Deadman Creek Chinook Restoration and Instream Incubation Trial (Year 2)

Prepared For
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EXECUTIVE SUMMARY

This project continued to test the use of instream egg incubation to restore a Chinook spawning population to Deadman Creek, a tributary of Teslin Lake in the Teslin River watershed. Local knowledge indicates that Deadman Creek once had a small spawning population; however, the specific reason for the loss and the timing of the spawning population is unknown. The project involved the following components: establishment of access (walking) trails along lower Deadman Creek, water temperature monitoring, hydrometric monitoring, juvenile monitoring, instream egg incubation and success monitoring.

The juvenile monitoring was conducted during June, July, August and September 2017 to update baseline information on juvenile habitat utilization in the stream. No juvenile Chinook were captured during June and capture rates increased during July to September with the greatest number captured during September. Non-natal juvenile Chinook migrate into Deadman Creek during the mid- to late summer and it is unclear whether the smaller juveniles captured during August to September originated from eggs planted in the stream during August 2016. The instream egg incubation component involved site preparations in both Deadman Creek and the control stream (Morley River) to construct artificial redds with stream substrate to mimic natural conditions. Broodstock for the project was collected in Morley River and eggs and milt were transported to Deadman Creek. A cumulative total of 27,712 eggs were planted at 15 discrete sites in the lower 7 km of Deadman Creek and 7,513 eggs were planted at four sites in Morley River in the vicinity of the Alaska Highway crossing to serve as controls. Eggs were deployed in both streams using a combination of open and closed incubation media including: Whitlock Vibert boxes, Jordan Scotty incubators and enclosed Whitlock-Vibert boxes (mesh bags). Eggs were also planted directly in the artificial redds through the use of egg insertion pipes. Success monitoring included methods to determine both hatching and emergence success. Hatching success was generally very high in Morley River with mean survival of 85% and a range of 74-98%. Hatching data from Deadman Creek was highly variable between sites and incubation media; however, the overall average was 56% with a range of 11-86%. In Morley River, survival to emergence ranged from 91-94% and in Deadman Creek ranged from 2-60%.

Water temperatures and associated accumulated thermal units (ATU) data were considerably different between Morley River and Deadman Creek. Egg development was considerably quicker in Morley River, with egg hatching taking place during early October and emergence during mid-February. Due to colder water temperatures, egg hatching occurred in Deadman Creek during early to mid-January and at ATUs which were considerably lower than what is published for this species in the literature. Fry emergence occurred in Deadman Creek during June 2018. Analysis of ATU data indicates that at cold temperatures, the eggs and alevin in Deadman Creek continue to develop at a rate equivalent to approximately 1.6 temperature units per day.

The methods used for this trial project and the results gathered suggest that the approach used has merit for reintroducing a spawning population to Deadman Creek. A number of lessons were learned over the duration of the 2017/2018 field studies and these experiences can be incorporated into an expanded operational trial of the project during future years.

ACKNOWLEDGEMENTS

Gillian Rourke of the Teslin Tlingit Council contributed significantly to all aspects of this project and along with Tommy Dewhurst, assisted with all field components of the project. Sean Collins and Trix Tanner (Fisheries and Oceans Canada) assisted with project permitting and provided advice on overall project direction. Yukon Youth Conservation Corps (Y2C2) crew members with the site preparation work for the egg planting component of the project. TTC summer students, Nick Hogan, Shania Hogan, and Susanna Carlick also assisted with site preparation. Funding for this project was provided by the Yukon River Panel's Restoration and Enhancement Fund.

AUTHORSHIP

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1 INTRODUCTION

Chinook salmon are a vitally important resource for Teslin Tlingit citizens, being both culturally significant and important for subsistence. Chinook salmon must successfully migrate through all fisheries on the mainstem Yukon River in both Alaska and Yukon to return to the Teslin River watershed; additionally there are environmental threats such as predators and changing river conditions (e.g., temperature, rainfall) along the length of the river. Given the length of the Chinook salmon migration back to the Teslin watershed, the health of this run has long been understood by the Teslin Tlingit as an important indicator of the overall health and strength of the Yukon River Chinook salmon run. In response to alarming and enduring declines in returning Chinook salmon, Teslin Tlingit Council (TTC) has been taking action for over 15 years, on a local, territorial, and international scale to conserve the Chinook run for future generations, the health of the environment, and for all fishers throughout the watershed.

Chinook salmon in the Teslin River watershed have one of the longest salmon migrations in North America with the headwaters of the Teslin River being nearly 3,000 km upstream from the Bering Sea. During the 2002 and 2003 drainage-wide Chinook telemetry project, the longest distance travelled by a tagged Chinook was located in the Teslin River watershed (Mercer and Eiler 2004). This individual was relocated in the McNeil River, a tributary of the upper Nisutlin River and had travelled nearly 2,700 km upstream from the tagging site on the lower Yukon River (Mercer and Eiler 2004). The Teslin River watershed is also a major spawning destination for Canadian-origin Chinook; the results from the in-season genetic analysis at Eagle, AK during 2016 indicated that 35% of the 2016 Canadian Chinook escapement were of Teslin River origin (JTC 2017).

Deadman Creek is a clear water tributary of Teslin Lake which flows into the lake 30 km north of the community of Teslin, YT (Map 1). The total drainage area of the watershed is approximately 150 km^2 and the stream is relatively accessible with the lower reaches accessed from the Alaska Highway crossing and an adjacent gravel pit. Adult Chinook salmon have not been observed in the creek in recent years (Wilson 2003), although local knowledge indicates that the stream once had a spawning population. Chinook carcasses were observed in the stream and had been incidentally caught by local fishers before large beaver dams began populating the creek. It is presumed that when the lower 10-15 kms of the creek were burned by a forest fire that this created ideal habitat for beaver due to the regrowth of deciduous vegetation (Wilson 2003). The creek was the focus of active beaver management and monitoring of juvenile Chinook utilization by TTC between 2001 and 2006 (Wilson 2003, 2004, 2005). This monitoring indicated various beaver dams in varying conditions; juvenile Chinook were, however, captured upstream of all dams including the uppermost sampling station located 8 km upstream of Teslin Lake. At the time of these surveys, the creek was actively forming a new channel around the largest beaver dam located in the lower reaches of the creek. Previous reports consistently recommended that methods to restore a spawning Chinook population to Deadman Creek be investigated (Wilson 2003, 2004, 2005).

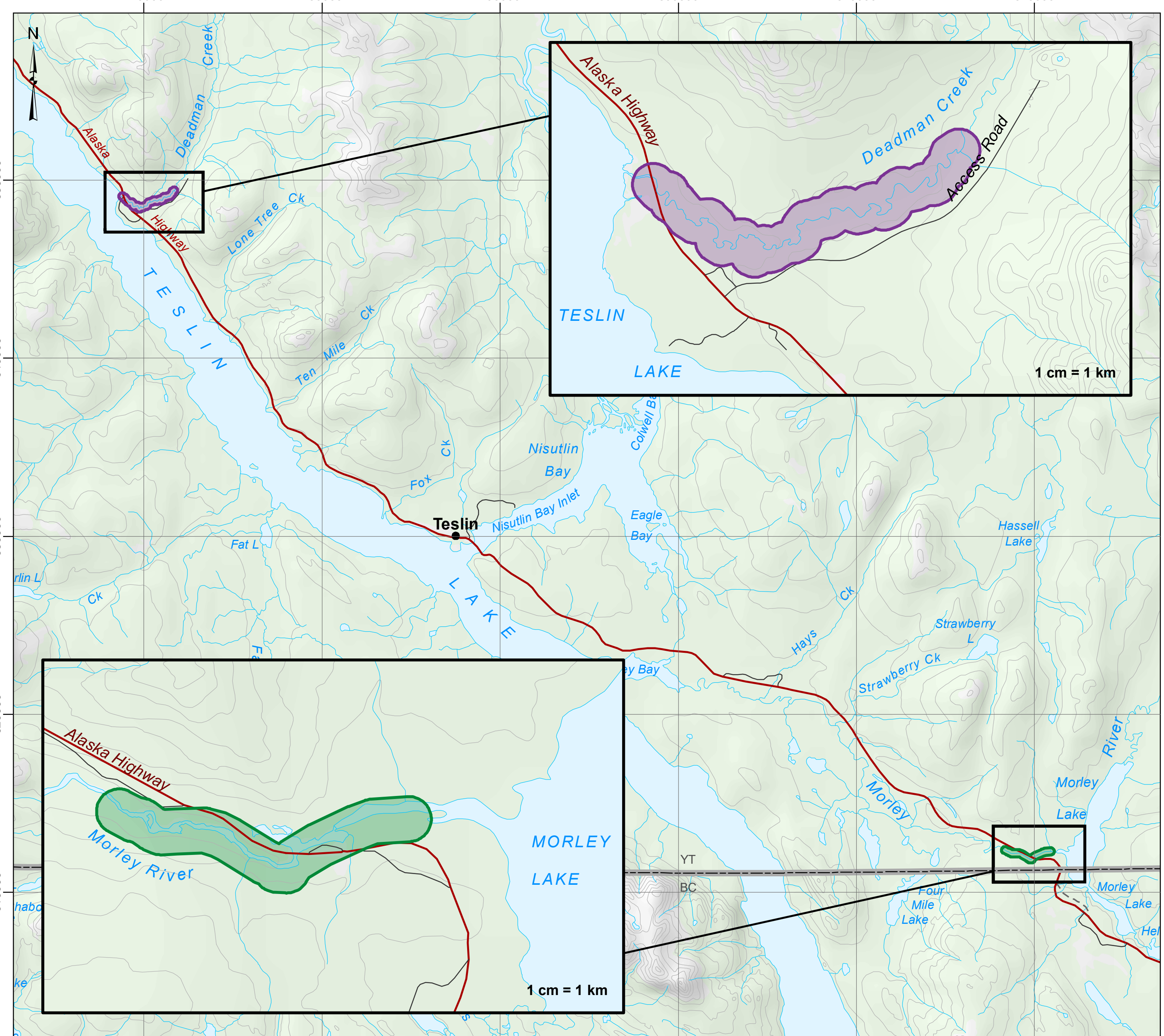
The current project was designed to build on a 2015 project funded by a Yukon River Panel Restoration & Enhancement project to identify a Chinook salmon stock restoration project in the Teslin River watershed. The 2015 project identified Deadman Creek as a suitable candidate for such a project due to the current lack of a spawning population and local/traditional knowledge which indicated that this was once a spawning stream. Habitat observations made during 2015 indicated appropriate flow and substrate for Chinook spawning and highly suitable juvenile rearing habitat. Consideration of this information resulted in the development of the 2016 pilot project to re-introduce a spawning population of Chinook salmon using in-stream egg incubation methods, and to establish control sites in Morley River, which is a spawning area currently used by Chinook. The inclusion of the egg deployment sites in Morley River allowed for the same methods used in Deadman Creek to be tested in a location with habitat currently known to be suitable for spawning and egg incubation, providing additional perspective on the effectiveness of these methods as a restoration tool.

The 2016 project planted a total of 6,524 fertilized eggs in Deadman Creek and 5,957 in Morley River (EDI 2017). Eggs were deployed in both streams using a combination of open and closed incubation media including: Whitlock Vibert boxes, Jordan Scotty incubators and egg tubes. Eggs were also planted directly in the artificial redds using egg insertion pipes. Success monitoring employed a variety of methods to determine hatching success in both streams. Hatching success was generally very high in Morley River with survival as high as 96% in some incubation media. Hatching data from Deadman Creek was highly variable between sites and incubation media; however, hatching success was as high as 74% and averaged approximately 50%. Additional components of the 2016 project included: water temperature monitoring in Deadman Creek and Morley River, juvenile Chinook monitoring in Deadman Creek (June and August), clearing of a walking trail along the lower reaches of Deadman Creek, and provision of local training/capacity building.

1.1 OBJECTIVES

The overall objective of this project was to restore a self-sustaining Chinook spawning population through the use of egg planting which is a culturally appropriate method for the TTC. The 2017 project built upon the 2016 pilot project and increased the number of eggs planted with many improvements from lessons learned throughout the 2016 project. The project also provided a unique learning opportunity to test the egg planting methods to determine the utility of this method for restoring Chinook stocks elsewhere in the Yukon River watershed. The specific objectives of the project were as follows:

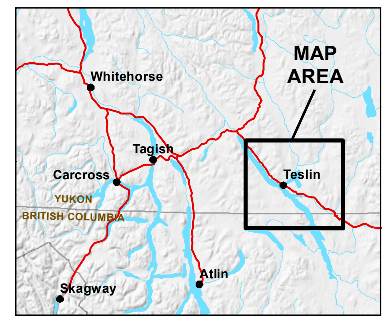
- Deploy approximately 30,000 fertilized Chinook eggs into Deadman Creek and Morley River (combined) to test the feasibility of egg planting methods to restore Chinook stocks in the Teslin River watershed.
- Conduct follow up monitoring during the winter and spring to determine the fate of the planted eggs in both streams.
- Conduct a juvenile Chinook sampling program during the summer of 2017 to collect data on habitat utilization by non-natal juveniles and the current status of beaver dams and/or other barriers.
- Provide local capacity building and technical training/employment for one local technician for 15 days.



Map 1. Overview of Brood Stock Collection and Egg Development Areas

Legend

- Alaska Highway
- Secondary Road
- Trail
- Egg Deployment Area
- Brood Stock Collection and Egg Deployment Area



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2 METHODS

2.1 ESTABLISHING THE WALKING TRAIL

Hand clearing of two additional segments of walking trail was conducted by TTC individuals to provide access to newly established egg planting sites and required two days to complete. The trails provided walking access from the Deadman gravel pit road to the riparian zone of Deadman Creek (Map 2). As with the trails established during 2016, the new trails were limited to a narrow foot trail in order to prevent ATV access. These new trails were necessary to allow for the egg planting and associated monitoring to be carried out in an effective manner at newly established sites further upstream from the 2016 egg planting sites.

2.2 WATER TEMPERATURE MONITORING

Water temperature monitoring during 2017 involved the retrieval and redeployment of temperature loggers originally deployed during 2015 and 2016 (EDI 2016, 2017) in Deadman Creek and Morley River. New loggers were also deployed during 2017 in conjunction with the egg planting sites in each of Deadman Creek and Morley River (see Section 2.6.4 below for additional information).

