FISH PASSAGE CENTER

847 NE 19th Avenue, #250, Portland, OR 97232
Phone: (503) 833-3900 Fax: (503) 232-1259
www.fpc.org/
e-mail us at fpcstaff@fpc.org

January 20, 2016

Mr. Orri Vigfússon
North Atlantic Salmon Fund
Skipholti 35
105 Reykjavík, Iceland

Dear Mr. Vigfússon,

In response to your request we have reviewed the English Translation of Section 10 "Effects on Aquatic Life" that was part of the larger document, *Decision by the Planning Authority of the Hvammsvirkjun project in the Lower Thjórsá*. The Planning Authority concludes in Section 10 of the document that an additional environmental impact assessment, beyond that conducted in 2003, is not necessary regarding the decision to move the Hvammsvirkjun to the utilization category of the Master Plan.

The Planning Authority recognizes that hydroproject development will have a significant impact on the biota of the lower Thjórsá River, but accepts that the implementation of countermeasures and monitoring are sufficient to limit the effects on aquatic life. Both the decision to move the Hvammur hydroproject to the utilization category, and the present decision to forgo additional environmental assessment, rely heavily on the development of proposed mitigation and countermeasures to ameliorate the significant impacts imposed by development. A 10- year monitoring period is presented as sufficient to assess the uncertainty of the effects the hydroprojects would have on fish populations, and the ability of the proposed countermeasures to address those effects.

The Planning Authority fails to take into consideration the significant knowledge and studies available from other countries that show that the implementation of countermeasures and monitoring does not equate to viable salmonid populations.

After reviewing Section 10 of the document, as well as past information in the process, we have the following concerns:

- The proposed countermeasures will not prevent the decline of fish populations. The cited estmates of juvenile passage success and survival are overstated. Previously provided comments regarding the efficacy of the countermeasures have been overlooked and ignored.

- Fish behavior is not predictable. Assuming juvenile passage countermeasures implemented at one hydroproject will work the same at another hydroproject is extremely risky.
- No recognition is given to the importance of the viability of Thjórsá River salmon to other Icelandic salmon populations and other Atlantic salmon populations.
- There is no recognition, nor are countermeasures provided, to address the iteroparous (repeat spawning) nature of the Thjórsá fish.
- The proposed measurements for assessing the success of countermeasures are not designed to measure the impacts of hydrosystem development on Thjórsá River salmon population viability.
- If implemented, the proposed 10-year monitoring period is insufficient to assess population viability
- Climate change was not considered in the decision to move the Hvammur hydroproject to the utilization category. Changes in river and ocean conditions associated with increasing global temperatures, and the impact on the salmon population, must be assessed.
- The potential cost of mitigation over time has not been addressed or incorporated into the decision-making process.
- The 2015 responses from Landsvirkjun to questions originally posed in 2012 shows a general lack of understanding regarding the ramifications of hydropower development on natural populations.

The proposed countermeasures will not prevent the decline of fish populations. The cited estmates of juvenile passage success and survival are overstated. Previously provided comments regarding the efficacy of the countermeasures have been overlooked and ignored.

We have previously provided you with extensive comments regarding the effectiveness of the proposed countermeasures. Those comments have been largely overlooked and ignored in the process. The comments were contained in a March 18, 2014, letter (attached) that concluded:

> "that the assumptions made for the success of the engineered mitigation solutions are overly optimistic, given what we know regarding implementation in the Columbia River as well as in other river systems. 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."

Our prior comments stated that there are three reasons why we do not agree that the juvenile passage structures will achieve the high performance suggested by the National Power Company. The reasons are: (1) that due to fish behaviors and variability, it is unlikely that the surface collection outlet systems (SFO) will achieve the assumed 91% efficiency; (2) the assumed 100% survival through the SFO is based on flawed studies; and, (3) the relation between juvenile migration through a hydroproject and the delayed mortality associated with this passage is ignored (see March 18, 2014, letter for more detailed discussion).

Specifics regarding the countermeasures that would be provided at the dams for juvenile passage were provided by Landsvirkjun in a letter dated September 2, 2015. The decision to develop a surface flow outlet (SFO) was based on the use and operation of SFO in the United States. The premise of an SFO is that fish tend to be distributed with a more surface orientation. The basis for the use of a SFO comes from the juvenile bypass system at Wells Dam on the Columbia River. The configuration of this project is unique in that it is a hydrocombine with a spillway that sits over the turbine units. The spillway has been modified to pass juvenile migrants and is considered to be effective at passing juveniles away from the turbine units (Skalski et al., 1996).

While the effectiveness SFO structures at Wells Dam are fairly high there is still considerable concern regarding the optimism of the cited estimates of passage success. The proposed SFO countermeasure for Hvammur is not the same as exists at the Wells Dam. Landsvirkjun contends that dye tests conducted and numerical models confirm the direction of flow and, therefore, gives them the 90%–95% efficiency of the countermeasure that they cite. Caution should be exercised in that, while dye tests and numerical models provide some knowledge, they do not represent fish behavior. Simply stated, scale models using plastic beads or dye do not predict how fish will travel. For example, at Bonneville Dam on the Columbia River, dye traces were observed in a turbine intake model to develop a configuration for a large screen which could be placed into a turbine intake and intercept juveniles passing into the turbines. Based on the modeling results, a configuration was selected where nearly 100% of the dye moved above the screen. On testing the prototype in the field, however, less than 40% of the juveniles migrated above the screen. Inanimate objects do not adequately represent fish with behavior (Gessel et al. 1991).

