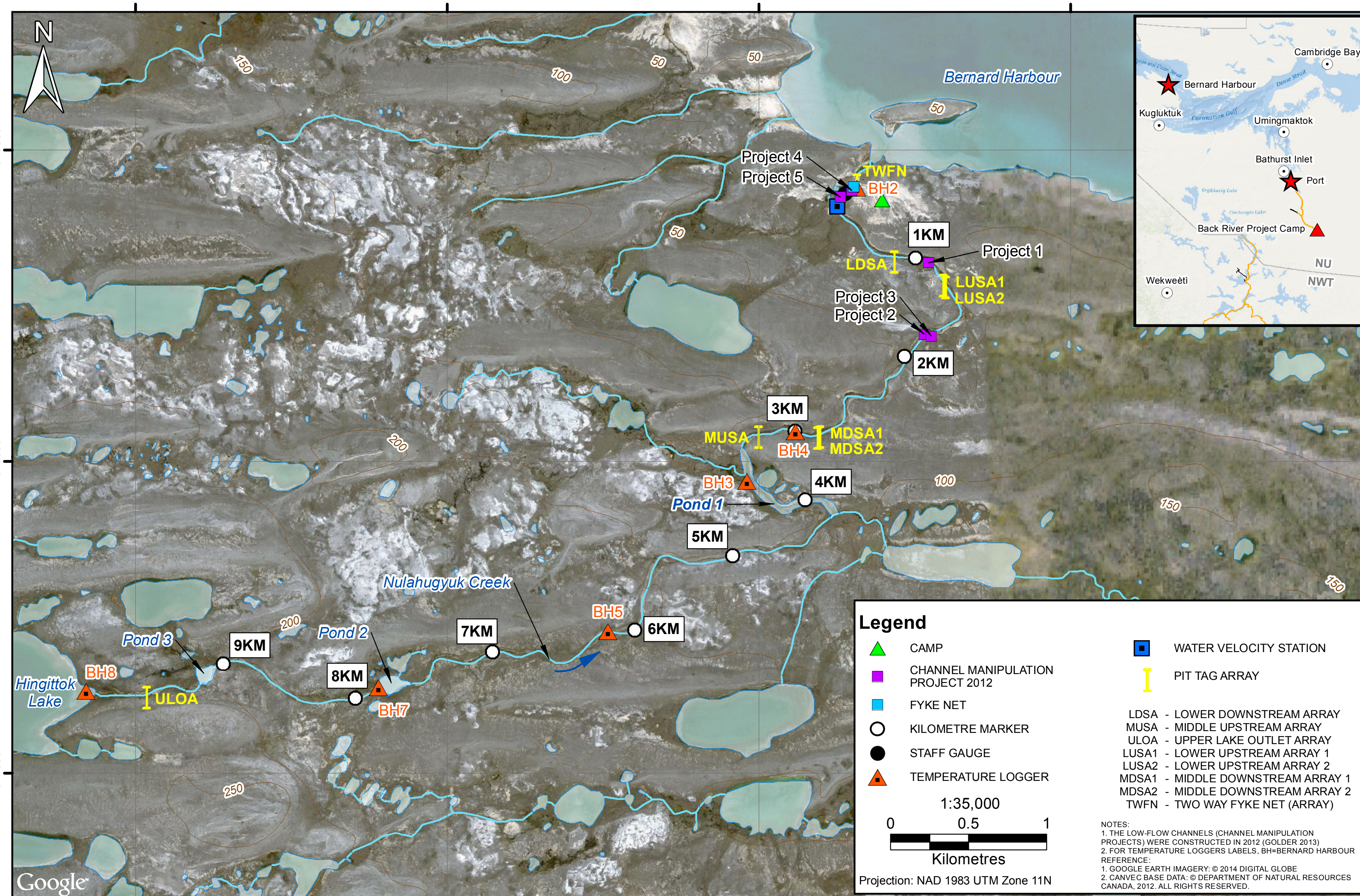

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Figure 7.1-1

NULAHUGYUK CREEK BASELINE MONITORING, BERNARD HARBOUR, 2014

In 2014, Sabina initiated a comprehensive study of the migratory Arctic Char population at Bernard Harbour. The main goal was to provide rigorous baseline data in support of an offsetting plan for the Project. The baseline information would provide a reference for future quantification of the potential benefits of using “low-flow channel” methods. Specifically, the baseline study was designed to address four objectives:

1) Monitor the timing and size of the annual migratory char run in Nulahugyuk Creek using two-way fyke net traps installed for the duration of the migration period; data was collected for the three migratory phases in 2014, including:
    a. the downstream (seaward) outmigration of adults (assumed to be spawners from the previous fall), which were predicted to be the first migratory fish captured in the trap during the spring freshet;
    b. the adult upstream (lakebound) migration (consisting of char that would spawn in the year following the sampling year); and,
    c. the downstream (seaward) outmigration of juveniles, which were assumed to be 4 or 5 years old and migrating later in the summer as occurred in 2012 (Golder 2013a).
2) Monitor rates of movement and successful upstream passage to Hingittok Lake during the 2014 open water season using Passive Integrated Transponder (PIT) tag methods (e.g., Hering et al. 2010; Puffer et al. 2014); the movement data complement data on the size and timing of the run by providing a direct measurement of the effects of migrations conditions on Arctic Char in the creek for the study year under examination.
3) Assess fish habitat and the relative abundance of fish species in Hingittok Lake using standard inventory methods to gain some understanding of the carrying capacity of the lake for Arctic Char as it relates to enhancement efforts being made to improve fish access in the creek.
4) Collect habitat data to prepare a remediation plan for using low-flow channels to improve upstream passage for fish in Nulahugyuk Creek; this objective was performed in 2014 and 2015 and is a direct follow-up of work initiated by Golder in 2012 and includes:
    a. Assessments of the structural integrity and performance of low-flow channels previously constructed; and
    b. Scoping-level assessments of the number of problem locations and total length of the creek where low-flow channels could be constructed to effectively increase fish production.