2.3 HYDROMETRIC MONITORING

Hydrometric monitoring for this project (Deadman Creek) is comprised of three components: continuous water level monitoring, water level surveys and discharge measurements. The objective of this monitoring is to monitor changes in water levels during the egg incubation period (short term) and, over the longer term, establish a continuous record of water levels and discharge at site 2 to inform the characterization of the aquatic habitat throughout the year.

Deadman Creek Site 2 hydrometric station was installed on July 17, 2017 and removed on May 8, 2018 after the well was damaged by ice movement triggered by spring thaw. A new station was established at a more secure location on June 8, 2018. The station consists of a stilling well, continuous water level logger, continuous barometric pressure logger, staff gauge and water level survey benchmarks.

Water level surveys/discharge measurements have been conducted in 2017 open water season (three data points) and winter discharge was also measured in February 2018 (one data point).

Additional water level surveys and discharge measurements in high and low flow conditions are required in order to develop a rating curve (water level – discharge relationship) and derive a continuous discharge based on the water level logger continuous record.

2.3.1 STREAM DISCHARGE

The velocity-area mid-section method will be used to determine discharge at hydrometric stations where channel criteria meet those outlined in standard guidance documents (RISC 2009; WSC 1999). Cross-section locations are located in close proximity to continuous data logger installations.The current meter used to obtain the velocity measurements is a 2-dimensional, side looking, FlowTracker2 Handheld Acoustic Doppler Velocimeter (ADV) (Sontek/Xylem 2016) or alternatively or Swoffer Model 2100 Current Velocity Meter. Discharge results are reported in m^3/s.

2.3.2 WATER SURFACE ELEVATION SURVEY

Typically, an elevation survey is completed during each hydrometric station visit in open water season. The purpose of these surveys is to tie the data logger water levels to the local station datum. The station has a local, relative datum defined by benchmarks in close proximity to the data logger and stilling well. Three benchmarks are installed at each continuous station as per RISC (2009) Data Grade A guidelines. Each survey includes a survey with a level and rod for Benchmark 1 (BM1), Benchmark 2 (BM2), Benchmark 3 (BM3), the top of the staff gauge (TOS), the water surface elevation (WATER) and the elevation of the fixed-length logger apparatus (TOR). The elevation of Benchmark 1 at every station defines a local elevation of 100.000 m above datum. The local datum is always located below the elevation of zero flow.

The benchmarks and the top of the staff gauge are regularly checked for shifting as a result of periglacial processes and survey error. While there is some apparent movement in the benchmark elevations and occasionally anomalous survey data, the water surface elevation data will be carefully reviewed using staff gauge readings and the field records of stilling well maintenance (logger or staff gauge shifts) before applying local datum offsets to the raw data logger record. All suspect data is excluded from the corrected data. All stage (i.e. water surface elevation) data is presented in metres referenced to the local datum unless otherwise noted.

Surveys are not completed during the winter because stage elevations are affected by ice, changing the relationship between stage and discharge; rating curves are not developed for the winter period.

2.3.3 CONTINUOUS RECORD

One Solinst Edge Levelogger pressure transducer was installed in the stilling well of the hydrometric station. One Solinst Edge Barologger barometric pressure transducer is installed on a tree near the station to compensate the water level loggers for atmospheric pressure. Readings are set at 15-minute intervals to create a continuous record. The pressure transducers are downloaded on each site visit. Pressure in water is recorded in metres of water column, atmospheric pressure in kPa and converted in metre of water column equivalent using a factor of 0.101972. Continuous stage is the result of total pressure in water minus the atmospheric pressure, which result is offset to match water surface elevation surveyed with the local datum. Continuous discharge is calculated using the stage-discharge rating curve developed for the rating period. The continuous stage record (rather than discharge record) is presented until a reliable rating curve can be developed.

2.4 WOLMAN PEBBLE COUNTS & SPOT VELOCITY MEASUREMENTS

Wolman pebble counts were conducted to determine the size of river bed material gravels/cobbles used by spawning Chinook salmon in Morley River as well as at each planting cluster in Deadman Creek and Morley River. One hundred random pebble samples were measured at each location; the length (mm) of the second largest axis (B-axis) of each pebble was recorded. The collection of this information helps to quantify the substrate sizes within both Deadman Creek and Morley River. By collecting data on the composition of the stream bed, we can demonstrate that the substrate within Deadman Creek and our planting sites in Morley River contain suitable sized substrate for egg survival. Additionally, spot velocities were collected using a Swoffer velocity meter at all egg planting sites as well as on three natural redds in Morley River. The spot velocities were collected to determine what flow rates Chinook salmon are spawning in and if this is a limiting factor in site selection.

2.5 JUVENILE MONITORING

Sampling for juvenile Chinook was conducted in Deadman Creek on four occasions under a Scientific Fish Collection License issued by the Department of Fisheries and Oceans (DFO) during 2017; June 22-23, July 17-18, August 2-9 and September 2-3. Previous work conducted in the watershed noted that non-natal Chinook did not appear to be present during June and started to arrive in early July with numbers increasing later in the summer. The June sampling event was intended to confirm these previous observations and determine if sampling during the early summer may be able to provide an indication of fry hatched from eggs planted during August 2016. The July, August and September sampling events were intended to coincide with higher non-natal juvenile Chinook abundance in the stream and to begin determining the relative abundance and extent of habitat utilization in the stream. Both sampling events are planned to continue (and be expanded) in future years of the restoration project to monitor these parameters in Deadman Creek.

Minnow traps were set in clusters of three to six traps per site and the amount of total trap sets ranged from 18 (June event) to 58 (August event). A total of 14 trap clusters were sampled in total and ranged from the Alaska Highway bridge upstream a distance of approximately 5 km (Map 2). All traps were baited with Yukon River origin salmon roe following Yukon River Panel protocols and left to soak overnight. Traps were set in slack water areas with high amounts of cover, including small and large woody debris, overhanging vegetation or undercut banks (Photo A1; APPENDIX A). In-situ water quality parameters (water temperature, pH, specific conductance and dissolved oxygen) were collected for each station along with water depth and a general description of habitat. Digital photos were collected for all sampling stations along with GPS co-ordinates and set/pull times. Upon retrieval of the traps, all fish were counted and identified to species with a minimum of 10 individuals of each species from each trap measured for fork length. Observations of the status of beaver dams and other potential barriers to fish passage were also recorded during the June and August sampling events.

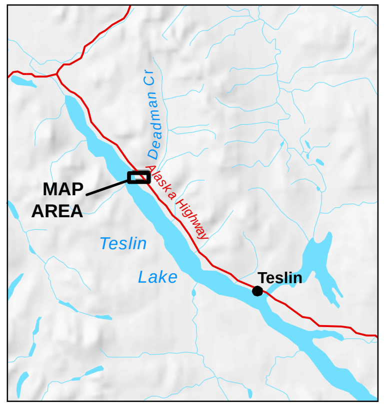
Map 2. Juvinile Chinook Monitoring Locations in Deadman Creek

Legend

- Alaska Highway
- Secondary Road

Juvenile Chinook Monitoring Locations

- June
- July
- August
- September



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Data Sources
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2.6 INSTREAM EGG INCUBATION

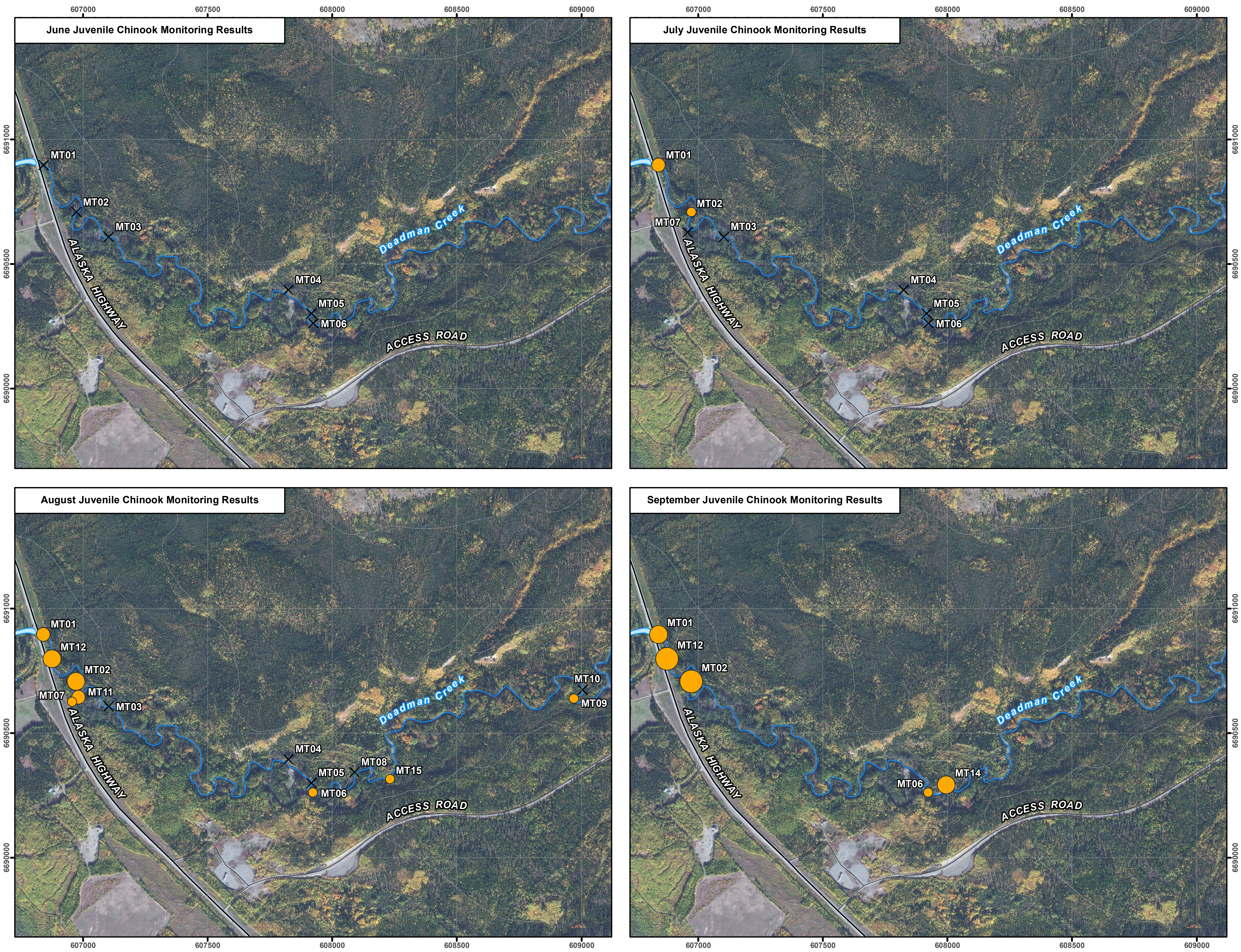
The project underwent a YESAB project review during the summer of 2017 and permits were issued for the work by DFO including a Scientific Fish Collection License for the broodstock collection and an Introduction, Transplant and Transport (ITT) permit for the egg planting in Deadman Creek and Morley River.

The instream egg incubation (egg planting) component of the project involved four components: (1) site selection and preparation, (2) broodstock collection, (3) egg fertilization, and (4) egg deployment (below sections).

2.6.1 SITE PREPARATION

During the site selection process, three of the five 2016/2017 sites were chosen for egg planting in 2017/2018 and a number of new sites were also chosen (Map 3). Both Site DC01 and Site DC05 were not considered for planting in 2017; Site DC01 experienced unfavorable ice conditions from water backing up, whereas Site DC05 had less flow and limited appropriately sized substrate. A total of 12 new sites were selected for planting and located further upstream. The new sites in the upper reaches were divided into four clusters each containing three sites (Sites DC06-08, DC09-11, and Sites DC12-14 and DC15-17). These new sites were selected based on suitable substrate, flow rates and potential for groundwater influence. Four of the five planting sites from 2016/2017 in Morley River were once again used for egg planting during the 2017/2018.

At all sites in both streams, working/cleaning of the substrate was required to mimic the natural redd construction and to prepare each of these sites for the egg planting (Photos A1-A2; APPENDIX A). This was accomplishing by digging/raking of the streambed, and in Deadman Creek, a specially modified pressure washer was also used to remove fine sediment from the streambed. In Morley River, care was taken to avoid disturbance to natural Chinook redds of which numerous were observed in the vicinity of the deployment sites. At sites that were the exact same as the previous year the crew watched for indication of failed planting sites (dead eggs or alevin) while preparing the sites. GPS co-ordinates were collected for all sites and a rock with a unique combination of colored flagging tape was placed on each prepared site to facilitate relocation of the sites. The final step of site preparation was to move all cleaned substrate to the sides of the deployment area between the two egg insertion pipes, thus leaving a trench. It was within this trench that the Jordan Scotty incubators, Whitlock-Vibert boxes, and egg tubes were placed during the egg deployment (Section 2.6.4).



Map 3. Juvinile Chinook Monitoring Results in Deadman Creek

Legend

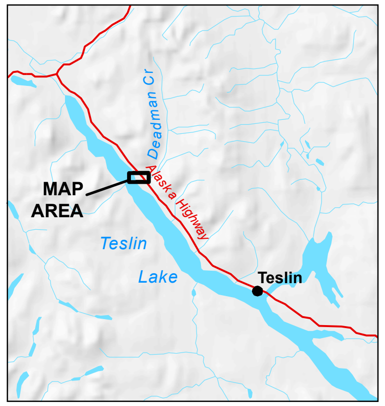
Alaska Highway

Secondary Road

Juvenile Chinook CPUE[1]

- 0
- >0 - 5
- 5 - 10
- 10 - 15
- 15 - 25

[1]Catch per unit effort: number captured per 24 hours (average 2-3 traps per site).