It is important to note, that all of the countermeasures described by Landsvirkjun, and many more, have been implemented in the Columbia River hydro system. However, in spite of the implementation of these countermeasures, and continued improvement and implementation of additional measures, the Columbia River does not support sustainable natural salmonid populations. Hydroprojects in the Columbia River impose sufficient mortality upon populations such that populations are maintained at levels that warrant their existence as species at risk of extinction. Even when implemented, the countermeasures proposed by Landsvirkjun are insufficient to assure the viability of the fish populations in the Thjorsá.

Fish behavior is not predictable. Assuming juvenile passage countermeasures implemented at one hydroproject will work the same at another hydroproject is extremely risky.

As we stated above, the proposed countermeasures for juvenile passage are premised on the success associated with surface flow outlets at Wells Dam on the Columbia River. However, we caution that this assumption of similar juvenile passage success on the Thjórsá is questionable and uncertain due to the unaddressed question of fish behavior.

Based on the success of the Wells Dam configuration, a second hydrocombine dam, the Cowlitz Falls Dam located on the Cowlitz River, Lewis County, Washington, was built and became operational in 1994. The decision to mimic the unique structure of Wells Dam was based on the success of the surface flow bypass for salmonid smolts. The initial juvenile bypass structures were installed in 1996 and annual estimates of fish passage collection via the surface flow collector have not achieved expectations. Studies have shown that juvenile steelhead

(*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*), and Chinook salmon (*Oncorhynchus tshawytscha*) located the collection entrances effectively (discovery rates of the surface collection system routinely exceeded 90 percent), but many of these fish did not pass the dam via the surface flow collector (Hausmann et al., 2001; Farley et al., 2003; Liedtke et al., 2010). Mark-recapture findings indicated that only about 50 percent of juvenile steelhead, 21 percent of juvenile Coho, and 20 percent of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) were bypassed annually during 1996–2012 (Serl and Heimbigner, 2013). Significant modifications have been made to improve passage through the surface passage routes without success.

Similar surface bypass structures implemented on two dams on the Snake River showed different passage results at similar proportions of water passing through the structures. At these dams a proportion of the total river flow is diverted to the spillway where a surface bypass collector is installed in the spillbay nearest the powerhouse. At 20% of the available spillway water passing through the spillbay containing the surface bypass structure at Lower Granite Dam, approximately 70% of Chinook salmon and 75% of steelhead salmon approaching the spillway passed through the surface bypass structure based on mark-recapture experiments. However, at Ice Harbor Dam, located 160 Km downstream, the surface bypass structure passed only 45% of Chinook salmon and 50% of steelhead salmon under the same conditions (Zabel et al., 2008, and http://www.cbr.washington.edu/analysis/compass).

The assumption by the Planning Authority is that if countermeasures do not work as intended, the actions described in the submitted action plan will address all concerns. This assumption appears short sighted.

No recognition is given to the importance of the viability of Thjórsá River salmon to other Icelandic salmon populations and other Atlantic salmon populations.

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 Thjórsá salmon populations are considered the largest in Iceland and consequently, increasing the risk to the Thjórsá salmon will likely affect the resiliency of many of the salmon populations in other parts of Iceland. Additionally, impacts to the Thjórsá population, which is likely a unique segment of the population, could also put other Atlantic salmon populations at risk.

There is no recognition, nor are countermeasures provided to address the iteroparous (repeat spawning) nature of the Thjórsá fish.

Kelts (or repeat spawners) are considered to be an important aspect of the overall life history of salmonids. Atlantic salmon, brown trout, and char are all repeat spawners migrating to the sea at various times of the year, various sizes and physical condition. Iteroparous populations generally have higher population abundance and productivity over their lifetime. While repeat spawners comprise a smaller percentage of the population, they represent a significant contribution to the life history diversity exhibited by these populations. In the Snake and Columbia River systems, fish passage facilities at hydroelectric dams were not designed or constructed to accommodate downstream-migrating, post-spawning adult kelts. From the passage mortality estimated for the few steelhead kelts, it has been established that the mortality on these fish has been very high when migrating downstream to the sea. Estimates of kelt passage survival in the Columbia River have ranged from 4.1 to 6.0 percent in the low flow year 2001 to 15.6 percent in 2002 and 34 percent in 2003 (Boggs and Peery 2004; Wertheimer and Evans 2005). Although some portion of the implied mortality would occur in a free-flowing river, fisheries managers expect that survival is low because turbine bypass systems were not designed to safely pass adult fish. In addition to causing injury and mortality, the mainstem hydro projects delay kelt downstream migrations (Wertheimer and Evans 2005). Thus, while there may be a relatively large number of kelts in Snake River, survival through the FCRPS may limit their contribution to the productivity of their respective populations.

There has been no consideration of kelt passage requirements or needs in this process.

The proposed measurements for assessing the success of countermeasures are not designed to measure the impacts of hydrosystem development on Thjórsá River salmon population viability.