In addition to the objectives outlined above, the 2014 and 2015 work was intended to complement and integrate objectives of the Kugluktuk HTO. This was to be achieved by incorporating students, organizations, and community members and by designing a study that fosters education, stewardship and community involvement in conservation initiatives. Past studies (e.g., Stern et al. 2008) have demonstrated a lasting positive change in environmental attitude, action, and knowledge following environmental education programs, such as the one implemented at Bernard Harbour.

A baseline study was also performed in 2016, with objectives similar to those described above. Results from that study are described in detail in FEIS Addendum V6-6H, and also summarized in Section 7.3.4.

7.2 STUDY AREA

The HLNC drainage at Bernard Harbour is located approximately 100 km directly north of the hamlet of Kugluktuk, Nunavut, along the south coast of Dolphin and Union Strait (Figure 7.1-1). The project site is about 4.5 hours (h) travel time by boat from the community. Nulahugyuk Creek, the outflow from Hingittok Lake (882 hectares [ha] in size), flows north for approximately 10 km before entering the sea at 68°44'52"N, 114°45'27"W. The contributing basin area at the mouth of creek is approximately 125 square kilometres (km^2) in area, and may be characterized by limited groundwater derived flows punctuated by precipitation-driven peak flows. It is expected that most of the precipitation falls as rain during the open water season. Based on 1981 to 2010 Canadian climate normal station data for Kugluktuk, mean total precipitation is approximately 247 millimetres (mm), of which 144 mm falls during June, July, August, and September (see http://climate.weather.gc.ca). Daily maximum temperatures, on average, are above zero for June through September, peaking in July at 15.6 °C, and below zero for the remaining months of the year.

7.3 BERNARD HARBOUR BASELINE

The field study in 2014 began on June 13 and was strategically planned to allow the field team to capture the first Arctic Char moving through Nulahugyuk Creek once the ice had melted enough to allow passage for fish. The commencement date was selected based on data collected during 2012 (Golder 2013a), anecdotal information from the Canadian Arctic Expedition in 1916 (Jenness and Jenness 1991), as well as information from Kugluktuk residents. Field personnel remained on site until July 17, 2014 to capture the downstream outmigration of juvenile char.

A short field program was also performed from July 21 to 25 in 2015 to collect supplemental information on habitat (fish were not monitored in 2015), and a field program was also performed from July 5 to 25 in 2016 focusing on the later stages of the upstream migration of adult Arctic Char (see FEIS Addendum V6-6H). The below sections focus on the 2014 study, which characterized the Arctic Char migration for the three migration types (i.e., the downstream outmigration of adults, upstream migration of adults, and downstream outmigration of juveniles).

7.3.1 Methods

7.3.1.1 Fish Capture and Sampling

Fish were captured in Nulahugyuk Creek using a two-way fyke net trap installed on June 16, 2014, operating continuously until July 17, 2014 (Figure 7.3-1). The fyke net was installed 0.3 km upstream from the mouth of the creek (Figure 7.1-1) in a shallow run area with a mean width of about 18 m. The wings of the fyke net were installed across the creek such that all fish moving upstream or downstream would be directed into the opening. Once they had entered the trap they were directed through a series of funnels. Captured Arctic Char were directed for a total distance of about 6.4 m prior entering a holding basket at the base of the net. The trap was checked several times daily and fish were removed and processed accordingly. The frequency of checks increased with water temperature and capture success to reduce crowding and potential stress to fish.

In Hingittok Lake, multiple gill net sets (short-duration sets) and angling events were used to provide information on fish species composition and abundance. Gill net mesh size and configuration were based on Broad Scale Monitoring (BSM) techniques for North American (NA1) and Ontario small mesh (ON2) gill nets (Sandstrom et. al. 2013). A series of bottom-set gill nets were deployed over four days in July 2014 (July 8, 11, 13, and 14). Each set consisted of either two large (NA1) or two small (ON2) gangs joined for a double-gang configuration. The nets were checked frequently (maximum soak time was approximately four hours) to minimize mortalities. Angling at Hingittok Lake was also performed on July 11 and 13, 2014 using a variety of unbaited, spoon-type lures.

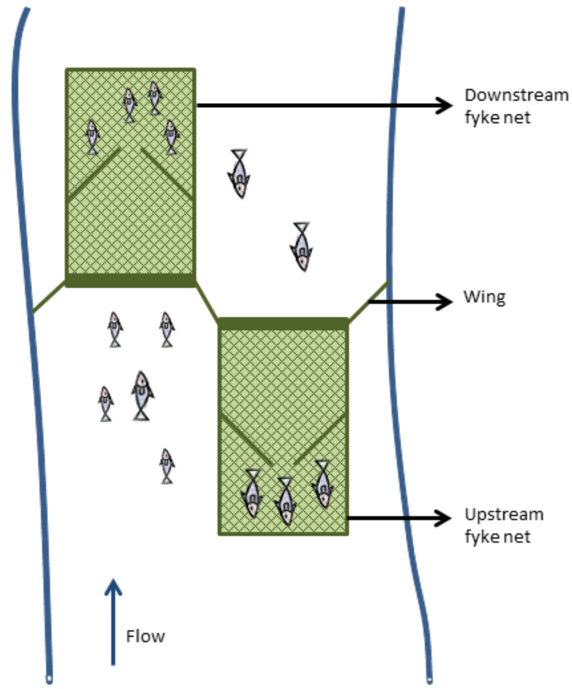

Figure 7.3-1. Conceptual Schematic Showing Two-Way Fyke Net Trap Configuration in Nulahugyuk Creek

Captured fish were enumerated, and identified to species, most of which were weighed (grams [g]) and measured (fork length [FL] [mm]), and a small number of representative individuals were photographed. To minimize stress during periods of warm water temperatures (>17°C), a small number of fish were enumerated but not processed at the fyke net trap (i.e., were immediately released on the side of the trap corresponding to their direction of travel). When possible, otoliths (the calcified structure from the inner ear) were removed from observed mortalities (e.g., from stranding at upstream locations), folded in parafilm, and stored in a labelled coin envelope for age analysis at a later date. For catch summaries, char smaller than 300 mm were classified as 'juveniles', fish between 300 and 550 mm were classified as 'immature' (or sub-adults), and fish larger than 550 mm were classified as adults (Golder 2013a).

