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Mr. Elvar Fridriksson, Program Director NASF Iceland
NASF Iceland
Kalkofnsvegur 2, 101 Reykjavík
Iceland

Mr. Snaebjörn Gudmundsson, Chairman Náttúrurgrid
Náttúrurgrid
Bergthórugata 17, 101 Reykjavík
Iceland

Mr. Árni Finnsson, CEO Náttúruverndarsamtök Íslands
Thórunnartún 2, 105 Reykjavík
Iceland

Dear Mr. Elvar Fridriksson, Mr. Snaebjörn Gudmundsson and Mr. Árni Finnsson,

I would like to share with you my concerns regarding the impact of hydroelectric power plants on fish stocks in the lower Thjorsa river, beginning with the imminent development of the Hvammsvirkjun Hydro Project (Hvammur). My concerns are based on thirty years of experience working at the Fish Passage Center studying hydro project operation and the impacts to fish stocks in the Columbia and Snake Rivers.

Rivers are an extremely important and diverse ecosystem. Rivers link environments through the delivery of water, sediment, organisms, and nutrients to floodplains, deltas, and coastal regions. The ability of rivers to sustain biodiversity and provide multiple ecosystem services is determined by the degree to which their natural flow regime and connectivity are maintained. (Thieme et al., 2021)

Considerable data is available estimating the success of mitigating methods for fish survival for the installation of hydroelectric projects. The conclusion is that these methods are rarely successful in maintaining naturally spawning, self-sustaining populations of salmon. It must be cautioned that the assumptions made for the success of the engineered mitigation solutions at Hvammur are, given what we know regarding implementation in the Columbia River as well as in other river systems, overly optimistic.

The issues surrounding hydropower development and operations on rivers are abundant and far-reaching. The implications to, not only the Thjorsa River salmon population, but potentially to the ecology and biodiversity of the region is of concern. Consequently, at a time when regions like the Columbia River are considering large scale dam removal to aid in the recovery of endangered salmon populations, further development of hydropower should be seriously reconsidered.

My specific concerns are as follows:

- **The proposed juvenile passage system is unlikely to provide the survivals estimated and will not prevent declines in Thjorsa River salmon populations.**
- **The assumptions made based on other dams regarding success of the juvenile passage system proposed for Hvammur are not appropriate. Fish behavior is not predictable.**
- **Not all species present in the Thjorsa River, nor fish life cycles (iteroparity), are considered in the analyses.**
- **The potential impacts of climate change on the region are ignored. Changes in temperature, leading to changes in flow volumes and patterns, could have profound effects coupled with warming ocean conditions.**
- **The proposed one-month provision of spill to aid juvenile fish passage is likely inadequate to maintain sufficient genetic diversity in the population. Genetic diversity allows a population to withstand environmental challenges.**
- **The impacts that the proposed tailrace conditions, and the shallow depths that will be encountered by juvenile migrants, in the 3 Km below Hvammur, are not considered in the overall survival of the salmon population.**
- **Juvenile salmonid migration impacts from passage conditions through dams can lead to early death at a later time, or life stage (delayed mortality).**
- **The damming of a river and creation of a reservoir lead to increases in the time it takes for juvenile migrants to reach the sea.**
- **While ocean survival is an important factor in salmon survival, it does not tell the whole story.**
- **The effects of declining populations in the Thjorsa are not limited to this river alone. The overall impact to the biodiversity of the region is ignored.**

In conclusion, given the importance of the Thjorsa salmon population to Icelandic salmon in general, and the potential impacts of climate change, proceeding **with the development of Hvammur will place these salmon populations and, potentially, this ecosystem and regional biodiversity at high risk.**

Sincerely,

Margaret J. Filardo, Ph.D.
Fisheries Scientist

Summary of Concerns Regarding Fish Survival due to the Proposed Hvammur Hydro Project

Substantial discussion of all the highlighted areas of concern were transmitted to the late Mr. Orri Vigfusson of the North Atlantic Salmon Fund in memorandum developed by the Fish Passage Center in 2011, 2013, 2014 and 2016. Considerable details of all the following topics are contained in those memoranda and are summarized here.

The proposed juvenile passage system is unlikely to provide the survivals estimated and will not prevent declines in fish populations.

