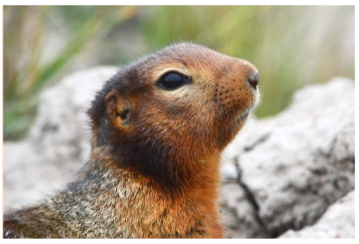
Appendix V5-6S

Doris North Project: 2015 Roberts Lake Fish Enhancement Monitoring Program







Prepared for:

TMAC RESOURCES

DORIS NORTH PROJECT

2015 Roberts Lake Fish Enhancement Monitoring Program

March 2016

The world's leading sustainability consultancy

ERM

TMAC Resources Inc.

DORIS NORTH PROJECT

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Project #0298923-0008

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EXECUTIVE SUMMARY

To compensate for the loss of fisheries in Tail Lake, a compensation plan was developed to ensure that no net losses would occur. The No Net Loss Plan (NNLP) and its updates proposed the following compensation strategies:

1. Increase the productive capacity of Roberts Lake by improving access of fish, primarily Arctic Char (*Salvelinus alpinus*), to critical overwintering habitat by creating a channel through the Roberts Lake Outflow boulder garden (completed in September 2012; Rescan 2012b).
2. Increase the quantity and quality of rearing habitat for juvenile Arctic Char in Stream E09, a tributary to Roberts Lake, by creating additional pool habitat (completed in September 2012; Rescan 2012b).
3. Increase the quantity and quality of rearing habitat available to juvenile Lake Trout (*Salvelinus namaycush*) in Windy Lake by installing four rock compensation shoals (completed in April 2011; Rescan 2011c).

A separate DFO Fisheries Authorization (NU-02-0117.3) was approved on January 19, 2011, to prescribe compensation requirements for the loss of Tail Lake Outflow through the following strategy:

1. Increase the quantity and quality of rearing habitat available to juvenile Lake Trout (*Salvelinus namaycush*) in Windy Lake by installing two rock compensation shoals (completed in April 2011; Rescan 2011c).

The Roberts Lake Fish Enhancement Monitoring Program (NNLP strategy 1 as outlined above) measures:

- *successful migration* of adult Arctic Char migrating through the enhanced boulder garden;
- the structural integrity of enhanced channels constructed in 2012;
- the quantification of juvenile Arctic Char densities at Stream E09 enhancement site and at reference sites; and
- the structural stability and vegetation recovery at the enhancement site in Stream E09.

This report presents the results of the 2015 Roberts Lake Fish Enhancement Monitoring Program, which constitutes the third of ten years of monitoring following the construction of enhancements at the Roberts Lake Outflow boulder garden. Monitoring was not required at the Stream E09 and Windy Lake enhancement sites in 2015. Monitoring for these programs will next be undertaken in 2016.

Since 2013, fish migrations have been monitored using the Vaki Riverwatcher system, which allows fish passage to be monitored remotely. *Successful migration* of anadromous Arctic Char through the boulder garden at Roberts Lake Outflow was 96% in 2015, whereas the average for all

pre-enhancement years was 62%. *Successful migration* was 94% in 2014 and 93% in 2013. *Successful migration* has been high in all years since the enhancement was constructed. In addition, *successful migration* now appears to be independent of discharge, since *successful migration* was high even during low flow periods. Prior to enhancement, the probability of *successful migration* was lowest during low flow conditions.

ACKNOWLEDGEMENTS

This report was prepared for TMAC Resources Inc. by ERM Consultants Canada Ltd. Data collection was conducted by Kevin Esseltine (M.Sc., R.P.Bio.), Fraser Ross (B.Sc., R.P.Bio.), and Greg Langston (M.Sc.). Field assistance was provided by Audla Buchan, Abraham Hiqinia, and Mark Ullikataq. The report was written by Fraser Ross and technically reviewed by Kerry Marchinko (Ph.D., R.P.Bio.). The compliance program was coordinated by Nicole Bishop (B.Sc.) and managed by April Hayward (Ph.D.) and Erin Forster (B.Sc., R.P.Bio.). Marc Wen (M.Sc., R.P.Bio.) was the Partner in Charge.

Field-related logistics support was provided by TMAC, Great Slave Helicopters, Braden Burry Expediting, and Nuna Logistics.

DORIS NORTH PROJECT

2015 Roberts Lake Fish Enhancement Monitoring Program

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

CI	Confidence Interval
DFO	Fisheries and Oceans Canada
ERM	ERM Consultants Canada Ltd.
FDR	False Discovery Rate
FL	Fork Length
HBML	Hope Bay Mining Ltd.
n	Sample Size
N	Population Size
NNLP	No Net Loss Plan
SD	Standard Deviation of the Mean
SE	Standard Error of the Mean
The Project	The Doris North Project
TIA	Tailings Impoundment Area
TMAC	TMAC Resources Inc.

1. INTRODUCTION

The Doris North Project (the Project) is located on the Hope Bay Belt, an 80 by 20 km property on the south shore of Melville Sound in Nunavut (Figure 1-1). The property consists of a greenstone belt (the Hope Bay Belt) that contains three main gold deposits. The Doris and Madrid deposits are located in the northern portion of the belt, and the Boston deposit is at the southern end. The Project is located on the southern shore of Melville Sound. The nearest communities are Cambridge Bay (Iqaluktuttiaq; 125 km northeast) Umingmaktok (75 km southwest), and Bathurst Inlet (Kingaok; 160 km southwest of the property).

TMAC Resources Inc. (TMAC) acquired the Hope Bay Belt Project from Newmont Corporation in March 2013. The acquisition included exploration and mineral rights over the Hope Bay Belt, including the Doris North Project and its permits, licences and authorizations for development received by previous owners. In late 2012, prior to the sale, the Project was placed into care and maintenance, and was seasonally closed during the winter of 2012/2013. TMAC re-opened the Doris Camp in March of 2013 for the purposes of conducting site water management and environmental compliance programs and to support exploration activities that have continued through 2015. Following notification to the Nunavut Impact Review Board (NIRB), construction was resumed during the spring of 2015.

Tail Lake was added to Schedule 2 of the Metal Mining Effluent Regulations, SOR/2002-222 on June 19, 2008 pursuant to SOR/2008-216. A condition of this amendment was that a compensation plan be developed to ensure that no net losses of fish habitat occur. The No Net Loss Plan and its updates (NNLP; Golder 2007b; Rescan 2010a, 2010b) proposed the following compensation strategies:

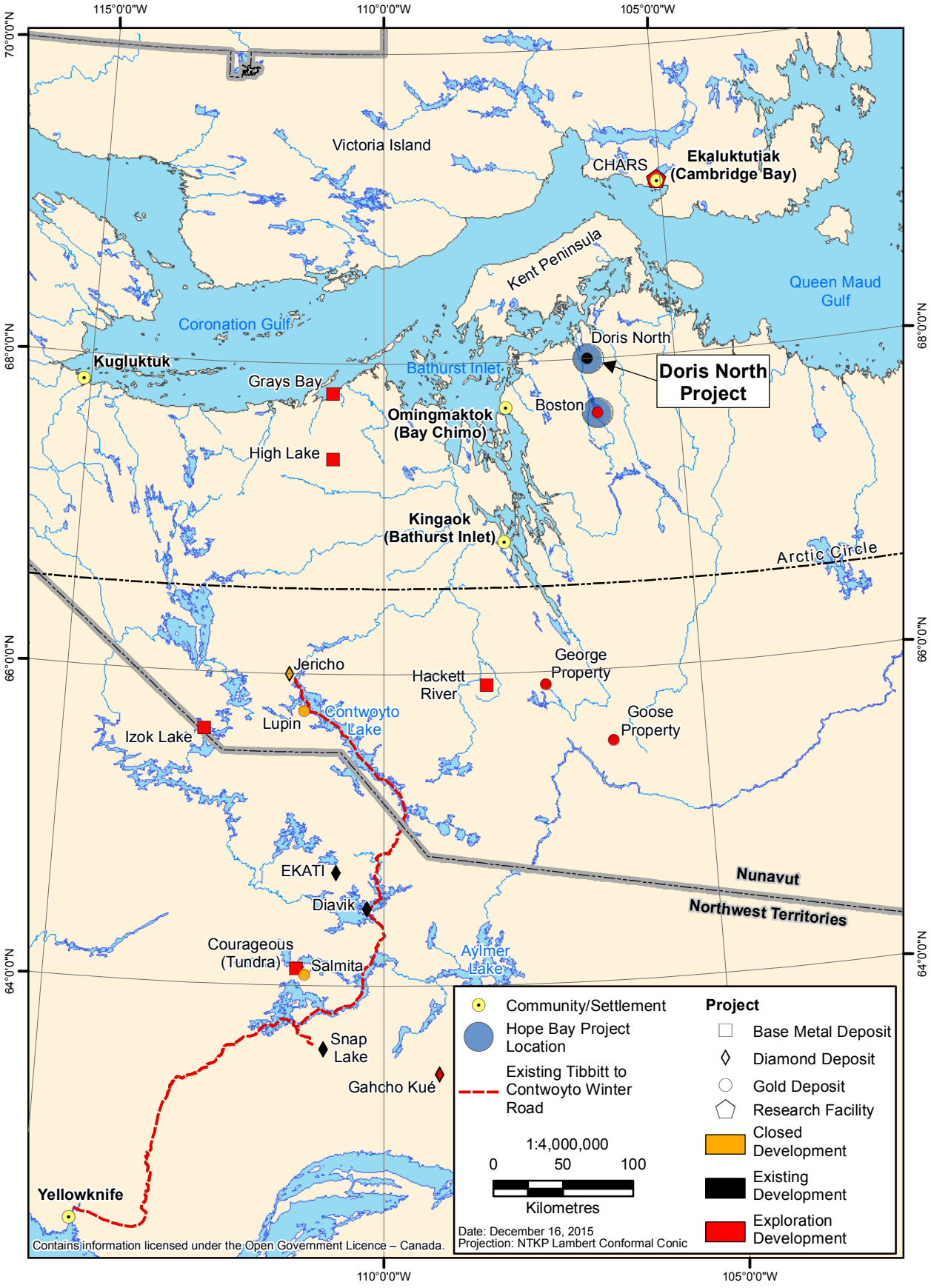
1. Increase the productive capacity of Roberts Lake by improving access of fish, primarily Arctic Char (*Salvelinus alpinus*), to critical overwintering habitat by creating a channel through the Roberts Lake Outflow boulder garden (completed in September 2012; Rescan 2012b).
2. Increase the quantity and quality of rearing habitat for juvenile Arctic Char in Stream E09, a tributary to Roberts Lake, by creating additional pool habitat (completed in July 2012; Rescan 2012b).
3. Increase the quantity and quality of rearing habitat available to juvenile Lake Trout (*Salvelinus namaycush*) in Windy Lake by installing four rock compensation shoals (completed in April 2011; Rescan 2011c).

A separate Fisheries and Oceans Canada (DFO) Fisheries Authorization (NU-02-0117.3) was approved on January 19, 2011, to prescribe compensation requirements for the loss of Tail Lake Outflow through the following strategy:

1. Increase the quantity and quality of rearing habitat available to juvenile Lake Trout (*Salvelinus namaycush*) in Windy Lake by installing two rock compensation shoals (completed in April 2011; Rescan 2011c).

Figure 1-1

Doris North Project Location



This report presents the results of the 2015 Roberts Lake Fish Enhancement Monitoring Program (the Program) which monitors the success of NNLP compensation strategy 1 as outlined above. The Program constitutes the third of ten years of monitoring following the construction of enhancements at the Roberts Lake Outflow boulder garden. Monitoring was not required at the Stream E09 and Windy Lake enhancement sites in 2015. Monitoring for these programs will next be undertaken in 2016.

2. 2015 MONITORING PROGRAM OBJECTIVES

The objective of the 2015 Program was to fulfil the requirements of the Roberts Lake Fish Enhancement Monitoring Program. More specifically, the 2015 Program was designed to evaluate changes in the productive capacity of Arctic Char in the Roberts Lake system following the completion of an enhancement project in 2012. The following tasks were completed to meet the overall objective of the monitoring program:

- quantify adult Arctic Char *successful migration* through the Roberts Lake Outflow enhancement during upstream migration using two infra-red fish counting fences; and
- assess the structural integrity of the boulder garden enhancement channels constructed in 2012 in Roberts Lake Outflow.