Mortality Surveys

Mortality data was collected opportunistically as incidental observations, for example, during habitat assessments. When there was an opportunity, field crew members visually surveyed the creek for dead char and when located, carcass information was documented using a hand-held GPS, photographs, and field notes. Carcasses were scanned with a hand-held tag reader (see further below for a description of tags and readers).

7.3.1.2 Movement Monitoring

Upstream movements for a subset of captured Arctic Char were monitored using implanted PIT tags and Radio Frequency Identification (RFID) antenna-reader arrays installed at strategic locations on the creek (Figure 7.1-1) (similar to methods discussed in Hering et al. 2010; Puffer et al. 2014). PIT tag methods are ideal for monitoring movements of fish in shallow streams such as Nulahugyuk Creek (i.e., constricted environments) because of the low cost of the tags and a high number of individuals can be tracked to reliably describe movements. PIT tags are also ideal for long-term studies since they contain no battery and will be operational for the lifespan of the tagged fish.

Seven PIT tag antennae-reader arrays were installed strategically in relation to the location of the 2012 low-flow channel project areas and reference sections. An array was also installed near the outlet of Hingittok Lake (Figure 7.1-1). The arrays were configured using either a single antennae (Lower Downstream Array [LDSA], Middle Upstream Array [MUSA], Upper Lake Outlet Array [ULOA]) or paired antennas (i.e., Lower Upstream Array 1 [LUSA1], Lower Upstream Array 2 [LUSA2] and Middle Downstream Array 1 [MDSA1], Middle Downstream Array 2 [MDSA2]), each of which was constructed from bound T90 cable.

Boulder spurs or weirs were constructed to prevent fish from moving around the arrays and to direct fish through the arrays. Antennas were oriented vertically to increase PIT tag reception range. The bottom of the antenna loop was embedded in the creek substrate and the top of the loop was suspended approximately 5 centimetres (cm) above the water surface. This configuration ensured that Arctic Char passed through the loop perpendicular to the antenna field. Antennas were connected to individual tuner boxes located creek-side, with twinax cable extending from the tuner boxes to a multi antenna HDX-PIT tag reader box. The arrays were powered by deep-cycle 130-ampere marine batteries, which were kept continually charged using solar panels.

<u>Statistical Analyses</u>

Detection probabilities (*p*) were generated for individual antennae by assigning binary detection values for individual char based on whether they were detected (1) or not (0) at a given array. Detection probabilities were calculated for each array based on the mean detection value. Zero values above the furthest upstream detection were excluded from the detectability calculations because these fish were assumed to have been removed from the system. Therefore, detection values for each array were based only on data where detection occurred, or was known to occur further upstream. Detectability for the ULOA array was based on the mean detectability of the downstream arrays, with the exception of MUSA where a technical malfunction reduced detectability at that site.

Binary logistic regressions were used to explore relationships between upstream migration success (fish detected [1], or not detected [0] at the lake outlet) and environmental and biological parameters including migration date, stream discharge (daily and 4-day mean), water temperature (daily and 4-day mean), length, weight and condition factor. Various models were compared based on their Akaike Information Criterion (AIC) score, with lower values identifying models better representing the data analyzed, and Receiver Operating Characteristic (ROC), with higher values indicating greater sensitivity and specificity of the model (Hosmer and Lemeshow 2000).

Arctic Char movement speed (metres per hour [m/h]) was compared between arrays using analysis of variance (ANOVA). Movement speed was square root transformed to meet assumptions of normality. The significance level, alpha (α), was defined a priori as $\alpha = 0.05$. Normality was assessed graphically by examining the distribution of residuals using normal probability plots (Zar 1999). All analyses were conducted using Systat 13 (Systat Software, San Jose, CA).

7.3.1.3 Habitat Surveys

<u>Water Temperature and Discharge Measurements</u>

A stream discharge station with staff gauge was established approximately 0.5 km upstream from the mouth of Nulahugyuk Creek (Figure 7.1-1). Water velocities and water depths were measured at 0.75 m intervals along a transect set perpendicular to flow of water at the station. Each point velocity was measured at 0.6 times the depth from the creek bed, which is representative of the mean velocity at that vertical profile. Velocity was measured using a direct read-out Swoffer™ Model 2100 velocity meter and top-setting wading rod. Discharge was calculated across the wetted width of the channel based on the point measurements of velocity, depth, and interval width represented by each point measurement. Stream discharge measurements were collected 22 times between June 13 and July 15, 2015; the staff gauge was read an additional 28 times between June 13 and July 16. Daily flows were also measured during the 2015 program (July 22 to 24).

Water temperatures were measured at 0.25 h intervals at six locations along Nulahugyuk Creek using Onset® HOBO Water Temperature Pro V2 Data Loggers in 2015 (Figure 7.1-1). The loggers collected data every 15 minutes and ran continuously for the duration of the field study.

<u>Nulahugyuk Creek Habitat</u>

Habitat was assessed along the entire length of Nulahugyuk Creek (approximately 10 km) between July 10 and July 14, 2014. Major habitat types within the sections were described in accordance with the classification system outlined in O'Neil and Hildebrand (1986). Supplemental information on problem locations (i.e., barriers) were then collected on July 16, 2014, and again on July 23 and 24, 2015, but with a focus on the lower 3.5 km of Nuluhugyuk Creek where most of the barriers are located on the creek (Golder and ANL 2007). The surveys for barriers were timed to coincide with both low flows and the upstream migration period of char. To prepare for future remedial works, global positioning system (GPS) coordinates were obtained for each problem location, and each problem location was rated according to level of adult char upstream impassibility. Field technicians assigned ratings (1 to 3) to all problem locations based on their knowledge of observations of mortalities and fish passage made in 2012 (Golder 2013a) and 2014 (Table 7.3-1), where higher rankings represent higher risks for fish strandings and barriers.