The cited estimates of juvenile passage success and survival are overstated for Hvammur. The estimates for survival through Kaplan turbines are very optimistic. The volume of flow proposed for release via juvenile passage system is inadequate based on systems used in the Columbia River Hydrosystem. There is considerable data available to suggest that mitigating for the installation of hydroelectric projects is rarely successful in maintaining naturally spawning, self-sustaining populations of salmon. It has been demonstrated that fish that survive juvenile bypass systems or powerhouse passage are less likely to survive the first ocean year, and less likely to return as adults. (Haeseker et al., 2012; Petrosky and Schaller, 2010; Tuomikoski et al., 2010; Fish Passage Center Memos October 6, 2010, January 19, 2011, and July 14, 2011; Schaller and Petrosky, 2007). This has not been considered in the Hvammur project.

The assumptions made based on other dams regarding success of the juvenile passage system proposed for Hvammur are not appropriate. Fish behavior is not predictable.

Assuming juvenile passage countermeasures implemented at one hydro project will work the same at another hydro project is extremely risky. The decision to develop the spillway for juvenile fish passage was based on the use and operation of the juvenile bypass system at Wells Dam on the Columbia River. The configuration of the Wells project is unique in that it is a hydro combine with a spillway that sits over the turbine units. The proposed juvenile system for Hvammur is not the same as exists at the Wells Dam. Hvammur is a penstock project where water is drawn from the reservoir to the powerhouse and then returned some 3 Km below the project. Some water is being proposed to spill as protection for juvenile salmon. At Wells Dam, the flow net approaching the dam is 100 percent in the direction of the spill gates, whereas, at Hvammur the proposed powerhouse flow (352 m^3/sec), removed just above the dam and the juvenile spillway, is 10 times the amount proposed as mitigation flows over the spillway (35m^3/sec) during the fish migration. This is important since we know migrating juveniles are often passive in their swimming and go in the direction of most flow.

Not all species present in the Thjorsa River, nor fish life cycles (iteroparity), are considered it the analyses.

There is no recognition, nor are countermeasures provided, to address the iteroparous (repeat spawning) nature of the Thjorsa fish. Nor is there consideration of other species movement in-river. In the Columbia River steelhead trout are iteroparous and, while there are adult ladders allowing for the up-river return of these fish, no accommodations are made for a return migration to the sea. Consequently, most of these adult fish pass through turbine units and suffer large percentages of mortality. Iteroparity rates of Snake River steelhead are the lowest recorded for the steelhead species. This is an important consideration because repeat spawners generally produce larger eggs and by repeated spawning, provide additional potential for population growth. This life history strategy provides important genetic diversity for the species survival.

The potential impacts of climate change on the region are ignored. Changes in temperature, leading to changes in flow volumes and patterns, could have profound effects coupled with warming ocean conditions.

Climate change was not addressed as a potential impact to fish migrations and survivals during river life stages. Changes in river and ocean conditions associated with increasing global temperatures, and the impact on the salmon population, must be assessed. The development of reservoirs and diminished water supplies immediately downriver of the project could negatively affect both river temperature and flow. The impact of climate change is not considered in the estimations and how this can affect the situation in the river and the migration behavior.

The proposed one-month provision of spill to aid juvenile fish passage is likely inadequate to maintain sufficient genetic diversity in the population. Genetic diversity allows a population to withstand environmental challenges.

The limited spill period (up to 4 weeks) is based on summaries from some past studies conducted in the Thjorsa. These summaries are based on limited sampling periods. Fish migrations occur in a bell-shaped curve and, while most fish move is a short time period, limiting protection to that part of the run limits the protection of the genetic diversity contained in the beginning and end portion of the migration. Genetic diversity is critical for a species' ability to survive. Protecting the whole run is extremely important in that if disease occurs, or if there are environmental changes in parameters like flow and temperature, some fish will have the genetic traits to survive and reproduce. This will ensure that the species will have a better chance at surviving changes that might occur with global warming. The genetic diversity provides population resiliency to environmental stress imposed by climate change.

The impacts that the proposed tailrace conditions, and the shallow depths that will be encountered by juvenile migrants, in the 3 Km below Hvammur are not considered in the overall survival of the salmon population.

The location of juvenile tailrace exit and the water velocity are important considerations in determining predation mortality after passing the juvenile facility. Any delay in the migration that might occur due to low flow and tailrace conditions can increase the exposure time to predators and increase mortality.

In addition, spilling water over a hydroelectric project can generate atmospheric total dissolved gas supersaturation of the river water that may have detrimental effects on fish. This total dissolved gas supersaturation can cause fish to suffer from gas bubble trauma by producing emboli in the blood, heart and gill filaments that can lead to death. In the Columbia system, the amount of total dissolved gas supersaturation can vary and become as high as 125% without causing issues, primarily due to the depth of the river. The amount of total dissolved gas supersaturation in the water column is dependent on pressure, and decreases with depth. Therefore, if fish travel deeper in the water column, they are less affected. However, the impact of total dissolved gas supersaturation at the shallow depths encountered in the 3 km downstream of Hvammur, prior to the reentry of the powerhouse flow, could adversely affect fish survival.

