 and 5). Given that the recommendations to minimize risk were published in a scientific report by his own department, it is difficult to understand why Minister Wilkinson has concerns related to science.

In addition, we would like to point out that, in the case of Risk 4, it was DFO's delay in issuing the permit for smolt capture in 2018 that could potentially introduce the risk of "obtaining a smaller genetic component of the population". We would also mention that the Northwest Miramichi drainage composite is comprised of the Northwest itself and the Little Southwest Miramichi. The rivers intersect below the head-of-tide. This introduces the opportunity to easily comply with Mitigations 5 and 6, with alternate-year SAS programs implemented on each river. In addition, the Canadian Rivers Institute recently published an article in the

Journal Molecular Ecology in which they reported that there was no genetic variability among Atlantic salmon in the various Miramichi tributaries. This greatly decreases the genetic risks from an SAS program at the scale at which it is proposed by CAST. However, to comply with mitigation #4 (*Adjust the ratio of SAS releases to wild spawners annually such that SAS inputs do not exceed returns of wild fish.*), the permissible scope of potential annual SAS releases decreases with decreasing forecast wild adult returns.

The peer review does not address the concerns about First Nations' role in the process. However, it is the NBSC's understanding that consultation with First Nations must occur on a nation-to-nation level. Since a peer review published in their own report series has determined that the proposed project will pose little risk to wild populations, the Government of Canada, through DFO, should have facilitated these consultations.

The SAS program on the NW and LSW Miramichi is intended to address low-and-declining adult return rates and resultant low salmon spawning rates on these rivers. By saving smolts from an unacceptably-high probability of predation by striped bass, and allowing the salmon to mature and spawn, the ongoing SAS program helps to address the bass-precipitated low egg-deposition problem of recent years. If the striped bass population is rapidly brought into ecological balance through well-managed harvests, the SAS program will allow a rapid return of the salmon population to levels which will also support both a First Nation Food, Social and Ceremonial (FSC) harvest and continued recreational angling.

We think that this would be tragic for the ongoing SAS program to be cancelled because of a lack of permission to release the adult salmon that are produced. The program could keep the NW/LSW Miramichi salmon populations from descending to levels where they would exhibit depressed population phenomenon.

Of course, all of this is moot until the First Nations have a chance to independently review the science and come to their own conclusions as to the proper course of action.

Appendix A – Evidence for Striped Bass Predation as the Principal Cause of the Recent Decrease in Adult Atlantic Salmon Returns on the Northwest and Little Southwest Miramichi Rivers and Proposals for Mitigation

Within the last 10 to 15 years there has been a sharp increase in the striped bass population that spawns in the estuary of the Northwest (NW) Miramichi River. Figure A1 depicts the Department of Fisheries and Oceans' (DFO, 2018) annual estimates of the NW Miramichi (and essentially the Gulf of St. Lawrence) striped bass spawning population. The figure is on a log scale to enable the full range in population strength to be demonstrated.