3. METHODS

3.1 STUDY DESIGN

Anadromous Arctic Char cannot spend the winter in Arctic marine environments (Swanson, Kidd, and Reist 2010) and must migrate to appropriately deep freshwater winter habitat before freeze-up each year. Roberts Lake is the only lake in the Doris-Roberts watershed that provides critical overwintering habitat for anadromous Arctic Char (Swanson et al. 2010). Doris Lake is upstream of a 4 m high impassable waterfall (Golder 2007b) and Little Roberts Lake is too small and shallow (approximately 4 m deep) to provide substantial overwintering habitat (ERM Rescan 2014a).

To reach Roberts Lake, upstream migrants must pass through a boulder garden at the lake outflow. Prior to enhancement, movement through this section of the stream was challenging for fish, particularly during periods of low discharge when flow became braided and shallow. The period of lowest discharge in Roberts Lake Outflow typically occurs during August and September (ERM Rescan 2014b), concurrent with upstream migrations of anadromous Arctic Char when, historically, a large fraction (21% to 68% in baseline years) of the population perished from stranding and predation (Golder 2007b; Rescan 2011a, 2012a, 2013). Prior to enhancement, variation in the fraction of the population that perished while migrating through the boulder garden was highly dependent on flow conditions, with low flow years resulting in the highest level of mortality (ERM Rescan 2014c).

The NNLP required that a fish passageway through the boulder garden be built to provide better access for migrants to Roberts Lake (Golder 2007b). It was predicted that increased *successful migration* of returning adults would lead to an increase in the spawning population and, over time, increase the productive capacity of the lake. According to the 2007 design, the efficacy of the enhancement was to be measured by monitoring the outmigration of Arctic Char smolts in spring before and after enhancement. In 2012, DFO approved a revision to the sampling program so that it focused on monitoring the success of returning adults (G. Williston [DFO] pers. comm. to M. McGurk [Hope Bay Mining Ltd.]). A history outlining differences in the sampling programs among years and the rationale for these changes is provided in Section 3.1.2.

The current monitoring program uses two metrics to assess the effectiveness of habitat enhancement in Roberts Lake Outflow (i.e., *successful migration* and *adult returns*; Table 3.1-1). The *successful migration* metric is evaluated by comparing survival probabilities for adult Arctic Char migrating upstream before and after enhancement construction. *Successful migration* percentage is determined by enumerating fish downstream and upstream of the boulder garden on an annual basis (Figure 3.1-1). The *adult returns* metric is evaluated by comparing total abundance of adult migrants among years to determine whether the enhancement has increased the overall anadromous population of Arctic Char.

Figure 3.1-1

Sampling Location for the Roberts Lake Outflow Fish Enhancement Monitoring Program, Doris North Project, 2015

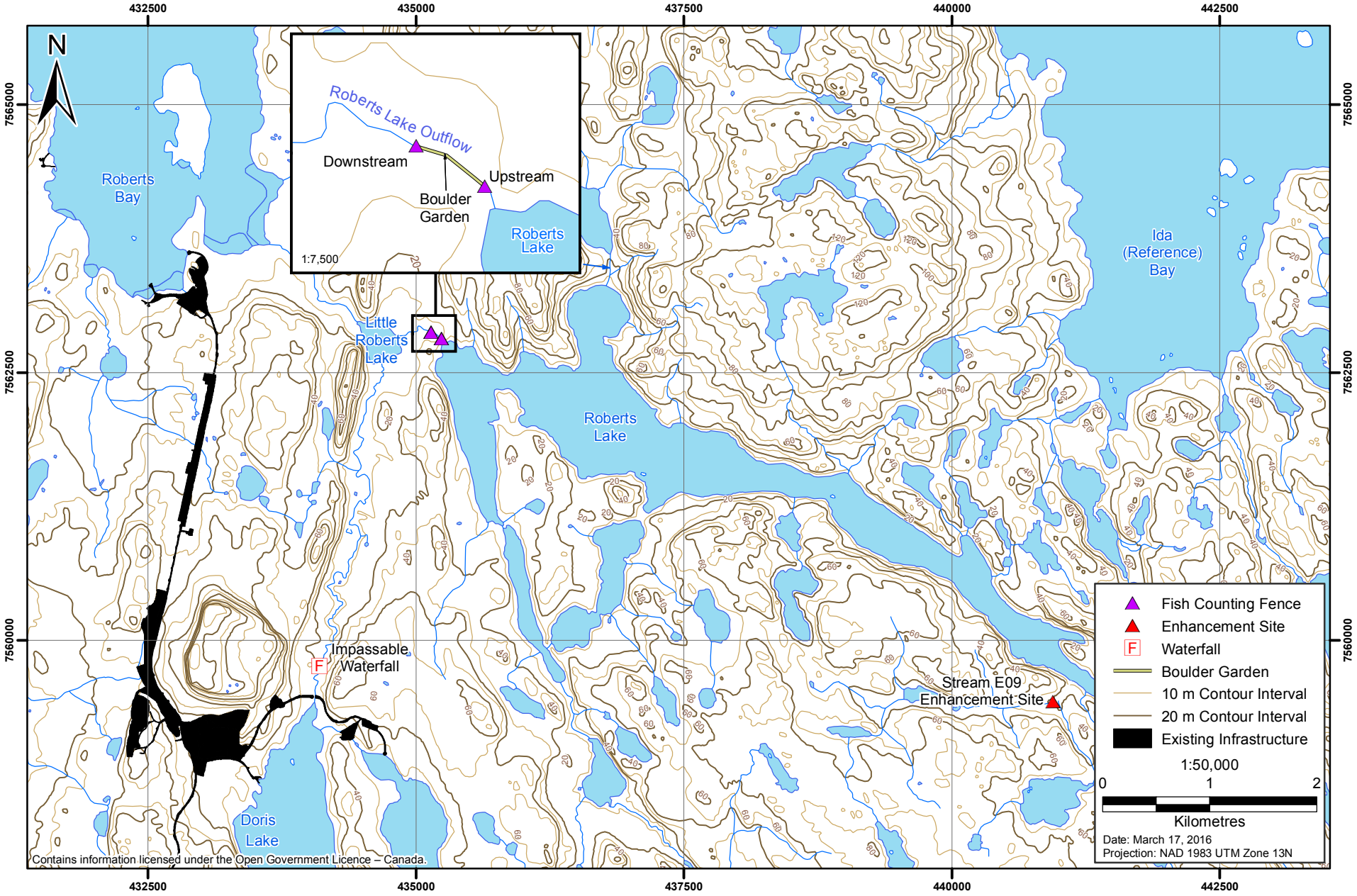


Table 3.1-1. Roberts Lake Outflow Productivity Capacity Metrics, Doris North Project, 2015

Tier	Metric	Measurement	Predicted Biological Response	Biological Assumptions
Primary	*Successful Migration*	Calculate survival (%) of adults migrating between the lower and upper boulder garden fences.	The enhanced channel may lead to an immediate increase in *successful migration* of fish moving through the boulder garden. This is a direct measure of success of the enhancement.	100% trap capture or sampling efficiencies at both fish fences (or partial but equivalent efficiencies at both fences).
Secondary	*Adult Returns*	Calculate abundance of Arctic Char migrating through the upper boulder garden fence.	Over time, a decrease in boulder garden mortality may increase the total number of fish returning each year. This effect may be non-detectable or slight immediately after the enhancement. The magnitude of the effect may begin growing at a faster rate when the earliest post-enhancement smolts recruited into the population undertake their first outmigration and return to Roberts Lake (4 or more years post-enhancement).	Roberts Lake is not at productive capacity for smolt production. Constant annual marine survival of adults. Constant smoltification proportion of char population. Site fidelity sufficiently high to cause a detectable population increase. Sampling period covers the entire migration period or a comparable portion among years.

Calculating the second metric for assessing the enhancement's efficacy - *adult returns* - will not begin until 2017 as no detectable change is expected until that time. Generally, Arctic Char smolts are four to nine years old when they make their first seaward migration (McPhail and Lindsay 1970; Scott and Crossman 1973). In the Roberts Lake watershed, first-time Arctic Char outmigrants range in age from three to six years (Swanson et al. 2010). Since the enhancement was constructed in fall 2012, spring 2013 was the first time when the juvenile population in Roberts Lake could have benefitted from the enhancement. Though the earliest that any of these fish would be ready to undertake their first outmigration to the ocean is spring 2016, a surge in the number of post-enhancement Arctic Char returning to Roberts Lake is not expected for an additional two to three years. Consequently, a formal evaluation of a change in abundance of returning Arctic Char will begin in 2017; until that time, *successful migration* will be the only measure of success of the enhancement.

The habitat enhancement to the boulder garden in Roberts Lake Outflow was completed in the fall of 2012, following the conclusion of pre-enhancement data collection for that year (Rescan 2012b). This report presents the results of the third year of post-enhancement monitoring of *successful migration* of anadromous Arctic Char.

3.2 PROGRAM HISTORY

Fish fences have operated at the Roberts Lake Outflow boulder garden for twelve years, between 2002 and 2015. The number of fences, methods used, and locations of fences have changed throughout the development of the monitoring program. Table 3.2-1 summarizes the dates, locations, and direction of capture of fish fences installed from 2002 to 2015.

Table 3.2-1. Summary of Sampling at Roberts Lake Outflow, Doris North Project, 2002 to 2015

Year	Operation Dates	Fence Type	Fish Fence Location Relative to Boulder Garden (A/B)	Capture Direction (D/U)	Data Source
2002	Aug 16 - Aug 30	Manual Trap	A	U	RL&L/Golder (2003a)
2003	Aug 7 - Sept 8	Manual Trap	A/B	U	RL&L/Golder (2003b)
2004	Aug 9 - Sept 8	Manual Trap	A/B	U	Golder (2005)
2005	Aug 4 - Sept 12	Manual Trap	A/B	U	Golder (2006)
2006	June 19 – July 22	Manual Trap	B	D	Golder (2007a)
2007	June 28 – July 26	Manual Trap	B	D	Golder (2008)
2010	June 29 - Aug 22	Manual Trap	A/B	D/U	Rescan (2011b)
2011	July 14 - Aug 9	Manual Trap	B	D/U	Rescan (2012a)
2012	June 29 - Aug 30	Manual Trap	A/B	D/U	Rescan (2013)
2013	July 17 – Sep 7	Automated Counter	A/B	D/U	ERM Rescan (2014c)
2014	July 12 – Sep 6	Automated Counter	A/B	D/U	ERM (2015b)
2015	August 12 – Sep 15	Automated Counter	A/B	D/U	This report

Notes:
A = fish fence above (i.e., upstream of) boulder garden; B = fish fence below (i.e., downstream of) boulder garden
U = fish migrating upstream; D = fish migrating downstream
Grey shading indicates years that were used for successful migration *estimates as the data were comparable to 2015 data.*

In 2002, the upstream migration of adult Arctic Char was monitored using one fish fence upstream of the boulder garden. The objective was to enumerate the upstream migration of returning Arctic Char into Roberts Lake in August and early September.

The fence was relocated downstream of the boulder garden in 2003, and a modified fyke net was installed immediately above the boulder garden. The fyke net was installed so that it functioned in the same manner as the fish fence; there was a central trap and two wings that stretched from the trap to each shore, blocking the full width of the channel. This change was made so that *successful migration* through the boulder garden could be determined, along with the total number of fish entering Roberts Lake.

In 2004 and 2005 two fish fences were installed each year; one upstream and one downstream of the boulder garden. Again, the purpose was to assess *successful migration* through the boulder garden, along with the total number of fish entering Roberts Lake.

In 2006 the program was amended so that data collection would meet the objectives of the draft NNLP. Monitoring of adult Arctic Char migrating into Roberts Lake during the low-discharge period of August and early September was discontinued. Monitoring focused on the abundance of char smolts migrating out of Roberts Lake to the sea during the high-discharge period of late June and early July. One fence was installed downstream of the boulder garden that caught downstream migrants. This sampling program was repeated in 2007, and no fish fences were installed in 2008 or 2009.

In 2010, the program was amended so that fish fences were installed both upstream and downstream of the boulder garden and so that upstream and downstream migrating fish were captured at each

fence. The fences were installed at the end of June to catch the downstream migration of smolts and the plan was to operate the fences until mid-September, when the upstream adult migration occurs. However, safety concerns arising from persistent grizzly bear (*Ursus arctos horribilis*) activity in the boulder garden resulted in the termination of the program on August 22, 2010.

The sampling approach was changed in 2011, following the bear encounters that occurred toward the end of the previous field season. One fence was installed downstream of the boulder garden in Roberts Lake Outflow during the freshet period to monitor smolt outmigration, following the approach proposed in the NNLP. The program was scheduled to end before the main upstream return of adult char to minimize conflict with bears. However, 2011 was the highest freshet flow year on record for Roberts Lake Outflow. The conditions delayed fence installation by several weeks causing the majority of outmigrants to be missed.

