MEETING REPORT

Main Issue: Entrainment
Meeting Date: October 06, 2009.
Attendees:

1. Bruce Hanna, DFO (person)
2. Nicola Johnson, DFO (phone)
3. Rick Gervais, DFO (phone)
4. Barry Chilibeck, DFO consultant, (phone)
5. Linda Zurkirchen, Dezé consultant (person)
6. Jason Cote, Dezé consultant (phone)

Summary of Discussion:

A number of issues surrounding entrainment were discussed, as presented below. These are in relation to the Commitments identified in the Oct 01 – 05th technical session transcripts as:

> Commitment 2: Dezé Energy to provide in writing, by October 30th, 2009, rational and additional information on the specific life history movement characteristics of the fish species that may use the canal to support the three assumptions presented in Section 15.3.2.8.1.5
>
> Commitment 3: DE to provide in writing, by October 30th, 2009, revised proposed mortality estimates presented in Section 15.3.2.8.1.5.
>
> Commitment 4: DE to provide in writing, by October 30th, 2009, an assessment of the potential for downstream displacement or entrainment of fish during the operation of the Nonacho Lake control structure, as well as the requirement for fish passage for lake trout and/or other species.
>
> Commitment 5: To provide in writing, by October 30th, 2009, an assessment of potential population level impacts and fish movement characteristics for lake trout, northern pike, and lake white fish in Nonacho Lake.
>
> Commitment 16: DE to indicate how mortality estimates included both direct immediate mortality and indirect delayed morality from injury.
>
> Commitment 17: DE to provide calculations on the mortality of large fish and views on potential impact.

General Entrainment Discussion

A small proportion of the fish population may become entrained in the turbines. Fish passage through the turbines may result in fish mortality and injuries due to various stress-inducing mechanisms (Larinier and Travade, 2002; Čada 2001).

Common mitigation techniques available to prevent fish entrainment and mortality at the hydroelectric facilities fall into one of two categories: physical or behavioural deterrents and turbines that are designed to reduce fish mortality. Mitigation strategies for the Taltson Hydroelectric Project would include both of the above categories. The North Gorge canal would be designed as a 1,250 m blasted-rock channel with no in-stream submergent or emergent vegetation, woody debris or other in-stream complexities. The creation of canals void of habitat features is anticipated to discourage fish use and lower the potential for fish entrainment. Although examples of hydroelectric projects utilizing intake canals designed to be unsuitable for fish habitat are rare, it is well known that fish density increases with increased habitat complexity (presence of cover, large and small woody debris, different substrate, side channels and pools). Low complexity physical habitat in an artificial stream in the Northwest Territories appeared to limit the productivity of benthic invertebrates and fish (Jones et al. 2003) and higher habitat complexity was found to be related to the higher fish numbers (Smokorowski and Pratt 2006). According to Birtwell et al. (2005), high fish densities were found to be associated with the well-developed pool-riffle structure, while streams with little habitat complexity contained lower densities of fish. Woody debris was an important feature of the high fish density streams, providing cover and facilitating development of small pools. Based on the above information, it is logical to conclude that an intake canal void of cover, pool, large and small woody debris and different substrate would result in low fish densities utilizing this area. Additionally, penstocks for both facilities would be screened and intake canals would be cleaned and maintained regularly to prevent accumulation of woody debris and other organic matter.

Of the fish that choose to enter and use the canals in the North Gorge, the likelihood of entrainment is reduced as a result of the intake velocities (range between 0.3 m/s to <1 m/s), which would likely be within the burst speed range of adult and juvenile fish. Physical velocity measurements will be collected within the North Gorge canal as part of an Entrainment Monitoring Program, to assess the ability of adult and juvenile fish to swim out of the canal.

Additionally, low-head Kaplan or Francis turbines would be installed in the new powerhouse. Large "low-head" Kaplan turbines have been shown to result in relatively low fish mortality and be among the most "fish-friendly" turbines (Čada, 2001). High survival rates (>95%) for juvenile salmonids have been recorded for the low-head Francis and Kaplan turbines (Larinier and Travade, 2002). In addition, turbines with the least number of blades (fewer blades results in lower fish mortality) could be used where technically viable to further minimize the potential for fish mortality.