The monitoring of the success of countermeasures focuses on at-structure direct mortality or passage sucess. There appears to be a lack of concern for measuring the indirect effects of structure passage, or the delayed effects of hydrosystem passage. Indirect mortality is mortality that occurs within the hydrosystem as a result of hydroproject passage, but are not measured in at-project mortality eestimates. Delayed mortality is directly related to hydrssytem 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. This mortality is often comingled with the measurement of ocean mortality.

The assumptions made by Landsvirkjun for juvenile survival ignore indirect mortality as well as delayed mortality by assigning it to ocean mortality. The implication made by Landsvirkjun is that there is no relation between in-river and ocean processes. This is incorrect. The monitoring that will be conducted will prove insufficient for measuring the actual impacts imposed by hydroproject development over the entire life cycle.

If implemented, the 10 year monitoring period is insufficient.

The Atlantic salmon life cycle is comprised of one to five years spent in fresh water and one to four years spent at sea. In order to have an adequate understanding of the efficacy of the proposed countermeasures it is absolutely necessary to measure the impacts in terms of survival of fish to adulthood. Given the life cycle of Atlantic salmon it would be imperative to continue monitoring significantly longer than ten years and include a smolt-to-adult survival metric. Focusing on the success of a ladder, or juvenile bypass system, on the basis of only one life stage is not sufficient to assess the actual impacts of the new hydro projects on the Thjórsá River salmon population. Again, it is extremely important to evaluate the effects of countermeasures over the entire life cycle.

To illustrate the potential failure associated with focusing on one life stage when measuring the effects of countermeasures, after more than 35 years of developing and implementing state-of-the-art countermeasures and focusing on success at a specific life stage, Pacific salmon stocks remain endangered and remain at risk of extinction.

Climate change was not considered in the decision to move the Hvammur hydroproject to the utilization category. Changes in river and ocean conditions associated with increasing global temperature, and the potential impact on the salmon population, must be assessed.

Salmon populations all across the northern hemispheres are challenged and stressed by the impacts of climate change. The variability in environmental conditions is increasing for salmon populations across the northern hemisphere for both ocean and freshwater environments. These variable conditions are stressing the resiliency of numerous salmon populations; in particular the populations that are impacted by anthropogenic development. The decision to move the Hvammur hydroproject to the utilization category and the present decision to forgo additional environmental assessment appears to ignore the projections that future environmental conditions will greatly increase in variability and along with further development of the Thjórsá River likely impact the resiliency of salmon populations.

Salmon recruitment success in the ocean environment is generally believed to occur largely during the first critical months at sea (Ricker 1976; Mueter et al. 2002; Pyper et al. 2005). Salmon exhibit complex life histories and variable levels of survival rates as a result of conditions in freshwater and ocean environments. For many of the salmon populations along the west coast of North America, overall life-cycle survival appears to be regulated by conditions of both the freshwater and marine environments (Bradford 1995; Bisbal and McConnaha 1998; Lawson et al. 2004). The Northwest Power and Conservation Council highlighted the need to identify the effects of ocean conditions on anadromous fish survival so that broad conservation and management actions taken inland will provide the greatest benefit in terms of improving the likelihood that Columbia River basin salmon can survive varying ocean conditions (NPCC 2009). While distinguishing between the influence of ocean and freshwater factors on salmon survival is difficult and requires long time series of life-stage-specific demographic data because of possible confounding factors, the knowledge is critical to predict best what potential inland protection and restoration actions are needed to conserve and recover depressed populations of salmon (Schaller et al. 2014).

With the prospect of changing climate, migratory temperate zone animals could be pressured into smaller geographic ranges, making conservation initiatives and planning efforts even more important, and requiring more aggressive protective actions than are currently planned. Maintaining the resiliency within metapopulations, such as Thjórsá River salmon, demands a broad scale suite of protective actions within their inland freshwater environment that considers the effects over entire life cycle.

The potential cost of mitigation over time is not addressed or incorporated into the decision-making process.

We do not believe that the actual cost of countermeasures, in terms of the real amount of money that will be spent on mitigation and success, have been fully incorporated into the decisions made thus far regarding hydropower development. Countermeasures to protect fishery resources cost significant amounts of money and are rarely successful. Countermeasures, monitoring, research and state-of-the-art improvements have been implemented in the Columbia River since the late 1970s. In spite of these countermeasures there was a continued decline of salmon viability causing a listing under the United States Endangered Species Act in the early 1990s. Salmon stocks remain on the endangered species list and do not meet viability standards for producing self-sustaining populations over time.

In 1980 a federal law (the Northwest Power Act) was passed in the United States to address the impact of hydroelectric dams on the Columbia River in the Pacific Northwest. The act established the Northwest Power and Conservation Council, which is responsible for the development of a Fish and Wildlife Program to be implemented in the Columbia River. That Program is funded through ratepayer dollars from hydrosystem operation. In fiscal year 2014 (NPCC 2015) the total fish and wildlife costs were estimated at approximately $782.3 million U.S. dollars. The $782.3 million U.S. dollars was used for: investments in fish passage and fish production, funding the Northwest Power and Conservation Council; paying the fixed costs (interest, amortization, and depreciation) of capital investments for facilities such as hatcheries, fish-passage facilities at dams, and some land purchases for fish and wildlife habitat; offsetting forgone hydropower sales revenue that results from dam operations that benefit fish but reduce hydropower generation; and, in making power purchases during periods when dam operations to protect migrating fish reduce hydropower generation, such as by spilling water over dams in the spring or storing it behind dams in winter months in anticipation of required spring spill.

