Atlantic salmon Stressor Analysis for Iceland – preliminary results being represented in a Special Session during the 2025 Annual Meeting

1. Introduction

The Stressor Analysis for Icelandic salmon populations was based on the methodology which was first developed in Norway (Forseth et al. 2017) and has been used, and updated annually, by the Norwegian Scientific Advisory Committee for Atlantic Salmon (Forseth et al. 2024). For many of the salmon rivers in Iceland, data on all the stressors are not available and not being measured so for a large part of the analysis the results was based on best available scientific knowledge and judgement from experts at the Marine and Freshwater Research Institute in Iceland (MFRI). It should be considered preliminary as it has not gone through appropriate formal introductions process with the relevant stakeholders. Here we present the top three stressors based on the preliminary results of the analysis.

2. Adaptations to methodology

The methodology used in Forseth et al. (2017) was followed closely but with some adaptations to the Icelandic situation. The Stressors that were evaluated were the same as used in the Norwegian analyses except *Gyrodactylus salaris* which is not present in Icelandic rivers, and *Acidification* which was not considered to be affecting salmon because of the basaltic bedrock in Iceland. Furthermore, *Stocking* was added and evaluated as a stressor for Icelandic salmon. Stocking has taken place in several rivers as enhancement of rod fisheries. There is no framework in place to define salmon rivers in Iceland, but for the 133 (whereof 37 are tributaries that are managed separately) rivers that were analysed the criteria for being included was twofold. Firstly, the catch data needed to be available in the MFRI catch database and catch statistics be provided on a regular basis (at least 10 entries since 1974), and secondly, the average annual catch of Atlantic salmon had to be at least 25 fish.

There was a need to adapt only slightly the criteria used to the Icelandic environment. The criteria and scoring for the number of affected populations in Iceland was adapted to the lower number of rivers being assessed as follows; 1: <15, 2: 15-25, 3: 25-50, 4:>50. Otherwise, the methodology from Forseth et al. (2017) was followed.

3. Preliminary Results of the Stressor Analysis

General results

In general, the results of the Stressor Analysis indicate that the anthropogenic stressors considered were much less pronounced and many were measured or judged to be found in only few rivers. This can be attributed to the fact that for many rivers in Iceland the environment that they run through can still be considered as uninhabited, pristine wilderness. The European Union Wilderness Register have shown that Iceland retains approximately 43 percent of Europe's top one percent wildest areas (Kuiters et al. 2013). This is mostly attributed to extensive icecaps of Icelandic glaciers but also considerable part of the highlands with its pristine rivers. The fluctuations seen in Atlantic salmon populations size are more often related to changes in environmental and ecological factors, both in freshwater and at sea. When the results for the Stressor Analysis are compared to the newest Norwegian update (Forseth et al. 2024) there is a clear indication that these

anthropogenic stressors are less expressed in Iceland (Figure 1). This is mostly because the anthropogenic stressors are affecting fewer populations and there hasn't been seen any reduction that can be related to any single stressor – in some cases there might be a reduction that results from cumulative effects of multiple stressors, but the method applied looks at every single stressor individually. Furthermore, since the effects of most of the anthropogenic stressor is not measurable or is expertly judged not to have an impact to the scores on the development axis in this preliminary analysis are mostly low. However, keeping these scores low, by putting effort into not introducing or increasing the effect of these stressor, will be the biggest challenge facing the management of Atlantic salmon in Iceland.