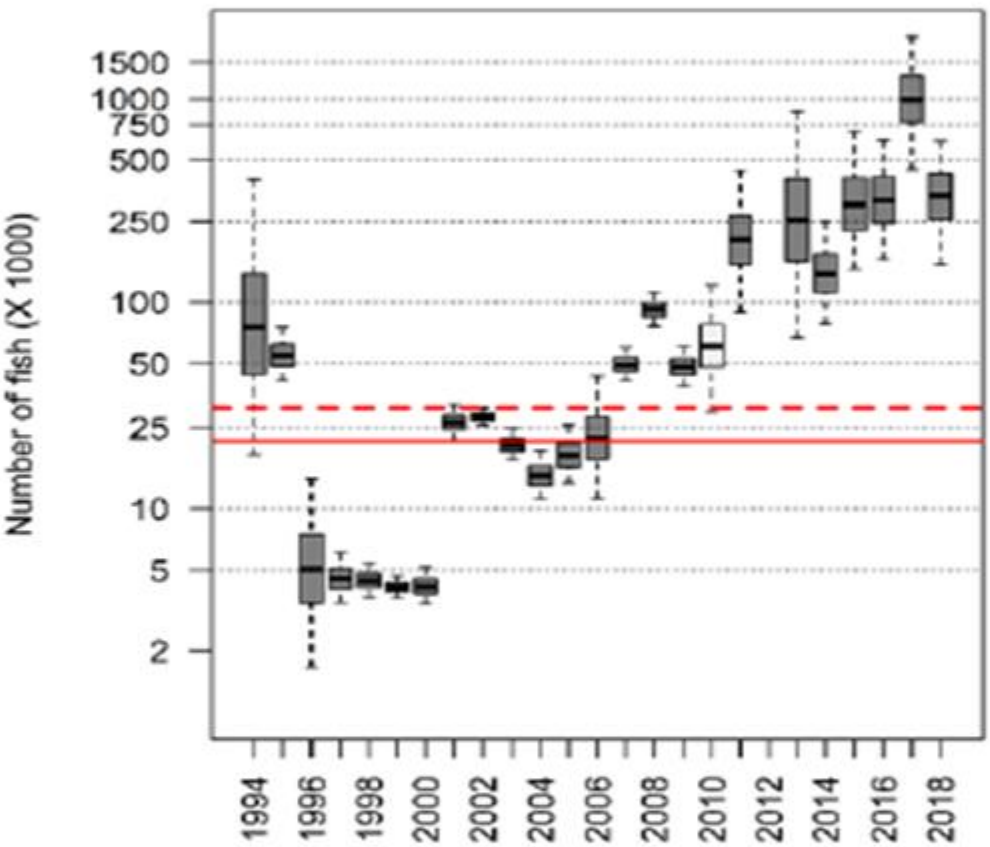

Figure A1 the Annual Miramichi Striped Bass Population - 1994 to 2018

A steep decline in Atlantic salmon returns to the Northwest (NW) Miramichi River has recently coincided with the striped bass population explosion. Since the late 1980s, a salmon-protection barrier has been installed in the headwaters of several NB rivers including the NW Miramichi. All small salmon (or grilse) and large salmon (or multi-sea-winter <MSW> salmon) that reach the barrier from June through mid-October are detained in a short section of river between two barrier nets and guarded 24-hours per day by wardens. The fish are released just prior to spawning. The Department of Fisheries and Oceans (DFO) also captures salmon and grilse in live traps that are located below the head-of-tide. Multiple mark-recapture techniques are employed to estimate the annual returns. However, the confidence intervals for these estimates is wide, and there are subsequent mortalities among the salmon and grilse that are counted in the traps. Despite these uncertainties, the raw estimates, adjusted for only theoretical catch-and-release incidental mortalities in the angling fishery, are used by DFO in salmon egg deposition calculations (DFO, 2019). Although they account for only a small portion of the returns, the barrier counts are precise, and there is an almost 100% certainty that the fish detained in and, then released from the barrier pools actually spawn within a few days of their release. Therefore, the NBSC has concluded that the grilse and MSW salmon counts provide a better index for the strength of the annual spawning run than the DFO counts that include interpretation of trap data.

The annual barrier count numbers are presented in Figure A2. In recent years, salmon sports fisheries on the NW Miramichi have been mandatory catch-and-release and First Nations have greatly reduced their FSC harvests. Otherwise recent counts of salmon and grilse reaching the barrier would be lower. Conversely, in the early years, if similar recent reductions in harvests had occurred, the numbers would be higher. What is immediately apparent in this figure is the rapid drop in grilse returns in the decade of the 2010s.