The intake canals do not present hazards to fish populations that do not already exist naturally. At the Twin Gorges site, the intake canal will result in water being diverted from the South Valley Spillway, which is also an impassable barrier – fish swept over the SVS are lost from their parent population in the Forebay. No upstream or downstream migration is expected in the Twin Gorges Forebay due to presence of the current and pre-Twin Gorges fish barriers.

Commitment 3: DE to provide in writing, by October 30th, 2009, revised proposed mortality estimates presented in Section 15.3.2.8.1.5.

Commitment 17: DE to provide calculations on the mortality of large fish and views on potential impact.

Anadromous fish species that migrate to complete their lifecycle are at highest risk of turbine entrainment (Čada, 2001), while resident fresh-water fish species were shown to have low risk of entrainment (FERC, 1995). In addition, the majority (over 90%) of entrained fish are young-of-year or small fish (Winchell et al. 2000; Acres International, 2005). Juvenile fish are anticipated to be the age class with the highest potential to become entrained (CH2M HILL, 2003). Due to the above two factors, the probability of entrainment for large resident fresh-water fish is very low.

Čada et al. (2006) and Hecker and Cook (2005) studies investigated the entrainment-related mortalities of small anadromous fish. As mentioned above, majority of the studies focus on juvenile anadromous fish, as this group is vulnerable to entrainment and is, therefore, at high risk from the turbine-related mortalities. Large resident fish species are generally not considered to face significant risk from turbine-related mortalities and are typically not a subject of such studies.

Acres International (2005) indicated that the differences in fish species did not cause significant differences in survival probability of entrained fish (Franke et al., 1997; Winchell et al. 2000). The rates of survival and entrainment are more dependent on the size of fish (Acres International, 2005; CH2M HILL, 2003). Smaller fish size was found to be proportional to a higher survival rate due to lower strike frequency by turbine parts (Collins and Ruggles, 1982).

Fish mortalities resulting from operation of the turbines at the North Gorge and Nonacho Lake were estimated using equations presented in Lariner and Travade (2002), which were developed by Larinier and Dartiguelongue (1989). Although it is assumed that Kaplan turbines would be used for the North Gorge, fish survival rates were also determined for Francis turbines. Kaplan turbines were assumed for Nonacho Lake. Survival rates were calculated to range between 91.1%-93.5% (8.9-6.5% mortality) for North Gorge turbines and 89.9%-98.6% (10.1%-1.4% mortality). The above equations were developed and tested for the juvenile anadromous fish, as these fish make up majority of the entrained fish. The formulas can be applied to other fish, as fish size and not fish species has been shown to have greatest effect on the rate of survival. The equations were not developed or tested on larger fish, therefore, application of these equations to larger fish sizes would be highly uncertain.

Observed mean fish survival after passing through the Kaplan turbines in Čada et al. (2006) study was 91% (9% mortality) to 97% (3% mortality), indicating mortality of less then 10%. These results are similar to the above survival rates estimated using Lariner and Travade (2002) equations. Survival rates for the fish passing though the pilot-scale turbines described in Hecker and Cook (2005) study varied between 83% (17% mortality) for 0.175 m long fish to 98% (2% mortality) for 0.06 m long fish. This result is again very similar to the survival rates for the Taltson Project turbines estimated using Lariner and Travade (2002) equations. This result is not surprising, as large low-head Kaplan turbines are considered to be fish-friendly and result in low fish mortality.

Very little is known about the survival rates of adult fish passing through the turbines, as previous research focused mainly on juveniles (Čada, 2001). However, a North/South Consultants Inc. (2009) reference provided by DFO indicates relatively high adult fish survival probability after passing through retrofitted Kaplan turbine. The 48 h survival was 87.8% (12.2% mortality) for walleye and 75.5% (24.5% mortality) for northern pike. North/South Consultants Inc. (2009) concluded that turbine passage is likely to have no substantial effect on the populations of northern pike, walleye, and similar large-bodied species.