Further modifications to the program were proposed prior to the 2012 field season due to the low number of smolts captured in 2011. A letter sent from Hope Bay Mining Ltd. (HBML) to DFO dated June 2, 2012 requested that the program be shifted back to monitoring only adult *successful migration* for the following scientific, human safety, and practical reasons. Smolt outmigration peaks during spring freshet, yet installing and maintaining a fish fence during that time of year is logistically difficult and potentially dangerous. In addition, smolt enumeration only serves as an indirect measure of the effectiveness of the habitat enhancement, since smolt abundance is strongly influenced by other factors, including population dynamics, marine survival, and lake carrying capacity. Returning adult individuals are in the life stage that is most likely to benefit directly from the habitat enhancement to Roberts Lake Outflow, as their passage through the boulder garden is most likely to be restricted during periods of low discharge.

In 2012, both smolt outmigration and adult upstream migration were monitored. The enhancement channels were constructed in the fall of 2012 after the completion of the smolt and adult migration monitoring programs. Wildlife encounters were frequent during the latter portion of the monitoring program, when field crews had to be evacuated from site by helicopter on several occasions. Consequently, additional modifications to the methods were made prior to the 2013 field season.

In 2013, the manual traps were replaced with the Vaki Riverwatcher system, which allows fish passage through a fence to be monitored remotely. This approach has continued though the 2015 field season with only minor changes made to the setup. The system automatically monitors the movements of individual fish passing through a chute using infra-red scanners and a high-resolution video camera. Species, length, and direction of travel are recorded for each passing individual. In contrast, the earlier trap count method required biologists to make daily site visits to count and measure fish that were trapped in holding cages at each fish fence. Aside from the hardware that is specific to each method, fish fence design and construction has been held constant since 2010. This consistency helps minimize the between-fence and among-year variation in detection probability. These modifications to the monitoring program were approved by DFO prior to the 2013 field season (G. Williston [DFO] pers. comm. to A. Holzapfel [HBML]).

Because a rapid transition in fish counting methods was needed to minimize encounters between humans and potentially dangerous wildlife, there were no years in which the two counting methods were used simultaneously. Thus, it was not possible to compare fish detection probabilities between

the two sampling methods. Based on other studies, however, it is known that fish detection probability for the trap capture approach may be strongly dependent on efficiencies of the traps used for this purpose, which can, in turn, vary according to flow rate, time of day, size of individuals, and species of fish (Roni 2005). According to the available data, Vaki Riverwatcher systems have detection probabilities that are slightly less than detection probabilities obtained by trap counts (Pyper, Lando, and Justice 2006; Baumgartner et al. 2012). The most accurate fish counts from the Riverwatcher system seem to be produced at low densities of migrating fish (Baumgartner et al. 2012), such as the densities of anadromous Arctic Char observed in Roberts Lake Outflow over the past several years (e.g., Rescan 2011b, 2011a, 2012b).

Changes in fish enumeration methods due to wildlife safety concerns are not expected to affect the validity of the assessment of the habitat enhancement's efficacy with respect to the key metric for success, *successful migration*, which can be made by comparing percentage survival before and after the enhancement. Enumeration methods were the same at the downstream and upstream fish fences in any given year in which *successful migration* data were collected, which largely normalizes the data across the slight to moderate differences in detection probability between methods.

Similarly, changes in fish enumeration methods through time are not expected to affect the validity of the assessment of the habitat enhancement's efficacy with respect to *adult returns* because the post-enhancement enumeration method tends to underestimate fish counts relative to the pre-enhancement method (trap counts), while the boulder garden enhancement is expected to eventually increase the abundance of anadromous Arctic Char in Roberts Lake relative to the pre-enhancement period. Thus, a finding of a significant increase in post-enhancement Arctic Char abundance would serve as a conservative estimate of a successful habitat enhancement.

3.3 *SUCCESSFUL MIGRATION* OF ARCTIC CHAR

3.3.1 Arctic Char Enumeration

Successful migration of Arctic Char traversing the boulder garden at Roberts Lake Outflow was monitored in 2015 using two Vaki Riverwatchers, one installed upstream and one installed downstream of this potential barrier to fish migration (Table 3.3-1). The Riverwatcher system consists of an infra-red scanner, a high-resolution camera, and an ultra-violet lighting system powered by four 120 W solar panels and 12 6 V deep cycle batteries (Plate 3.3-1). As a fish swims through the Riverwatcher, the infra-red scanner calculates total length and direction of travel. When the scanner is triggered, the video camera is activated and captures a video that is used at a later date for species identification and quality control.

Table 3.3-1. Roberts Lake Outflow Fish Counting Fence Locations, Doris North Project, 2015

	UTM		
Fish Fence	Zone	Easting	Northing
Lower	13 W	435142	7562877
Upper	13 W	435225	7562806

Plate 3.3-1. Solar panels providing power to the Vaki Riverwatcher upstream of the boulder garden, July 21, 2015.

Each fish counter was installed in the centre of the channel and the infra-red scanner was orientated perpendicular to the direction of flow. Wings were constructed between each Riverwatcher and the stream banks so that fish could not pass through undetected (Plate 3.3-2). The wings consisted of aluminum frames with removable conduit rods (1.8 cm diameter) spaced 1.3 cm apart, and were reinforced with galvanized mesh hardware cloth and sand bags. Wooden "A" frames supported the panels and were held in position with large weighted buckets. An electric fence was constructed around the perimeter of the work area to prevent damage from bears.

The scanner and video recorder simultaneously logged the date, time, direction, and fish length for each passing fish and paired these data with a video recording to be used for species identification (Appendix 3.3-1). Data and videos were saved on computers in weather-proof containers located next to the stream. In addition, the Riverwatchers continuously logged water temperature throughout the sampling period.

Field crews made site visits every five to seven days throughout the monitoring period to verify that the scanner and computer were operational. Crews downloaded data, checked the battery status, cleaned the scanner and underwater video tunnel, checked and cleaned the fence wings, and made notes of wildlife activity in the area.

In 2015, the fish counters began operating on July 21 and were removed on September 16. The underwater lights allow the system to operate 24 hours a day. A rainfall event in the latter half of July caused unseasonably high flow conditions in streams around the Doris North Project area. At the Roberts Lake Outflow Hydrometric Station, peak discharge in late July was similar to peak

discharge during spring freshet (4.66 m^3/s on July 27 whereas the freshet peak on June 15 was 4.84 m^3/s; ERM 2015a). Elevated flow conditions damaged the downstream fence, where a hole may have permitted fish to pass the scanner undetected. Repairs to the downstream fence were made on August 12; data collected prior to the repair were excluded from analyses.

Plate 3.3-2. Fish fence downstream of the boulder garden on July 21, 2015.

3.3.2 Species Identification and Enumeration

Underwater video was used to determine the species of each fish recorded by the Vaki Riverwatcher (Plates 3.3-3 and 3.3-4). Silhouettes generated for each record were reviewed using Winari software to determine whether the scanner was triggered by a fish or if it was a false trigger (Plate 3.3-5). Where the silhouette was unclear, the corresponding video recording was reviewed to confirm whether a fish had triggered the scanner. A subsample of 20% of all fish records (previously confirmed from silhouettes) was reviewed to determine the ratio of species in the sample. To ensure an even distribution of samples were selected from throughout the sample period, approximately 20% of videos from each day were reviewed. Videos were selected from within each day using the random number generator "runif" function in R. As the Riverwatcher uses both white lights and infra-red lights to illuminate passing fish, data were able to be collected 24 hours a day so no diurnal bias is introduced.

Arctic Char smolts (first-time migrants to seawater) are generally classified as individuals 150 to 250 mm in length (Scott and Crossman 1973; Johnson 1980), but in the Roberts Lake Watershed, Arctic Char smolts can grow as large as 350 mm prior to their first ocean migration (Golder 2008; Swanson et al. 2010). In this study, Arctic Char that measured greater than 350 mm by the infrared scanner were classified as adults.

Plate 3.3-3 An adult Arctic Char swims upstream through the Vaki Riverwatcher located downstream of the boulder garden on August 13, 2015.

Plate 3.3-4. A Lake Trout swims upstream on August 14, 2015.

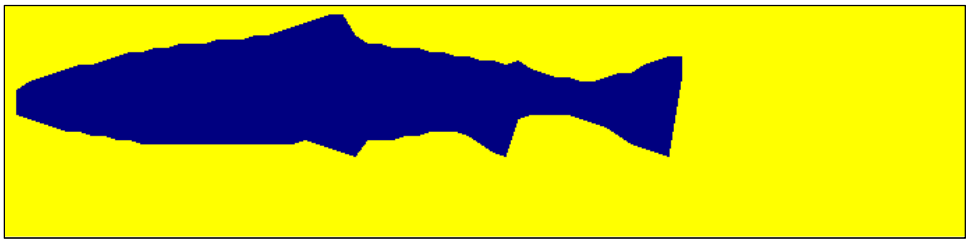


Plate 3.3-5. Silhouette of a fish swimming upstream on August 21, 2015.

3.3.3 Stream Hydrology

A hydrometric station has been used to measure water level and compute discharge at Roberts Lake Outflow since 2003 (ERM 2015a). The 2015 station consisted of a pressure transducer with an integrated data logger (Aquistar PT-2X Smart Sensor® model 0 to 5 psi, vented [Instrumentation Northwest Inc.]). The transducer continuously sampled water level and these data were recorded at 10 minute intervals. Full details of the hydrology monitoring program including data processing methods are described in ERM (2015a).

3.4 ENHANCEMENT STABILITY ASSESSMENT

Visual stability assessments were completed on August 12 and September 5, 2015. The same personnel that completed construction in 2012 inspected each channel, looking for signs of infilling or erosion. Representative photographs were taken to document the structural integrity.

Section 4.1.2 of the NNLP specifies the creation of a clear flow path 12 to 15 m in length through the "stranding zone" in the middle of the boulder garden in Roberts Lake Outflow. In place of a single channel, four channels were built with a total length of 69 m between September 3 and 10, 2012 (Rescan 2012b). The three additional channels provide alternative routes for fish if the structural integrity of any one channel was to deteriorate over time.

3.5 DATA ANALYSIS

3.5.1 Boulder Garden *Successful Migration*

Successful migration (percent survival, %) of adult Arctic Char moving upstream through the boulder garden was calculated for each year in which both an upstream and a downstream fence were in operation (Table 3.2-1).

Successful migration (%) through the boulder garden was calculated using the equation:

$$\textit{Successful Migration} = \frac{\textit{net number of Arctic Char caught in the upstream fence}}{\textit{net number of Arctic Char caught in the downstream fence}} \times 100\%$$

To accommodate for the travel time between fences, an appropriate end date for the lower fence was calculated (referred to as the enumeration end date). This was completed because fish that passed the lower fence toward the end of the program may have had inadequate time to reach the upper fence before sampling ended. Thus, a portion of these fish would have survived but would have

been classified as mortalities if they had not passed the upper fence at the end of the sampling period (causing an overestimation of mortality).

The enumeration end date calculation for the lower fence involved determining the total number of days required for 95% of fish to pass between the fences across all pre-enhancement years and then subtracting the number of days from the last sampling/removal day. This value equaled seven days. This means that, within seven days, 95% of fish successfully passed upstream from one fence to the other and that fish not passing through within seven days suffered mortality. This approach assumes that 5% of the mortalities may have successfully migrated through the boulder garden after seven days and is analogous to a 5% error rate (or alpha 0.05). It should be noted that the upstream and downstream fences are less than 100 m apart.

The same seven day window was used to calculate the enumeration start date for the upstream fence. If simultaneous start dates were used for both fences, fish between the fences at the start would only be counted at the upstream fence, causing an overestimation of survival. The enumeration start date calculation for the upper fence involved subtracting the seven days from the upper fence installation day.

As an example, if fences were installed July 1 and removed September 1, then the enumeration interval for the downstream fence would be July 1 to August 26, whereas the enumeration interval for the upstream fence would be July 7 to September 1.

Successful migration rates from baseline years were recalculated following these methods, which generally resulted in a slight increase in *successful migration* (less than 5%) estimates for most baseline years.