The highest risk locations (rank 3) were those where fish stranding and partial barriers to movement may be common during average-to below average conditions through most of the upstream migration period. These locations were characterized by dispersed flows and boulder fields at the reach-level, impeding upstream movements and may directly expose fish to terrestrial predators, such as gulls. Higher-risk locations were also characterized by significant barriers to movement during average to below-average flow conditions during the later stages of migration. Rank 2 locations were those that may be difficult for fish to pass during peak periods of migration under below average flow conditions and may also present a high potential for stranding and partial blockage of movements during the later stages of migration when water levels decline (even during average years). Rank 1 locations were those that are likely passable through most of the upstream migration period during average flow conditions, but present the potential for stranding and stressful conditions during below-average flow conditions and towards the later stages of migration when water levels decline in summer.

Table 7.3-1. Characterization of Barriers and Problem Locations for Fish Passage

	Ranking of Expected Risk of Mortality and Failed Migration (Higher Rank = Higher Risk)	
Types of Barriers	**Average Flows**	**Below Average Flows**
Small-scale partial barrier	Rank 1	Rank 2
Large-scale partial barrier	Rank 2	Rank 3
Small-scale full barrier	Rank 3	Rank 3
Large-scale partial blockage with complete barriers present	Rank 3	Rank 3

The integrity of previously completed low-flow channels was also visually assessed and photographed during low discharge conditions (July 18, 2014, and again on July 22, 2015). Supporting information on channel width, velocity and depth within the assumed thalweg (deepest area of channel) was collected every 2 m for the length of each project. Mean values and standard deviations of channel characteristics are reported.

Hingittok Lake Bathymetry

Bathymetry at Hingittok Lake was determined while gill nets were in place as part of the lake fish inventory. Bathymetry transects were completed from July 8 to July 11, 2014 using a Garmin GPSMAP 298 sounder (Garmin, Olathe, KS) coupled with a GPS. Transect layout consisted of longitudinal transects in a north/south orientation along the lake, bisected by lateral transects across the width of the lake. Longitudinal and lateral transects were approximately equally spaced to provide as much coverage of the lake as possible. Data were stored in the boat-mounted sonar with a GPS enabled and downloaded onto a computer as 'gpx' file. Bathymetry data (i.e., depth and GPS position) were then transcribed onto a 1-m bathymetric contour map using the ArcGIS 'topo to raster' tool (ArcMapTM v9.3.1, 2009). Erroneous points were screened out by eliminating any unrealistic depths with the visual aid of georeferenced aerial imagery provided by Google Earth.

7.3.2 Results

7.3.2.1 Fish Capture and Sampling

Nulahugyuk Creek

The fyke net was in place for a total of 35 days, 16 hours and 17 minutes beginning the evening of June 12, 2014 (18:15) and ending July 17, 2014 (10:32). In total, 1,332 Arctic Char were captured from Nulahugyuk Creek with the first char captured moving downstream on June 16 (Figure 7.3-2). Three distinct groups of migratory char were described including adults moving downstream after overwintering in Hingittok Lake (*n* = 478), adults moving upstream (*n* = 332) to overwinter and potentially spawning first, and juveniles moving downstream from Hingittok Lake (*n* = 522). Downstream movement by adults was documented from the first day of the program and was largely completed by July 4 (Figure 7.3-2). Upstream movement attempts by adults began on June 25 and continued through to the completion of the field study. Downstream movement by juveniles began on June 25 and continued to the completion of the field study. Migration successes were quantified for adult Arctic Char migrating upstream from the ocean to Hingittok Lake (see below – Upstream Passage).

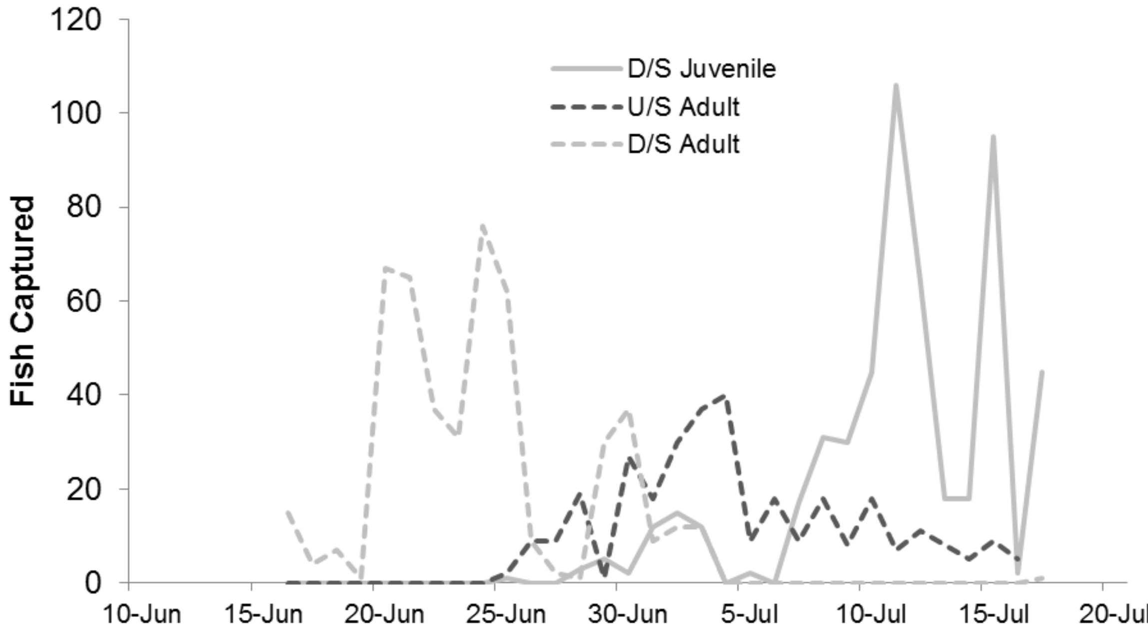

Figure 7.3-2. Daily Captures of Migratory Arctic Char in Nulahugyuk Creek, 2014

Note: D/S = downstream travelling fish and U/S = upstream travelling fish

Arctic Char catch-per-unit-effort (CPUE) for the upstream fyke net was 0.39 fish/hour, while CPUE for the downstream fyke net was 1.17 fish/hour. The combined CPUE for upstream and downstream fyke nets was 1.56 fish per hour. Three Ninespine Stickleback were also captured but not included in CPUE calculations. Maximum daily upstream CPUE for adults was 1.17 fish/hour on July 4, 2014; whereas maximum downstream CPUE for adults was 3.17 fish/hour on June 24, 2014; and maximum daily juvenile CPUE (migrating downstream) was 4.42 fish/hour on July 11, 2014.