To summarize the above, the probability of entrainment for large resident fresh-water fish is very low, survival of adult fish was shown to be over 75% and no long term effects were found via acoustic tracking. Therefore, no significant effects on large fish are anticipated.

<u>Commitment 4: DE to provide in writing, by October 30th, 2009, an assessment of the potential for downstream displacement or entrainment of fish during the operation of the Nonacho Lake control structure, as well as the requirement for fish passage for lake trout and/or other species.</u>

As stated in Section 15.3.3.8.3, at the outlet of Nonacho Lake and under baseline conditions, fish species can move downstream from Nonacho Lake and into the Taltson River through the existing sluice gates and over the spillway channel. The regulation of flows would not result in the addition of any new diversion channels from Nonacho Lake into the Taltson River or the introduction of a new or invasive species to a water body. Therefore, the operation of the new control structure at Nonacho Lake would not result in a new corridor for fish migration that did not exist under baseline conditions.

The intake canal does not present hazards to fish populations that do not already exist naturally. Currently at Nonacho, fish can be swept downstream over an impassable barrier and lost permanently to the Nonacho Lake population.

<u>Commitment 2: Dezé Energy to provide in writing, by October 30th, 2009, rational and additional information on the specific life history movement characteristics of the fish species that may use the canal to support the three assumptions presented in Section 15.3.2.8.1.5</u>

<u>Commitment 5: To provide in writing, by October 30th, 2009, an assessment of potential population level impacts and fish movement characteristics for lake trout, northern pike, and lake white fish in Nonacho Lake and Twin Gorges.</u>

The effects of turbine entrainment on fish populations are highest for anadromous species, which migrate from the fresh-water streams into the ocean (Čada, 2001).Entrainment rates were shown to be low for the resident fresh-water fish species, as they do not have to pass through turbines during their upstream or downstream migration (FERC, 1995). The following fish species were captured in the Twin Gorges Forebay and Nonacho Lake: lake whitefish, lake cisco, white sucker, lake trout, northern pike, longnose sucker and trout perch, lake chub and burbot (Cambria Gordon, 2009). All of the above are resident fresh-water fish species that do not need to migrate to complete their lifecycle. The life history characteristics of these species suggest that juveniles do not migrate great distances from their natal grounds, rather they rear in the shallows where they emerged and move to deeper waters in mid to late summer. Species movement characteristics are presented below.

<u>Lake trout</u>

Lake trout are generally found in lakes, although some populations occur in large clear rivers. They spawn in September through October at shallow in-shore areas. They spawn over rocks and cobbles or rubble areas free of sand, silt or clay. Some wave action is preferred as it keeps the substrate free from silt and clay. Lake trout generally spawn at depths of 0.12 m to 55 m. The eggs settle in the cracks in the rocks, hatching in March and April the next spring. The young remain in the spawning area for several weeks up to several months, moving into deeper water as the summer water temperatures rise. Adults rear in depths greater than 10 m and seek cool waters near 10 °C. Lake trout feed on fish, crustaceans and molluscs.

Lake whitefish

Lake whitefish are most commonly found in lake systems; however, they have been documented in larger rivers and brackish waters. Lake whitefish exhibit both adfluvial and lacustrine life histories. Adfluvial lake whitefish live in lakes and move into the rivers to spawn. River spawners utilize shallow running waters or rapids with cobble and gravel sized substrate materials (Richardson et al. 2001).

Lake whitefish typically spawn in late summer or fall, from September to October. Lacustrine lake whitefish spend most of their life-cycle within lakes and use a variety of types of substrates from large boulders to gravel and occasionally sand for spawning. Juvenile lake whitefish usually remain next to the spawning grounds; however as surface water temperature increases during summer, juvenile lake whitefish move to deeper waters (3 m to 15 m), where they gradually adopt the bottom feeding habits typical of adults. Juveniles remain in the deeper water habitats until they reach sexual maturity (Richardson et al. 2001).