Juvenile salmonid migration impacts from passage conditions through dams can lead to early death at a later time, or life stage (delayed mortality).

Indirect mortality is mortality that occurs within the hydrosystem as a result of hydro project passage, but are not measured in at-project mortality estimates. Consequently, estimates of fish survival cited for at-project survival are underestimates.

Additionally, delayed mortality is directly related to hydrosystem passage, but is expressed at a later life stage. The factors believed to contribute to delayed mortality include: delayed arrival timing in the estuary and ocean (the series of dams and reservoirs increases juvenile travel time through the migration corridor); sublethal injuries or stress incurred during migration through juvenile bypass systems, turbines, or spillways; disease transmission or stress resulting from the artificial concentration of fish in bypass systems; and the depletion of energy reserves from prolonged migrations.

There is considerable evidence that Snake River stream-type Chinook experience substantial latent, or delayed, mortality in the marine environment as a result of their outmigration experience through the Columbia River hydrosystem. This outmigration experience results in an accumulation of injuries, multiple stress events, and alteration of estuary arrival timing: mechanisms that may explain levels of delayed mortality. Limiting the assessment of hydrosystem impacts to simple passage issues is inadequate. Again, the delayed mortality from the accumulation of multiple dam and reservoir passages can manifest into poor survival during estuary and marine life stages

The damming of a river and creation of a reservoir lead to increases in the time it takes for juvenile migrants to reach the sea.

Decreased water velocity and dam passage has been related to large increases in the time required for juveniles to migrate to sea leading to reductions in life cycle survival, smolt to adult returns, and marine survival rates for Snake River Chinook Salmon. Based on the experience in the Columbia River in the United States, juvenile fish migration time would increase with the development of reservoirs in the Thjorsa. Increasing the amount of time it takes for juvenile fish to migrate to sea decreases juvenile survival and subsequently, the survival of returning adults. This reduction in survival is due to increased exposure time to predation and increased temperature, and by altering a fish’s timing of seawater entry.

While ocean survival is an important factor in salmon survival, it does not tell the whole story.

Rates of smolt-to-adult return for populations of salmon and steelhead in the Columbia River Basin reflect the influence of various factors acting throughout the life-cycles of fishes in each population. These factors include temperature and flow conditions during outmigration, direct effects of hydro-system passage, estuary survival, delayed mortality, ocean conditions, predation, harvest, and freshwater temperatures and flow conditions during the adult return. While there are several factors that may dictate survival of fish to adulthood in any given year, the strong influence of hydrosystem effects is evident when comparing the success of populations in different subbasins throughout the system. Storch et al. (2022) found that the major factors that limit recovery of important migratory fish species are well-documented. Many analyses, representing decades of study, suggest listed populations of Snake/Columbia River Basin salmon and steelhead face seemingly insurmountable constraints to recovery owing to development and operation of the Columbia River Hydrosystem (Schaller et al. 1999, 2014a; Haeseker et al., 2012; Petrosky et al., 2020).

The effects of declining populations in the Thjorsa are not limited to this river alone. The overall impact to the biodiversity of the region is ignored.

No recognition is given to the importance of the viability of Thjorsa River salmon to other Icelandic salmon populations, other Atlantic salmon populations, or to other species. The Icelandic populations of salmon represent the northern extent of the distribution of salmon. Consequently, these salmon likely have unique adaptations given the unusual geology of Iceland. Given that, the salmon populations of Iceland likely function as metapopulations (Hanski, 1999), where populations are not completely isolated and are connected by the movement of individuals (immigration and emigration) among them, their population viability is extremely important. The Thjorsa salmon populations are considered the largest in Iceland and consequently, increasing the risk to the Thjorsa salmon will likely affect the resiliency of many of the salmon populations in other parts of Iceland. Additionally, impacts to the Thjorsa population, which is likely a unique segment of the population, could also put other Atlantic salmon populations at risk.

In addition, recent substantial scientific evidence has highlighted the important relationship between salmon from the Columbia Basin, particularly Snake River Chinook, and the future survival of the critically endangered Southern Resident Killer Whales (Orca). Restoring healthy, abundant salmon to the Snake River is critical to providing an adequate prey base for Orcas. This demonstrates the importance of Columbia River Chinook salmon to the overall biodiversity of the Pacific Northwest of the United States.

The possible implications of a decline in the viability of Thjorsa River salmon, as well as other species, and the impacts to the biodiversity of the Icelandic region are not considered.

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