In baseline years, the net number of fish caught at both fences was calculated by direct enumeration of individually tagged fish passing upstream in each fence. Thus, an individual was counted moving upstream once, even if it was observed to pass upstream and downstream at a single fence multiple times. Beginning in 2013 an extra step in this calculation was required, because individual fish were not tagged, resulting in an inability to track individuals moving two or more times (upstream then downstream) through a single fence. To account for this, the net number of fish in both fences was calculated by subtracting the number of char moving downstream from the number moving upstream separately for each fence. The subsequent calculation of *successful migration* was then completed in the same manner as baseline years.

3.5.2 Discharge Calculations

Rating curves were established for Roberts Lake Outflow hydrologic station so that water level data could be converted into a continuous discharge time series (i.e., a hydrograph). Rating curves are hydraulic functions expressed as a parabolic equation of the form:

$$Q = C\,(h - a)^{b}$$

where Q is the discharge (m^3/s), C and b are regression coefficients, h is the stage (water level in m), and a is the stage at zero flow (datum correction in m). Data and discharge calculations are presented in ERM (2015a).

3.5.3 Statistical Analysis

The post-enhancement *successful migration* rate (2015) was compared to baseline *successful migration* rate (pooled among years) and then to each baseline year separately (2003, 2004, 2005, 2010, and 2012) using the χ^2 (chi square) test for independence. For comparisons to each baseline year, each test was carried out using a fixed significance level of $\alpha = 0.05$, but was then adjusted to account for the increase in error rate caused by multiple testing using the False Discovery Rate (FDR; Whitlock and Schluter 2009).

Beta regression was used to examine the relationship between Arctic Char *successful migration* through the boulder garden and flow (mean discharge during the sampling period) for pre-enhancement years. Beta regression was selected because the dependent variable (*successful migration*) is a proportion bounded by the unit interval (0,1). Beta regression was developed as a maximum likelihood fitting method to model the association of a continuous, proportional dependent variable to one or more independent variables using the beta distribution (Ferrari and Cribari-Neto 2004). This analysis was conducted using the betareg function within the "betareg" package in R.

SigmaPlot 12.3 software and R 3.0.2 (R Core Team 2013) were used for statistical analyses. For all statistical analysis, significance was accepted at $\alpha = 0.05$, except where multiple testing was performed as indicated above.

3.6 QUALITY ASSURANCE AND CONTROL

Following the initial assessment of underwater videos, a second fish biologist randomly selected and reviewed 10% of the videos to check the accuracy of species identification. A single difference in assigned species was found (from 58 videos checked); a small fish was identified as a Lake Trout and a Lake Whitefish. This equated to an error rate of 1.7%.

4. RESULTS AND DISCUSSION

A sum of 576 records of fish movement (including multiple movements by any one individual) were identified in underwater video recordings from two infra-red fish counting fences at Roberts Lake Outflow between August 12 and September 15, 2015. Appendix 3.3-1 lists species, date, direction of migration, and total length for all fish records.

The downstream fence was installed on July 15, 2015 but it was damaged during high flow conditions in the second half of July. Once the flow level receded, the fence was repaired on August 12. All data collected prior to August 12 were excluded as fish could have passed the downstream fence undetected.

The number of Arctic Char migrating upstream per day at the fish fence downstream of the boulder garden ranged between 0 and 28, while the range was from 0 to 24 at the upstream fence. The main peak of the run occurred between August 12 and 20, immediately following the fence repair. From August 20 to the end of the monitoring period (September 15) the daily numbers of fish were low; the maximum occurred on August 27 when a total of ten fish were counted at both fences.

4.1 PRE- AND POST-ENHANCEMENT *SUCCESSFUL MIGRATION*

Successful migration through the boulder garden in 2015 was 96%: significantly greater when compared to combined survival prior to enhancement ($\chi^2_{(1,5)} = 6.38$, $P = 0.01$). In addition, combined *successful migration* from all years of post-enhancement monitoring was significantly greater than combined *successful migration* prior to enhancement ($\chi^2_{(1,5)} = 6.24$, $P = 0.01$). A total of 182 of 190 Arctic Char successfully migrated through the boulder garden in 2015 (Table 4.1-1). The remaining 8 Arctic Char (4%) were unaccounted for, possibly dying in the boulder garden or they may have been between the fences at the end of the sampling period.

Successful migration in 2015 was greater than in any year of baseline sampling (Table 4.1-1). To further examine which particular pre-enhancement years were significantly lower in *successful migration* than 2015, each pre-enhancement year was tested against *successful migration* in 2015 separately. These comparisons showed that the key metric for measuring enhancement success, *successful migration*, was significantly greater in 2015 than three of the five years of pre-enhancement data (greater than 2012, 2005, and 2004; Table 4.1-2), though *successful migration* in 2015 was always higher than pre-enhancement years. Similar results were observed when *successful migration* in other post-enhancement years (2013 and 2014) were compared to pre-enhancement years (ERM Rescan 2014c; ERM 2015b)

Variability in yearly *successful migration* was high in pre-enhancement years, ranging from 32% to 79% (Table 4.1-1; Note: these percentages only reflect *successful migration* during the sampling interval, and not the entire run for that year, as outlined in Section 3.3). Combined pre-enhancement *successful migration* was 62%, with a total of 693 adult Arctic Char passing the fence downstream of the boulder garden and 427 upstream over 216 days of sampling in five years. Since enhancement, *successful migration* has been similar in each of the three years of monitoring; 93% in 2013, 94% in

2014, and 96% in 2015. A total of 612 out of 649 Arctic Char successfully traversed the boulder garden in 141 days of sampling over three years.

Table 4.1-1. Summary of *Successful Migration* of Arctic Char Passing Upstream through Roberts Lake Outflow, Doris North Project, 2003 to 2015

Year	Sampling Period	Mean Flow (m^3/s)	Total Fish	Successful Fish	Unsuccessful Fish	Successful Migration (%)
Pre-enhancement						
2003	August 7 - August 30	0.67	286	221	65	77
2004	August 9 - September 2	0.15	106	34	72	32
2005	August 4 - September 12	0.57	110	52	58	47
2010	June 30 - August 17	1.32	47	37	10	79
2012	July 30 - August 23	0.74	144	83	61	58
Average	**2003 to 2012**	**0.69**	**139**	**85**	**53**	**62**
Post-enhancement						
2013	July 18 – September 6	0.29	226	211	15	93
2014	July 12 – September 6	0.97	233	219	14	94
2015	August 12 – September 16	0.71	190	182	8	96
Average	**2013 to 2015**	**0.66**	**216**	**204**	**12**	**94**

Table 4.1-2. Comparisons of Post-enhancement *Successful Migration* to Each Pre-enhancement Year for Arctic Char in Roberts Lake Outflow, Doris North Project, 2003 to 2015

Comparison (2015 vs.)	$\chi 2$	Degrees of Freedom	FDR Adjusted P Value
2003	2.25	1	0.17
2004	24.31	1	<0.001
2005	12.30	1	0.001
2010	0.47	1	0.49
2012	8.24	1	<0.01

Note: P values were adjusted using the False Discovery Rate to account for multiple comparisons (Whitlock and Schluter 2009).

The numbers of Arctic Char migrating into Roberts Lake in each year are shown by date along with temperature and discharge in Figures 4.1-1 to 4.1-5. It appears that the main upstream migration period occurs during the latter half of August, though timing is somewhat variable among years. Annual discharge peaks each year in June, when melting snow and ice create a spring freshet. Discharge typically declines steadily following freshet and when the Arctic Char migration peaks in late August discharge is at, or close to, its lowest level of the year.

Although flow is not strongly associated with daily migration (Figures 4.1-1 to 4.1-5), the mean annual flow rate showed a significant relationship with *successful migration* through the boulder garden in pre-enhancement years ($Z_{(slope)} = 3.21$, $P = 0.001$, $R^2 = 0.70$). Thus, during pre-enhancement years *successful migration* was highly dependent on flow, with flow accounting for 70% of the variation in *successful migration*.

Figure 4.1-1

Water Temperature, Discharge, and Number of Arctic Char per Day in Roberts Lake Outflow, Doris North Project, 2015

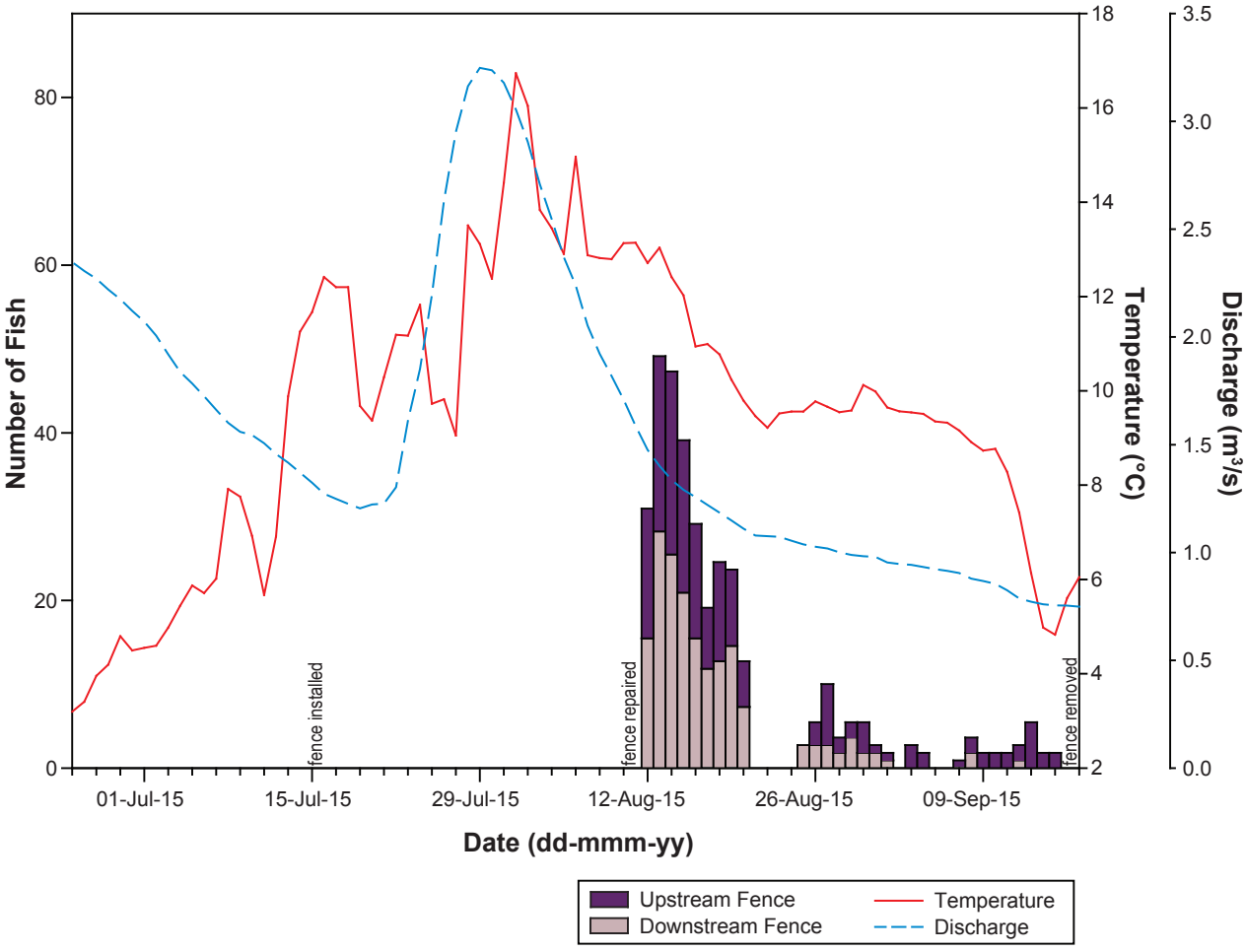
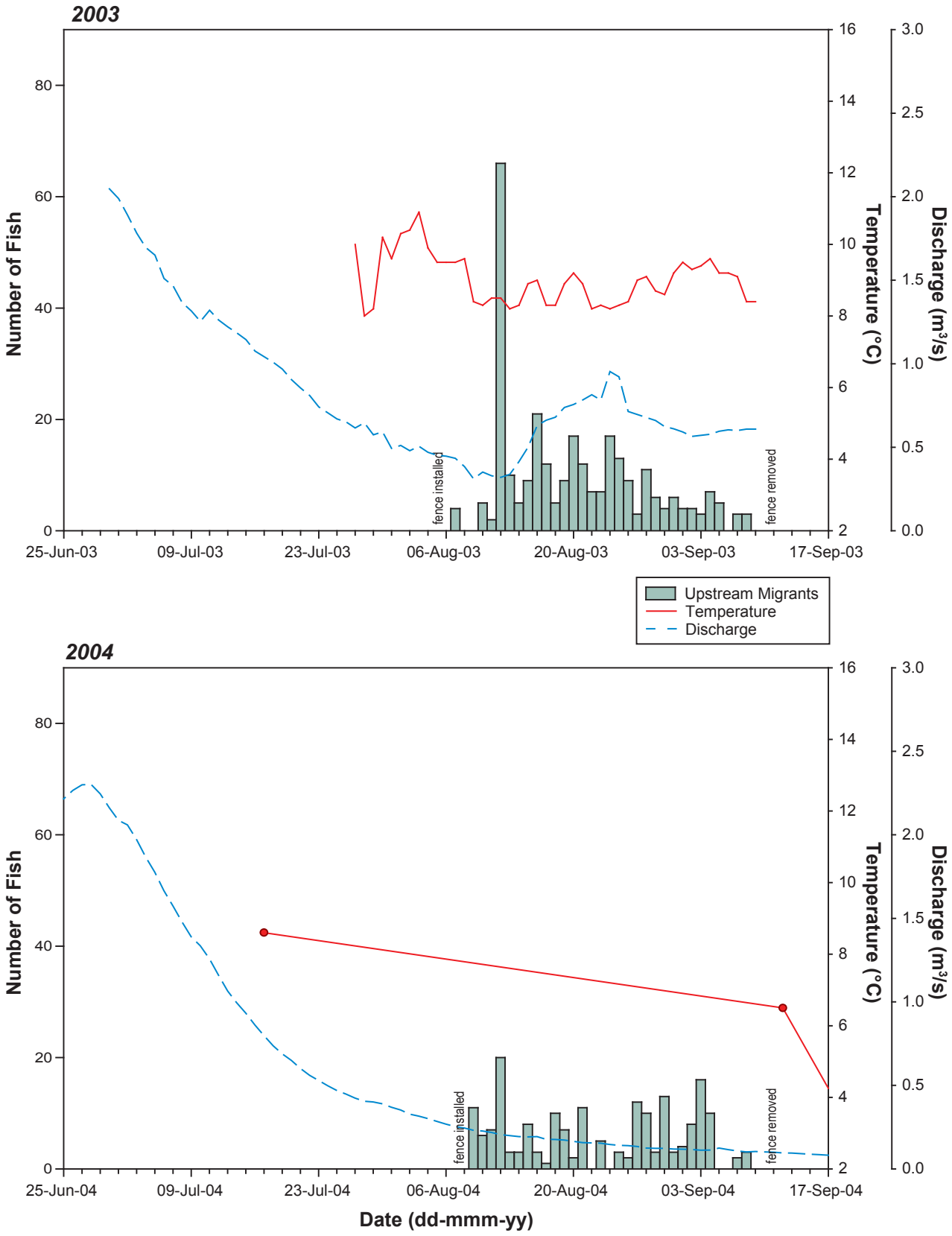