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2.6.2 BROODSTOCK COLLECTION

Broodstock collection was conducted on Morley River in the vicinity of the Alaska Highway crossing from August 12-17, 2017. All fish handled were captured by angling/snagging, and visual observation counts of redds and spawning females were collected during the broodstock collection week to determine the number of spawners and redds present. All Chinook salmon captured were measured from mid-eye to fork and snout to fork length, sexed, sampled for scales and genetics (paired auxiliary processes); scale and genetic samples were provided to DFO for analysis. Fish not suitable for broodstock were released promptly and those to be used for broodstock were temporarily placed in holding tubes or bags (Photo A4-A5; APPENDIX A) to allow for eggs and milt to be collected simultaneously. All Chinook salmon captured were tagged with a brightly colored Floy tag near the base of the dorsal fin. Each tag had a unique identifier and different colors were used for males and females to make identification possible without having to recapture fish.

2.6.3 EGG FERTILIZATION

When a sufficient number of males and females were captured to conduct an egg take, each fish had its vent carefully wiped dry and the eggs/milt were placed in new, dry plastic containers. Eggs were enumerated by weight to obtain an estimate of the total number collected. Eggs and milt were kept in a clean dark cooler with an ice pack to keep cool until fertilization.

Egg fertilization was conducted in close proximity to each egg planting site to reduce the amount of handling and transport into the stream. A clean and sterilized heath tray was set up at the site with a small gas powered water pump to provide a continuous flow of water from the stream through the tray. An umbrella was set up over the heath tray to provide shelter from the rain and sun during the fertilization and water hardening process. Prior to fertilization, all eggs were mixed such that individual sites had a mix of eggs from various females. The fertilization was done in batches with only enough eggs to fertilize one to three sites to reduce the amount of egg holding time between fertilization and planting into the stream. Eggs were weighed to estimate the number required for each site(s) and milt from three males was used for each batch of fertilization. After being fertilized, the eggs were placed in the heath tray to water harden and flush for 20 minutes before being loaded into the various incubation media for planting in the stream.

2.6.4 EGG DEPLOYMENT

The egg deployment at each site involved the use of three methods of egg planting: Jordan Scotty incubators (200 eggs each), Whitlock-Vibert boxes (98 to 200 eggs each), and egg insertion pipes (artificial redds; Photos A7-A11; APPENDIX A). Egg insertion pipes involved the use of a metal or plastic PVC pipe inserted into cleaned substrate; one to three of these pipes were used at each site, with 164 to 650 eggs placed into each pipe depending on eggs available for planting and substrate size (larger amount of substrate allowed for more egg planting). Half of the eggs were placed into the pipe at a depth of approximately 25 cm below the surface of the bed, with the remainder deposited 5-10 cm closer to the bed surface. Additionally, mesh bags were sewn to test a "closed" method of the Whitlock-Vibert boxes as well as the artificial redds. The mesh bags were constructed of fine mesh and were designed to hold either rocks or bio-rings (artificial substrate) to allow for the fate of all eggs/alevin to be determined following retrieval. All incubation media were marked with a unique color combination of flagging tape and sketched onto a site plan to facilitate success monitoring. Following the placement of all eggs at each site, previously cleaned substrate was piled into a mound to protect the eggs and mimic the construction of a natural Chinook redd.

2.7 SUCCESS MONITORING

Success monitoring was conducted from October 2017 through to June 2018 in both Deadman Creek and Morley River. The primary objective of this monitoring was to determine the egg hatching in all incubation media in both Morley River and Deadman Creek. Methods were also tested to determine the feasibility of measuring survival through to the emergence stage in both streams.

2.7.1 MORLEY RIVER

The first monitoring event in Morley River was conducted on October 12, 2017 and was intended to retrieve all open egg incubation media (Whitlock-Vibert boxes and Jordan Scotty incubators) to obtain a measure of hatching success. All boxes and incubators were removed from the substrate and brought to shore to process the contents. The contents were placed into a container with water, and the fate of all individuals was determined. Following counting, any dead eggs/alevin were removed and the live alevins were placed back into the substrate of the initial egg planting site using an egg insertion pipe.

The second monitoring event was conducted in Morley River on January 5, 2018 with the objective of checking on the development status of the alevin in the closed incubation media. The closed Whitlock-Vibert box (mesh bag) at Site M01 was retrieved, the contents were assessed for survival, and the live alevin were planted back into the substrate.

Based upon the development of the alevins observed at site M01 on January 5, a follow-up site visit was conducted at Morley River on February 15, 2018 to determine emergence success in the remaining closed Whitlock-Vibert boxes (mesh bags) at sites M02 and M03. Survival of the contents was determined and the swim-up fry were released into a slack water area of the river.

2.7.2 DEADMAN CREEK

Based upon the results of previous year's monitoring (EDI 2017), it is known that hatching in Deadman Creek occurs during the winter months and is delayed compared to Morley River due to colder water temperatures. For this reason, monitoring was not conducted in Deadman Creek until January 2018. Three single day site visits were conducted to site DC4 between January 5 and 17, 2018, with each event retrieving the same Whitlock-Vibert box determine a hatching date.

Once a hatching date was determined for Deadman Creek (January 5-17, 2018), a visit to all sites was conducted from February 15-18, 2018 to document winter conditions and determine hatching success where applicable. Using methods consistent with Morley River, all open Whitlock-Vibert boxes and Jordan Scotty incubators were retrieved to determine hatching success[1]. A subset of the closed Whitlock-Vibert boxes (mesh bags) were also retrieved to assess the feasibility of this method for determining hatching and emergence success.

The remaining closed Whitlock-Vibert boxes (mesh bags) were retrieved immediately following spring freshet on June 6 and 7, 2018. Each mesh bag was retrieved, and the fate of all eggs determined; in many instances, it was not possible to determine an exact number of dead alevin and/or eggs present due to decomposition. In such cases, the number of live swim up fry and the initial count of fertilized eggs placed into the bags were used to determine survival. A portion of the closed Whitlock-Vibert boxes had been dislodged from their initial deployment locations and their contents were not used for success monitoring as they were not representative of incubation conditions.

[1] The six Jordan Scotty incubators at site DC6 could not be retrieved during February 2018 due to ice contact with a portion of the large boulder substrate at this site. The retrieval of these incubators was conducted during the June 2018 site visit.

3 RESULTS

3.1 WALKING TRAIL ESTABLISHMENT

Hand clearing of the access trails to the new, upper planting sites (Sites DC6-11 and DC12-17) on Deadman Creek was completed by the site preparation crews and was completed using hand tools. The trails travelled shortest distance to Deadman Creek and was limited to a foot trail in order to prevent access by ATVs. The clearing of this trail was essential to allow for the carrying of egg planting equipment into and out of each site. It is envisioned that this walking trail will be expanded upon in future years of the restoration project to continue to allow for more efficient walking access to the stream during the juvenile Chinook sampling and egg planting, and to possibly incorporate interpretive signage.

3.2 WATER TEMPERATURE MONITORING

Surface water temperature loggers in Deadman Creek and Morley River were retrieved, downloaded and redeployed during the 2017/2018 egg incubation period. Water temperatures in Morley River are warmer than those in Deadman Creek for the entire record period (Figure 1). Water temperatures in Morley River displayed fewer fluctuations during night and day measurements. Water temperatures in Morley River also show less day to day variability and remain above 0 ˚C during the winter months. In contrast, the temperature in Deadman was consistently at 0 ˚C from November 6, 2017 to April 12, 2018.

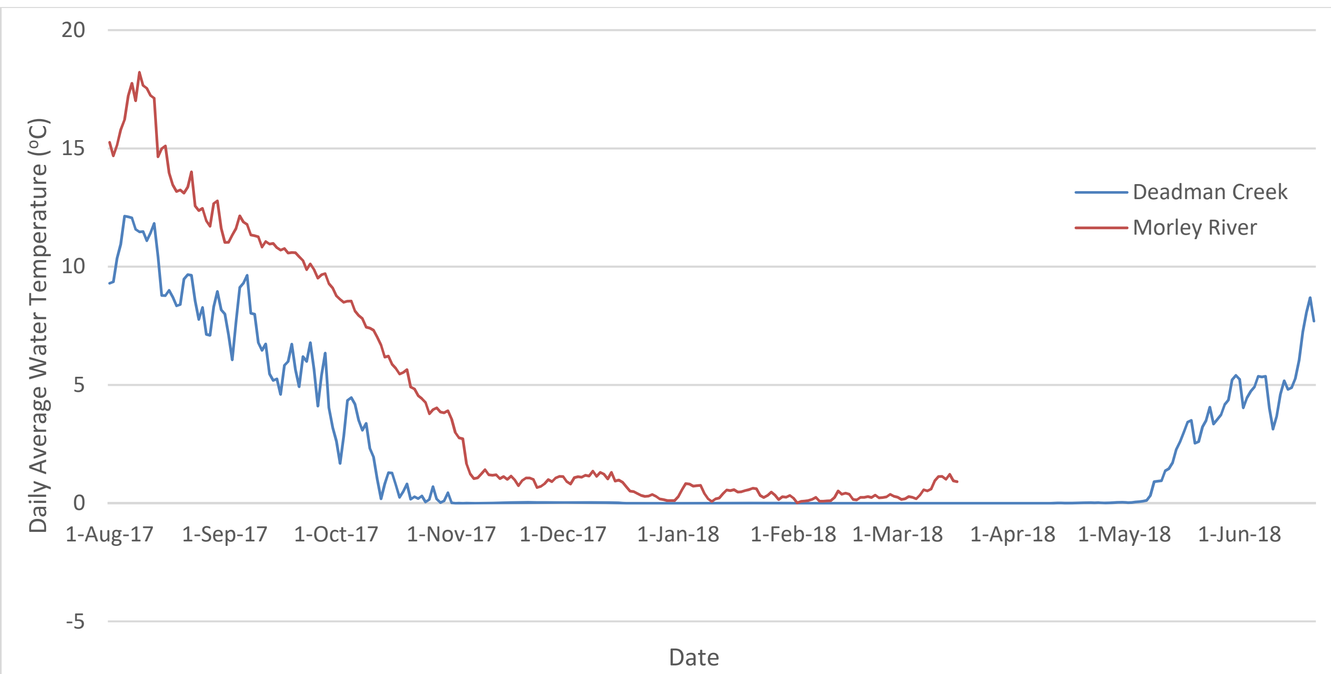


Figure 1. Hourly water temperature in Morley River and Deadman Creek during the 2017/2018 egg incubation period.

Water temperature loggers were buried in the substrate at representative egg planting sites in both Deadman Creek and Morley River (Figure 2; Figure 3). Water temperatures in Deadman Creek decreased steadily from early September through to mid-October at which time they remained close to zero for the duration of the winter before rising sharply in mid-May. All eight sites monitored showed a similar pattern although some slight differences between sites were noted. Site DC2 in the very lower portion of the stream was generally warmer during the open water period. Very slight differences were noted during the winter months with some sites being very near freezing and other sites (DC8, 10 and 15) being up to 0.5 °C for much of the winter, particularly the early winter (Figure 2). In Morley River, the two sites monitored showed very similar results during the period of overlap. The temperature gradually decreased from 14 °C to approximately 1 °C in early November. For the duration of the winter, the temperature hovered between 1 °C and 0.5 °C with a few short periods closer to 0 °C (Figure 3).

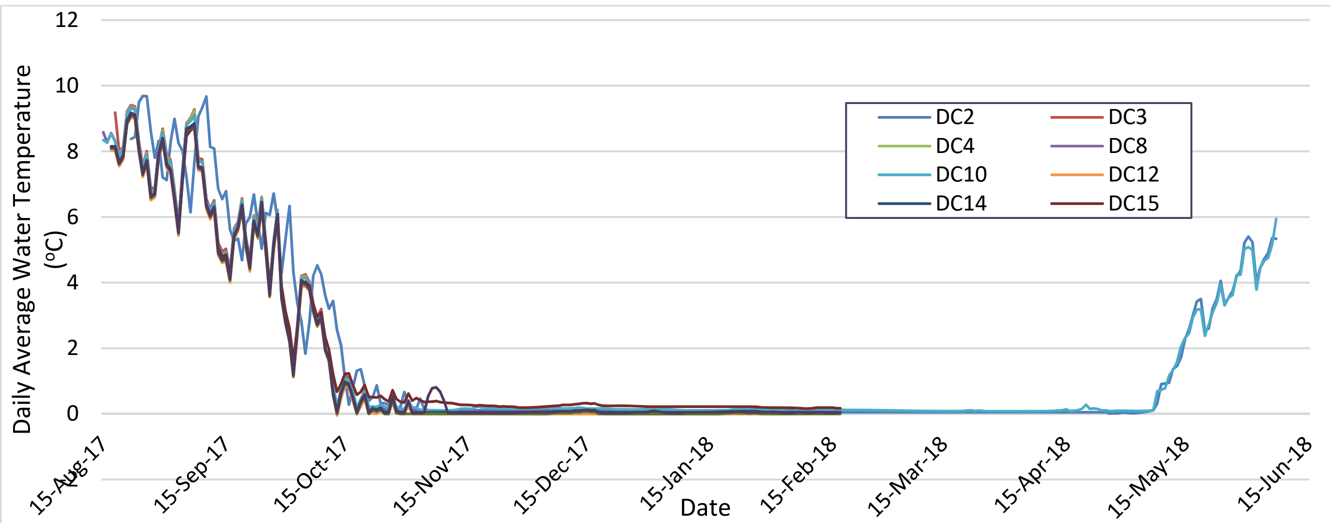


Figure 2. Water temperatures at egg planting sites in Deadman Creek from the timing of egg planting through to fry emergence.