In spite of substantial modifications to flow and spill in the hydrosystem, both within and outside of the fish passage season, as well as the installment of surface flow outlets, most fish populations are not viable. The *2015 Comparative Survival Study (CSS) of PIT-tagged spring/summer/fall Chinook, Summer Steelhead and Sockeye* (McCann et al., 2015) found that smolt-to-adult return rates (SARs) for most species are not meeting regional goals for salmon and steelhead recovery. Fish remain in danger of extinction.

The 2015 responses from Landsvirkjun to questions originally posed to in 2012 show a general lack of understanding regarding the ramifications of hydro development on natural populations.

In January of 2012, we provided you a list of questions that you might pose to Landsvirkjun regarding the hydro development of the lower Thjórsá River in Iceland. The list was based on our experience of the factors that have the most effect on salmonid survival. A response to those questions was received from the Power Company in September of 2015. We have not yet responded to the Landsvirkjun response, but have some preliminary concerns that we can share here regarding the response to several of the questions originally posed.

We asked about the impact that hydro development in the Thjórsá has already had on the natural hydrograph. We were concerned that the hydro development of the Thjórsá River had already significantly affected the river's flow regime. Typically, in a hydro-developed river, with seasonal flows, water is stored in upstream reservoirs during periods of high runoff or melt and used to produce power when flows would typically be low (i.e., during the winter). The information provided confirmed that the annual hydrograph has been considerably altered by hydro development. Historically (pre-development) flow was low during the winter period and high during the spring and early summer period. Post hydro development (2001–2009), higher flows now occur during the winter period and flows during the spring and early summer period (the juvenile fish migration period) are lower than pre-hydro development.

Presently, since the river is free flowing and no reservoirs exist, the shape of the river channel assures that there is little variation in water speed that occurs over a range of flows. This is why the hydro development in the upper Thjórsá has had little impact on the juvenile migratory populations. With the addition of reservoirs in the fish migration corridor, it is anticipated that due to the shape of the reservoirs there will be a change in the speed at which juvenile fish migrate to the sea, as demonstrated by changes in water transit time.

Water transit time does not equate to fish migration speed and the Landsvirkjun conclusion that the addition of three hydroelectric projects will only delay the juvenile migration by a total of 30 hours is completely erroneous.

The exercise does show that the change in water transit time pre-development in the lower Thjórsá to post development can effectively be more than doubled after development of the three hydro projects. This suggests there will be a significant impact on the amount of time it takes for juvenile migrants to reach the sea. During this increased time period, juvenile migrants are exposed to increased predation and other issues associated with the migration corridor. The relation between flow (or water transit time) and juvenile survival through the migration corridor has long been demonstrated. A longer juvenile migration time translates to a lower juvenile survival through the migration corridor.

We asked about an objective for a smolt-to-adult survival rate. There is no objective anywhere in this process for maintaining a juvenile (or smolt) to adult survival rate. This is extremely short sighted. Landsvirkjun concludes that such an objective is not necessary when they wrote, "Since almost all losses (99%) happens in the ocean outside the river, no target objective in terms of maintaining a specific smolt to adult survival has been specified."

The assumption that a good deal of mortality takes place in the ocean, where there is no control, is true. However, the assumption that there is no impact of the hydro development on the juvenile life stage is incorrect on two counts:

1) If the percent of juveniles surviving the migration to the sea is decreased due to hydro development, then the number of adult fish returning decreases, since a dead juvenile cannot translate to a live adult.

2) There have been numerous studies demonstrating the existence of delayed mortality associated with juvenile passage through the hydrosystem. This mortality occurs during the ocean phase, but is directly attributable to the juvenile hydro system passage experience.

In summary, the process that has occurred thus far regarding the movement of the Hvammur hydroproject to the utilization category and the decision to forgo an updated Environmental Assessment, relies on building the dam and then observing what the effectiveness of the countermeasures are on aquatic life in the Thjórsá River. This approach does not address the substantial information of the impacts of hydro development on aquatic populations from rivers around the world. If that information were taken into consideration the only logical conclusion would be that there is more "certainty" associated the impacts of hydro development than "uncertainty." Regardless of the implementation of countermeasures and monitoring, once Hvammur is built there will be substantial negative impacts to the aquatic life of the Thjórsá.