Figure 4.1-2

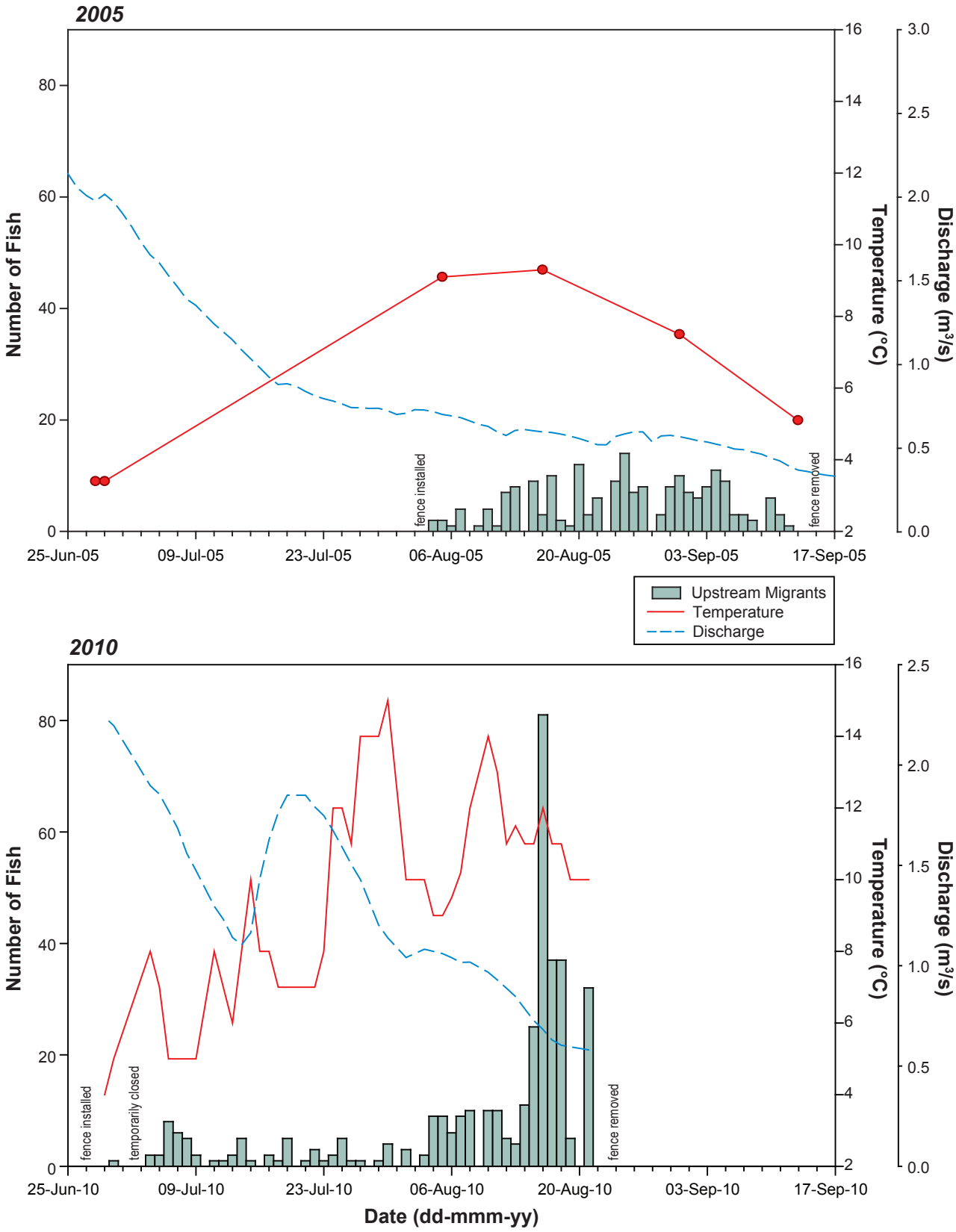
Water Temperature, Discharge, and Number of Arctic Char Migrating Upstream to Roberts Lake, Doris North Project, 2003 and 2004



Notes: Dots indicate measured values and the associated line is the assumed missing data. This was used when daily values were not available

Figure 4.1-3

Water Temperature, Discharge, and Number of Arctic Char Migrating Upstream to Roberts Lake, Doris North Project, 2005 and 2010



Notes: Dots indicate measured values and the associated line is the assumed missing data.
This was used when daily values were not available.

Figure 4.1-4

Water Temperature, Discharge, and Number of Arctic Char Migrating Upstream to Roberts Lake, Doris North Project, 2012 and 2013

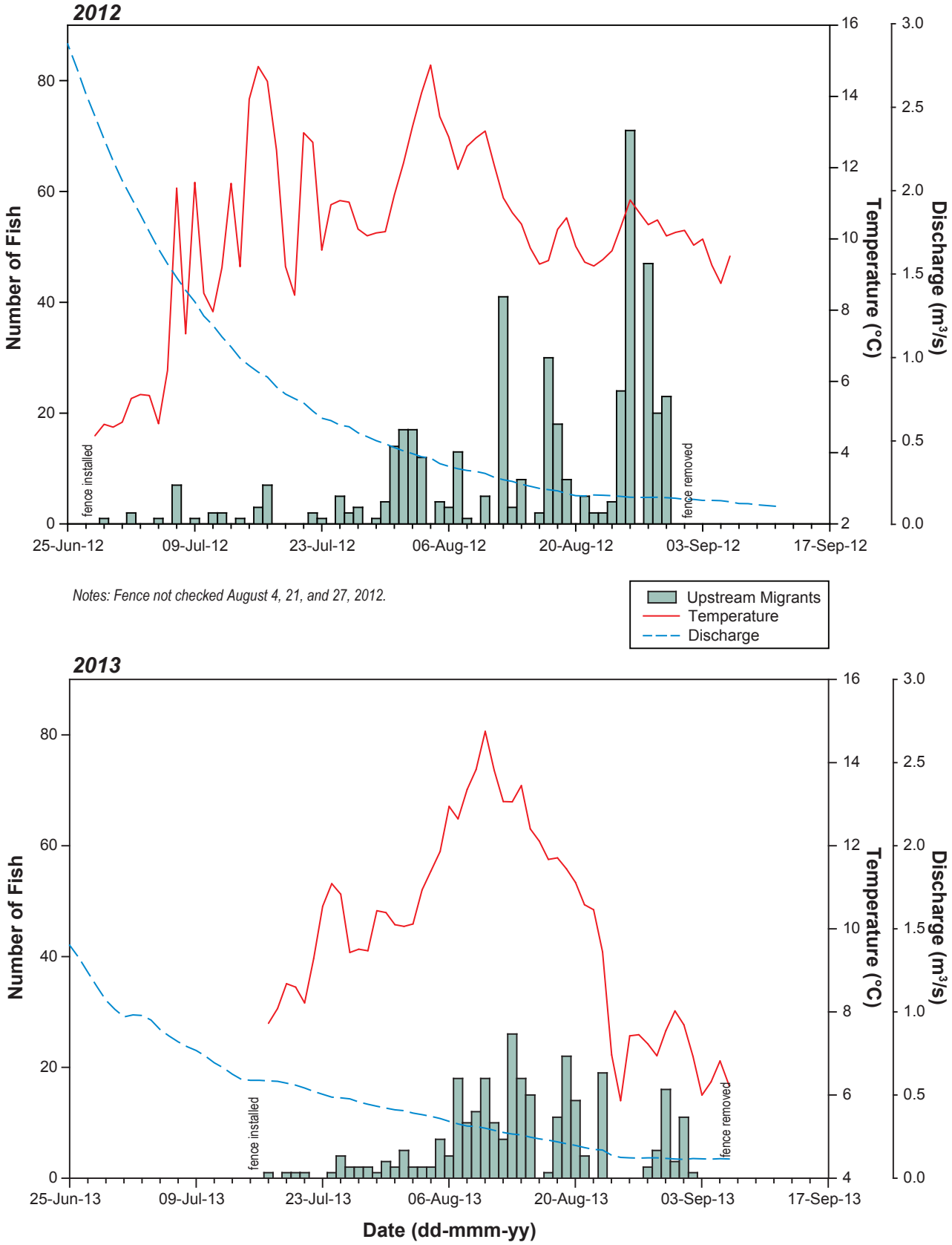
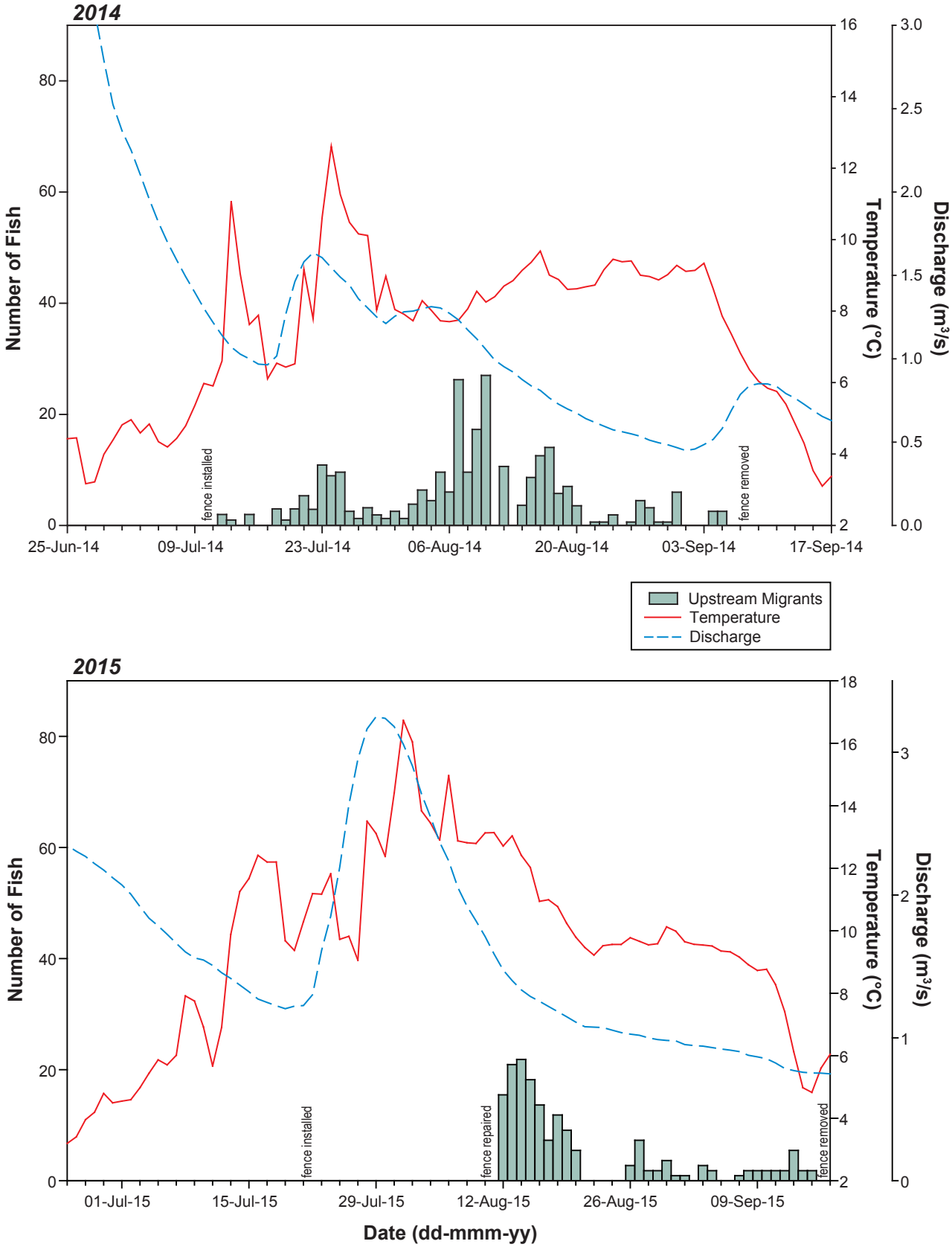