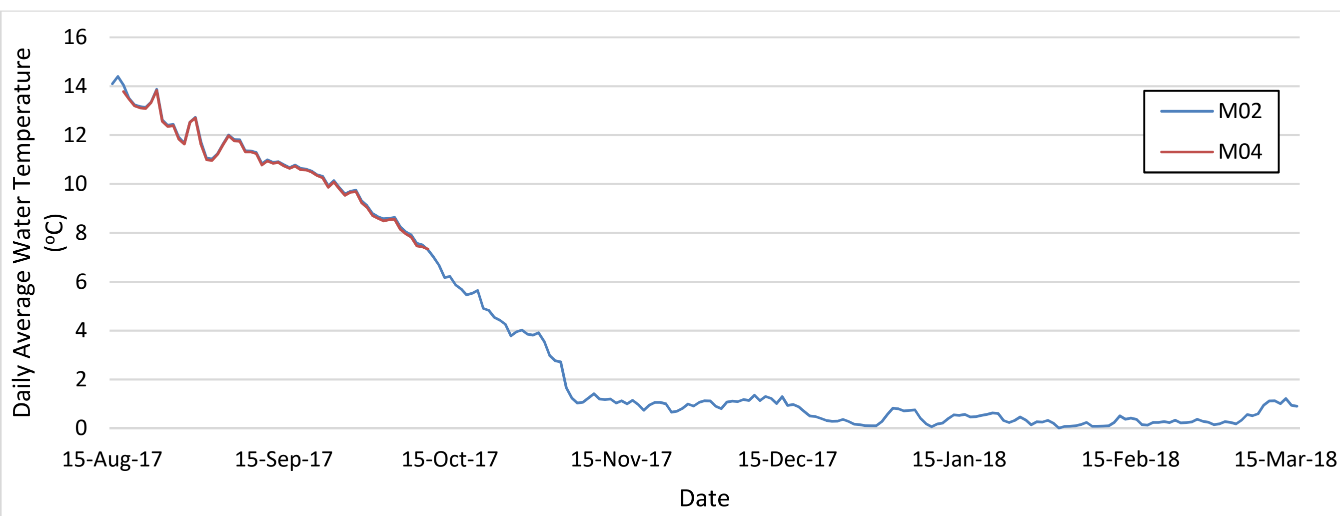


Figure 3. Water temperatures at egg planting sites in Morley River from the timing of egg planting through to fry emergence.

3.3 HYDROMETRIC MONITORING

Deadman Creek is a mountain stream with no lake storage upstream of the hydrometric station at Site 2 near the mouth of the creek (Teslin Lake). Flow patterns at Site DC02 are dynamic and sensitive to seasonal variations, weather events and ice effects (Table 1, Figure 4). Annual peak flows occur in response to the spring snowmelt. In 2017, the exact date for peak flow was not determined since the continuous hydrometric station was not installed until July 17. In 2018, peak flow was not fully recorded since the station was removed from the stream on May 8 after the well was damaged by ice movement triggered by spring thaw. Discharge measurements during spring freshet peak flows have not been collected.

Summer and fall high flows also occur in response to rainfall events. Examples include July 17, 2017 discharge measurement (2.996 m^3/s), and August 23, 2017 (high water level recorded by logger). Moderate flows occurred from late July to late October 2017, with discharge measurements on September 1 (1.213 m^3/s) and October 11 (0.933 m^3/s).

Freeze up likely occurred around October 28, 2017 and winter ice conditions prevailed until May 1, 2018. These dates are estimated from observations of the continuous record of water levels and water temperatures. Water levels recorded by the instrument between late October and early May is affected by ice forming at the surface and on the streambed (i.e. backwater effects) and the changing of the channel morphology. Therefore, water level recorded in the winter is not a reliable indicator of discharge. Typically, there is an elevated water level due to ice effects for a corresponding low discharge. Winter discharge was measured on February 18, 2018 at low flow (0.148 m^3/s), anchor ice was present mid-channel and the ice cover was approximately 65 cm thick.

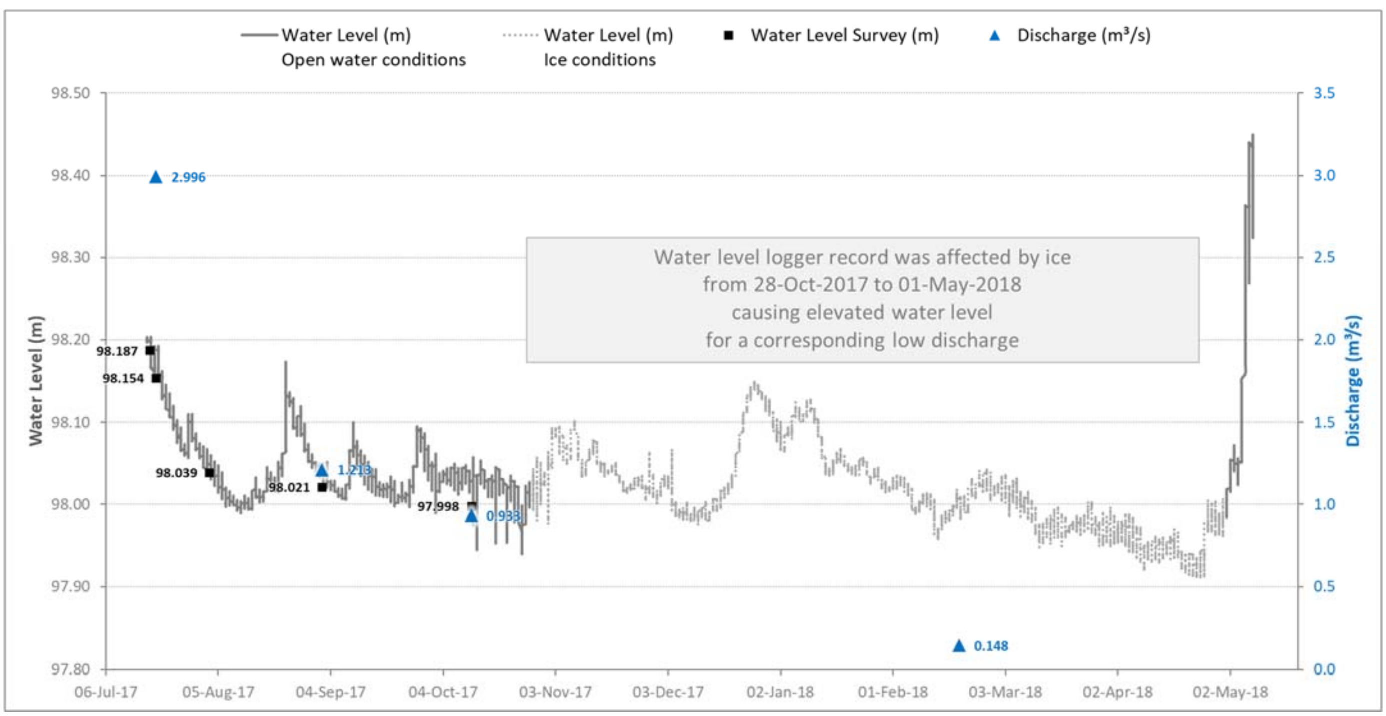


Figure 4. Stage-discharge hydrgraph at Site DC02 in Deadman Creek from July 17, 2017 to May 8, 2018.

Table 1. Stage-discharge measurements for at Site DC02 in Deadman Creek from July 17, 2017 to May 8, 2018.

Date and Time	Water Surface Elevation (m; local datum)	Discharge (m^3/s)	Method	Notes
17/07/2017 18:29	98.187	-	-	Station installed
19/07/2017 09:18	98.154	2.996	Velocity-area, mid-section. Instrument: Swoffer	High flow (rain) Stage estimated (staff gauge reading, offset with 17/07/2017 surveyed elevations)
02/08/2017 12:12	98.039	-	-	Stage estimated (staff gauge reading, offset with 17/07/2017 surveyed elevations)
01/09/2017 13:49	98.021	1.213	Velocity-area, mid-section. Instrument: ADV	Moderate flow
11/10/2017 10:55	97.998	0.933	Velocity-area, mid-section. Instrument: ADV	Moderate flow

3.4 WOLMAN PEBBLE COUNTS & SPOT VELOCITY MEASUREMENTS

Eleven Wolman pebble counts were conducted in Morley River and Deadman Creek to compare substrate size at natural Chinook redds in Morley River to the artificial egg planting sites in both streams. Of the 11 pebble counts, two were collected on natural redds and two were collected in clusters on Morley, and the remaining seven were conducted at planting sites distributed throughout Deadman Creek. Although there were some differences between substrate size in Morley River and Deadman Creek, the majority of the sites were fairly similar (Table 2; Figure 5). Although the data shows Chinook spawning in smaller substrate in Morley River, Chinook were also observed spawning in areas with larger substrate; however due to deeper and swifter conditions at these sites we were unable to safely conduct pebble counts in these areas.

Table 2. Summary of Wolman pebble counts conducted on Deadman Creek and Morley River in August 2017.

Parameter	Deadman Creek Sites							Morley River Sites			
	2	3	4	6,7,8	9,10,11	12,13,14	15,16,17	1,2,3	4,5	Natural Redd 1	Natural Redd 2
Median (mm)	65	55	46	46	42	51	60	41	50	44	27
Mean (mm)	64	60	54	51	45	58	64	44	52	46	29

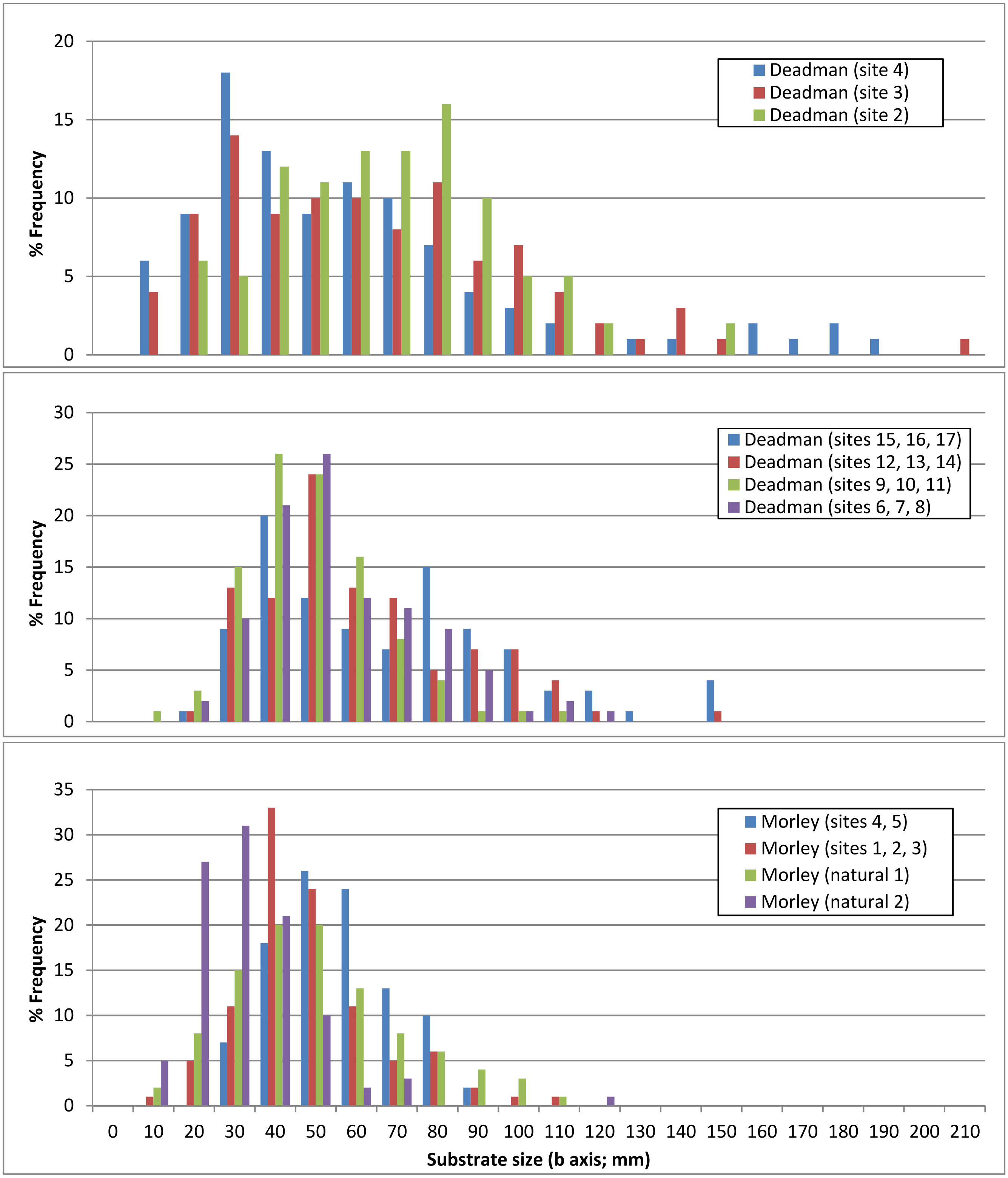


Figure 5. Wolman Pebble Count data collected at egg planting sites (Deadman Creek, Morley River) and natural spawning redds (Morley River) during 2017.