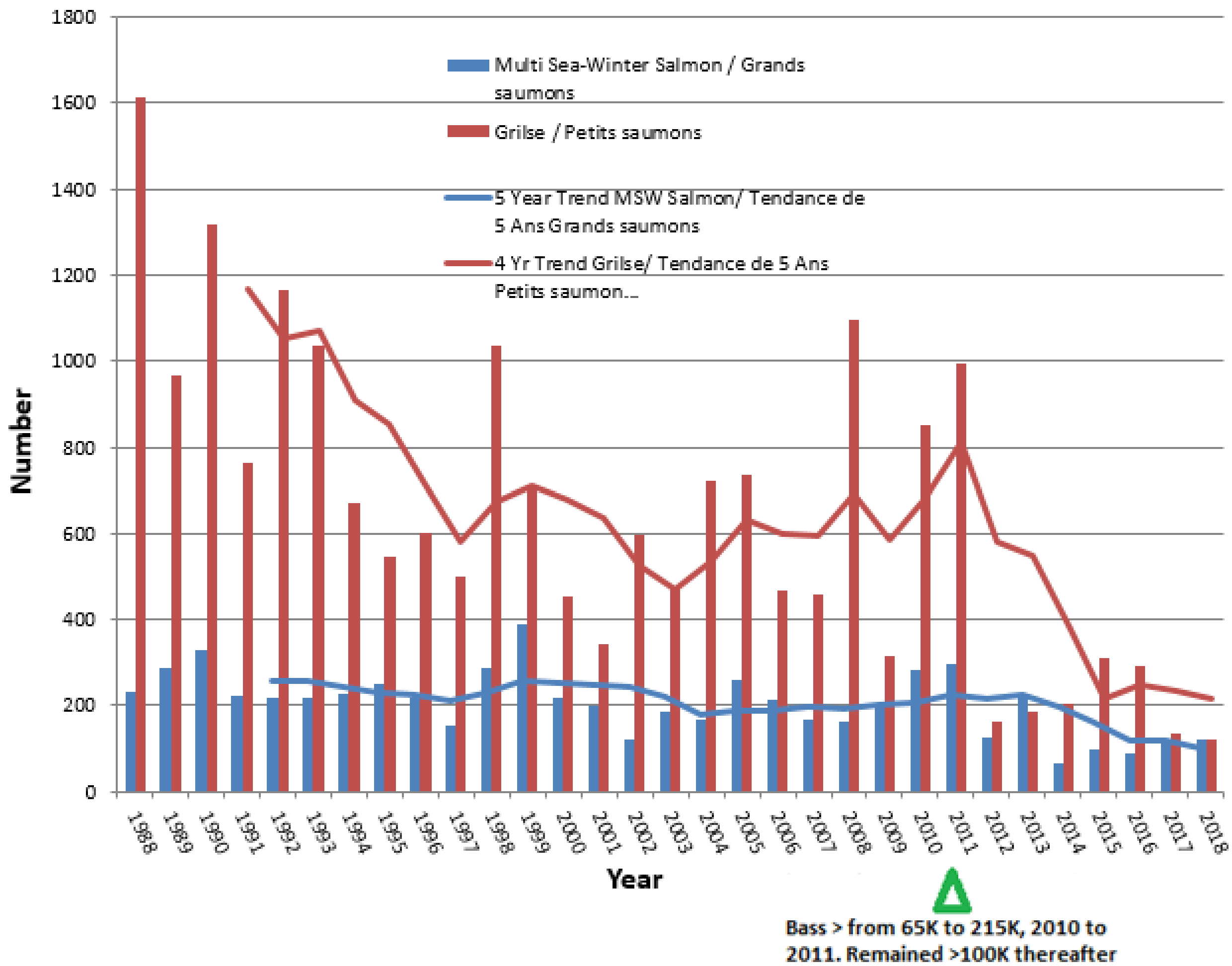

Figure A2 Annual Return Rates for Large (MSW) and Small (Grilse) Salmon to the Northwest Miramichi Salmon Protection Barrier

There is an obvious potential pathway of effect between striped bass and salmon numbers in that Atlantic salmon smolts, which are 12 to 18 cm long and only 20 to 50 g, migrate to the ocean from the various branches of the Miramichi in May at the same time every mature striped bass in the Gulf of St. Lawrence is spawning at, or travelling to or from their only known spawning grounds in the NW / Little Southwest (LSW) arm of the upper Miramichi estuary. Mature bass weigh 1.5 kg of more. The salmon smolts from the NW and LSW Miramichi rivers migrate directly through the bass spawning grounds (Figure A3). Although bass don't tend to feed while they are actively spawning, they do not spawn all the time during the spawning season. Bass eat salmon smolts and other things (Figure A4).

Figure A3 Striped Bass Spawning Closure Area in the Northwest / Little Southwest Miramichi Estuary


Figure A4 Striped Bass Stomach Contents – Several Salmon Smolts in left photo / Juvenile Lobsters in right photo (Source: Bonnie Wright, Coalition for Better Salmon Management)

Since the early 2000s, the Atlantic Salmon Federation and (the ASF) and DFO have surgically-implanted acoustic tags (pingers) into smolts on their seaward migration from the Northwest, Little Southwest and Southwest Miramichi rivers as well as into smolts from the Cascapedia and Restigouche rivers that drain to the Bay of Chaleur. Surviving fish are detected and recorded by acoustic receivers situated at critical points along the smolts' migration path. If pingers are not detected, the smolts are assumed to have died in the region between the last point of detection and the point that they were not detected. Figure A5 depicts the locations of the rivers studied and the major points of detection (receiver arrays) for the smolt tagging study.