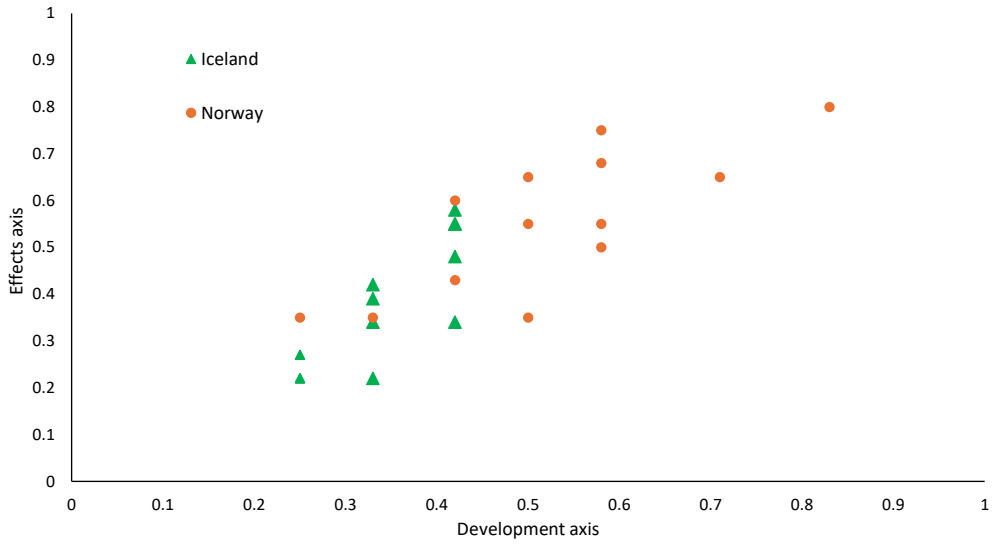

Figure 1. Comparison of the preliminary results from Icelandic Stressor Analysis (green triangles) and the most recent Norwegian results (orange circles) (Forseth et al. 2024).

Top three Stressors

In the stressor matrix for the Effect axis there were two criteria that were given the same score for all stressors – these were 1) *Reduction in returning adults*, which was assessed as being 1 for all stressors indicating that no single stressor has been attributed to more than 10% reduction, and 2) *Number of lost or critically endangered populations in nature*, which did not apply to any river so all stressors were given the score of 1. This means that for the effect axis there are only three criteria that drive the scores, 1) *Number of affected populations*, 2) *Geographical distribution*, and 3) *Implemented mitigation measures*. The first two are giving very similar scoring and are somewhat correlated which increases the impact they will have on the overall score. Therefore, the top three Stressors from the preliminary analysis were stressor that were found in the highest number of rivers and these were: 1) escaped farmed salmon, 2) pink salmon and 3) stocking (Figure 2).