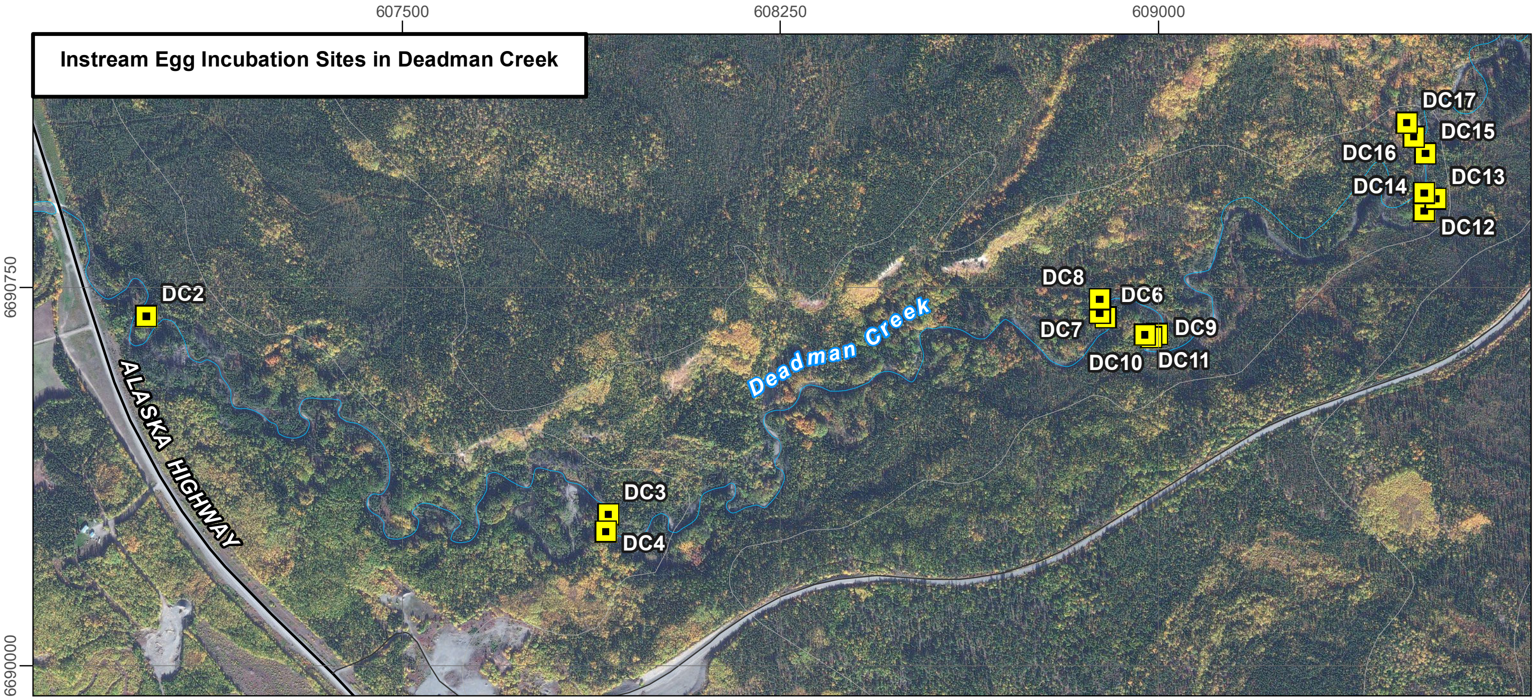
Similar to the Wolman pebble counts, spot velocities were collected at all egg planting sites in both streams and three natural Chinook redds in Morley River. Three areas of the water column were measured for water velocity: just above the substrate (best indication of intra-gravel flow), 10 cm above the substrate, and at 60% of the total water depth. When considering the measurements just above the bed, the three natural redds ranged from 0.26 to 0.50 m/s with an average of 0.39 m/s (Table 3). The four artificial egg planting sites in Morley River had very similar spot velocities to the natural redds (range = 0.26 to 0.51 m/s; average = 0.32 m/s). In Deadman Creek, the egg planting sites had a very similar average velocity as compared to Morley River (0.33 m/s) but encompassed a broader range of velocities, ranging from 0.15 to 0.65 m/s.

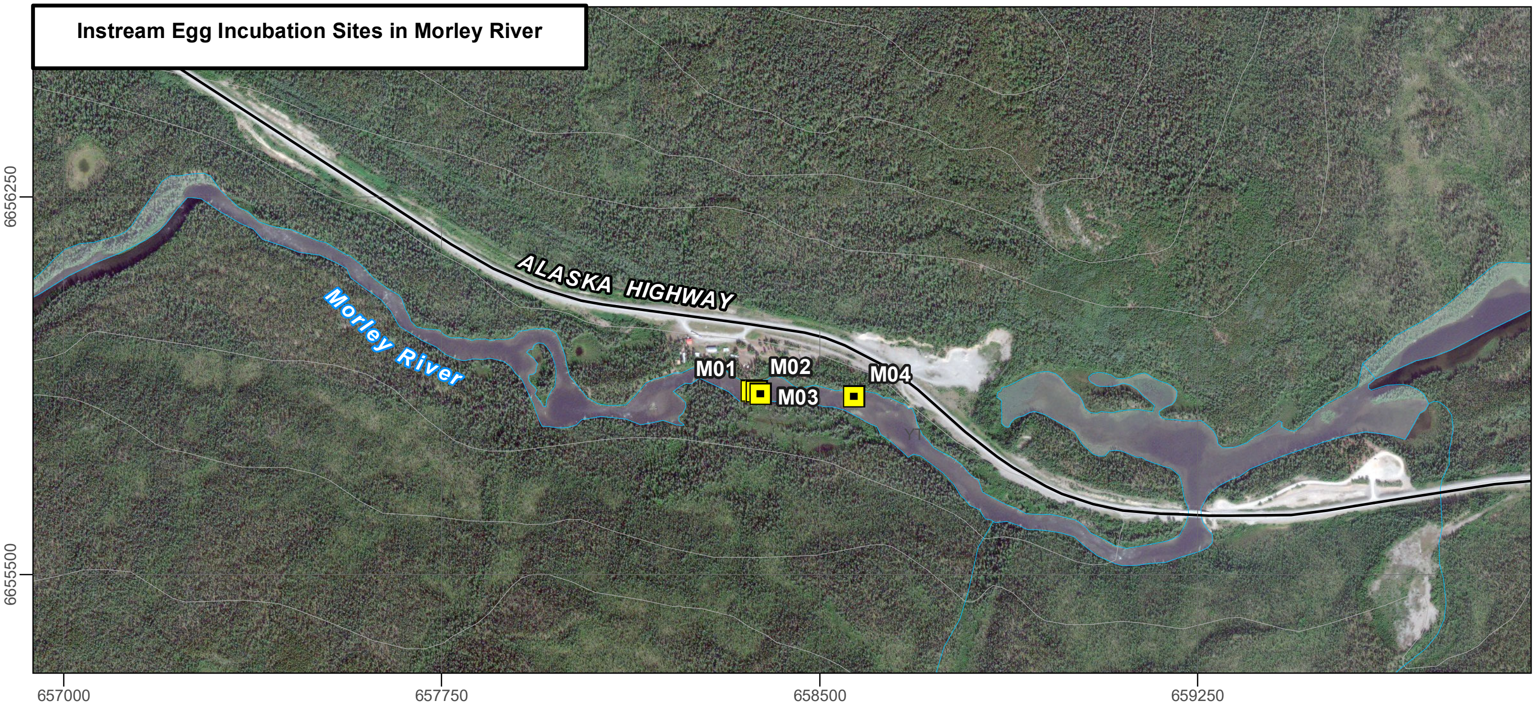
Table 3. Spot velocity measurements collected at all artificial redds and three natural redds using a Swoffer velocimeter, August 19, 2017.

Waterbody	Site Name	Site Depth (cm)	Velocity just above bed (m/s)	Velocity 10 cm above bed (m/s)	Velocity at 60% depth (m/s)
Deadman Creek	DC2	77	0.15	0.20	0.22
Deadman Creek	DC3	57	0.32	0.49	0.50
Deadman Creek	DC4	38	0.37	0.60	0.66
Deadman Creek	DC6	36	0.65	0.79	0.90
Deadman Creek	DC7	38	0.41	0.52	0.69
Deadman Creek	DC8	77	0.20	0.38	0.77
Deadman Creek	DC9	45	0.25	0.37	0.47
Deadman Creek	DC10	64	0.26	0.29	0.37
Deadman Creek	DC11	49	0.28	0.34	0.39
Deadman Creek	DC12	68	0.23	0.27	0.24
Deadman Creek	DC13	62	0.35	0.40	0.43
Deadman Creek	DC14	63	0.24	0.38	0.63
Deadman Creek	DC15	56	0.22	0.35	0.56
Deadman Creek	DC16	49	0.44	0.52	0.58
Deadman Creek	DC17	64	0.56	0.53	0.49
Morley River	M01	71	0.26	0.31	0.57
Morley River	M02	79	0.26	0.29	0.40
Morley River	M03	73	0.25	0.37	0.41
Morley River	M04	60	0.51	0.55	0.73
Morley River	M05/Natural Redd	51	0.50	0.93	1.15
Morley River	Rec. Site Dune, Natural Redd	56	0.26	0.75	0.84
Morley River	Old Lodge, Natural Redd	68	0.42	0.28	0.57

3.5 JUVENILE MONITORING

The juvenile Chinook sampling events captured 532 fish of three species, with the catch dominated by slimy sculpin in June and juvenile Chinook in July, August and September (Map 4, Table 4). Zero Chinook were captured during the June sampling event but were captured during the July sampling event and increased in relative abundance during August and September. The sampling stations near the highway crossing captured the only juvenile Chinook during July and had the highest captures in both August and September (Map 4, Table 4).

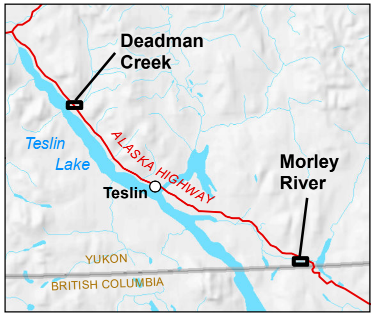




Map 4. Instream Egg Incubation Sites in Deadman Creek and Morley River

Legend

- Instream Egg Incubation Sites
- Alaska Highway
- Secondary Road



0 100 200 300 400 500
Metres

Map scale 1:15,000 (printed at 8.5x11)
Map Projection: NAD 1983 UTM Zone 8N

Data Sources
Digital Elevation Model,1:250,000, and 1:1,000,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

High Resolution Satellite Imagery provided by Yukon government, 2017

Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2017) was obtained using Garmin GPS technology.

Disclaimer
This document is not an official land survey and the spatial data presented is subject to change.

Drawn: HG	Checked: BSc	Date: 10/24/2018

Teslin Tlingit Council

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Path: O:\2017\17Y0167_TTC_Deadman\GIS\FinalMaps\Map4_EggIncubation.mxd

Table 4. Summary of Deadman Creek juvenile Chinook sampling, June, July, August and September, 2017.

Sampling Event	Species	Average CPUE (#/12 trap hours)	Total Individuals	Traps with Species Captured
June (18 traps set)	Chinook Salmon	0.00	0	0
	Burbot	0.00	0	0
	Slimy Sculpin	0.87	25	10
July (21 traps set)	Chinook Salmon	0.61	29	5
	Burbot	0.02	1	1
	Slimy Sculpin	0.36	17	9
August (58 traps set)	Chinook Salmon	1.73	192	18
	Burbot	0.02	2	2
	Slimy Sculpin	0.19	21	14
September (19 traps set)	Chinook Salmon	7.02	243	17
	Burbot	0.00	0	0
	Slimy Sculpin	0.06	2	2

As would be expected, there was an increase in fork length of juveniles captured over the duration of summer. The majority of Chinook salmon captured were likely 0+ young-of-the-year; however, an individual captured during July (102 mm) and another in August (105 mm) were likely 1+ juveniles (Duncan and Bradford 2006). Excluding these two individuals, the median fork length during July (62 mm) increased to 70 mm during August, and once again to 76 mm in September (Figure 6).

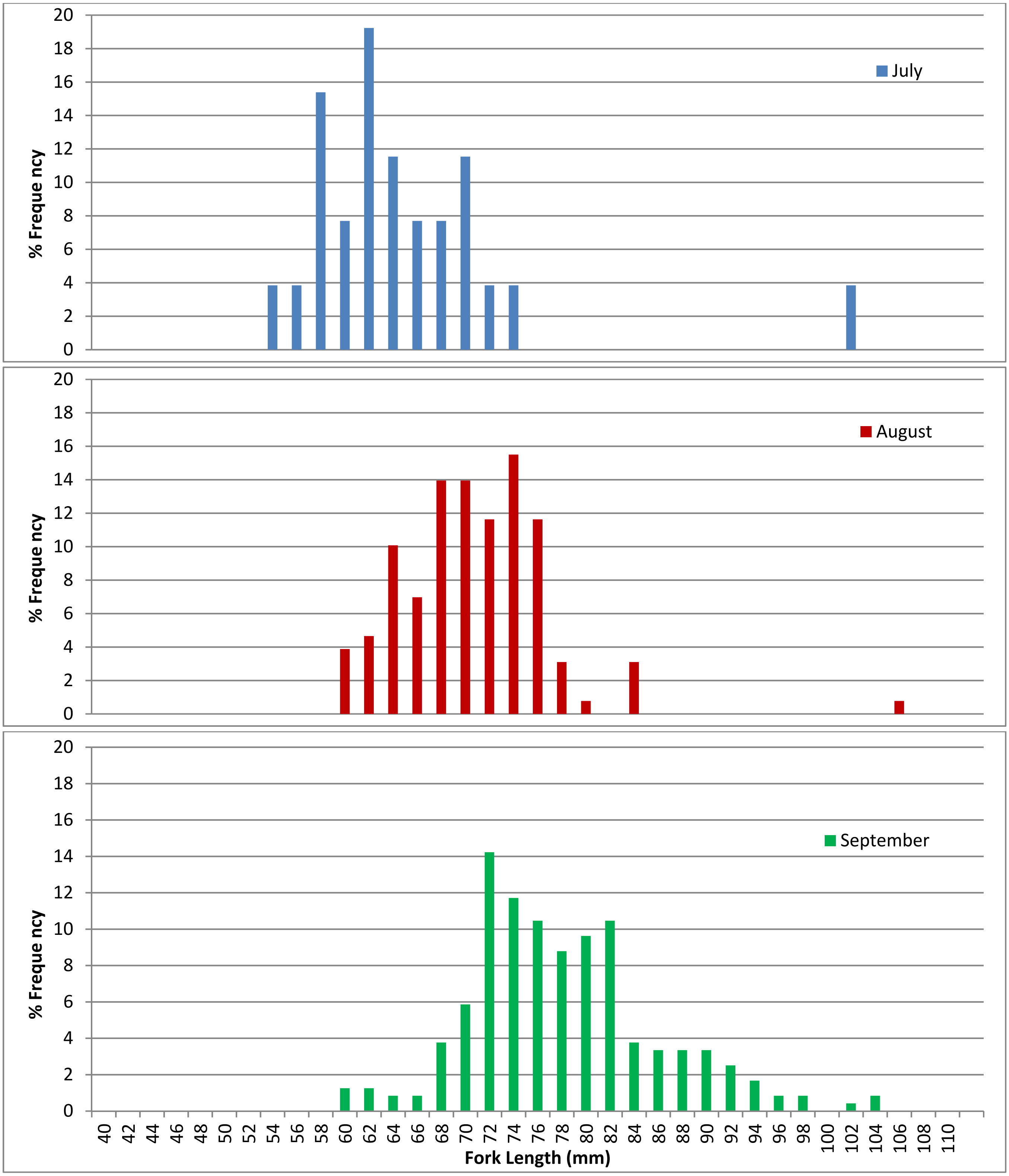


Figure 6. Deadman Creek juvenile Chinook fork length frequencies from July, August, and September 2017 (n=464).