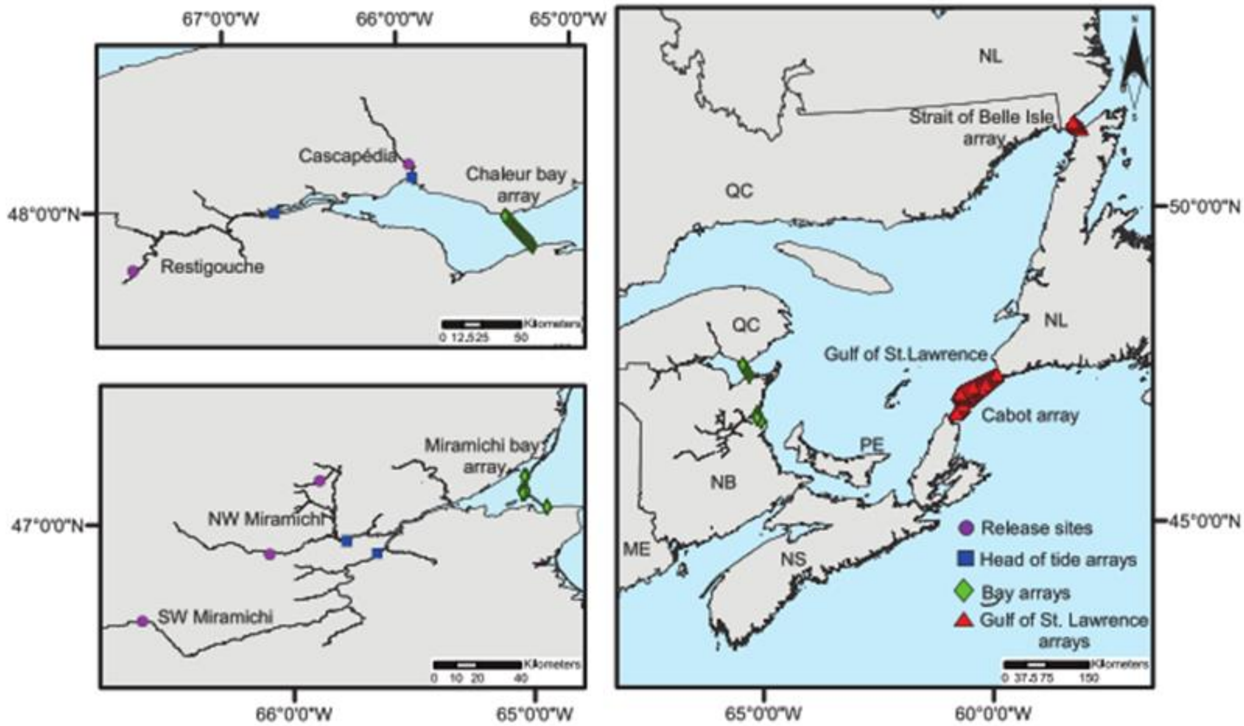

Figure A5 Locations of Rivers, Tagged Smolt Release Points and Receiver Arrays in the Post-Smolt (Source: Chaput et. al., 2018)

Figure A6 presents the smolt mortality rates that the study found for NW and LSW Miramichi smolts (i.e. those fish that must migrate through the striped bass spawning grounds and then through the short distance of Miramichi Bay), with mortality rates of smolts from the Restigouche and Cascapedia rivers that don't have spawning bass populations. Restigouche and Cascapedia salmon smolts migrate through the Bay of Chaleur to reach the Gulf of St. Lawrence, a much greater travel distance than for Miramichi smolts. There was a 34-percentage point increase in the mean mortality rate of NW/LSW Miramichi River smolts during the 2013 to 2017 period when compared with the 2003 to 2008 period. During the 2004 to 2017 period that was studied, the mean annual smolt mortality rate for smolts migrating through the Bay of Chaleur was consistent, and low in comparison with rates from both the early and late Miramichi periods.