Northern pike

Northern pike inhabit densely vegetated or weedy areas of slow meandering rivers and weedy bays of lakes and marshes. Typically, northern pike begin to spawn after ice break-up in May through to June in the shallows of lakes or the backwaters of rivers. Lake and riverine spawners use habitats with very shallow water (<1 m) that are wind-sheltered with a variety of vegetation types. Short emergent vegetation such as grasses, sedges and bull rushes are the best substrates for egg deposition. Bottom substrate at spawning grounds consists primarily of soft fine sediments of silt and mud, although spawning may occur in areas with gravel, cobble or boulder.

Eggs are laid and adhere to the vegetation above the substrate and incubate for 10 to 21 days. After hatching, young northern pike remain attached to the vegetation for 6 to 10 days before they become free-swimming, remaining in spawning areas for several weeks.

Young-of-the-year northern pike are typically found in areas <1 m deep but frequently move to deeper water in the summer or when water temperatures rise.

Adult northern pike remain in areas <5 m deep for most of the year and move into deeper water to overwinter. As adult northern pike are ambush predators, they require moderate densities of vegetation in addition to logs or stumps for cover. An excess of cover tends to inhibit foraging capabilities. Adult northern pike prefer soft substrates, although they may be found in areas with boulders, cobbles and gravel substrates (Richardson et al. 2001).

Loss of fish due to entrainment is considered low as:

- Habitat around the canal holds no unique features that would attract fish;
- Habitat in the canal is poor and would act as a fish deterrent;
- The likelihood of purposeful downstream fish migration is low as the identified species are not migratory and all the preferred habitat conditions for each species life stage are met in Nonacho Lake and the Forebay; and
- Adult and juvenile fish will be able to avoid entrainment as the approach velocities are anticipated to be less than their burst speeds. Physical velocity measurements will be collected in the North Gorge to confirm that juvenile and adult burst speeds are not exceeded at the inlet location.

Based on the species movement characteristics, existing downstream migration options (South Valley Spillway or Twin Gorges facility), historic downstream migration options (Twin Gorges), and survival rates of the proposed turbines, the Project is not anticipated to affect up or downstream populations.

Commitment 16: DE to indicate how mortality estimates included both direct immediate mortality and indirect delayed morality from injury.

A study performed by the North/South Consultants Inc. (2009) investigated short-term (48 hours) and long-term (3-4 months) survival and behaviour of adult northern pike and walleye after passing through retrofitted Kaplan turbines at Manitoba Hydro's Kelsey Generation Station. The 48 h direct survival estimate of adult pike was 75.5%. The 1 h survival estimates on sub-adult pike was 88.9%; however, the 48 h rate could not be established because of high control fish mortality. Acoustic-tracking of more than 100 turbine-passed and control northern pike and walleye for 1 to 4 months, and up to 2 years for some, indicated no evidence of long-term effect of entrainment on fish mortality or movement patterns. The observed patterns of pike and walleye show no clear difference between control and treatment fish. Previous literature and data on pike and walleye in the Nelson River system also suggested that turbine passage did not have a significant effect on fish movements.

Developer Commitments

Dezé remains committed to the mitigation measures discussed here and described in the DAR, to minimize effects of entrainment.

Dezé also commits to:

- Investigating if screen sizes <100 mm are effective in preventing applicable fish species and life stages from being entrained and if they are operationally feasible
- Incorporating a screen on the intake facilities for the Nonacho turbine, and investigating an operationally feasible mesh size that assists with fish entrainment mitigation
- Investigating technical feasibility of utilizing turbines with the least impact to fish (i.e. minimal blades etc.).
- Developing a monitoring program to confirm the assumption that North Gorge intake canal fish use would be low and that adult and juvenile fish can escape the canal if they swim into it.
- Discuss outcome of monitoring program with DFO and identify if additional monitoring or mitigation / adaptive management is required to protect fish populations.

Outstanding Issues:

None

Signature of Party Representative:

Signature of Developer Representative: ______________________ L. Zurkirchen

Date: October 29, 2009

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