3.6 INSTREAM EGG INCUBATION

3.6.1 SITE PREPARATION

The preparation of the 20 egg planting sites required 3.5 days to complete; however, this involved a relatively large crew of eight individuals, occasionally up to 20 individuals including TTC summer students and a Yukon Youth Conservation Corps (Y2C2) crew, and a Conservation Action Team (CAT) Camp.

3.6.2 BROODSTOCK COLLECTION

The broodstock collection and egg fertilization was conducted in batches to allow for sufficient time to plant the eggs within a given day and thus minimize egg handling time. A total of 34 spawning Chinook salmon were captured while attempting to obtain broodstock with the majority of these fish ripe and suitable for the collection of eggs or milt. Milt was collected from a total of 16 males with at least three males being used to fertilize each batch of eggs. A total of 10 females were live spawned for broodstock; however, only four of these were complete egg takes, with another four being partially spent and yielding between 287-2,943 eggs. The last two females were only partially spawned in order to achieve the number of eggs required for planting, while maintaining maximizing genetic diversity of the planted eggs and were released to spawn their remaining eggs naturally. Four of the females handled were spent and one was a freshly dead male carcass. A small (180 mm fork length) male Chinook salmon was caught angling and was injured due to its small size and the large hook; this residual male was ripe and producing milt but was not used as brood stock. Several other residual Chinook salmon were visually observed while planting eggs within Morley River sites M02 and M03.

Age, sex and length data along with genetic samples were collected from 32 of the captured Chinook and were provided to DFO for analysis. Scale samples from 23 individuals were analyzed by the Pacific Biological Station (PBS) with results indicating that the majority of Chinook aged were from the 2011 brood year (65.2%) with the remainder from the 2012 brood year (34.8%). The Chinook salmon sampled during broodstock collection had fork lengths ranging from 665 to 1,000 mm with an average of 866 mm. Females were slightly larger (average = 883 mm) compared to males (average = 820 mm).

3.6.3 EGG FERTILIZATION AND DEPLOYMENT

A total of 35,225 eggs were planted during this project; 27,712 eggs were planted in Deadman Creek, and 7,513 eggs were planted in Morley River (Table 5). This was slightly above the initial target of 30,000 eggs total and was a result of a measurement error when enumerating the eggs by weight. The majority of the ovarian fluid was removed from the eggs prior to weighing them, however not all of it was able to be removed during weighing which resulted in an underestimate of the number of eggs obtained from each female. Conversely, a weight estimate was used for calculating the number of eggs deployed in the insertion pipes, which may overestimate the total number of eggs planted. The overall discrepancy between initial egg numeration and planted numeration was 3,373 eggs.

Table 5. Summary of egg planting in Deadman Creek and Morley River.

Water body	Site Name	Jordan Scotty Incubator	Whitlock-Vibert Box						Egg Insertion Pipe				Total Eggs Planted
			Open	Open	Single & closed (bio rings)	Single & closed (rocks)	Paired & closed (Bio rings)	Paired & closed (rocks)	A	B	C	D	
Morley River	M01	2 / 200	-	-	-	-	2 / 100	2 / 100	520	520	-	-	1,840
Morley River	M02	2 / 200	4 / 200	-	-	1 / 200	-	-	415	465	-	-	2,280
Morley River	M03	-	2 / 150	1 / 98	-	-	-	-	400	400	400	-	1,598
Morley River	M04	2 / 200	-	-	-	-	-	-	465	465	465	-	1,795
Morley River	M05	*2016 site not planted during 2017*											0
Total Planted													**7,513**
Deadman Creek	DC1	*2016 site not planted during 2017*											0
Deadman Creek	DC2	2 / 200	2 / 200	-	-	-	-	4 / 100	299	300	298	-	2,097
Deadman Creek	DC3	2 / 200	1 / 200	-	-	1 / 200	-	-	427	-	400	-	1,627
Deadman Creek	DC4	2 / 200	1 / 200	-	-	1 / 200	-	-	400	400	400	-	2,000
Deadman Creek	DC5	*2016 site not planted during 2017*											0
Deadman Creek	DC6	6 / 200	-	-	-	-	-	-	550	650	650	-	3,050
Deadman Creek	DC7	-	-	-	-	-	-	-	470	505	510	550	2,035
Deadman Creek	DC8	2 / 200	2 / 200	-	-	-	-	-	365	455	375	-	1,995
Deadman Creek	DC9	2 / 200	-	-	-	-	2 / 100	2 / 100	327	255	245	-	1,627
Deadman Creek	DC10	2 / 200	-	-	1 / 200	1 / 200	-	-	341	364	364	320	2,189
Deadman Creek	DC11	-	1 / 100	-	-	-	-	-	318	245	164	-	827
Deadman Creek	DC12	2 / 200	2 / 200	-	-	-	-	-	421	-	-	-	1,221
Deadman Creek	DC13	-	-	-	-	-	-	-	568	397	368	-	1,333
Deadman Creek	DC14	2 / 200	-	-	-	-	-	-	516	484	500	-	1,900
Deadman Creek	DC15	2 / 200	-	-	-	-	2 / 100	2 / 100	453	421	474	-	2,148
Deadman Creek	DC16	-	2 / 200	-	-	-	-	-	505	453	200	-	1,558
Deadman Creek	DC17	2 / 200	-	-	1 / 200	1 / 200	-	-	442	442	421	-	2,105
Total Planted													**27,712**

3.6.4 SUCCESS MONITORING

The success monitoring results are presented separately in the following sections for Morley River and Deadman Creek. These two streams have different water temperature regimes, with Deadman Creek being cooler, and therefore the timing of the success monitoring differs.

3.6.4.1 Morley River

The open Whitlock-Vibert boxes and Jordan Scotty incubators were retrieved from Morley River on October 12, 2017 and across both incubator methods and all sites, had a mean hatching success of 85% (Table 6). This measure of survival does not include data from site M01, as this site was disturbed following planting in August 2017. It is unclear how the site became disturbed; however, the incubation media were exposed and compacted with sand.

Mean inferred survival was highest at site M02 (92%), followed by site M03 (87%) and M04 (81%; Table 6). Majority of the alevins which remained in the incubators were relatively small and appeared to be recently hatched (Photo A13; APPENDIX A). ATUs at the three sites ranged from 599 (Site 4) to 638 (Site M02) at the time of retrieval. This variation is due to differing dates of egg deployment rather than a difference in temperatures between sites.

Table 6. Summary of Morley River Whitlock-Vibert box and Jordan Scotty results (October 12, 2018).

Site	Incubator Type [A]	Total Eggs Planted	ATUs	Dead Eggs	Dead Alevin	Live Alevin	Inferred Survival [B] (%)
M02	WVB	200	638	30	-	-	85
	WVB	200		26	-	-	87
	WVB	200		15	-	-	93
	WVB	200		4	-	-	98
	Scotty	200		13	-	20	94
	Scotty	200		11	-	16	95
M03	WVB	98	-	25	-	-	74
	WVB	150		32	1	-	78
	WVB	150		30	-	-	80
M04	Scotty	200	599	48	-	1	76
	Scotty	200		41	-	2	80

[A] Where WVB – Whitlock-Vibert box and Scotty – Jordan Scotty incubator.
[B] Inferred survival assumes that a large proportion of the alevins had already exited the incubators.

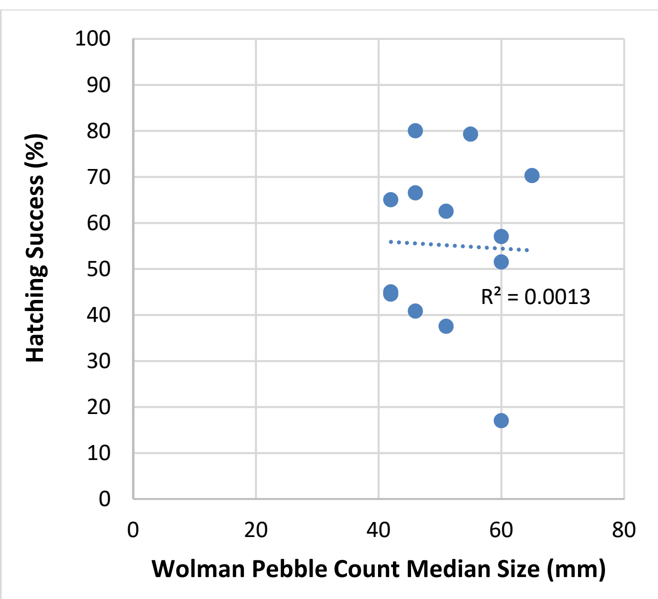
The site visit to Morley River on January 5, 2018 indicated that the alevin were very advanced and nearly the swim up fry stage at 798 ATUs (Photo A14; APPENDIX A). The two remaining closed Whitlock-Vibert boxes (mesh bags) were left in place until February 15, 2018 when they were retrieved, and a measure of emergence determined (811 ATUs). These two Whitlock-Vibert boxes (mesh bags) had very high survival (91% at Site M02 and 94% at Site M03) with individuals being at the swim up fry stage (Photo A15-A16; APPENDIX A). During both winter sites visits, the egg planting sites in Morley River were free of surface ice and there appeared to be sufficient water flow over all sites (Photo A17; APPENDIX A).

3.6.4.2 Deadman Creek

Three site visits were conducted at site DC4 in Deadman Creek during the first two weeks of January to determine a hatching date which would inform the remaining winter success monitoring. Based upon these site visits, it was determined that egg hatching at this site occurred on approximately January 15, 2018 at a water temperature of 0° C and ATUs of 337 (Photos A18-A19; APPENDIX A).

A winter site visit to Deadman Creek was conducted on February 15-18, 2018 to document winter conditions and retrieve as many open incubation media as possible and check on a portion of the closed incubation media. Incubators were assessed for the number of eggs that had hatched at this time. The mean hatching rate was 56%; however, there was variation between sites and incubation media type (Table 7). The highest hatching rate (80%) was located at site DC4 as compared to the lowest (17%) at site DC16 (Table 7). This difference suggests that there is considerable variation in the suitability of incubation conditions in Deadman Creek. In general, hatching success was highest at the sites further downstream in Deadman Creek (sites DC2, DC3 and DC4) and lower further upstream (Table 7). The closed Whitlock-Vibert boxes (mesh bags) had the highest mean hatching rate (64.5%, SE = 11.96, n = 4) followed by the Jordan Scotty incubators (55.2%, SE = 4.4, n = 24) and Whitlock-Vibert boxes (53.6%, SE = 6.5, n = 10; Table 7). Hatching success was compared to substrate size and water velocity (just above bed) at the time of egg planting in August 2017. The was no trend with substrate size and a very weak trend with water velocity; however, this negative trend appears to be driven by a single data point (17 % hatching success at site DC16; Figure 7).

At the time of the winter site visit, all sites had complete ice cover and although there was considerable variation in ice thickness, all sites appeared to have sufficient water flow over the egg incubation media (Photo A20; APPENDIX A). One possible exception was site DC6 where substantial ice coverage had contacted some of the larger boulders at the site and prohibited the ability to assess water flow conditions.



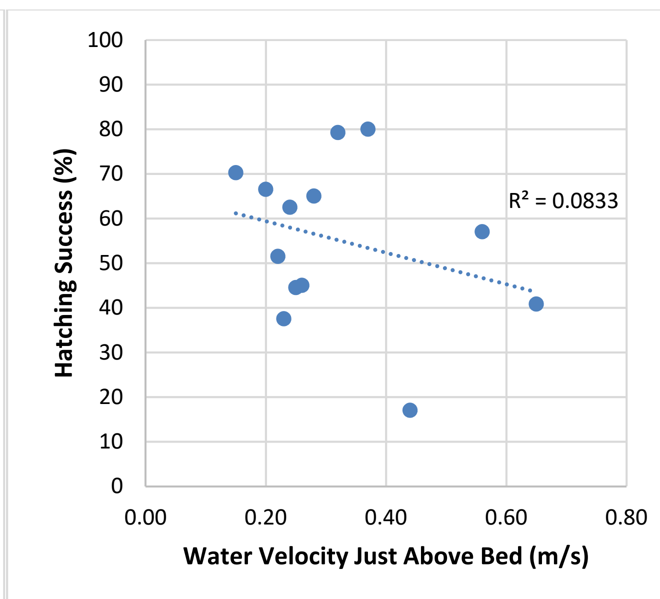


Figure 7. Deadman Creek hatching success compared to substrate size (left) and water velocity (right).

Table 7. Summary of Deadman Creek hatching success (February 15-18, 2018).

Site	Incubator Type [A]	Total Eggs Planted	ATUs	Dead Eggs	Dead Alevin	Live Eyed	Live Alevin	Inferred Hatching Success [B] (%)
DC2	WVB	200	355	96	4		52	50
	WVB	200		54	3		97	72
	Scotty	200		37	16		63	74
	Scotty	200		24	6		108	85
DC3	WVB	200	343	30		5	152	85
	Mesh bag	190		22	4		164	86
	Scotty	200		61	1		100	69
	Scotty	200		43	4		121	77
DC4	Mesh bag	200	334	34			166	83
	Scotty	200		44	4		98	76
	Scotty	200		36	2		130	81
DC6 [C]	Scotty	200	-	35				83
	Scotty	200 [D]		96	21			42
	Scotty	200 [D]		139				31
	Scotty	200 [D]		134				33
	Scotty	200 [D]		181				10
	Scotty	200 [D]		108				46
DC8	WVB	200	372	46	16		44	69
	WVB	200		20	2		136	89
	Scotty	200		9	92	1	64	50
	Scotty	200		5	79		87	58
DC9	Mesh bag	89	-	42	1		46	52
	Mesh bag	100		63			37	37
DC10	Scotty	200	375	45	76		51	40
	Scotty	200		68	33		67	50
DC11	WVB	100	-	33	2		54	65
DC12	WVB	200	324	128	5		53	34
	WVB	200		119	5		45	38
	Scotty	200		61	26		41	57
	Scotty	200		127	32		31	21
DC14	Scotty	200	340	82	1		78	59
	Scotty	200		64	5		67	66
DC15	Scotty	200	368	83	9		59	54
	Scotty	200		86	16		69	49
DC16	WVB	200	328	119	36		13	23
	WVB	200		163	15		2	11
DC17	Scotty	200	339	84	19		56	49
	Scotty	200		53	17		103	65

[A] Where WVB – Whitlock-Vibert box, Scotty – Jordan Scotty incubator and mesh bag – closed WVB box.
[B] Inferred survival assumes that a proportion of the alevins had already exited the incubators.
[C] Could not be retrieved in February due to ice contact with large boulders at the site. Incubators retrieved June 6, 2018.
[D] These Scotty incubators were deployed in a 5 pack which is inconsistent with all other Scotty incubators which were deployed in single packs.