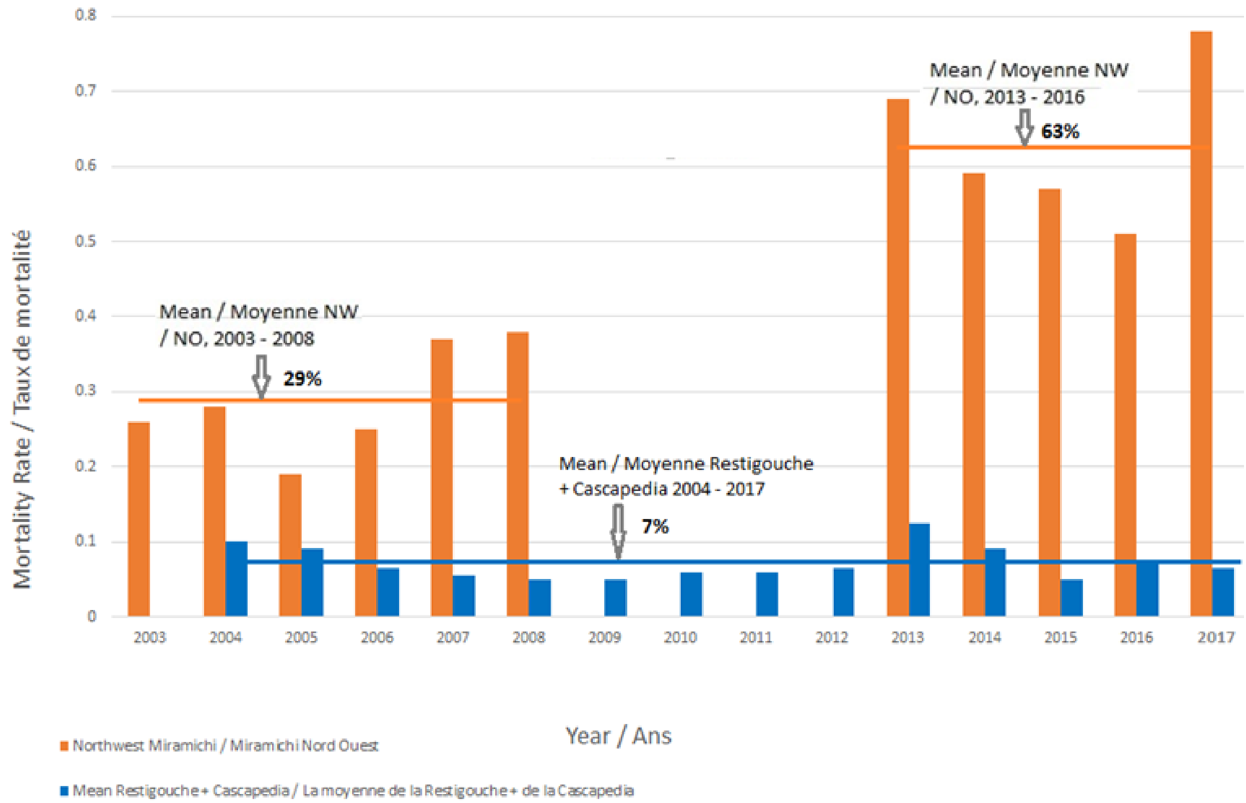

Figure A6 Annual Mortality Rates for the Northwest / Little Southwest Miramichi River Smolts during Miramichi Bay Passage Compared with the Mean Mortality Rates for Cascapedia and Restigouche River Smolts through the Bay of Chaleur

These results were recently published (Chaput et. al., 2018). The authors indeed concluded that, among NW / LSW Miramichi smolts travelling through Miramichi Bay, there had been an increase in their mean annual mortality rate compared with a decade earlier and compared with the relatively stable and low mortality rate among smolts travelling through the Bay of Chaleur. The authors admitted that one possible reason for the increased mortality was from increased predation from the coincident increase in the numbers of spawning striped bass present at the time of the smolt migration. However, they offered alternative explanations they considered worth exploring. These were:

1. The authors referred to an earlier paper (Daniels et. al., 2018) on which three of them collaborated. The study looked at the 2013 to 2016 migration paths of smolts and striped bass in the Miramichi estuary. They found that acoustically-tagged smolts travelled from their home rivers and rapidly moved straight out to sea. Tagged striped bass moved around in the estuary, travelling intermittently towards, and then away from the head-of-tide. They reasoned that any smolt eaten by a bass would adopt a "bass trajectory" as they assumed that the acoustic transmitter would have been eaten along with the smolt. They found that from 2013 to 2016, 1.9% to 17.5% of the 514 tagged smolts adopted a bass-like migration pattern. This was far lower that indicated in the more recently published analysis of the mean within-estuary smolt mortality for Northwest Miramichi River smolts (i.e. 63% for '13 to '17 – Figure A6).

   Therefore, the NBSC assumes the authors are suggesting that another or additional major mortality factors to bass predation have caused the recently elevated Northwest / Little Southwest Miramichi smolt mortality rates. However, officials of the ASF, the organization that employs three of the authors of the later paper, readily admit that tags in smolts could be spit out by bass, not consumed, defecated out, or that the bass, after swallowing a transmitter, might not cross enough acoustic receiver lines to allow the track to be interpreted as a predation event.

2. The authors (Chaput et. al., 2018) found that shorter smolts had higher mortality rates than for longer individuals. They speculated that the NW Miramichi River smolts used in the 2013 to 2016 period may have been shorter than the LSW Miramichi smolts that were tagged in 2003 to 2008. The authors however did not present the actual smolt length data for the various years. By failing so, they demonstrate little confidence in this hypothesis.

3. The authors noted that the 2013 to 2016 smolts came from the Northwest Miramichi, into which leachate from the tailings from a decommissioned copper / lead / zinc mine drained, whereas the '03 to '08 smolts came from the un-impacted Little Southwest Miramichi drainage. They raised the spectre of "Atlantic salmon smolt vulnerability to episodic acidification and elevated concentrations of bioavailable aluminum during spring snow melt", which "cannot be excluded as a factor contributing to the lower apparent survival rates in the Northwest Miramichi smolts in the latter part of the time series as well as a factor contributing to differences between the Miramichi Bay and the Chaleur Bay rivers."

   When the NBSC asked an NB Department of Environment and Local Government (NBDELG) Approvals Branch official about this hypothesis, he pointed out that the acid tailings run-off had been effectively neutralized decades ago, and that the decommissioned mine had undergone a major tailings treatment system upgrade prior to mine closure in 2000. In addition, many additional improvements have been made since then (D. Stymiest, NBDELG, pers. comm. to J. Bagnall, 2019). Furthermore, the NBDELG official offered the conclusions of an Environmental Effects Monitoring program from 2015. In summary, they were:

   - All water quality parameters met Canadian Water Quality Guidelines in the Tomogonops River (the Northwest Miramichi River tributary into which the mine effluent drains).

   - Standard fish health evaluation indicated no effects on the early life stage survival or growth of the bioassay species, the brook trout.

   - Assessment of fish health of the South Branch Tomogonops River suggested no effects on the early life history survival, and little, if any, mine-related effects on the trout population.