Arctic Char length and weight measurements and condition factor for the three migratory groups and one immature individual are summarized and described in Table 7.3-2 and Figure 7.3-3 (not every individual was measured). The largest captured Arctic Char was 887 mm in length with a weight of 6,645 g. Adult char moving upstream had the highest average condition factor (± standard deviation [SD]) of the three migratory groups (K_{us} = 1.09 [± 0.1]); whereas, downstream-moving juveniles had lowest average condition factor (K_{juv} = 0.81 [± 0.1]). Adult char moving downstream had an average condition factor of 0.84 (± 0.1). Adult char moving downstream from Hingittok Lake were approximately 27% lighter in weight than char moving upstream from the ocean. It was noted by the field crew that although none appeared obviously ripe for spawning, many char moving upstream were developing spawning colours had better condition (visual judgment of weight to length ratio) than adults moving downstream.

Table 7.3-2. Summary of Arctic Char by Size Class Captured in Fyke Nets in Nulahugyuk Creek, June 12 to July 17, 2014

Migratory Group	Number of Char	Length Range (mm)	Mean Length (mm) ± SD	Weight Range (g)	Mean Weight (g) ± SD	Mean Condition Factor ± SD
Adults moving upstream	329	602 to 887	728.8 ± 53.9 *(n = 328)*	2,250 to 7,545	4,271.2 ± 991.3 *(n = 329)*	1.09 ± 0.1
Adults moving downstream	476	509 to 859	717.0 ± 54.3 (*n* = 475)	1,545 to 5,080	3,134.6 ± 747.6 (*n* = 473)	0.84 ± 0.1
Immature fish moving downstream	1	305	-	243	-	0.86
Juveniles moving downstream	521	145 to 261	192.5 ± 19.1 *(n = 347)*	25 to 140	60.3 ± 18.2 *(n = 313)*	0.81 ± 0.1

Note: mm = millimetres; ± = plus or minus; SD = standard deviation; g = grams; n = number of fish; - = no data

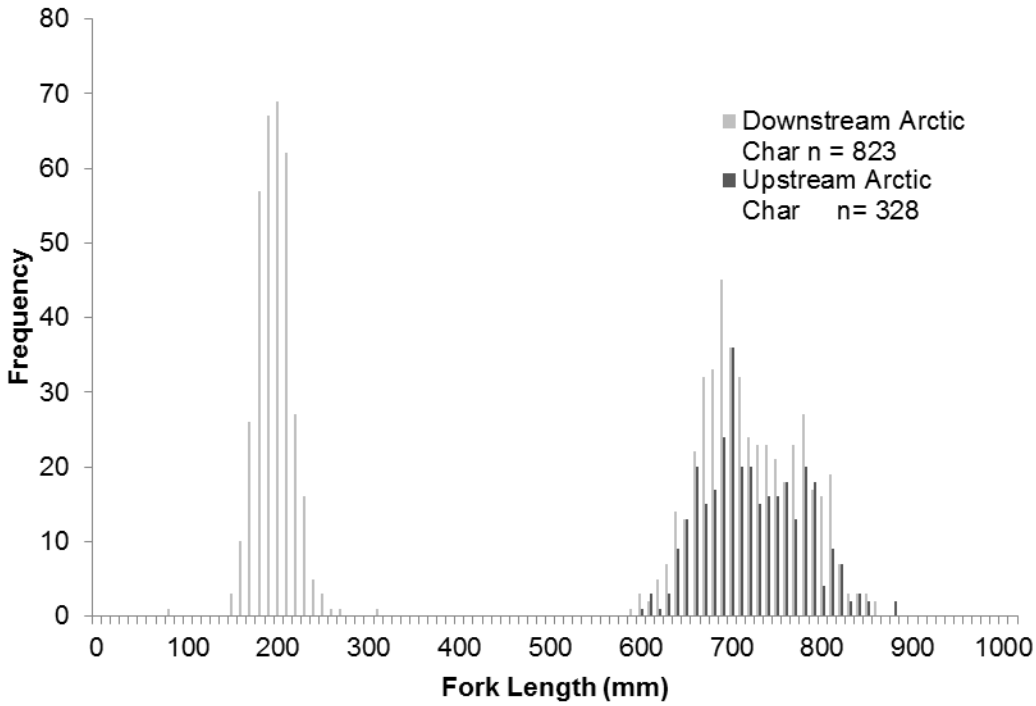

Figure 7.3-3. Length-Frequency Distribution of Arctic Char Captured in the Fyke Net Trap

Hingittok Lake

Twenty-nine short-duration gill net sets were deployed for a total of approximately 65 hours in Hingittok Lake in 2014 (Figure 7.3-4). Gill netting efforts in Hingittok Lake captured a total of 54 fish including 36 Lake Trout (*Salvelinus namaycush*), 10 Arctic Char, 7 Cisco (*Coregonus artedi*), and 1 Ninespine Stickleback (*Pungitius pungitius*). Of the 10 char captured, 7 were adults and 3 were juveniles. Mean CPUE for large mesh nets was 2.16 fish/h/100 m; approximately twice that of small mesh nets which was 1.07 fish/h/100 m. It is noteworthy that two of the captured char were PIT tagged earlier in the season in 2014.