Data on fry emergence in Deadman Creek was collected through the retrieval of closed Whitlock-Vibert boxes (mesh bags) on June 6 and 7, 2018 (Photo A21-A22; APPENDIX A); ATUs for the egg planting sites ranged from 461 to 484 at the time of retrieval (only two of the sites contained temperature loggers). Mean emergence success was 25 % (SE = 9.3 , n = 7) but was widely variable ranging from a low of 2% to a high of 60% (Table 8). Variability was also high within sites, with both sites DC2 and DC15 showing very different emergence success for paired closed incubation media which were located directly beside one and other. During mean emergence success calculations, the closed incubation media from sites DC10 and DC17 were excluded, as they were found exposed/dislodged at the time of retrieval. Many of the mesh bags were found to contain a large accumulation of sand at the time of retrieval, which appeared to be correlated with emergence success (Photos A23-A24; APPENDIX A). These findings are also supported in the literature, where higher sediment loads have been shown to affect salmonid emergence and development (Burton et al. 1990, Greig et al. 2005)

Table 8. Summary of Deadman Creek emergence success (June 6-7, 2018).

Site	Incubator Type [A]	Total Eggs Planted	ATUs	Dead Eggs	Dead Alevin	Live Fry	Inferred Emergence (%) [B]
DC2	Mesh bag	200	461	77	3	119	60
	Mesh bag	200		61	107	9	5
DC8	Pipe bag	200	-		3	11	6
DC9	Mesh bag	200	-	76		4	2
DC10	Mesh bag	200	484	114	19	56	28
DC15	Mesh bag	200	-	107	59	29	15
	Mesh bag	200	-	71		114	57

[A] Where mesh bag – closed WVB box and pipe bag – egg insertion pipe into a mesh bag.
[B] Inferred survival incorporates the number of live emergent fry observed and the total number of eggs initially planted. In many instances, the fate of individual dead eggs/alevin could not be determined.

Accumulated thermal unit data from Deadman Creek indicate that the rate of development was considerably different than the typical development for Chinook salmon (Vano Pers. Comm. 2017). Yukon River Chinook typically become eyed eggs around 280 ATUs and hatch into alevin at 480 to 540 ATUs. The Deadman Creek eggs (site DC4) hatched on approximately January 15, 2018 at 337 ATUs. Emergence as fry typically occurs from 900-1000 ATUs; however, very advanced alevin at or near emergence were documented at less than 500 ATUs at 5 sites in Deadman Creek during early June 2018.

4 DISCUSSION

The juvenile Chinook monitoring during 2017 confirmed that Deadman Creek is used for rearing by non-natal juveniles. The lack of Chinook captured in the stream during June followed by increasing numbers during the late summer and fall is also consistent with previous sampling in the watershed (Wilson 2003, 2004, EDI 2017). It appears likely that the non-natal juveniles originate further upstream in the Teslin River watershed and enter Deadman Creek during the mid-summer to take advantage of the high-quality rearing habitats. For the purpose of this restoration project, the presence of large numbers of non-natal juveniles complicates the ability to determine the presence of fry originated from eggs planted in the stream during the previous year. The September sampling event did capture a number of smaller juveniles; however, it cannot be said for certain if these individuals originated from eggs planted in Deadman Creek during August 2016. With an increased number of eggs planted during August 2017, it is possible that additional minnow trapping during the fall of 2018 may provide further insights into the presence of fry originating from eggs planted in the stream.

The Whitlock-Vibert boxes and Jordan-Scotty incubators in Deadman Creek are used to provide a measure of hatching success. The mean hatching rate was lower in Deadman Creek than Morley River; however, a portion of the sites had hatching success which was comparable to Morley River. In order to determine which factors may influence hatching success in Deadman, we compared substrate size and water velocity at the time of egg planting. Neither of these parameters explain the variability in hatching success. Based upon the observation of site conditions, the amount of sediment in the incubators appears to be correlated with hatching success; greater sediment accumulation is correlated with lower survival (Burton et al. 1990, Greig et al. 2005). For this reason, the placement of the egg planting sites in proximity to the thalweg of the stream is likely a key factor which influences hatching success. This is particularly important during the winter months when the stream is completely ice covered and water velocities are decreased. For example, sites DC4 had the highest hatching success (80%) and was located in the thalweg of a riffle. Such conditions would have allowed for the eggs to remain oxygenated despite slight sedimentation and reduced flows during the winter months.

Consistent with the results from the 2016/2017 project (EDI 2017) the high egg hatching rate at the control sites in Morley River suggest that the methods used to fertilize and plant the eggs are valid and that egg incubation conditions in this location are very good. These highly suitable incubation conditions allowed for the feasibility of a new egg incubation media (closed Whitlock-Vibert boxes/mesh bags) to be tested with the purpose of providing a measure of emergence success beyond hatching success. This incubator was developed to provide a surrogate for eggs deployed in the egg insertion pipes which are 'open'. The two incubators of this type had very high survival in Morley River (91% and 94%) which demonstrates their effectiveness. Of the 10 closed mesh bags which were left in Deadman Creek through to fry emergence (June), survival data was available from seven of the bags as three were dislodged during spring freshet. There was a considerable amount of variation in emergence success which appeared to be related to sedimentation. Deadman Creek experienced a very large freshet event during the spring of 2018 and it is possible that this may have adversely effected alevin survival in the mesh bags. Despite the variation in survival observed in the mesh bags, the survival of approximately 60% at two different sites provides promise for the continued use of this planting method. The closed mesh incubators were filled with river bed material and likely provide the most natural representation of egg to fry survival over the open Whitlock-Vibert boxes and Jordan-Scotty incubators which are an artificial form of incubation. It is also possible that the closed mesh bags may underestimate emergence success; during challenging conditions for survival (sedimentation), the alevins contained within the bags are unable to move within the stream. Under high sediment conditions, survival may be higher if the alevin are able to move within the substrate in order to find microhabitats which are more conducive to survival and provide respite from sedimentation.

The ATU data collected in combination with the egg planting sites suggests that the rate of development in Deadman Creek is more accelerated than would be suggested by the literature and knowledge from elsewhere. Our findings indicate that eggs/alevin continue to develop at some minimum rate, despite very cold temperatures. At planting site DC4, hatching occurred on approximately January 15, 2018 at 327 ATUs, approximately 170 ATUs less than what would have been expected. Based upon this information, we can calculate that the eggs continued to develop at a rate of approximately 1.6 ATUs per day to achieve a total of 480 ATUs by the observed hatching date in January 2018. This rate of development was despite actual water temperatures less than 0.2 ˚C from mid-October through the remainder of the winter. The same calculation was continued to early June at the time of the emergence monitoring. This resulted in a modified ATU count 784 (actual 441) which appears to be appropriate for the development of the emergent fry observed.

5 CONCLUSION

The current project continued to refine the methods used for restoring a Chinook stock to Deadman Creek through the use of egg planting. Over the previous two years, the ability to successfully collect broodstock and plant fertilized eggs has been confirmed; however, we continue to focus on determining the most feasible and effective methods of success monitoring. Morley River provides a suitable control for testing such monitoring methods given the highly suitable incubation conditions present, and future years of the project should continue to utilize this control area for this purpose. Hatching and emergence success was quite variable in Deadman Creek during 2017/2018; however, the presence of some sites with high survival is promising for the long-term success of this projects. In future years of the project, it is recommended that an adaptive approach be used to maximize egg survival through a combination of more informed site selection, egg planting methods and associated success monitoring.

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APPENDIX A. PHOTOGRAPHS

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Photo A1. Baited minnow trap set in Deadman Creek, Site 1 shown.

Photo A2. Site preparations at Site DC4 in Deadman Creek. Red pipes indicate egg insertion pipe locations.

Photo A3. **Site preparations in Deadman Creek. Plastic bins of stream bed material are pre-filled to expedite their placement during the egg planting component of the work.**

Photo A4. **Female Chinook brood stock captured in Morley River.**

Photo A5. Male Chinook brood stock captured in Morley River. Note the yellow Floy tag inserted below the dorsal fin for later identification.

Photo A6. Y2C2 students observe a Chinook egg take on Morley River.

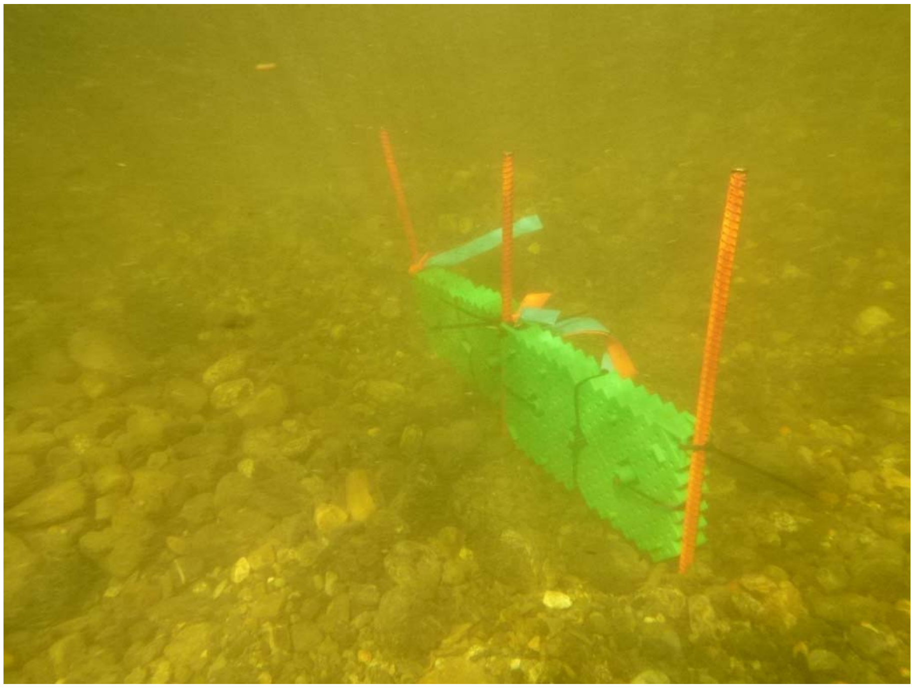

Photo A7. **Loaded Jordan Scotty incubators mounted to the stream bed in Morley River (prior to buried with substrate).**

Photo A8. **Loaded Jordan Scotty incubators mounted to the stream bed in Morley River (after being buried with substrate). Note the white PVC pipe – egg insertion pipe in the background.**

Photo A9. Closed Whitlock-Vibert boxes (mesh bag) contained in a mesh bag/plastic box prior to placement in Morley River.

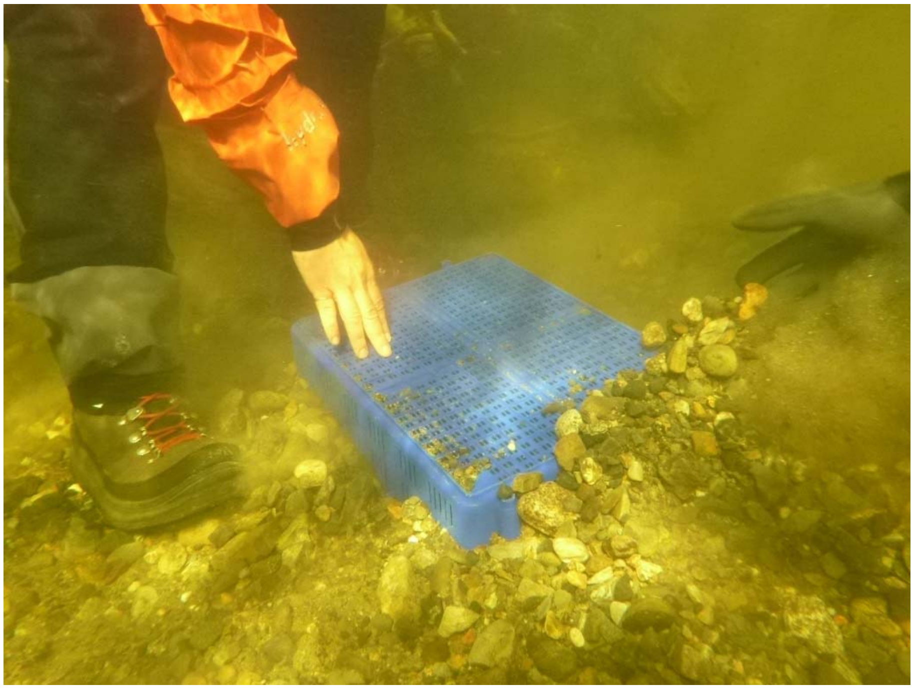

Photo A10. Closed Whitlock-Vibert boxes (mesh bag) contained in a mesh bag/plastic box being buried with substrate in Morley River.

Photo A11. Egg insertion pipes (white PVC tubes) prepared at sites DC09 (foreground), DC10 and DC11 (background) in Deadman Creek.

Photo A12. Mixing eggs with milt during egg fertilization.

Photo A13. Recently hatched alevin in Morley River on October 12, 2017; site M02 shown; ATUs = 638.

