NOVA SCOTIA AQUACULTURE REVIEW BOARD

Applications by KELLY COVE SALMON LTD. for a BOUNDARY AMENDMENT and TWO NEW MARINE FINFISH AQUACULTURE LICENSES and LEASES for the cultivation of ATLANTIC SALMON (Salmo salar) - AQ#1205x, AQ#1432, AQ#1433 in LIVERPOOL BAY, QUEENS COUNTY.

Supplemental Affidavit of Dr. Edmund Halfyard

I, Dr. Edmund Halfyard, of Middle Sackville, in the Halifax Regional Municipality, Province of Nova Scotia, AFFIRM AS FOLLOWS:

1. I have been asked to review and provide an expert opinion regarding the accuracy, reliability, and completeness of the report prepared by Dr. Kurt Samways, exhibited to his affidavit affirmed January 19, 2024 (the "**Samways Report**"), on behalf of the intervenor Protect Liverpool Bay Association. In particular, I have been asked to provide my expert opinion with respect to the statements in paragraph 11 of the Samways Report concerning the prospects for recovery of wild Atlantic salmon in the LaHave and St. Mary's Rivers.

2. I have prepared a supplementary report addressing the statements made in paragraph 11 of the Samways Report. The Supplementary Report is attached to my affidavit as **Exhibit "A".** The Supplementary Report represents my objective opinion with respect to the accuracy, reliability, and completeness of the statements in the Samways Report concerning the prospects for recovery of wild salmon in the LaHave and St. Mary's Rivers. I have exercised my professional judgment to the best of my training, knowledge and ability regarding the data, analysis and conclusions set out in the Supplementary Report.

3. My qualifications as a subject matter expert on the survival, conservation and recovery of wild Atlantic salmon are set out in my Curriculum Vitae, which is attached as **Exhibit "B"** to my affidavit affirmed January 19, 2024.

4. I affirm this affidavit in support of Protect Liverpool Bay Association's intervention before the Aquaculture Review Board and for no other or improper purpose.

Affirmed before me on this)
16 day of February, 2024)
at Halifax, Nova Scotia)
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A Commissioner of Oaths in and for the)
Province of Nova Scotia)

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Dr. Edmund Halfyard

This is **Exhibit "A"** referred to in the affidavit of **Dr. Edmund Halfyard**, affirmed before me this 16th day of February, 2024.

[redacted]

Sarah McDonald
A commissioner of the
Supreme Court of Nova Scotia

Sarah McDonald
Barrister, Solicitor, Notary Public
and a Commissioner of Oaths
in and for the Province of Nova Scotia

Edmund A. Halfyard, PhD comments in response to the Affidavit of Kurt Samways, PhD affirmed on January 19,2024.

I have reviewed the report prepared by Dr. Kurt Samways, exhibited to his affidavit affirmed January 19, 2024. At paragraph 11 of his report, Dr. Samways relies on a 2013 study by Gibson and Bowlby to make comments with respect to the prospects for recovery of wild salmon in the LaHave and St. Mary's Rivers. In this supplementary report, I provide my expert opinion in response to the statements in paragraph 11 of Dr. Samways' report.

I agree that the results of population equilibrium modelling reported by Gibson and Bowlby (2013) show that under the current population-level dynamics (e.g., egg-to-smolt survival in freshwater, marine survival, age at maturity, number of eggs per female, male-to-female sex ratios, etc.) for Atlantic Salmon in the LaHave and St. Mary's Rivers the populations are not likely to recover and will most likely extirpate if dynamics remain unchanged. However, there are significant freshwater restoration efforts underway which are likely to improve population dynamics and lead to more optimistic population trajectories.

The Gibson and Bowlby population equilibrium model consists of two major inputs: (1) egg-to-smolt survival (i.e., freshwater survival) and (2) smolt-to-egg production, which is coarsely a proxy for the marine survival of Atlantic Salmon. Changes in either of these components will influence population trajectories.

Simulated population trajectories under non-static dynamics are shown on pages 42-47 of the same Recovery Potential Assessment research document (Gibson and Bowlby 2013) which show that preventing extirpation, and potentially population recovery, is fully feasible with changing dynamics. The authors write:

> "*In conclusion, population viability analyses indicate that relatively small increases in either freshwater productivity or at-sea survival are expected to decrease extinction probabilities. For example, for the LaHave River (above Morgan Falls) population increasing freshwater productivity by 20% decreases the probability of extinction within 50 years from 87% to 21%, while a freshwater productivity increase of 50% decreases the probability of extinction within 50 years to near zero.*"

Below, I make three points for your consideration:

1) **It is possible to increase freshwater productivity to a level that increases population viability and there is strong local and international evidence supporting the assertion that we can increase freshwater productivity within the LaHave, St. Mary's and Medway Rivers to levels meaningful for recovery.**

Acid rain mitigation in Nova Scotia has occurred since the 1980s, with the Nova Scotia Salmon Association (NSSA) providing leadership in acid rain work since the early 2000s. The NSSA has operated a multifaceted program in on the West River in Sheet Harbour, NS that includes two automated lime dosers, helicopter liming and, recently, the development of land-based liming tools. We have also run scientific and monitoring programs to assess the efficacy of these efforts. As a very brief summary, the water chemistry has improved dramatically with acidification metrics improving from poor to levels that can sustain Atlantic Salmon. As an example, springtime pH in the river has increased from the 4.5-4.9 to 5.8 to 6.4 across much of the salmon habitat. The distribution of wild Atlantic Salmon has also increased

and the freshwater production of wild Atlantic Salmon smolts has increased by approximately 300% since the project began. The NSSA experience of increasing freshwater survival related to improved water chemistry is an example of increasing freshwater productivity as defined in the Gibson and Bowlby model. The experience and expertise generated in the Sheet Harbour project are directly translatable to the LaHave River and St. Mary's River that were detailed in the Gibson and Bowlby paper, as well as the Medway River.