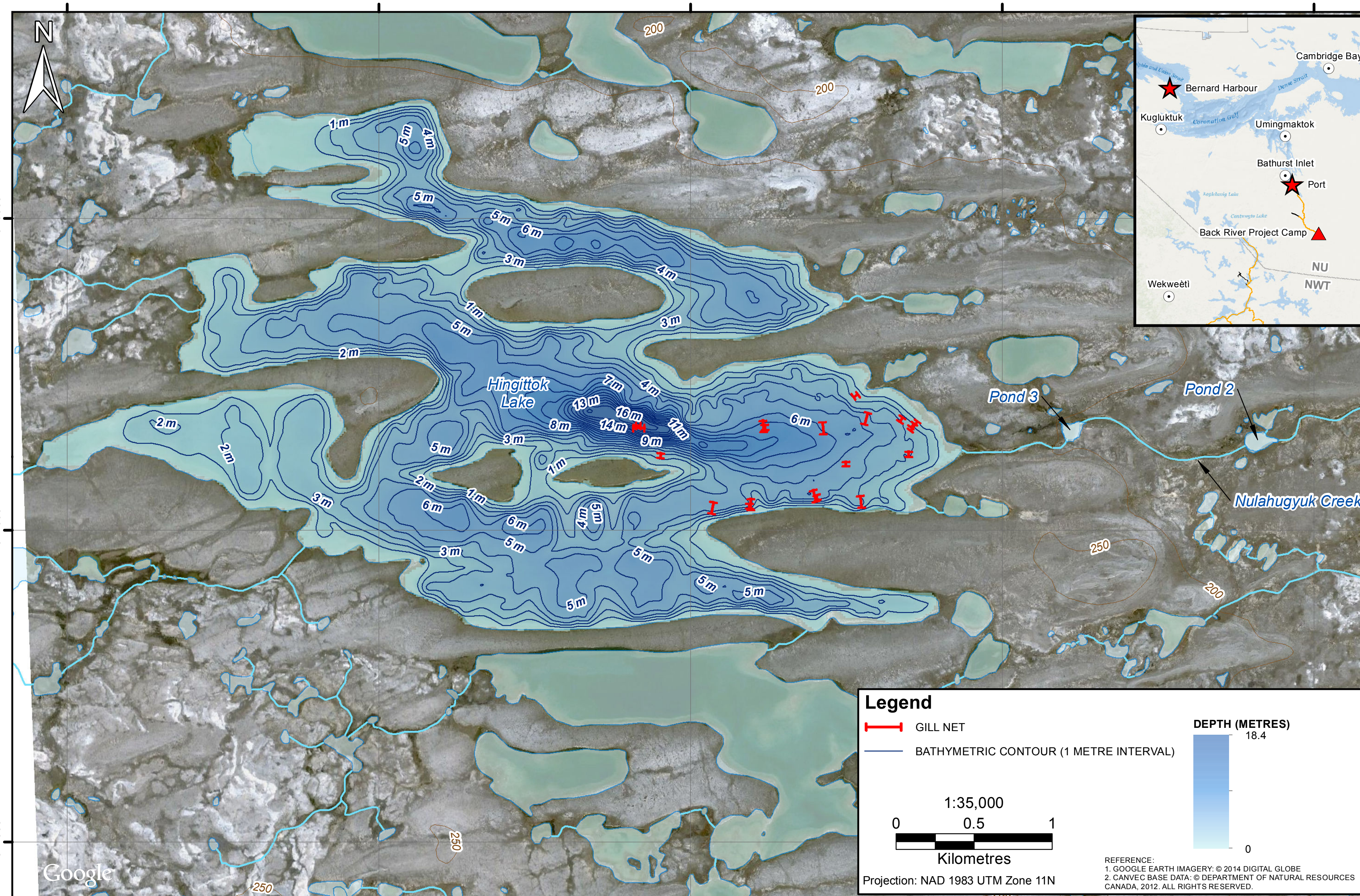

Figure 7.3-4

Sabina Gold & Silver Corp.

HINGITTOK LAKE FISH BASELINE MONITORING, BERNARD HARBOUR, 2014

A total of 2.5 hours, mid to late afternoon, was spent angling by two crew members in the lake, resulting in the capture of eight Lake Trout (CPUE of 1.5 fish/angler hour). Overall, Lake Trout was the dominant species captured from Hingittok Lake (based on gill netting and angling combined), contributing 71% to the total catch (Figure 7.3-5).

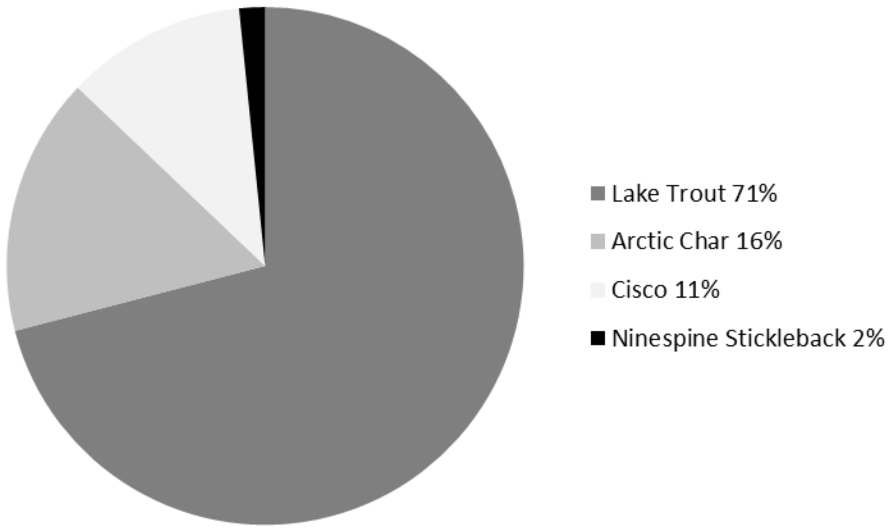

Figure 7.3-5. Fish Species Composition in Hingittok Lake, 2014

7.3.2.2 Upstream Passage

In total, 315 upstream migrating adult char were implanted with PIT tags with unique identification numbers. Selected Arctic Char for PIT tag monitoring were a representative sample of the population moving upstream, and characterized by an average length (± SD) of 726.8 (± 52.4) mm, weight of 4229.8 (± 949.8) g and condition factor or 1.09 (± 0.1).