Sincerely,

Margaret J. Filardo, Ph.D.
Supervisory Fish Biologist

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Attachment to Letter Dated January 20, 2016

FISH PASSAGE CENTER

847 N.E. 19th Avenue, #250, Portland, Oregon 97232

Phone: (503) 833-3900 Fax: (503) 232-1259

www.fpc.org

e-mail us at fpcstaff@fpc.org

March 18, 2014

Mr. Orri Vigfússon
North Atlantic Salmon Fund
Skipholti 35
105 Reykjavík, Iceland

Dear Mr. Vigfússon,

We understand that pursuant to our last correspondence relative to the 2011 Master Plan Review, the Ministry for the Environment and Natural Resources appointed a Specialist Group to provide an evaluation of the impact of development on salmonids in the Thjorsa River, stemming from the proposed Hvammur, Holt and Urridafoss hydro-electric plants in the lower reaches of the river. The group was charged with assessing the uncertainty associated with existing information. The draft recommendation of the Specialist Group (December 19, 2013), now in consultation, is to re-classify the Hvammur hydroelectric plant from the “on hold” category to the “utilization” category, while retaining the Holt and Urridafoss plants in the “on hold” category.

It has been duly recognized that hydro development has significant impacts on the survival of fish stocks in the Thjorsa. Skulason and Ingvason (2013) conducted an independent evaluation of available research on the ecology of Atlantic salmon (*Salmo salar*) in the Thjorsa in relation to the proposed hydroelectric power plants and dams in the lower part of the river and concluded that “the overall impact of the hydroelectric power plan in the lower Thjorsa system would have significant and irreversible negative effects on their populations.” The question remains whether the proposed mitigation and countermeasures presented can ameliorate the significant impacts imposed by development. It appears that by recommending the re-classification of the Hvammur project, the Specialist Group accepts that the countermeasures offered can address the impacts of the development and maintain fish stocks in the Thjorsa.

The justification for the mitigation and countermeasures offered appears to rely heavily on the research conducted on the Columbia River in the USA. However, based on the experience of the efficacy of the mitigation measures implemented on the Columbia River, it must be cautioned that the assumptions made for the success of the engineered mitigation solutions are overly optimistic, given what we know regarding implementation in the Columbia River as well as in other river systems. 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. We have previously stated, and will reiterate here, that in spite of an estimated 11.9 billion U.S. dollars spent between 1979 and 2008 attempting to recover Columbia River salmon stocks by implementing, and continuing to modify mitigation efforts, we have failed to recover natural populations that remain as endangered species and are at risk of extinction.

These comments focus on the recommended development of the Hvammur project, but recognize that one of the primary justifications for developing the Hvammur plant is to research the proposed mitigation using this plant for future application to the other two proposed hydroelectric projects. We received several specific questions from you relative to these documents. To facilitate our review you provided an English translation of the following documents:

Skulason, S and H.R. Ingvason. Evaluation of Available research on salmonids in the river Thjorsa in S-Iceland and proposed countermeasures and mitigation efforts in relation to three proposed hydroelectric power plants in the lower part of the river. October, 2013.

Specialist evaluation of uncertainty of existing information on the impact of salmonids in the Thjorsa River, stemming from the proposed Hvammur, Holt and Urridafoss hydro-electric plants in the lower reaches of the river. Report to the Master Plan Steering Committee, November 4, 2013.

Response from the National Power Company regarding the October 22, 2013 request. Letter Dated October 31, 2013.

In general, the documents seem to suggest that mitigation for the presence of a Hvammur hydroelectric project will successfully mitigate the damage caused from hydro development. The National Power Company offers limited details, but suggests that mitigation is simple and can be very effective. This is an overly optimistic stance and is based on many questionable assumptions with large uncertainties. In response to your request we have the following answers to your questions.

Is the juvenile passage structure proposed for installation at Hvammur likely to meet the passage and survival estimates proposed by the National Power Company?

No, it is highly unlikely that the juvenile passage structures will meet the suggested passage and survival estimates provided by the National Power Company. In the October 31, 2013, letter from Landsvirkjun it is stated that a juvenile fish bypass structure will be included at Hvammur with a design similar to that proposed for Urridafoss. The National Power Company projects that based on their studies 91% of fish will pass the project via the surface flow bypass, with nearly 100% survival. The remaining 9% of fish are predicted to pass through the turbine units. The proposed Kaplan turbines are “fish friendly” turbines that have minimum gap runners, and a higher juvenile fish survival rate. Consequently, one is led to believe that the installation of the hydro project will be benign to the passage of juvenile and adult migrants.

There are three reasons why we do not agree that the juvenile passage structure will achieve the high performance suggested by the National Power Company: (1) Due to fish behaviors and variability, it is unlikely that the surface collection outlet systems (SFO) will achieve the assumed 91% efficiency; (2) the assumed 100% survival through the SFO is based on flawed studies; and, (3) the relation between bypass and powerhouse passage to latent mortality associated with these passage routes is ignored.

Assumption of 91% Fish Passage via Surface Flow Bypass

Surface collection outlet systems (SFO) are effective because juvenile salmonids typically migrate near the surface. However, in order to collect and pass fish, conditions in a dam forebay must be favorable to fish discovering, entering, and being retained in the system (Coutant and Whitney, 2000; Johnson and Dauble, 2006). The National Power Company expects that 91% of the juvenile fish approaching the project will pass via the surface flow bypass system. This assumption is based on two Master of Science theses (Gunnarsson, 2012; Gudmundsson, 2013) that have been completed developing either a physical model (Hvammur) or a physical model with validation using a numerical model (Urridafoss). The concept of a surface bypass collector for fish passage is based on the hydro-combine dam arrangement at Wells Dam on the Columbia River, USA. At Wells Dam the juvenile bypass system sits on top of the turbine units and has been very effective in passing juvenile migrants. Consequently, given the success at Wells Dam, this arrangement has been proposed for consideration as mitigation at other dams. What has been found from these other applications is that each project is unique and what works well in the case of Wells Dam, may not be applicable at other projects. For example, the Urridafoss thesis mentions the SFO at the Cowlitz Falls Dam, and recognizes that it has not worked as expected. It is a good illustration, since even with knowledge of juvenile fish behavior, this surface collection system has not worked as predicted.