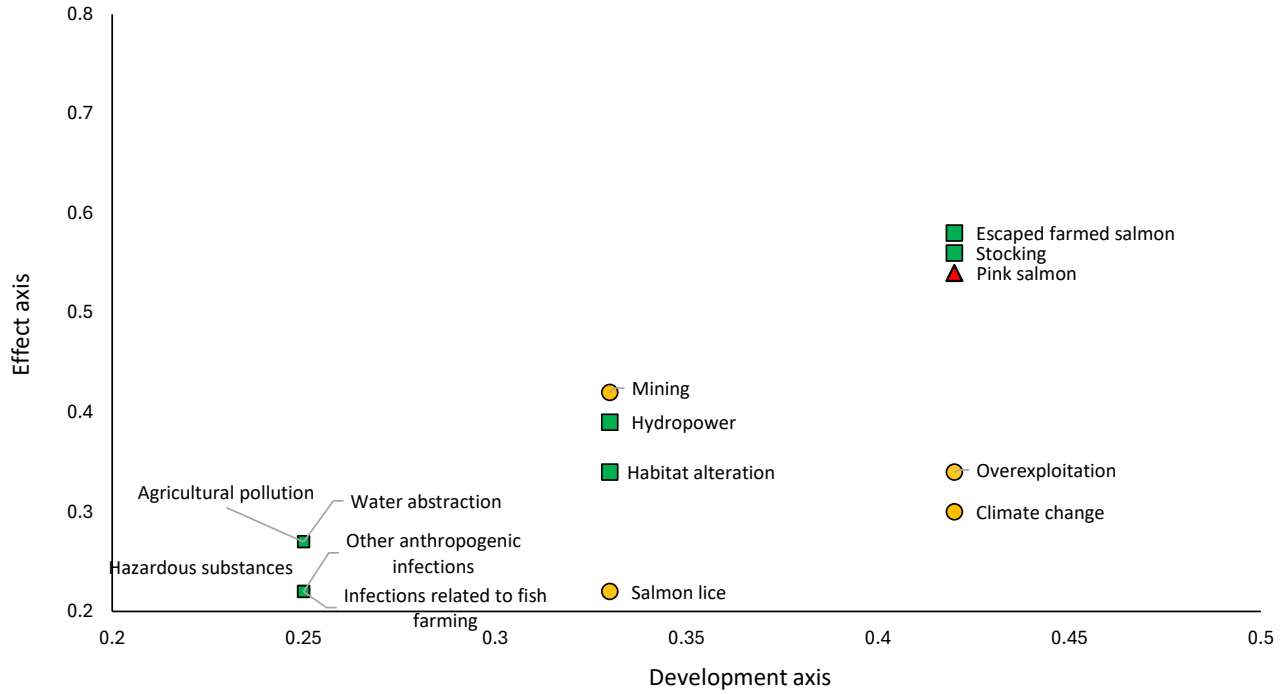

Figure 2. The preliminary results of the Stressor Analysis in Icelandic Salmon Rivers. The Stressors are coloured according to the confidence of the knowledge from good (green squares), medium (yellow circles), no uncertain (red triangle).

i. Escaped farmed salmon

The number of rivers that have confirmed presence of escaped farmed salmon (adult catch or genetic screening of juveniles) were 43 out of the 133 assessed and found in all regions in Iceland. This number grew considerably in 2023 when a large escapee event occurred in the Westfjords of Iceland. Even though the number of escaped farmed salmon was estimated to be low, the number of fish eventually captured in rivers was relatively high and spread across a large area (Svavarsdóttir et al. 2024). Mitigation measures are in place that aims to minimize the risk of introgression of farmed salmon both by limiting the total allowable production according to an intrusion-risk-assessment that aims at keeping the intrusion level below 4%, and also by restricting the production of farmed salmon to the Westfjords and the Eastfjords which keeps the production in areas distant from most major salmon rivers.

ii. Pink salmon

The newly established pink salmon comes as one of the top stressors, primarily, for the same reason as escaped farmed salmon, because it has been caught in large number of rivers across all regions in Iceland. This is an invasive, alien species that originate in the Pacific but was introduced to the Atlantic Ocean and has been spreading quickly across the North Atlantic in the most recent years. The numbers have grown steadily in Iceland in the most recent years, but so far, not to the exponential extend seen in Norway were more than 360.000 pink salmon were caught in 2023. Even though the numbers have increased in Icelandic rivers, the knowledge on the effects, and future development is uncertain.

iii. Stocking

Stocking was conducted either in the most recent years or was currently being conducted in 27 rivers out of the 133 being assessed and was found on a national scale across Iceland. In some rivers the spawning potential of the wild salmon is very limited, and the stock must be maintained by hatchery reared smolts. These rivers are commonly called “salmon ranching rivers”. In other cases, Atlantic salmon usually has great potential to spawn in the natural environment, but a portion of the spawning stock is being removed from the spawning grounds to be used for broodstocks in a hatchery. It needs to be noted all stocking needs to follow an

enhancement plan accepted by the Directorate of Fisheries and transfer of hatchery reared fish between rivers is prohibited by law. The offspring from the hatchery are in most cases being reared to the smolt stage and released into the rivers in which their parents originated from. The potential risk associated with stocking can be mitigated by best management practices, but in many cases the stocking of salmon may to the long-term result in negative effect. In essence this is mainly due to removal of natural selection through exposure to the natural environment, which is being replaced by artificial hatchery environment and low number of parental fish. This could have negative effects on the genetic structure of the wild population.

4. Future development

This is the first development of a Stressor Analysis for Icelandic rivers, and it realises heavily on expert judgement as there is in many cases limited or no available data or measurement on the stressors across Iceland. It should be stressed that there was an emphasis on viewing the stressor from an anthropogenic viewpoint so stressors that arise from more natural cause like e.g. predation, competition or productivity were not considered. It might be argued that stressors arising from natural sources can be, in many rivers in Iceland, overarching the stressors of the anthropogenic origin which are being considered here. This natural type of stressors might be considered in later versions if this analysis will be updated on a regular basis. At this stage the results need to be introduced to the appropriate stakeholders and further engagement with them should be a part of the process before introducing this as the final version of the analysis.

References

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