Technical Report Overview

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Report: Upper Fording River Westslope Cutthroat Trout Population Monitoring Project: 2017

Overview: This report presents the 2017 recommendations for a long-term Westslope Cutthroat Trout Population monitoring strategy in the upper Fording River. The report addresses the recommendations from the Westslope Cutthroat Trout Population Assessment and Telemetry Project Report.

This report was prepared for Teck by Westslope Fisheries Ltd.

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Upper Fording River Westslope Cutthroat Trout Population Monitoring Project: 2017

Study Period: 2012 to 2017

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Cover Photo: Two snorkel team members enumerating Westslope Cutthroat Trout on Fording River Operations (FRO) property, upper Fording River, September, 2012.

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[3] Data has been archived and is considered confidential. Data requests should be referred to Teck Coal Limited, Sparwood Environmental Office, 124B Aspen Drive, Sparwood, BC, V0B 2G0.

Executive Summary

The upper Fording River Westslope Cutthroat Trout Population Monitoring Project: 2017 addresses the recommendation of the Westslope Cutthroat Trout Population Assessment and Telemetry Project Final Report for a long-term population monitoring strategy. The recommendation was made to track trends of Westslope Cutthroat Trout abundance in the upper Fording River to ensure the long-term objectives of population viability and sustainability are being met. This was considered necessary given the statistical uncertainty remaining in population estimates, perceived threats identified that may limit population productivity and the rehabilitation habitat offsetting measures under way that are designed to address those perceived threats (*i.e.,* limiting factors) and improve population productivity.

The upper Fording River Westslope Cutthroat Trout population monitoring program recognizes catch-per-unit-effort (CPUE) indexing methods are extremely sensitive to methodology deviations that affect catchability. For this reason, trend monitoring included two independent CPUE population metrics to increase confidence in the interpretation of population trends. These included; 1) sub-adult and adult snorkel counts (fish greater than 200 mm) and a Pooled Peterson Model that used previously calibrated observer efficiencies, and 2) fry and juvenile (fish less than 200 mm) three pass removal-depletion density estimates.

The 2017 snorkel program enumerated 3,672 fish in total. This was more than double the previous survey counts in 2012, 2013 and 2014. This includes 2,099 juveniles less than 200 mm and 1,573 sub-adults and adults greater than 200 mm. Since the previous snorkel count (2014), the juvenile count increased fivefold (*i.e.,* 407%) and the sub-adult and adult count of fish greater than 200 mm increased by 46%. While the snorkel count includes juveniles in the database (fish less than 200 mm), this data is tracked as a count but not included in the population estimate. This was due to the limitations of the mark – recapture methods employed in 2012 through 2014 (*i.e.,* fish greater than 200 mm). Observer efficiency is correlated with fish size and a separate mark recapture observer efficiency calibration would be required. This was considered unnecessary as relative juvenile abundance is tracked through three pass removal depletion estimates and the metric of interest for the snorkel methods was the number of mature fish within the population.

A Pooled Peterson model utilizing the 2017 count data and the previous years' mark – recovery calculation and observer efficiency estimates (2012, 2013, 2014) was used for the estimation of sub-adult and adult population abundance. The resulting three 2017 abundance estimates vary between 3,690 to 6,240 fish greater than 200 mm (median 4,908). Note that while all three 2017 model estimates are presented, these estimates are not a range but represent a measure of sensitivity to CPUE (catchability or observer efficiency) depending on which of the three previous years observer efficiencies are input into the 2017 pooled Peterson model.

The median and range of the three Pooled Peterson model estimates for 2017 most likely over-estimate the 2017 population abundance based on the flow and visibility conditions in 2017. The 2017 environmental conditions (flow) were most consistent with the highest of the three model estimates for observer efficiencies (42% in 2012) and visibility ratings (*i.e.,* catchability) were most consistent with the higher two of the three model estimates for observer efficiencies (42% in 2012, 32% in 2014). This would provide weight to the lower two model estimates of 3,690 and 4,908 Westslope Cutthroat Trout greater than 200 mm. This was consistent with the professional judgement of the biologists who were snorkel

observers in all four surveys who indicated the expected value should be consistent with the 2012 conditions and observer efficiencies.

Therefore, given the above rationale (flow and visibility and their effect on observer efficiency) and based on a recommended precautionary Westslope Cutthroat Trout management approach when faced with uncertainty, the estimate of 3,690 Westslope Cutthroat Trout greater than 200 mm was used for further trend and regional comparisons.