The Cowlitz Falls Dam, located on the Cowlitz River in Washington State, is a concrete gravity dam with spill bays located directly above the generating units. Two Kaplan turbines are located below the two center spillways in a hydro-combine design. The initial juvenile bypass structures were installed in 1996 and annual estimates of fish passage collection via the surface flow collector has been less than stellar over those years. Studies have shown that discovery rates of the surface collection system routinely exceed 90 percent at Cowlitz Falls Dam (Hausmann et al., 2001; Farley et al., 2003; Liedtke et al., 2010). However, mark-recapture findings indicate that only about 50 percent of juvenile steelhead, 21 percent of juvenile coho, and 20 percent of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) were bypassed annually during 1996–2012 (Serl and Heimbigner, 2013). Significant modifications have been made to improve passage through the surface passage routes, but as recently as 2013 turbine passage was the most common route for fish passage at this project.

Estimates of 100% juvenile survival through Surface Flow Bypass Structures

The near 100% juvenile survival estimates are derived from performance standards testing studies conducted in the Columbia River. While performance standards tests conducted at Columbia River dams often report survival estimates near 100%, both the applicability and development of these estimates has been in question. Acoustic tag studies provide only short-term survivals for specific projects, and current performance testing does not include important metrics such as forebay residence time, travel time, or indirect mortality expressed a short distance below the dam. The location of juvenile bypass exits and the environmental conditions can greatly affect survival below the hydroelectric project. Increased avian and piscivorous predation can contribute to mortality at the juvenile exit location if conditions are not sufficient in terms of flow and hydrology.

In addition to the inappropriate use of these limited application performance standards estimates, there have been serious questions raised regarding the study design and conduct for these experiments. These concerns include the high-grading of the sample population, artificial inflation of estimates through the use of multiple control groups, effects of handling and tag burden, and the lack of assessment of long-term or delayed mortality (Fish Passage Center, January 4, 2013).

Due to size and fish condition, not all smolts can be tagged with the JSATS tags used in the survival studies. The number of fish rejected indicates that the study fish do not represent the population in the river, and so the results may not be applicable to estimating population survival. Rejection rates as high as 18% have been reported for these studies.

The virtual/paired-release design used in most of the tests utilizes two control groups, one released in the tailrace of the dam and one released further downstream. The further downstream group is intended to account for any handling mortality experienced by the tailrace group, which could inflate survival estimates. Under this experimental design, however, upward biasing of survival estimates could be caused by high mortality in the tailrace group. It is unlikely that tagged fish in both stretches of river encounter the same environmental conditions, especially since predation rates are higher in the forebay and tailrace than mid-reservoir at many projects (Petersen 1994, Ward et al. 1995). If survival in the tailrace group is lower than survival in the further downstream group, the ratios of survivals artificially increase estimates of dam survival.

Survival estimates generated with this multiple-release design may further increase dam survival estimates due to random sampling effects. If there is limited handling and transportation mortality, the use of the further downstream group will introduce additional variation to the study. Beeman et al. (2011) concluded that this result is “contrary to the goal of adjusting a paired-release estimate downward to account for handling mortality.”

In addition, in the Virtual-Paired Release design, fish are released upstream of the dam so they achieve a distribution through passage routes that reflects the run at large. Fish that die between tagging and the forebay of the dam are not included in the study. However, this means that fish that have lower survival through the reaches will not be included in the study. Mortality between tagging and detection was as high as 12.5% in yearling Chinook in 2012. As with the effects of tagging only healthy fish, this means that only the healthiest of tagged fish are included in the dam survival estimates.

Given all of these limitations associated with the studies, it is unlikely that actual survivals through the bypass systems are actually anywhere near 100%.

Failure to Incorporate Delayed Effects of Dam Passage

Similar to the link between cigarette smoking and subsequent development of cancer at a later life stage, the long-term effects of hydro project passage routes for juvenile fish have been well documented in recent years. 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).

Reservoir mortality in the Columbia River can be significant after fish have experienced bypass passage though hydroelectric dams. The cumulative effect of passing through dams and reservoirs can also have direct and delayed impacts on salmon survival (Schaller and Petrosky 2007, Tuomikoski et al. 2012, 2013). The delayed mortality from the accumulation of dam and reservoir passages can manifest into poor survival during estuary and marine life stages (Budy et al. 2002, Schaller & Petrosky 2007, and Schaller et al. 2014).

Has adequate pre-development baseline data been collected to allow accurate monitoring of the impacts of development to all species at risk?