Figure 4.1-5

Water Temperature, Discharge, and Number of Arctic Char Migrating Upstream to Roberts Lake, Doris North Project, 2014 and 2015



Pre-enhancement years with low mean annual flow had lower *successful migration* rates of Arctic Char through the boulder garden (Figure 4.1-6). *Successful migration* was higher than expected in 2003, a pattern that was likely caused by an unusual increase in discharge during the peak of the migration in late August (Figure 4.1-2). This peak was not observed in any other pre-enhancement year.

In contrast, in enhanced years the *successful migration* of Arctic Char through the boulder garden is independent of flow; there was no relationship between *successful migration* and discharge ($Z_{(slope)} = 0.902$, $P = 0.367$, $R^2 = 0.16$). *Successful migration* in 2015 was higher than expected based on flow conditions during baseline sampling, falling outside the 95% confidence limits of the regression of *successful migration* on discharge (Figure 4.1-6). The regression of *successful migration* on mean annual pre-enhancement discharge predicted a rate of 61% based on 2015 flow conditions. This indicates that if Roberts Lake Outflow was not enhanced, 61%, as opposed to 96% of the Arctic Char would have survived migration through the boulder garden. The observed rate of 96% was 35 percentage points greater (a 57% increase) than the predicted rate. All years of post-enhancement data have shown a similar trend. These results suggest that the *successful migration* of Arctic Char through the boulder garden is now less dependent on stream discharge than in baseline years.

4.2 ENHANCEMENT STABILITY ASSESSMENT

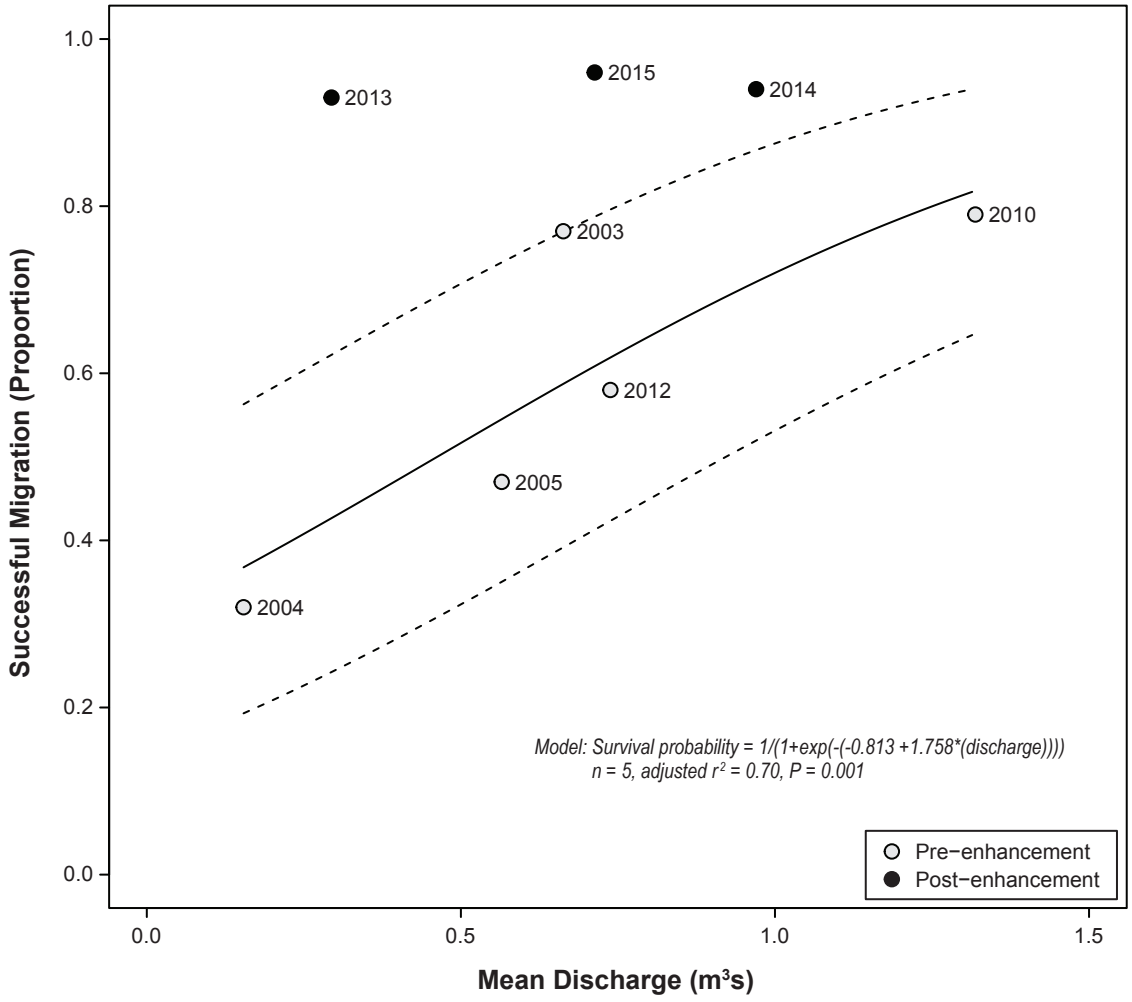
The enhancement channels were stable during the 2015 assessment; no signs of infilling or erosion were observed in any of the channels. Each channel was inspected and no obstacles to fish egress were observed, even during low discharge conditions.

In the three years since the enhancement channels were constructed they show no sign of structural instability. The boulder garden is naturally stable as boulders (> 256 mm diameter) are the predominant substrate type and the substrate has a high degree of embeddedness. The stream has inadequate energy to transport boulders even in freshet; there are no boulders in the channel downstream of the boulder garden. The channels were mostly constructed parallel to the direction of flow to increase their stability. Boulders that were removed to create the channels were relocated downstream so they could not re-enter the channels during subsequent freshets.

In 2012, field crews observed adult Arctic Char easily passing through the boulder garden after the channels were constructed. *Successful migration* through the boulder garden in 2013 was far higher than any baseline year despite extremely low discharge conditions and *successful migration* in 2014 and 2015 were similarly high. The visual inspection found that the channels appear stable and show no signs of erosion or infilling. These factors indicate that the channels are functioning as intended, and they have not deteriorated since construction.

Figure 4.1-6

Relationship between Discharge and Adult Arctic Char *Successful Migration* in Pre- and Post-enhancement Years



Notes: Dotted lines represent 95% CI.
Solid line represents beta regression model.

5. SUMMARY

The objective of the Roberts Lake Fish Enhancement Monitoring Program is to evaluate whether the enhancements to Roberts Lake Outflow boulder garden and Stream E09 (not sampled in 2015) have increased the productive capacity of anadromous Arctic Char in the watershed. The increase in productive capacity is intended to offset for the losses (and therefore achieve no net loss) of fish habitat in Tail Lake. The assessments conducted in 2015, and described herein, fulfill the requirements to monitor during the third year following enhancement at the Roberts Lake Outflow boulder garden. These requirements were laid out in the Fisheries Authorization for the Project (NU-02-0117.3) and in the Project's No Net Loss Plan and its updates (Golder 2007b; Rescan 2010a, 2010b). Monitoring was not required at the Stream E09 enhancement site in 2015; this program will resume in 2016.

Channels constructed in the Roberts Lake Outflow boulder garden in 2012 were designed to improve *successful migration* of anadromous Arctic Char migrating to critical overwintering habitat in Roberts Lake, particularly during periods of low discharge. Field crews observed an immediate improvement in the ability of fish to pass through the boulder garden following the completion of the channels in 2012. No signs of structural degradation have been observed since construction. There are currently 69 m of functioning channels in the boulder garden, 4.5 times more than the 12 to 15 m required by the NNLP.

Three years of post-enhancement monitoring indicates that the channels have increased *successful migration*, the key metric for enhancement success, through the Roberts Lake Outflow boulder garden. *Successful migration* of Arctic Char was 96% in 2015, 94% in 2014, and 93% in 2013; the average for all pre-enhancement years was 62%. Post-enhancement *successful migration* now appears to be independent of discharge, since *successful migration* was high in 2013 despite low flow conditions. Prior to enhancement, the probability of *successful migration* was lowest during low flow conditions.

The results indicate that the enhancement is functioning as it was intended and it is likely to increase the number of Arctic Char returning to overwinter and spawn in Roberts Lake.

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Appendix 3.3-1

Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

DORIS NORTH PROJECT

2015 Roberts Lake Fish Enhancement Monitoring Program

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
12-Aug-15	12:14	L	Up	Unidentifiable	42
	12:28	U	Up	Not identified	75
	12:58	L	Up	Arctic Char	82
	13:33	L	Up	Arctic Char	80
	14:14	U	Up	Not identified	76
	14:14	U	Up	Not identified	80
	15:14	L	Up	Arctic Char	91
	15:37	U	Up	Not identified	81
	15:39	U	Up	Not identified	89
	15:41	L	Up	Arctic Char	79
	15:41	L	Up	Arctic Char	85
	15:41	L	Up	Arctic Char	91
	15:41	L	Up	Arctic Char	94
	15:41	L	Up	Arctic Char	96
	15:56	U	Up	Not identified	90
	16:06	U	Up	Not identified	81
	16:06	U	Up	Not identified	84
	16:12	L	Up	Arctic Char	82
	16:12	L	Up	Arctic Char	82
	16:33	U	Up	Not identified	85
	16:34	U	Up	Not identified	81
	16:58	U	Up	Not identified	78
	16:59	U	Up	Not identified	73
	17:22	L	Up	Lake Trout	53
	17:58	U	Up	Not identified	51
	18:24	L	Up	Arctic Char	53
	19:25	U	Up	Not identified	51
	20:18	L	Up	Arctic Char	64
	20:23	L	Up	Arctic Char	103
	21:00	U	Up	Not identified	57
	22:18	L	Up	Arctic Char	82
	22:18	L	Up	Arctic Char	85
	22:19	L	Down	Arctic Char	73
	22:29	L	Up	Arctic Char	84
	23:02	U	Up	Not identified	87
	23:06	U	Up	Not identified	78
13-Aug-15	3:27	L	Up	Arctic Char	77
	3:28	L	Down	Arctic Char	75
	3:28	L	Up	Arctic Char	85
	3:28	L	Down	Arctic Char	105
	3:29	L	Up	Arctic Char	86
	3:35	L	Down	Arctic Char	77
	3:35	L	Up	Arctic Char	85
	3:36	L	Up	Unidentifiable	61
	3:41	L	Down	Arctic Char	64
	3:41	L	Up	Arctic Char	82
	3:42	L	Up	Arctic Char	86
	3:42	L	Down	Arctic Char	117
	3:45	L	Up	Arctic Char	91
	3:45	L	Up	Arctic Char	-
	3:46	L	Down	Arctic Char	43