   Furthermore, the salmon barrier counts (Figure A2) don't suggest an environmental problem in the Northwest Miramichi River in the 1980s and '90s. This was before the new treatment system upgrade had been implemented, and when the Tomogonops River tributary to the Northwest Miramichi, the stream that received effluent actually was contaminated with heavy metals. Salmon fishing in the 1980s and '90s was much more productive than it has been in recent years.

The NB Salmon Council questions why DFO does not admit the obvious: The decline in salmon returns in the years after 2011 was caused by increased predation by striped bass. Suggesting alternative causes is classic "paralysis by analysis". Figure A7 uses the moving-average count for the year in question plus previous three years (four-year moving average) to establish the trend in annual Miramichi estuary striped bass spawning numbers (green line) as well as that of grilse returns to the Northwest Miramichi Salmon barrier (red line). Grilse returns are a better indicator of potential bass predation rates than those of large, multi-sea-winter salmon because grilse were smolts during the spring prior to their return year. MSW salmon return as maiden fish two years after migrating as smolts, and since Atlantic salmon survive after spawning, the MSW component of an annual run can be comprised of several smolt year classes. Therefore, Figure A7 compares bass numbers (in thousands) in one year (the year of smolt migration and potential exposure to bass predation) with grilse returns to the barrier one year later. When bass numbers increased from <100,000 to >200,00 between 2010 and 2011, grilse returns to the protection barrier one year later plunged.

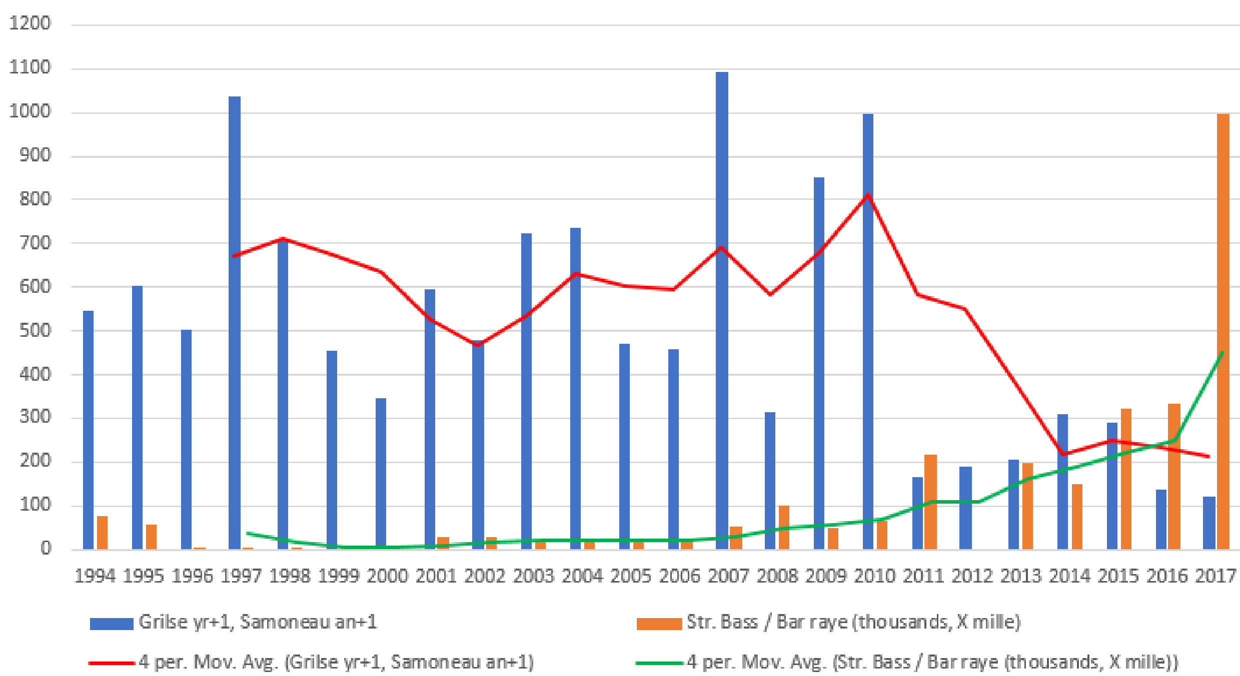

Figure A7 Values and Four Year (One Grilse Generation) Moving Average Trends in Grilse and Striped Bass Return Rates

Correlation is often used to evaluate the relationship between two sets of numbers. If one set increases or decreases in lock-step with the other, the correlation coefficient approaches 1, or 100%. If the set of numbers decreases as the other increases and vice versa, the coefficient approaches minus -1, or minus-100%. A coefficient value of zero means there is no correlation between the two sets of numbers. The correlation coefficient between the numbers of bass spawners and salmon returns to the Northwest Miramichi barrier over the entire period illustrated in Figure 7 is minus-57%. That for 2013 to 2017 is minus-67%. The correlation for the entire period can be judged as "moderately strong", and the recent value is "strong" (bjm.com, undated).