The fact that the development of the Thjorsa will have impact to salmonid and other species survival is not disputed. The question is how large an impact and whether that impact can be mitigated. The ability to determine the magnitude of an impact is only as good as the information available before the perturbation. There has been insufficient collection of the appropriate biological data and an insufficient evaluation of the potential impacts using population viability analyses. The previous focus of the agencies that operate the Columbia River hydrosystem has been to approach mitigation as addressing the immediate impact of the structure. What we have learned over years of research is that, while the at-dam survival is important, the latent effects, which can be greater than direct effects, must be addressed if the viability of the population over the long term is of interest. As we have learned through recent research, the link between the routes by which juvenile fish migrate through hydro projects and subsequent survival to adulthood is extremely important.

Previous guidance according to the US National Marine Fisheries Service (NMFS 2008) at a minimum the following biological information should be provided for the development of the preliminary design for hydro-development:

1. Type, life stage, run size, period of migration, and spawning location and timing for each life stage and species present at the site.
2. Other species (including life stage) present at the proposed fish passage site that also require passage.
3. Predatory species that may be present.
4. High and low design passage flow for periods of upstream fish passage. The design streamflow range for fish passage, bracketed by the designated fish passage design high and low flows, constitutes the bounds of the fish passage facility design where fish

passage facilities must operate within the specified design criteria. Within this range of streamflow, the fishway design must allow for safe, timely, and efficient fish passage.

5. Any known fish behavioral aspects that affect salmonid passage.
6. What is known and what needs to be researched about fish migration routes approaching the site.
7. Document, or estimate, minimum streamflow required to allow migration around the impediment during low water period.
8. Poaching/illegal trespass – describe the degree of human activity in the immediate area and the need for security measures to reduce or eliminate illegal activity.
9. Water quality factors that may affect fish passage at the site. Fish may not migrate if water temperature and quality are marginal, instead seeking holding zones until water quality conditions improve.

Biological data has been collected by the Institute for Freshwater Fisheries (IFF) that address some of the items listed above relative to life stage, timing of juvenile salmon migration, and abundance. However, several of the listed information needs appear insufficiently addressed based on the available information reviewed.

Additionally, as we have stressed repeatedly, newer research has clearly demonstrated the link between hydro project passage and its effect on salmon survival at a later life stage. Consequently, it is of extreme importance to collect a significant time series of smolt-to-adult return rates (SARs) and conduct a Population Viability Analysis (PVA). It is impossible to apply a risk assessment without some measurement of life cycle survival, like SARs. The PVA will likely identify critical uncertainties associated with the potential impacts of dams over variations in marine conditions and climate change. This analysis would provide a risk assessment of hydro development for Thjorsa populations, while considering the variation in marine conditions and the impacts of climate change.

Are the countermeasures and emergency plan described in the Oct. 31, 2013, letter from the National Power Company likely to protect anadromous species in the Thjorsa and mitigate for the hydropower development?

Based on the information provided in the October 31 letter and the experience in the Columbia River, it is unlikely that the proposed countermeasures and emergency plan will mitigate for the hydro power development. In general, the proposed countermeasures include: constructing juvenile bypasses and adult fishways; providing managed and minimum flows in parts of the riverbed with reduced flow and avoidance of sudden flow fluctuations; opening up new habitat for migrating fish; and designing structures and turbines to avoid the oversaturation of dissolved gasses or death of fish. In addition, the National Power Company recommends additional research on (1) the effects of hydro projects and results of countermeasures, (2) the downstream and upstream migration of fish in Thjorsa, and (3) the effects of Hvammur on bottom fauna in Thjorsa.

All of the countermeasures described by the National Power Company, and more, are presently implemented in the Columbia River hydro system. However, in the Columbia River these countermeasures do not provide for sustainable natural populations. Hydro projects in the Columbia impose sufficient mortality upon populations such that populations are maintained at a level that warrants their existence as species at risk of extinction.

Additionally, the proposed countermeasures and emergency plan specifics are poorly defined and/or rely on future research. For example, the National Power Company recommends "providing managed and minimum flows in parts of the riverbed with reduced flow and avoidance of sudden flow fluctuations," without specifically defining operations beyond establishing a minimum flow below each of the projects. In the Columbia River extensive modifications and restrictions on flow regimes are used. Fall Chinook salmon (*Oncorhynchus tshawytscha*) have suffered severe impacts from the hydroelectric development. Fall Chinook salmon rely heavily on mainstem habitats for all phases of their life cycle, and mainstem hydroelectric dams have inundated or blocked areas that were historically used for spawning and rearing (Dauble et al., 2003, Anglin et al., 2006). The natural flow pattern that existed in the historic period has been altered by the dam development, and the operation of the dams to produce power to meet short-term needs in electricity (termed power peaking) produces unnatural fluctuations in flow over a 24-hour cycle. These flow fluctuations alter the physical habitat and disrupt the cues that salmon use to select spawning sites, as well as strand fish in near-shore habitat that becomes dewatered. Furthermore, the quality of spawning gravels has been affected by dam construction, flood protection, and agricultural and industrial development. In some cases, the riverbed is armored such that it is more difficult for spawners to move, while in other cases the intrusion of fine sediment into spawning gravels has reduced water flow to sensitive eggs and young fry. To address some of the impacts of development in the Columbia significant restrictions on seasonal and daily flow variations have been established. These restrictions are in place throughout spawning, incubation, emergence and juvenile rearing; often extending over a six month period.