A high degree of detectability was obtained at most antennae-reader arrays (Table 7.3-3). The only exception was MUSA which suffered from a series of technical issues including a malfunctioning battery from July 8 to July 9, and suboptimal tuning prior to July 11, resulting in reduced detectability.

Of the 315-tagged Arctic Char, 103 were detected at the ULOA indicating the completion of a successful upstream movement from the sea. Adjusted for array detectability, this equated to 110-tagged fish, or a success rate of 34.9% between June 25 and July 17, 2014 (Table 7.3-3). Although migratory success was relatively high early on in the study (93%), it declined rapidly over time with none of the fish tagged after July 6 detected at the ULOA (Figure 7.3-6). This indicates that a threshold was reached and stream conditions became impassable for char after this date. Any remaining fish either perished, likely from exhaustion, predation, or stranding, or remained in the ponds located in the middle and upper reaches of the creek. Twelve tagged char were incidentally confirmed as mortalities while field crews were working along the creek in July 2014; half of the mortalities were observed after July 6.

Table 7.3-3. Location of Radio Frequency Identification (RFID) Arrays and Detection Information

Array	Approximate Distance Upstream from Bernard Harbour (km)	Detection Probability	Detected Total	Corrected Total
Two-way fyke net (TWFN)	0.30	1.00	315	315
Lower Downstream Array (LDSA)	0.75	0.90	263	293
Lower Upstream Array 1 (LUSA1)	1.14	0.93	261	280
Lower Upstream Array 2 (LUSA2)	1.16	0.91	255	279
Middle Downstream Array 1 (MDSA1)	2.73	0.97	205	212
Middle Downstream Array 2 (MDSA2)	2.75	0.96	202	211
Middle Upstream Array (MUSA)	3.15	0.59	94	158
Upper Lake Outlet Array (ULOA)	9.43	0.93	103	110

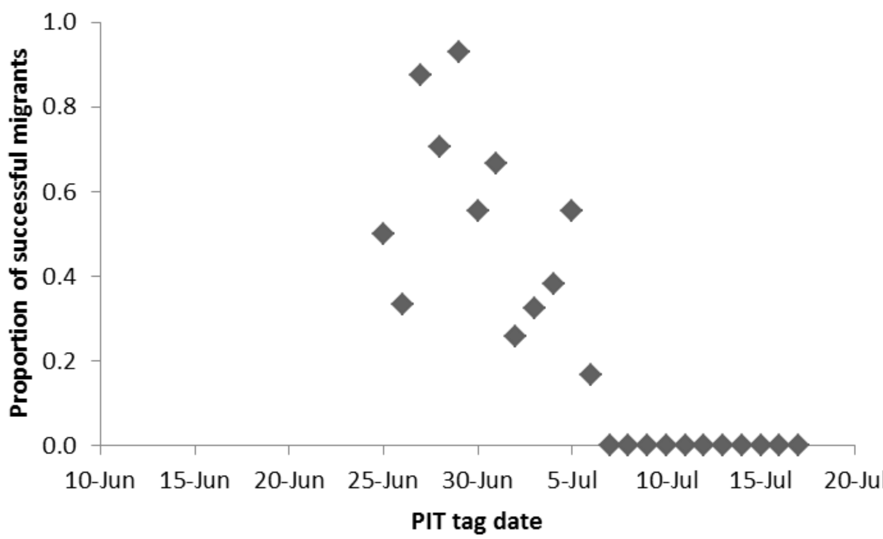

Figure 7.3-6. Proportion of Successful Migrants Detected at ULOA Plotted Against Passive Integrated Transponder (PIT) Tag Implantation Date

For those fish recorded as being successful migrants to Hingittok Lake, migration time between the farthest downstream array and the farthest upstream array (distance of 8.68 km) varied among individuals and throughout the study period with a mean migration time (± standard error) of 108.3 h (± 4.7). The fastest fish completed the migration in 34.2 h, and the slowest in 239.0 h. The migration time was generally faster from June 25 to June 30 (79.3 h [± 5.4]) than from June 30 to July 6 (123 h [± 5.8]).

Migration Success Model

The number of Arctic Char observed among the RFID arrays declined sequentially as the fish moved upstream. Prior to July 6, a considerable reduction in detected char occurred over a 0.35 km reach between MDSA2 (2.75 km) and MUSA (3.15 km) with a 24% reduction in individuals occurring in this area. After July 6, a 50% reduction in the number of char detected occurred over a 1.57 km reach between LUDS2 (1.16 km) and MDSA1 (2.73 km), with no fish detected after MUSA (>3.15 km).

Using a binary logistic regression, the primary factors influencing migratory success were determined to be four-day mean discharge and char weight (Table 7.3-4). Model fit was significant ($p < 0.001$) with an ROC value of 0.84. The output of the formula (when fish weight is held constant at 4.2 kg) is presented graphically in Figure 7.3-7. With respect to the four-day mean discharge, the probability of migration success ranged from a high of 85% at greater than 1.5 m^3/s, declining to a low of 0% at 0.5 m^3/s and lower discharge values. Regarding fish weight, the probability of migratory success ranged from a high of 95% for fish that weigh 2.5 kg to a low of 31% in fish that weigh 7.5 kg when discharge was held constant at 1.76 m^3/s.

Table 7.3-4. Parameter Estimates for Binary Logistic Model Predicting Migration Success

Parameter	Estimate	Standard Error	*Z*	p-Value	95% Confidence Interval Lower	Upper
Constant	-8.398	2.417	-3.48	0.001	-13.134	-3.661
Four day mean discharge	15.714	4.134	3.8	<0.001	7.612	23.815
Four day mean discharge (squared)	-4.612	1.643	-2.81	0.005	-7.831	-1.392
Weight	-0.77	0.192	-4.02	<0.001	-1.146	-0.395

Note: Z = statistical score; p-Value = probability value; percentage = percent; < = less than; kg = kilograms.