Correlation does not necessarily equate with causation, but lack of correlation eliminates causation. In the recent hearings of the House of Common's Standing Committee on Fisheries and Oceans on the "Impact of the Rapid Increase of the Striped Bass in The Miramichi River and the Gulf of St. Lawrence", Mr. Jeff Wilson, the Striper Cup organizer, implied lack of causation, when he stated that it was global warming rather than striped bass predation that was cause of salmon decline. He stated that warm weather for several years in a row caused the bass population explosion, and that warmer water had caused the decline in the salmon population. In other words, according to Mr. Wilson, there was a common cause (increasing temperatures) rather than cause (too many predatory striped bass) and effect (decline of salmon populations). Interpretation of Figure A6 suggests it is during their migration through Miramichi Bay in the spring that salmon have experienced their recent decline in abundance, and that the decline is probably due to predation. At this time of year, the water temperatures in Miramichi Bay are far below the lethal threshold for salmon. Also, river reaches within all branches of the greater Miramichi system become lethally warm for pre-spawning adult salmon, and even juvenile salmon, every year. Pre-spawning adults avoid this warm water by travelling to the cool headwaters early in the year, and adults and juveniles also avoid lethal temperatures by congregating in cold, groundwater-influenced refuges.

Mr. Wilson also raised a 2016 unpublished DFO study of bass stomach contents that estimated salmon smolts comprised only 2% of that content. Considering bass can eat up 3% of their body weight per day (Harrell, undated), this could be 100s of thousands of smolts. The unpublished study (DFO, 2016) was referenced by Andrews et. al. (2018). These authors concluded that "It is difficult to assess the stated predation rate". However, they noted that "1844 Striped Bass stomachs were examined, ~600 from May 1-June 9 (2013-2015) by means of angling and commercial trap nets for herring" <probably actually gaspereau>. "Among those sampled, 32% (n=587) stomachs contained prey. Five percent (n=28) of the Striped Bass that had consumed prey … consumed smolt, and these 28 individuals collectively consumed 48 smolt". The NBSC notes that the 40-day (May 1 to June 9) duration of the focused portion of the study is still too long, as the smolt migration on the Miramichi river is complete with three weeks (T. Pettigrew, NBDERD fisheries biologist, retired, pers. comm. to J. Bagnall, 2018). This means that during much of the study, there were no salmon smolts present for the bass to consume.

Mr. Wilson also emphasized that a decline in the rainbow smelt run in 2018 may have caused the decline in striped bass numbers from 2017 to 2018 (Figure A1). The smelt is an important forage species for many predators including post-spawned Atlantic salmon and striped bass. We at the NBSC agree that there seemed to be a large decline in smelt population in 2018 in comparison with previous years. We suspect that the decline was due to heavy predation by the over-abundant striped bass population.

At the aforementioned hearings, one MP agreed with DFO officials, when he implied that since other rivers without nearby bass populations have also experienced steep declines in their populations, bass could not be definitively recognized as the cause of the decline on the Miramichi. The NBSC looked at grilse returns to the salmon protection barrier on the Northwest Upsalquitch River, which could serve as an index site for the Restigouche River, which does not have a spawning striped bass population. Figure A8 depicts the returns.