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
13-Aug-15	3:48	L	Down	Arctic Char	61
(cont'd)	3:48	L	Up	Arctic Char	88
	4:00	L	Up	Arctic Char	83
	4:01	L	Down	Unidentifiable	75
	4:01	L	Up	Unidentifiable	76
	4:01	L	Up	Arctic Char	83
	4:03	L	Up	Unidentifiable	76
	4:03	L	Down	Unidentifiable	76
	4:18	U	Up	Not identified	69
	4:29	L	Up	Arctic Char	57
	4:29	L	Up	Arctic Char	64
	4:43	L	Up	Arctic Char	55
	4:43	L	Up	Arctic Char	82
	4:43	U	Up	Not identified	58
	4:43	U	Up	Not identified	61
	4:43	U	Up	Not identified	80
	4:43	U	Up	Not identified	82
	4:44	L	Up	Unidentifiable	105
	5:20	L	Up	Arctic Char	57
	5:44	U	Up	Not identified	103
	6:23	L	Up	Arctic Char	67
	6:46	U	Up	Not identified	73
	6:54	L	Up	Lake Trout	54
	7:34	U	Up	Not identified	66
	7:52	L	Up	Lake Trout	57
	7:55	U	Up	Not identified	55
	8:44	L	Up	Arctic Char	88
	9:41	U	Up	Not identified	83
	9:49	L	Up	Arctic Char	88
	10:29	L	Up	Lake Trout	57
	10:44	L	Up	Arctic Char	74
	11:01	U	Up	Not identified	83
	11:09	U	Up	Not identified	63
	11:12	L	Up	Arctic Char	48
	11:12	L	Up	Lake Trout	57
	11:16	U	Up	Not identified	49
	11:43	U	Up	Not identified	55
	12:03	U	Up	Not identified	46
	12:30	L	Up	Arctic Char	54
	13:04	L	Up	Arctic Char	112
	13:54	U	Up	Not identified	108
	15:03	L	Up	Arctic Char	58
	15:03	L	Up	Arctic Char	-
	15:43	U	Up	Not identified	52
	15:43	U	Up	Not identified	55
	17:33	L	Up	Lake Trout	63
	18:30	U	Up	Not identified	59
	20:11	L	Up	Arctic Char	39
	20:11	L	Up	Arctic Char	45
	20:11	L	Up	Arctic Char	51
	21:06	U	Up	Not identified	40

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
13-Aug-15	22:04	L	Up	Lake Trout	55
(cont'd)	22:09	U	Up	Not identified	54
	22:57	L	Up	Unidentifiable	57
	22:57	L	Up	Unidentifiable	60
	23:03	U	Up	Not identified	53
	23:04	U	Down	Not identified	37
	23:10	U	Up	Not identified	50
	23:10	U	Up	Not identified	78
	23:11	U	Down	Not identified	63
	23:12	U	Up	Not identified	69
	23:25	L	Down	Arctic Char	56
	23:25	L	Up	Arctic Char	67
	23:53	L	Up	Unidentifiable	48
	23:54	L	Down	Unidentifiable	39
14-Aug-15	1:09	L	Down	Arctic Char	61
	1:09	L	Up	Arctic Char	87
	1:28	L	Down	Arctic Char	57
	1:28	L	Up	Arctic Char	82
	1:46	L	Down	Unidentifiable	85
	1:46	L	Up	Arctic Char	87
	2:43	L	Up	Arctic Char	114
	3:04	U	Up	Not identified	101
	3:15	L	Up	Arctic Char	81
	3:23	L	Down	Arctic Char	71
	3:23	L	Up	Arctic Char	93
	3:24	L	Up	Arctic Char	91
	3:56	U	Up	Not identified	44
	3:58	U	Up	Not identified	88
	4:13	U	Up	Not identified	81
	4:47	L	Up	Unidentifiable	96
	4:49	L	Up	Lake Trout	55
	5:12	L	Up	Arctic Char	42
	5:12	L	Up	Arctic Char	45
	5:12	L	Up	Lake Trout	51
	5:12	L	Up	Arctic Char	54
	5:13	L	Down	Arctic Char	37
	5:25	U	Up	Not identified	49
	5:48	L	Up	Arctic Char	52
	6:01	U	Up	Not identified	40
	6:19	U	Up	Not identified	90
	6:29	U	Up	Not identified	42
	6:51	L	Up	Arctic Char	75
	7:03	L	Up	Arctic Char	61
	7:04	L	Up	Unidentifiable	46
	7:17	U	Up	Not identified	72
	7:58	U	Up	Not identified	47
	9:47	U	Up	Not identified	45
	11:10	L	Up	Not identified	58
	11:35	U	Up	Not identified	54
	12:16	L	Up	Lake Whitefish	80
	13:00	L	Up	Arctic Char	88

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
14-Aug-15	13:18	U	Up	Not identified	89
(cont'd)	14:10	L	Up	Lake Trout	55
	15:35	L	Up	Arctic Char	79
	15:36	L	Up	Arctic Char	85
	15:52	U	Up	Not identified	83
	16:26	L	Up	Arctic Char	84
	16:26	L	Up	Arctic Char	91
	16:51	U	Up	Not identified	76
	16:51	U	Up	Not identified	79
	16:51	U	Up	Not identified	88
	17:56	L	Up	Arctic Char	78
	18:13	L	Up	Arctic Char	82
	18:17	U	Up	Not identified	78
	19:25	U	Up	Not identified	52
	19:59	U	Up	Not identified	81
	20:12	L	Up	Arctic Char	67
	20:28	L	Up	Arctic Char	72
	20:28	L	Up	Arctic Char	83
	21:12	U	Up	Not identified	83
	21:28	U	Up	Not identified	67
	21:41	L	Up	Arctic Char	75
	21:51	L	Up	Arctic Char	58
	21:52	L	Up	Arctic Char	74
	22:52	U	Up	Not identified	73
	22:52	U	Up	Not identified	75
	22:59	U	Up	Not identified	74
	23:00	U	Down	Not identified	63
	23:01	U	Down	Not identified	63
	23:01	U	Up	Not identified	73
	23:04	U	Down	Not identified	55
	23:08	U	Up	Not identified	75
15-Aug-15	1:35	L	Down	Arctic Char	78
	1:35	L	Up	Arctic Char	90
	1:51	L	Up	Arctic Char	61
	1:51	L	Up	Arctic Char	92
	1:56	L	Up	Arctic Char	72
	2:06	L	Up	Arctic Char	74
	2:23	L	Down	Arctic Char	52
	2:23	L	Up	Arctic Char	90
	2:35	U	Up	Arctic Char	71
	5:24	L	Up	Arctic Char	58
	6:24	L	Up	Arctic Char	75
	6:24	L	Up	Arctic Char	79
	6:48	U	Up	Arctic Char	69
	6:53	U	Up	Arctic Char	76
	8:53	L	Down	Arctic Char	60
	8:53	L	Up	Arctic Char	86
	8:55	L	Up	Arctic Char	100
	8:58	L	Down	Arctic Char	58
	8:58	L	Up	Unidentifiable	64
	8:58	L	Up	Unidentifiable	81

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
15-Aug-15	8:58	L	Up	Arctic Char	82
(cont'd)	8:59	L	Up	Arctic Char	81
	8:59	L	Up	Arctic Char	91
	9:04	L	Up	Arctic Char	65
	9:04	L	Up	Arctic Char	81
	9:23	U	Up	Unidentifiable	63
	9:23	U	Up	Arctic Char	75
	9:39	U	Up	Arctic Char	78
	9:40	U	Up	Arctic Char	77
	9:40	U	Up	Unidentifiable	90
	9:41	U	Up	Arctic Char	61
	9:41	U	Up	Arctic Char	?
	9:43	U	Up	Arctic Char	96
	9:44	L	Up	Arctic Char	93
	9:51	L	Up	Arctic Char	91
	9:57	L	Up	Arctic Char	78
	10:33	U	Up	Arctic Char	72
	10:33	U	Up	Arctic Char	94
	10:48	U	Up	Arctic Char	88
	14:55	L	Up	Arctic Char	57
	15:19	U	Up	Arctic Char	57
	16:19	U	Up	Arctic Char	51
	16:50	L	Down	Arctic Char	54
	16:50	L	Up	Arctic Char	57
	16:56	L	Up	Unidentifiable	42
	17:16	L	Up	Arctic Char	57
	17:49	U	Up	Arctic Char	53
	17:49	U	Up	Arctic Char	-
	19:13	L	Up	Arctic Char	87
	20:45	L	Up	Arctic Char	43
	20:50	L	Up	Arctic Char	55
	21:37	U	Up	Arctic Char	44
	23:16	L	Down	Arctic Char	58
	23:16	L	Up	Arctic Char	72
	23:23	U	Up	Arctic Char	78
	23:26	L	Down	Arctic Char	58
	23:26	L	Up	Arctic Char	73
16-Aug-15	0:19	L	Up	Arctic Char	76
	0:20	L	Down	Arctic Char	76
	0:30	L	Down	Arctic Char	92
	0:30	L	Up	Arctic Char	109
	1:50	L	Down	Arctic Char	94
	1:50	L	Up	Arctic Char	101
	3:50	U	Up	Arctic Char	93
	4:18	L	Up	Arctic Char	76
	4:18	L	Down	Arctic Char	87
	4:25	L	Up	Arctic Char	83
	4:28	L	Up	Arctic Char	82
	4:56	U	Up	Arctic Char	75
	5:26	U	Up	Arctic Char	80
	5:53	L	Up	Lake Trout	47

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
16-Aug-15	7:29	L	Up	Arctic Char	92
(cont'd)	7:29	L	Up	Arctic Char	94
	7:35	L	Up	Arctic Char	72
	7:54	L	Up	Unidentifiable	46
	7:55	U	Up	Arctic Char	92
	8:17	U	Up	Arctic Char	93
	8:35	L	Up	Unidentifiable	45
	8:36	U	Up	Arctic Char	70
	9:32	U	Up	Unidentifiable	45
	10:00	L	Up	Arctic Char	82
	10:52	U	Up	Arctic Char	81
	15:11	L	Up	Arctic Char	77
	15:46	U	Up	Arctic Char	68
	16:17	L	Up	Arctic Char	55
	16:17	L	Up	Arctic Char	58
	16:32	U	Up	Arctic Char	54
	16:38	U	Up	Arctic Char	54
	16:41	L	Up	Arctic Char	83
	19:37	L	Up	Lake Trout	41
	19:56	U	Up	Arctic Char	82
	20:00	L	Up	Arctic Char	86
	20:57	U	Up	Arctic Char	86
	21:48	L	Up	Arctic Char	49
	21:48	L	Down	Arctic Char	51
	21:48	L	Up	Arctic Char	62
	21:51	L	Up	Arctic Char	51
	22:31	U	Up	Arctic Char	63
	23:05	U	Up	Lake Trout	46
	23:39	L	Up	Unidentifiable	43
17-Aug-15	5:04	L	Up	Unidentifiable	48
	7:10	L	Up	Arctic Char	39
	7:10	L	Down	Arctic Char	40
	7:57	L	Up	Arctic Char	63
	8:56	U	Up	Arctic Char	69
	9:21	L	Up	Arctic Char	80
	9:38	L	Up	Arctic Char	66
	9:38	L	Up	Arctic Char	74
	15:13	U	Up	Arctic Char	72
	18:31	L	Up	Lake Trout	48
	18:38	L	Up	Arctic Char	56
	18:42	L	Up	Arctic Char	55
	18:42	L	Down	Arctic Char	58
	18:42	L	Up	Arctic Char	63
	18:42	L	Down	Arctic Char	68
	18:42	L	Up	Arctic Char	72
	18:42	L	Up	Arctic Char	78
	19:58	L	Down	Arctic Char	57
	19:58	L	Up	Arctic Char	61
	19:58	L	Up	Arctic Char	68
	20:01	L	Up	Arctic Char	87
	20:05	L	Up	Arctic Char	58