Based on the 2017 model estimate of 3,690 fish greater than 200 mm (*i.e.,* sub-adult and adult population) the point estimates appear to be increasing in the first three years (2012 to 2014) and stable since 2014, but the evidence of an increase in population size among the years was weak (95% confidence intervals overlap). The 2017 estimate (3,690 fish greater than 200 mm) represents an increase of 45% since 2012 and was essentially equal to the 2014 estimate.

While the adult population abundance appears to be stable, the current range of density estimates (2012, 2013, 2014, 2017) of between 22 to 28 fish per km for large Westslope Cutthroat trout (*i.e.,* fish greater than 300 mm) was much less than reference targets of between 45 and 95 fish per km to ensure, “The desired population target to maintain the population at or near a target abundance level that can provide sustainable societal benefits without risk of severe population decline and associated at-risk conservation determinations”, (DFO 2017).

The mean overall density of fry and juveniles combined (fish less than 200 mm) have shown a significant statistical increase every year since monitoring began. The 2017 mean density (13.38 fish/100 m^2) represents a 3.23 times increase since 2013 (4.14 fish/100 m^2). The data illustrates the increases in fry and juvenile densities have been broad based across all mainstem strata (lower, mid-, upper watershed) and the lower tributary strata. Upper tributary locations have not increased proportionally with the rest of the watershed strata and was assumed to be due to lost connectivity (*i.e.,* impassable culvert barriers or size based life stage limits to culvert passage) and resulting habitat fragmentation. The fry and juvenile density data generated using three pass removal depletion methods was further supported by the snorkel count data. The count data also documented a large increase in juvenile counts in 2017 (414 fish less than 200 mm in 2014 and 2,099 fish less than 200 mm in 2017). The majority of the juveniles were 1^+ to 3^+ age classes (60 to 200 mm) spawned in 2014, 2015, and 2016 after the 2013 flood event.

Fry and juvenile population monitoring began in 2013 immediately following the 2013 flood event (second highest flow event on record 1970 – 2017; Water Survey Canada Stn 08NK018). Fry and juvenile increases appear to be, at least in part, a recovery response to the stream channel and fish habitat impacts resulting from the 2013 flood. The recovery response may also represent high egg to fry survival conditions and strong juvenile year classes in the moderate to low freshet flows in the years immediately following the 2013 flushing event. A flushing event, refers to flood flows of sufficient force to result in bedload (*i.e.,* particles such as gravels and cobbles transported in water through rolling, sliding or saltating) that “flush” fines from streambed substrates to the benefit of salmonid embryo, alevin, fry and juvenile interstitial habitats.

In summary, fry and juvenile densities have increased significantly in the five years since the June 2013 flood event. Sub-adults and adults (fish greater than 200 mm) and large Westslope Cutthroat Trout (fish greater than 300 mm) have remained stable (or perhaps increased slightly). Such a response would be expected given the timeframe since angling prohibition (7 years), since monitoring began (5 years) and the time lag expected for Westslope Cutthroat Trout within the upper Fording River to reach a length greater than 300 mm (7 years). It was predicted the large cohort of juveniles documented in the snorkel count and in removal depletion density estimates will recruit into the sub-adult and adult population (fish greater than 200 mm) over the next three years (2018, 2019 and 2020); thus resulting in further increases in adult snorkel counts and additional power in interpreting an increasing population trend. Further increases should be possible and probable given; 1) the continued angling prohibition (since 2010), 2) improvements in juvenile densities due to post flood recovery, and 3) the habitat off-setting works targeting limiting factors and improvements to habitat carrying capacity.

The relative index methods were employed successfully and population monitoring objectives were achieved. It is recommended the upper Fording River Westslope Cutthroat Trout Population Monitoring Project proceed with the population monitoring as scheduled in 2019 and 2021. Given the large amount of ongoing habitat off-setting works and uncertainty in model estimates there may be value in considering annual population monitoring.

Acknowledgements

This study is part of a co-operative initiative funded by Teck. While Westslope Fisheries Ltd. has been retained by Teck to undertake the Project, the study team was a partnership between Westslope Fisheries Ltd., the Canadian Columbia River Inter-tribal Fisheries Commission (CCRIFC), Lotic Environmental Ltd., Nupqu Development Corporation, and Thomas Resources; with support from Dr. Carl Schwarz (Simon Fraser University) and Ktunaxa Nation Council, Lands and Resources Agency, GIS Services.