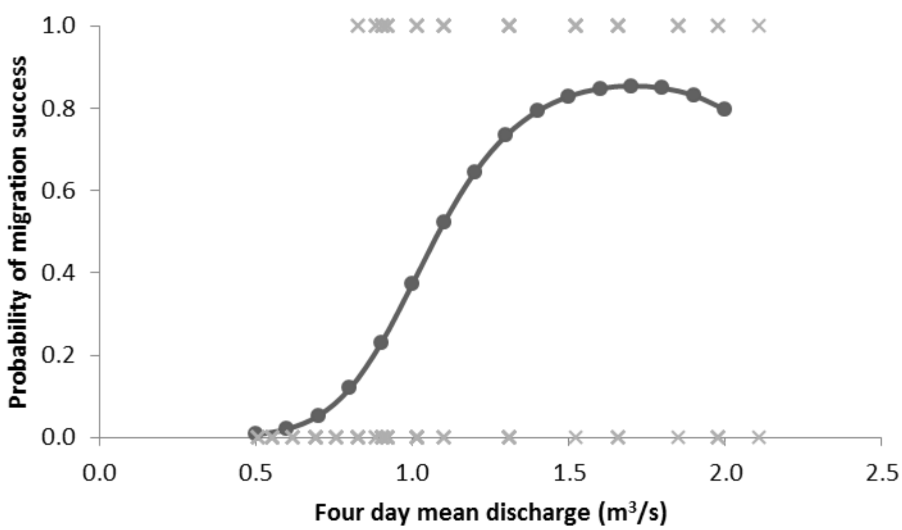

Figure 7.3-7. Results of Binary Logistic Regression Plotting the Probability of Migration Success Against Stream Discharge, Holding Arctic Char Body Weight Constant at 4.2 kg

Note: X symbols represent whether individual fish succeeded in migrating to ULOA (1) or not (0).

7.3.2.3 Fish Habitat

<u>Nulahugyuk Creek</u>

From the confluence with the sea, Nulahugyuk Creek transitions from faster moving riffles to run and pool habitats near Hingittok Lake. Approximately 82% of the lower section of the creek to the first pond was quantified as riffle habitat in July 2014 (Plate 7.3-1). The creek then transitions from riffle (44%) to run (53%) habitats in the middle section of the creek between the first and second ponds. It is largely shallow run habitat (90% or more) from the second pond to the outlet of Hingittok Lake.

Substrate was predominantly cobble (60% or more) and boulder (approximately 5 to 19%) and gravel (approximately 5 to 13%) with small amounts of sand and silt typically occurring in pool habitats. The maximum depth in the creek (excluding the three ponds on the creek) was less than 0.75 m.

In general the habitat characteristics of flowing sections of the creek indicate little cover for large fish with only small patches of intermittent (or discontinuous) cover provided by large boulders and undercut banks, and associated small pools. Where this habitat was provided (e.g., Plate 7.3-1), Arctic Char were often incidentally observed holding.

Plate 7.3-1. Riffle habitat with small pool provided near bank (left), looking upstream, approximately 1.3 from mouth of Nulahugyuk Creek, July 16, 2014.

Potential barriers to fish passage were identified at 13 sites in total (Table 7.3-5). These locations were characterized as difficult for adult Arctic Char to migrate upstream because of boulder barriers, 'broken' thalwegs and lack of water depth, resulting in possible strandings and mortalities (for example, see Plates 7.3-2a, 7.3-2b, 7.3-3a, and 7.3-3b). The problem sites are where low-flow-channel (enhancement) projects may benefit production of Arctic Char (Table 7.3-5). Three sites were identified as the highest the priority for site remediation, as a rank 3, followed by five rank 2 locations, and five rank 1 locations where remediation efforts are needed. Five of the problem sites were identified within a sharp bend in the lower section of the creek, starting 1.3 km from the mouth of Nulahugyuk Creek and for an upstream distance of approximately 800 m. Many strandings and mortalities were incidentally observed along this section during 2012 and 2014. Furthermore, most of the problem sites where remediation work is proposed (approximately 77%) are within the lower 3 km of the creek, which is consistent with previous habitat assessments of the creek (Golder and ANL 2007).

Table 7.3-5. Summary of Potential Locations for Fish Passage Enhancement Projects

Site Identification	Approximate Distance Upstream of Bernard Harbour (km)	Ranking Based on Expected Risk of Mortality and Blockage (Higher Ranking = Higher Risk)	Minimum Required Low-Flow Channel Length to Improve Passage (m)
Site 1*	1.3	Rank 3	41
Site 2	1.5	Rank 2	42**
Site 3	1.6	Rank 2	34***
Site 4	2.0	Rank 2	30
Site 5	2.1	Rank 3	22
Site 6	2.4	Rank 3	45
Site 7	2.9	Rank 2	14
Site 8	4.8	Rank 1	20
Site 9	5.7	Rank 1	40
Site 10	7.8	Rank 1	15
Site 11****	2.6	Rank 1	38
Site 12****	2.8	Rank 1	19
Site 13****	3.0	Rank 1	15

Note: km = kilometres; m = metre; extended rock weirs are recommended for most sites, for example, to direct migrating fish upstream through the low-flow channel.
** the site was initially described as two separate problem locations in 2014 but was later characterized in 2015 as one problem site requiring an extended low-flow channel (versus two separate consecutive channels); ** two parallel low-flow channels recommended (length represents combined length of parallel channels);*** requires further evaluation; a directional weir may be a viable alternative for this location; and **** problem sites identified in 2015.*

Plate 7.3-2a. Looking upstream towards barriers at Site 5, July 16, 2014.

Plate 7.3-2b. Looking downstream towards barriers at Site 5, July 16, 2014.