These results are in line with earlier published literature both in Nova Scotia and internationally. In Sweden and Norway, and a lesser extent in other countries, liming has been widely attributed to increased freshwater productivity and a recovery of Atlantic Salmon populations (e.g., Hesthagen et al. (2011, Mant et al. 2013, Lennox et al. 2021). In Canada, much of the preeminent research on the impacts of acidification on Atlantic Salmon has occurred within the Medway River. For example, Lacroix et al. (1985) held salmon fry in a flow-through system of tanks located in the Westfield River (Medway) (NSSA's SPU#38) which at the time had a mean pH = 5.0. Some tanks were treated with limestone to increase pH to 6.1 and increase calcium. Cumulative mortality of fry was 70% at pH 5.0 after 30 days in the ambient Westfield River water, whereas only 4% of fry died in the limed Westfield River water at pH 6.1. In the context of freshwater production, the results of this study over only 30 days would result in a 3.2x increase in freshwater productivity. The impacts are likely much greater considering the short duration of the study and after accounting for acidification impacts on salmon during the sensitive 'smolt' stage of their life history (see Farmer et a. 1989, Farmer 2000, Monette and McCormick 2008).

The NSSA's experience within the West River Sheet Harbour shows that watersheds impacted by acid rain can be improved such that acid-related mortality of Atlantic Salmon can be reduced to near zero.

Put in the context of the equilibrium analyses reported by Gibson and Bowlby (2013) for the Southern Upland Recovery Potential Assessment, acid rain mitigation can increase freshwater productivity enough to change the trajectory of Atlantic Salmon populations. For example, panel D of Figure 21 in Gibson and Bowlby (2013) assumed only a 2x increase in freshwater productivity in the LaHave River populations, which in itself would reduce the likelihood of extirpation to zero and result in the forecasted recovery of a small but viable population. A 3x increase in freshwater productivity would only improve this prognosis.

2) Additive marine mortality will negatively impact the recovery potential of LaHave, St. Mary's and Medway River Atlantic Salmon and will directly reduce the positive benefits of restoration efforts in freshwater.

It is projected that salmon populations within the LaHave and St. Mary's Rivers will extirpate in the absence of any restoration of freshwater habitat or any improvement in the marine survival of this population. There is no evidence to suggest that the outlook for the Medway River would differ. However, the time to extirpate is likely several generations beyond present, meaning that there remain opportunities for improvement to the population-level dynamics. Should open net pen salmon aquaculture lead to mortality of wild Atlantic Salmon in the ocean it would be considered 'additive marine mortality'. Any such additional additive marine mortality will expedite the loss of this genetically distinct population. Furthermore, as freshwater restoration efforts unfold, their potential positive impact would be reduced by additional sources of additive marine mortality.

3) Improving conditions in freshwater is likely to increase marine survival, meaning that recovery may be more rapidly achievable than previously expected.

Acidification impacts the survival of Atlantic Salmon in freshwater by directly causing acute (lethal) physiological responses and indirectly by altering food web productivity (e.g., food availability). The previously underappreciated aspect of acid rain impacts is the sublethal effects of low pH and elevated aluminum. In this scenario, fish survive their freshwater rearing but suffer reduced fitness and health. When these fish transition to life in the ocean they experience increased mortality as their bodies responds to new stressors, such as the need to osmoregulate (e.g., Staurnes et al. 1995). For example, Kroglund et al. (2007) reported a 20% to 50% reduction in marine return rate (e.g., the number of adults that return to the river as a mature adult per 1000 smolts going to sea) of River Imsa, Norway, Atlantic Salmon when exposed to only moderately acidic conditions of pH = 5.8 and inorganic aluminum concentrations of 5–15 µg/L. This is striking considering that the main Medway River averages ~0.8 pH units lower than this value during the spring period and average and the sublethal effects of freshwater acidification would likely be much higher.

Again, put in the context of the Gibson and Bowlby (2013) equilibrium model, these sublethal effects would manifest in the marine portion of the model, and would mean either (a) a smaller increase in freshwater productivity would be required to produce a viable population, or (b) a larger population would result from an equal freshwater intervention.

Conclusion

In conclusion, the LaHave River, St. Mary's River and, based on our best available information, the Medway River are all in a state of degradation and the wild Atlantic Salmon populations have suffered as a result. These populations were able to withstand this freshwater degradation when the marine survival of Atlantic Salmon was high (i.e., prior to 1990), however recent and persistent low marine survival has caused these populations to decline markedly. In the absence of intervention these populations are likely to become extirpated. This prognosis has led to innovation and planning for the recovery of the three rivers above. Environmental charitable groups, such as the NSSA, are planning for large-scale restoration efforts that include acid rain mitigation. These efforts are predicted to increase the viability of these populations and result in their recovery. Additional mortality in the marine environment, such as any imposed by open pen salmon aquaculture, will hinder restoration and recovery efforts.

References

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