The upper Fording River Westslope Cutthroat Trout Population Monitoring Project was implemented under the guidance and direction of the Elk Valley Fish and Fish Habitat Committee (EVFFHC). The EVFFHC consists of representatives from Teck, the Ktunaxa Nation Council, BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR), and Department of Fisheries and Oceans Canada (DFO).

Special thanks are extended to Teck as the funding source and for their striving for a standard of excellence that permitted the results of the Project. Special thanks to Lindsay Watson and Warn Franklin (Teck Project Managers) for their support, advice, and assistance. The many employees of Teck Fording River Operations that facilitated the safe and effective completion of field studies are greatly appreciated.

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1 Introduction

Teck Coal Limited ("Teck") operates three surface coal mines within the upper Fording River watershed upstream of Josephine Falls; 1) Fording River Operations (FRO), 2) Greenhills Operations (GHO), and 3) Line Creek Operations (LCO). The current permitted boundaries for the three operations are illustrated in Figure 1.1. The primary product is high-quality, metallurgical coal. The combined annual production capacity of the three mines is approximately 17 million metric tonnes of clean coal (Mtcc).

Production at FRO began in 1971 and the operation (approximately 7,000 ha) lies along the Fording River valley with mining on both the east and west sides of the river. GHO was originally opened in 1981 and the current operational area (approximately 3,100 ha) lies mostly along the height of land between the Fording River and the Elk River to the west. LCO includes activities in the upper Dry Creek watershed, a tributary within the upper Fording River watershed.

In addition to mining, forest harvesting, recreational activities, road, trail, railway, natural gas pipeline, wells and drill pad developments and exploration related disturbances also occur in the upper Fording River watershed. During the Environmental Assessment (EA) review process for the extension of mining development proposals in the area (*i.e.,* FRO Swift, LCO Phase II), concerns were raised by communities of interest about the lack of information regarding the status of the Westslope Cutthroat Trout population in the upper Fording River watershed.

In 2010, the Province of British Columbia closed the upper Fording River to angling due to uncertainty around the population status. In 2012, Teck commissioned the Upper Fording River Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Population Assessment and Telemetry Project, ("population assessment project") which was a 3.3 year study (August 2012 to November 2015, Cope *et al.* 2016). The population assessment project final report provided supporting data for decision making around land use planning and fisheries management in the upper Fording River watershed upstream of Josephine Falls.

The population assessment project concluded that the upper Fording River population metrics of adult abundance (2,552 to 3,874 fish greater than 200 mm), habitat availability (57.5 km of mainstem river plus 59 km of tributary) and genetic integrity (pure strain) represented a viable Westslope Cutthroat Trout population. However, there remained two key statistical uncertainties that required further population monitoring and four perceived threats to population resilience identified that required mitigation or offsetting to ensure long-term population sustainability.

Statistical uncertainty following the population assessment project remained due to; 1) point estimates for sub-adult and adult abundance appeared to be increasing over time (2012, 2013, 2014) but the 95% confidence intervals were wide enough (*i.e.,* overlap among years) that the evidence of an increase in population size among the three years was weak, and 2) differences between the mortality rate estimates of radio tagged Westslope Cutthroat Trout (*i.e.,* 21% to 32% per year) and those used by the model authors to estimate the amount of stream required to maintain a population (*i.e.,*10%, Hilderbrand and Kershner 2000).

The following perceived threats to population sustainability were identified; 1) water quality and quantity concerns, 2) loss of connectivity and resulting tributary habitat fragmentation due to valley infill and