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
17-Aug-15	20:21	L	Up	Unidentifiable	42
(cont'd)	20:21	U	Up	Arctic Char	74
	20:46	U	Up	Arctic Char	60
	20:46	U	Up	Arctic Char	89
	21:00	U	Up	Arctic Char	64
	22:09	U	Up	Arctic Char	56
	22:19	U	Up	Arctic Char	75
	23:42	L	Up	Arctic Char	45
	23:43	L	Down	Arctic Char	40
18-Aug-15	0:35	L	Up	Not identified	42
	0:36	L	Up	Not identified	78
	0:37	L	Down	Not identified	80
	2:40	L	Down	Not identified	36
	2:40	L	Up	Not identified	48
	2:41	L	Down	Not identified	43
	3:07	L	Up	Arctic Char	85
	3:07	L	Down	Arctic Char	96
	4:14	L	Up	Not identified	40
	4:16	L	Up	Not identified	43
	4:16	L	Down	Not identified	50
	4:16	U	Up	Unidentifiable	48
	4:19	L	Down	Not identified	42
	4:19	L	Up	Not identified	46
	4:20	L	Down	Not identified	36
	4:20	L	Up	Not identified	48
	4:20	L	Up	Not identified	52
	5:11	L	Up	Arctic Char	78
	5:29	U	Up	Lake Trout	39
	5:29	U	Up	Unidentifiable	42
	6:56	U	Up	Arctic Char	75
	11:26	L	Up	Not identified	59
	11:30	L	Up	Not identified	66
	12:44	U	Up	Arctic Char	55
	12:53	L	Up	Not identified	81
	13:36	U	Up	Arctic Char	79
	15:16	L	Up	Lake Trout	47
	15:28	L	Up	Not identified	49
	16:49	L	Up	Not identified	48
	16:49	L	Up	Not identified	64
	17:07	L	Up	Not identified	51
	17:34	L	Up	Not identified	75
	17:44	L	Up	Not identified	46
	18:04	U	Up	Arctic Char	49
	18:32	U	Up	Arctic Char	48
	18:55	U	Up	Arctic Char	61
	19:38	U	Up	Arctic Char	73
	20:09	U	Up	Arctic Char	45
	20:27	L	Up	Not identified	91
	21:02	U	Up	Arctic Char	62
	21:15	U	Up	Arctic Char	88

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
19-Aug-15	4:25	L	Up	Not identified	61
	4:27	L	Up	Not identified	69
	5:50	L	Up	Not identified	86
	6:28	U	Up	Arctic Char	91
	11:13	L	Up	Not identified	45
	11:25	L	Up	Not identified	36
	12:15	U	Up	Unidentifiable	39
	12:56	L	Up	Arctic Char	90
	12:57	L	Up	Not identified	43
	12:57	L	Up	Not identified	81
	13:20	U	Up	Arctic Char	75
	13:23	U	Up	Arctic Char	64
	13:23	U	Up	Arctic Char	87
	15:33	L	Up	Not identified	84
	15:45	L	Up	Not identified	91
	16:11	L	Up	Not identified	49
	16:22	U	Up	Arctic Char	84
	16:22	U	Up	Arctic Char	88
	16:37	L	Down	Not identified	52
	16:37	L	Up	Not identified	66
	17:07	U	Up	Arctic Char	46
	17:42	L	Down	Not identified	66
	17:42	L	Up	Not identified	67
	18:03	L	Up	Not identified	48
	18:03	L	Up	Not identified	67
	18:32	L	Up	Not identified	57
	18:51	L	Up	Not identified	72
	19:00	U	Up	Arctic Char	46
	21:11	L	Up	Not identified	42
	21:11	L	Down	Not identified	42
	21:20	L	Up	Not identified	39
	22:40	U	Up	Arctic Char	76
20-Aug-15	6:13	L	Up	Not identified	81
	7:23	U	Up	Arctic Char	79
	8:50	L	Up	Arctic Char	88
	9:37	U	Up	Arctic Char	89
	12:51	L	Up	Not identified	51
	13:20	L	Up	Not identified	67
	13:20	L	Up	Not identified	75
	14:34	U	Up	Arctic Char	70
	14:38	U	Up	Unidentifiable	45
	17:43	L	Up	Not identified	51
	17:44	L	Down	Not identified	48
	19:56	U	Up	Arctic Char	62
	20:20	L	Up	Not identified	69
	21:19	L	Up	Not identified	51
	21:19	L	Down	Not identified	52
	21:19	L	Up	Not identified	54
	21:31	L	Up	Not identified	85
	21:54	U	Up	Not identified	84

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
21-Aug-15	2:21	L	Up	Not identified	63
	2:21	L	Down	Not identified	88
25-Aug-15	18:36	L	Up	Not identified	39
	19:13	L	Up	Arctic Char	40
	21:19	L	Up	Not identified	43
26-Aug-15	1:29	L	Down	Not identified	48
	1:29	L	Up	Not identified	52
	2:35	L	Down	Arctic Char	54
	2:35	L	Up	Arctic Char	57
	2:38	L	Up	Not identified	52
	2:38	L	Down	Not identified	61
	2:43	L	Down	Not identified	55
	2:47	L	Up	Arctic Char	56
	2:48	L	Down	Arctic Char	54
	2:49	L	Up	Not identified	55
	2:50	L	Down	Not identified	39
	2:58	L	Up	Arctic Char	62
	2:59	L	Down	Arctic Char	52
	3:04	L	Up	Not identified	55
	3:15	L	Down	Not identified	46
	3:15	L	Up	Not identified	55
	3:29	L	Down	Not identified	42
	3:29	L	Up	Not identified	55
	4:02	U	Up	Arctic Char	52
	6:06	L	Up	Not identified	64
	6:07	L	Down	Not identified	43
	11:53	L	Up	Not identified	42
	13:08	L	Up	Not identified	40
	14:04	U	Up	Not identified	40
	14:08	U	Up	Unidentifiable	39
	14:59	L	Up	Not identified	45
27-Aug-15	2:13	L	Up	Not identified	46
	2:14	L	Down	Not identified	46
	2:35	L	Up	Not identified	106
	2:36	L	Down	Not identified	93
	2:38	L	Down	Not identified	59
	3:17	L	Down	Not identified	98
	3:17	L	Up	Not identified	112
	4:36	L	Down	Not identified	39
	5:17	L	Up	Not identified	43
	5:18	L	Down	Not identified	41
	5:24	L	Up	Not identified	46
	5:24	L	Down	Not identified	46
	6:38	L	Up	Not identified	44
	6:38	L	Down	Not identified	45
	6:40	L	Up	Not identified	47
	6:43	L	Up	Not identified	49
	8:24	U	Up	Unidentifiable	46
	8:41	L	Up	Not identified	42
	9:30	L	Up	Not identified	49
	9:31	L	Down	Not identified	48

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
27-Aug-15	9:40	U	Up	Arctic Char	103
(cont'd)	9:51	L	Up	Not identified	61
	9:58	L	Down	Not identified	40
	9:58	L	Up	Not identified	51
	10:47	U	Up	Unidentifiable	46
	12:43	L	Up	Not identified	46
	12:52	L	Up	Not identified	48
	12:52	U	Up	Arctic Char	58
	12:53	L	Up	Not identified	48
	12:58	L	Down	Not identified	49
	13:11	L	Down	Not identified	49
	13:17	L	Up	Not identified	66
	13:50	L	Down	Not identified	37
	13:50	U	Up	Unidentifiable	44
	13:54	U	Up	Arctic Char	73
	13:54	U	Up	Arctic Char	-
	13:54	U	Up	Arctic Char	-
	14:14	L	Up	Not identified	66
	14:20	L	Down	Not identified	49
	14:20	L	Up	Not identified	66
	14:37	L	Down	Not identified	36
	22:11	L	Up	Arctic Char	40
	22:12	L	Down	Arctic Char	39
	22:27	L	Up	Arctic Char	43
	22:27	L	Down	Arctic Char	63
	22:27	L	Up	Arctic Char	67
	22:28	L	Down	Arctic Char	53
28-Aug-15	14:37	L	Up	Not identified	68
	14:38	L	Down	Not identified	49
	15:21	L	Up	Not identified	49
	16:21	L	Up	Not identified	54
	17:15	U	Up	Unidentifiable	40
	17:25	U	Up	Unidentifiable	52
	22:10	L	Down	Not identified	42
	22:10	L	Up	Not identified	53
29-Aug-15	8:03	L	Up	Not identified	46
	8:22	L	Up	Not identified	51
	16:19	U	Up	Unidentifiable	46
	16:34	L	Up	Not identified	54
	17:09	U	Up	Arctic Char	55
	18:01	L	Up	Not identified	99
30-Aug-15	8:20	U	Up	Unidentifiable	39
	11:55	L	Up	Not identified	43
	12:43	U	Up	Arctic Char	43
	14:58	L	Up	Not identified	85
	15:34	U	Up	Arctic Char	40
	15:49	U	Up	Arctic Char	88
31-Aug-15	7:57	L	Up	Not identified	64
	14:07	L	Up	Not identified	42
	14:12	U	Up	Unidentifiable	39

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
1-Sep-15	8:45	L	Up	Not identified	43
	14:26	U	Up	Not identified	40
3-Sep-15	10:54	U	Down	Not identified	43
	10:59	U	Up	Not identified	45
	13:49	U	Up	Not identified	59
	15:44	U	Up	Not identified	42
	22:22	U	Up	Arctic Char	51
	22:22	U	Down	Arctic Char	51
	22:26	U	Up	Not identified	41
	22:26	U	Down	Not identified	54
	23:02	U	Up	Arctic Char	49
	23:03	U	Down	Arctic Char	39
	23:04	U	Up	Not identified	45
4-Sep-15	9:03	U	Up	Not identified	37
	22:05	U	Up	Not identified	42
5-Sep-15	2:17	U	Down	Not identified	51
	2:17	U	Up	Not identified	55
	2:40	U	Up	Not identified	48
	2:40	U	Down	Not identified	51
	3:33	U	Down	Not identified	50
	23:19	U	Down	Not identified	36
	23:19	U	Up	Not identified	51
7-Sep-15	12:29	L	Down	Not identified	52
	13:47	L	Up	Not identified	52
	13:48	L	Down	Not identified	39
	17:21	U	Up	Not identified	44
8-Sep-15	1:49	L	Down	Not identified	57
	1:49	L	Up	Not identified	70
	3:13	U	Up	Arctic Char	73
	10:40	L	Up	Not identified	35
	16:42	L	Up	Not identified	63
	17:25	U	Up	Arctic Char	57
	23:37	U	Down	Not identified	37
	23:37	U	Up	Not identified	42
9-Sep-15	3:55	U	Up	Not identified	41
	12:52	U	Up	Not identified	42
	14:56	L	Down	Arctic Char	52
	14:56	L	Up	Arctic Char	72
10-Sep-15	3:46	U	Up	Not identified	41
	3:47	U	Up	Not identified	37
11-Sep-15	5:33	U	Up	Not identified	46
	9:06	U	Up	Not identified	39
12-Sep-15	5:54	U	Up	Not identified	55
	15:55	L	Up	Not identified	58
	16:36	U	Up	Not identified	54
13-Sep-15	0:31	U	Up	Arctic Char	60
	4:01	U	Up	Arctic Char	52
	4:05	U	Down	Not identified	49
	4:41	U	Up	Not identified	43
	6:03	U	Up	Not identified	60
	6:12	U	Down	Not identified	39

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.

Appendix 3.1-1. Biological Data from Fish Counting Fences in Roberts Lake Outflow, Doris North Project, 2015

Date	Time (24 h clock)	Box Location (U/L)	Fish Direction (U/D)	Species	Fork Length (mm)
13-Sep-15	6:12	U	Up	Not identified	62
(cont'd)	21:15	U	Down	Not identified	50
	21:15	U	Up	Not identified	61
	21:17	U	Down	Arctic Char	57
	21:17	U	Up	Arctic Char	60
	21:20	U	Down	Arctic Char	58
	21:20	U	Up	Arctic Char	63
	21:21	U	Down	Not identified	60
	21:27	U	Up	Not identified	55
	23:01	U	Up	Not identified	45
	23:02	U	Down	Not identified	39
	23:14	U	Up	Not identified	46
	23:30	U	Up	Not identified	43
	23:43	U	Up	Not identified	46
	21:06	U	Up	Not identified	46
	21:21	U	Up	Not identified	49
	13:58	U	Up	Not identified	40
	13:58	U	Up	Not identified	57

Notes:
Box location: L = Lower, U = Upper
Fish direction: D = Downstream, U = Upstream
Dashes indicate not applicable.