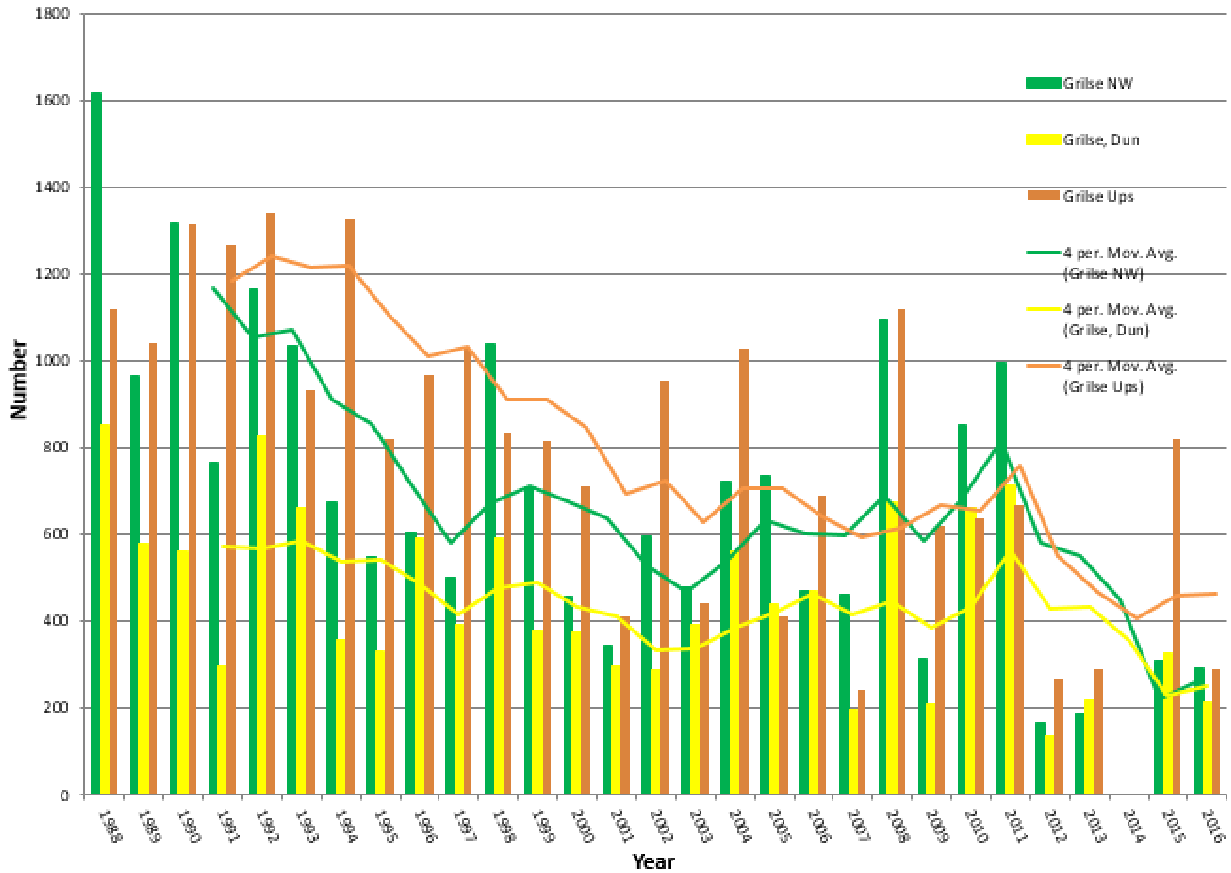

Figure A8 Annual Grilse Returns to Salmon Protection Barriers on the Northwest Miramichi, the Dungarvon and the Northwest Upsalquitch Rivers

Unfortunately, there were no data available for the Northwest Upsalquitch barrier for 2014, 2017 or 2018. Therefore, data for these years were removed from the Dungarvon (index for the Southwest Miramichi River) and the Northwest data series. The recent plunging trend in the returns is duplicated on the Dungarvon (yellow line) and is not nearly as prevalent on the Upsalquitch (orange line). This adds to the accumulating evidence that bass predation is a major contributing factor for the rapid decline in salmon returns to the NW/LSW Miramichi during the 2010s, and suggests that it is a problem on the Southwest Miramichi River as well.

After all is said, the NB Salmon Council agrees with Mr. Wilson in supporting the maintenance of a healthy striped bass population. However, we disagree with his proposed target number of >300,000 spawners. The data that we have presented here indicate that this bass population set point favoured by Mr. Wilson is too high and would continue to depress salmon populations as well as those of important forage species such as the rainbow smelt.

Following are the NBSC's recommendations for mitigating the effects of striped bass predation on Miramichi River Atlantic salmon. These mitigations are common-sense fisheries management practices that may have the additional benefit of avoiding a crash in the striped bass population such has happened in the past.

1. That a robust harvest of bass occurs, and that it be annually modified with the goal of bringing the Gulf striped bass population into balance with the environment. Comparing the annual bass abundance in Figure A1 with the salmon barrier counts (Figure A7), suggests that the bass number tipping point beyond which salmon returns suffer is approximately 100,000. The 100,000-bass target is greater than three times the Canadian Species at Risk Recovery Target of 31,200 for the species in the Gulf (the dashed red line in Figure A1), and almost five times the Recovery Limit of 21,600 (solid red line in the same figure) (DFO, 2011). In fact, this should be the "recruitment" (pre-fishery, pre-spawning abundance) target. Fisheries should be designed to reduce this number to a point at which the remaining spawners ultimately produce 100,000 pre-spawning fish annually. This will be difficult to do, but it should be the goal of every fishery that is managed under the Precautionary Approach as guided by the Beverton-Holt Stock-Recruitment Model.

2. That there be no length slot limit for bass retention in all fisheries, and that a liberal retention limit be established in the recreational fishery for striped bass, particularly in the upland, non-tidal river reaches of the Miramichi system, where striped bass have invaded, and are probably predating juvenile salmonids as well as other fish species that inhabit the river.

3. That a smolt-to-adult supplementation program be implemented in alternate years on the Northwest and Little Southwest Miramichi rivers and maintained until the salmon population rebounds and again provides acceptable First Nations' Food, Social, Ceremonial, and recreational angling benefits. Such a program would keep egg deposition, and therefore Atlantic salmon smolt production, at levels that will allow adult salmon returns to rapidly rebound following relief of the extraordinary predation pressure from striped bass. For additional protection of the genetic integrity of the Miramichi salmon population, only female SAS-produced fish should be released to spawn.

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