The National Power Company also mentions a commitment to ten years of monitoring, but does not specify the extent and funding level of commitment. In the Columbia River the operation of the dams requires continued real-time monitoring throughout the lifetime operation of the hydro project. In addition, millions of dollars are annually committed to fund research for the protection, mitigation, and enhancement of fish and wildlife affected by the construction and inundation impacts of the Federal Columbia River Power System (FCRPS).

Are there any additional concerns that you would like to indicate at this time?

There are several additional concerns that warrant comment at this time. The most serious additional concern is the complete lack of information or attention that has been given to the iteroparous nature of the fish stocks in the Thjorsa. Unlike Pacific salmon, Atlantic salmon, brown trout, and char are all repeat spawners migrating to the sea at various times of the year, sizes and physical condition. Iteroparous populations generally have higher population abundance and productivity over their lifetime. All of the proposed countermeasures and mitigation address only the seaward migration of juveniles, primarily based on information collected in the Columbia River where fish only spawn once. The exception to salmon spawning once in the Columbia is a small portion of the steelhead salmon. In the Snake and Columbia River systems, fish passage facilities at hydroelectric dams were not designed or constructed to accommodate downstream-migrating, post-spawning steelhead adults (kelts). From the passage mortality estimated for the few steelhead kelts it has been established that the mortality on these fish has been very high when migrating downstream to the sea. Given that the overall productivity of the Thjorsa population is dependent on kelts, and what information exists suggests that considerable mortality is incurred during downstream kelt passage, it is of significant concern that they are not considered or addressed.

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. The Thjorsa salmon populations are considered the largest in Iceland and consequently, increasing the risk to the Thjorsa salmon could affect 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.

The Specialist Group makes a differentiation between natural distribution areas of migratory fish in the Thjorsa river system, and distribution areas arising from human intervention. The Thjorsa is already a perturbed river system. Significant modification to seasonal and annual river flow has occurred as a result of the building of storage projects above the range of salmonid passage. Currently there are six hydroelectric power plants in the upper parts of the system. Due to this development the peak river flows that historically occurred during May through July have been reduced. That change in flow regime and development was partly mitigated by the installation of the fish ladder at Buddafoss. The installation of this fish ladder significantly increased the available range and habitat for anadromous species. However, the present range reflects the viable population. Reduction of this range could impact the viability of the population. Consequently, the reflection that the population above the historic range of the species is not vital to the continued viability of this population is premature and not based on any specific data.

Water quality can likely be an issue at the project, related primarily to temperature and changes in levels of dissolved gases. The Columbia River is managed to both national and state criteria for these potential pollutants. There have been no studies provided detailing the expected changes in total dissolved gases or temperature, water quality standards, and proposed mitigation for the Thjorsa River. Based on the predicted flows and the size of the power station, there are periods of the year when flow in excess of the hydraulic capacity of the proposed hydro project will occur and water will be spilled over the spillway. While the National Power Company says they will "Design structures and turbines to avoid oversaturation of dissolved gasses or death of fish," no information is available as to how they will accomplish that goal and whether, for example, they will design the project to include spill deflectors at the base of the spillways or construct gas dissipating tailraces below the project.

There is no mention of the restriction of operating turbines to a specific efficiency range to maximize fish survival. Kaplan turbine operating efficiency has a relatively direct effect on fish passage survival where the relationship between survival of juvenile fish passing through Kaplan turbines is positively correlated and roughly linear to the efficiency at which the turbines are operated. Bell (1981) recommended making every effort to operate turbines at best efficiency at a given head during periods of peak fish passage to minimize fish mortality. Turbine units at Columbia River projects are operated within 1% of peak efficiency, less than maximum rated output. This restriction on turbine energy production remains in effect throughout the juvenile fish migration period.

The National Power Company has suggested that a buy-out of net fishers will provide increased angling upstream and overall increases in numbers of fish returning. While it is true that decreasing fishing pressure in the lower river will lead to an immediate increase in the numbers of fish migrating through the river, the long-term sustainability of these increased numbers depends on the ability of the proposed mitigation to address the impacts of the projects.

Fishery impacts and adult passage are fairly established for anadromous salmon species, but very little information is available for arctic char and brown trout, or eels. Unlike salmon species that are anadromous, eels are catadromous where the adults migrate downstream to the ocean and juvenile migrate upstream from the ocean. In addition to migrating at different life stages, eels also tend to exhibit demersal behavior, while juvenile salmon are located in the upper parts of the water column. The passage countermeasures applied to the anadromous model of fish mitigation may not be at all applicable to this species. Arctic char populations, similar to bull trout in the Columbia River basin, (Anglin et al. 2010; Budy et al. 2005 and 2009) may migrate at multiple ages. Therefore, fish much larger than salmon smolts migrating to sea may be attempting to negotiate downstream passage structures designed for fish of different sizes. In addition, the time period during which juvenile migration takes place is different than observed for salmon smolts.

We realize that there are many more facets to each of the discussed issues, but we hope that we have addressed your questions adequately. Please feel free to contact us if you need additional information.

Sincerely,

Margaret J Filardo

Margaret J. Filardo, Ph.D.
Fishery Biologist

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