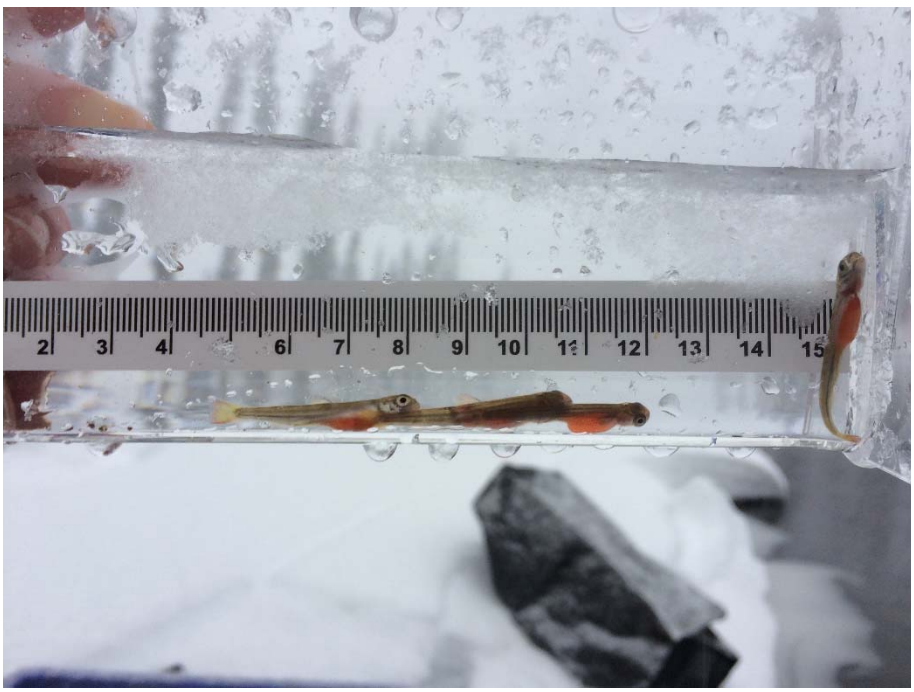

Photo A14. Well developed alevin retrieved from a closed Whitlock-Vibert box (mesh bag) at site M02 in Morley River on January 5, 2018; ATUs = 797.

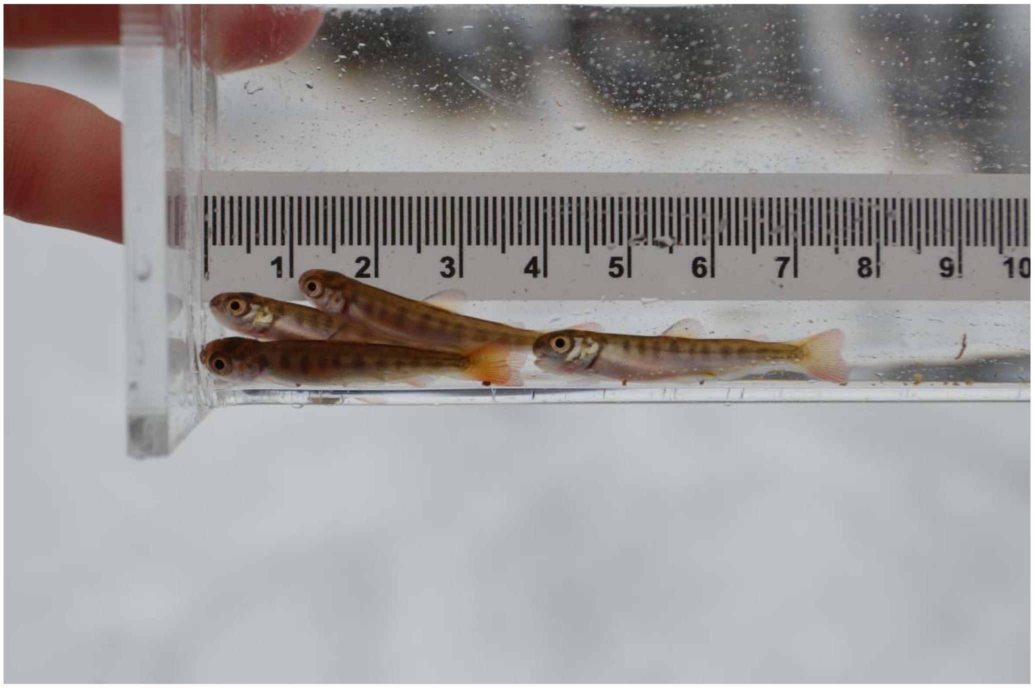

Photo A15. Side view of emergent fry retrieved from a closed Whitlock-Vibert box (mesh bag) at site M02 in Morley River on February 15, 2018; ATUs = 811.

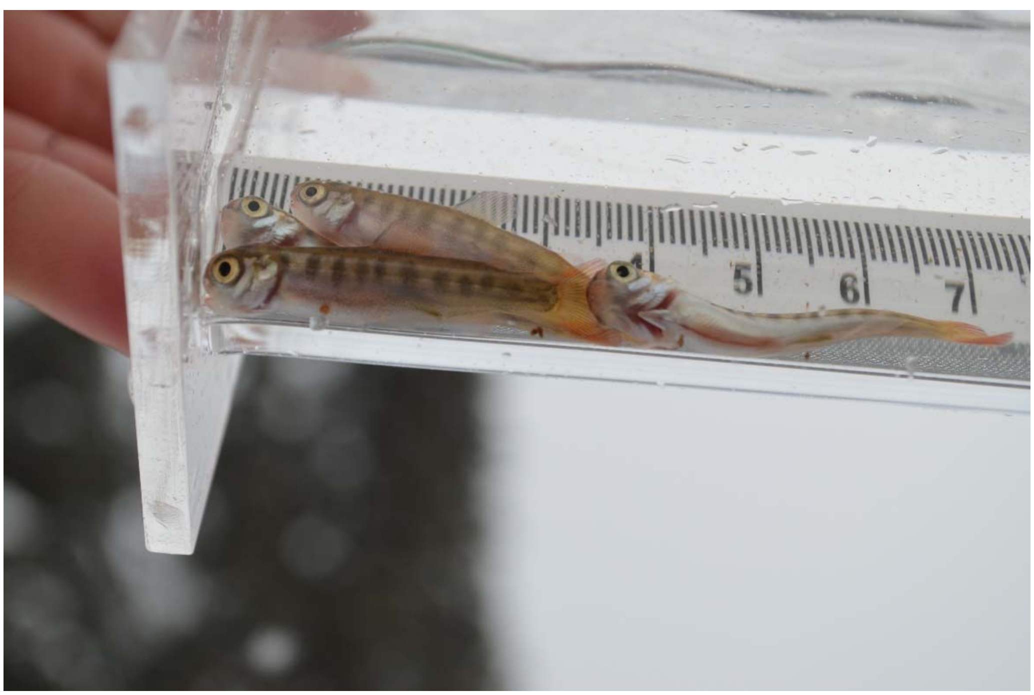

Photo A16. Ventral view of emergent fry retrieved from a closed Whitlock-Vibert box (mesh bag) at site M02 in Morley River on February 15, 2018; ATUs = 811.

Photo A17. Overview of typical winter conditions within the study area reach on Morley River, February 15, 2018. Note extensive open water and limited ice formation.

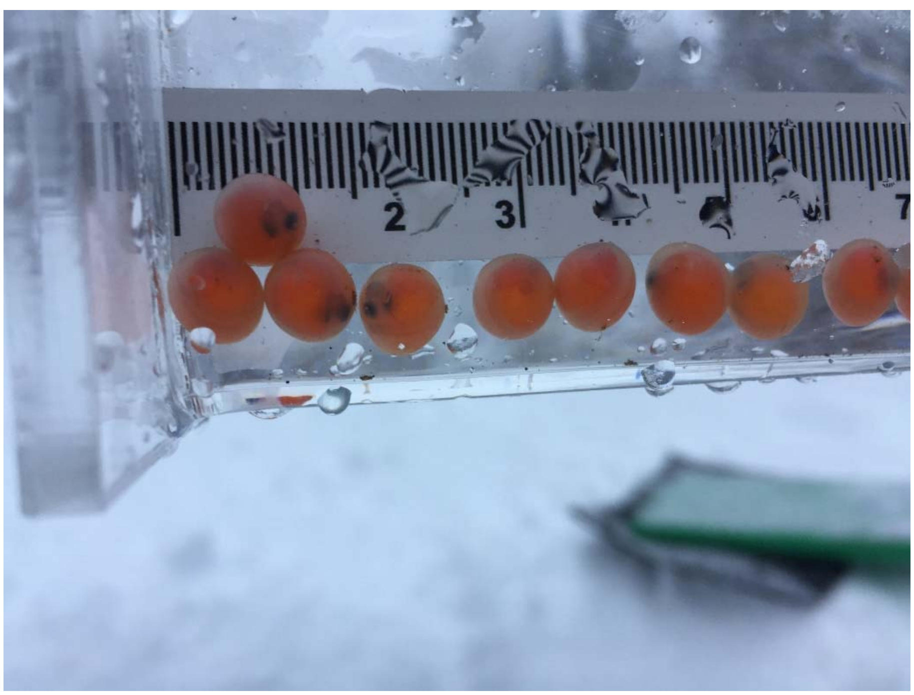

Photo A18. Advanced eyed eggs from site DC04 in Deadman Creek on January 5, 2018; ATUs = 333.

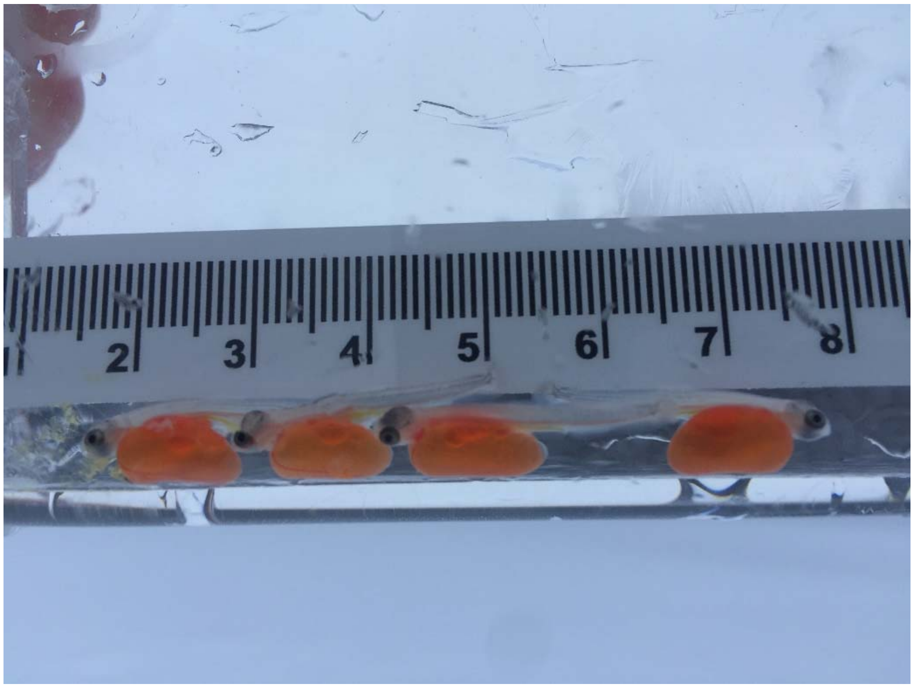

Photo A19. Recently hatched alevin from site DC04 in Deadman Creek on January 17, 2018; ATUs = 334.

Photo A20. Overview of typical winter conditions on Deadman Creek. Vicinity of site DC06 shown, February 16, 2018.

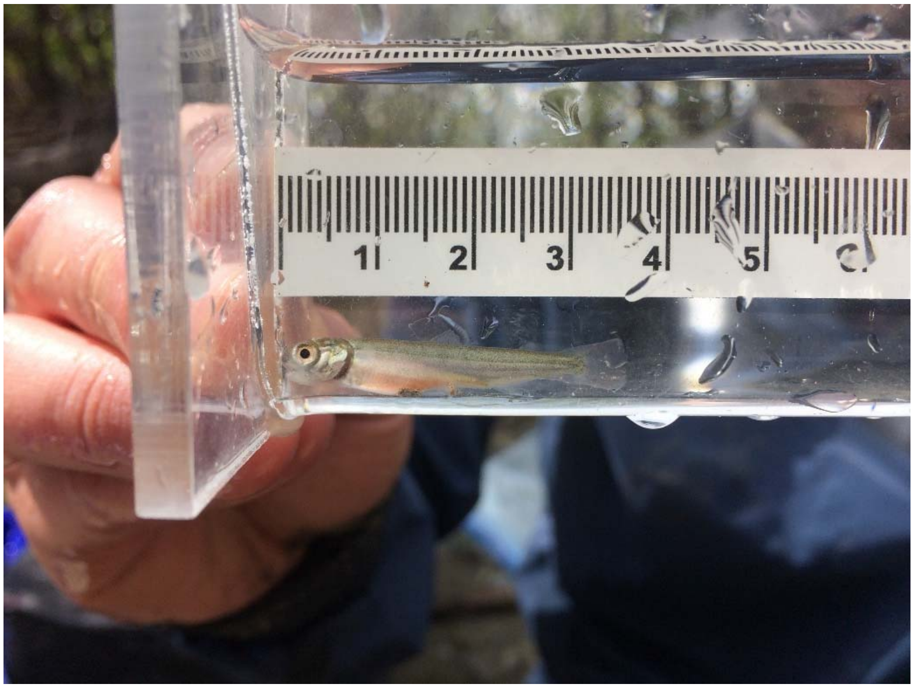

Photo A21. **Emergent fry from site DC02 on Deadman Creek, June 7, 2018; ATUS = 461.**

Photo A22. **Group of emergent fry from site DC02 on Deadman Creek, June 7, 2018; ATUs = 461.**

Photo A23. Closed Whitlock-Vibert boxes (mesh bag) retrieved from Deadman Creek on June 8, 2018. Site DC15 shown, note minimal amount of sediment within the bag. This bag contained 57% of live emergent fry.

Photo A24. Closed Whitlock-Vibert boxes (mesh bag) retrieved from Deadman Creek on June 8, 2018. Site DC09 shown, note extensive amount of sediment within the bag. This bag contained 2% of live emergent fry.