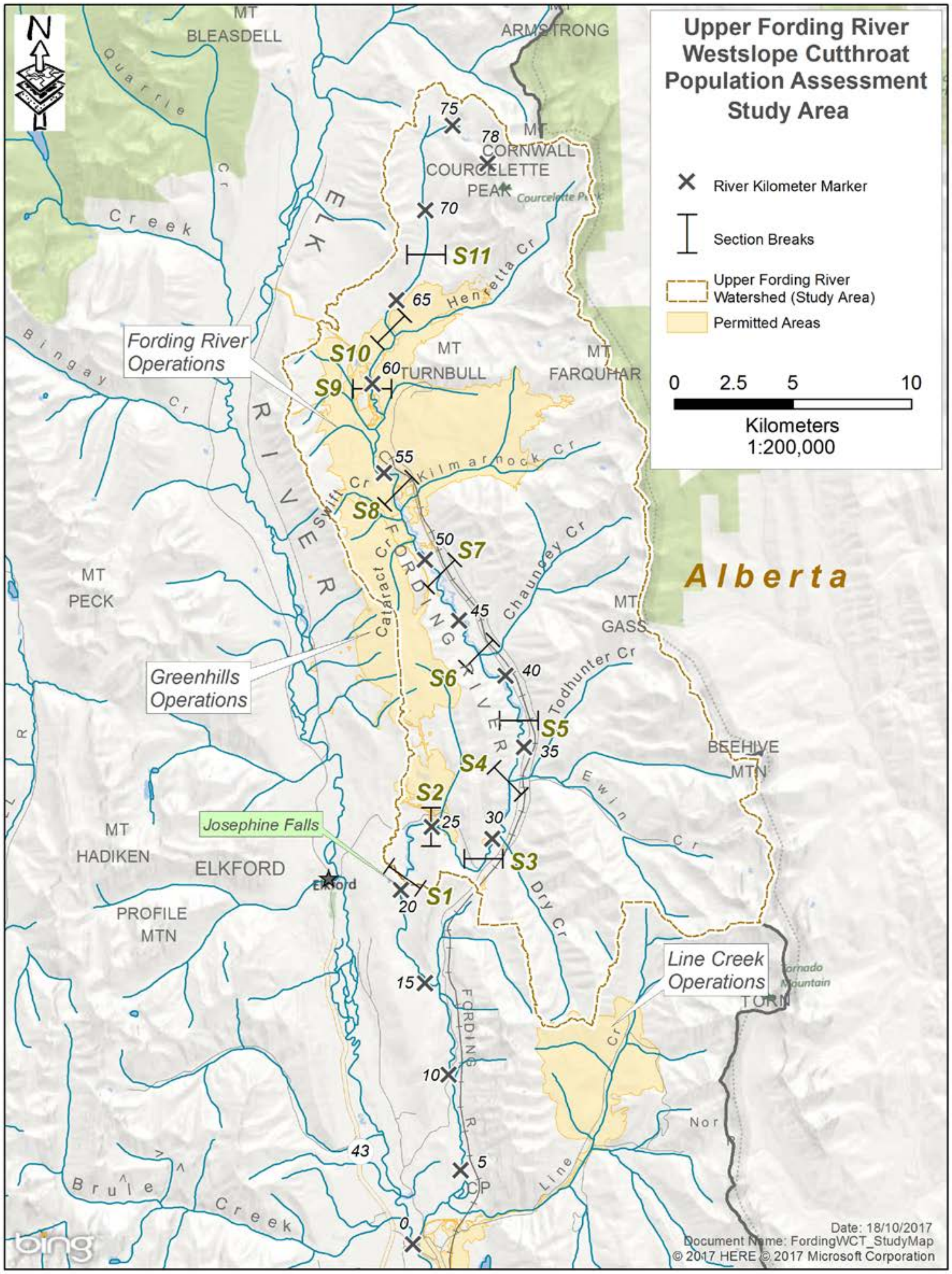


Figure 1.1. Upper Fording River study area illustrating population assessment river segments (S1 to S11) and mine property boundaries. Note that mine boundaries are for illustrative purposes and Teck should be contacted for the current or exact boundaries.

constructed fish passage barriers, 3) degraded stream channels, and 4) potential re-introduction of angling. The population assessment project concluded that the long-term sustainability of a healthy, self-sustaining population of Westslope Cutthroat Trout in the upper Fording River should be possible, if not probable, provided the implementation of suitable management strategies (*e.g.,* water quality treatment, water quantity protection, habitat protection, effective habitat offsetting, stream and riparian rehabilitation programs, and continued angling prohibition).

Perceived threats were identified as opportunities and ongoing initiatives by Teck have already targeted some of the identified threats for habitat offsetting projects focused on specific river segments and limiting factors. In 2016 and 2017, in collaboration with the Elk Valley Fish and Fish Habitat Committee (EVFFHC), habitat offsetting measures (rehabilitation) were constructed and additional offsetting measures are planned to be constructed over the next several years.

The upper Fording River Westslope Cutthroat Trout Population Monitoring Project: 2017 (“population monitoring project”) addresses the recommendation of the population assessment project for a long-term population monitoring strategy. The recommendation was made to track trends of Westslope Cutthroat Trout abundance in the upper Fording River to ensure the long-term objectives of population viability and sustainability are being met.

1.1 Background

Westslope Cutthroat Trout are a key fisheries resource in the Fording River watershed and is the only fish species known to occur in the upper Fording River upstream of Josephine Falls. The presence of Josephine Falls prevents upstream movement of fish protecting this population from hybridization with non-native Rainbow Trout (and competition with non-native species in general). As such, the upper Fording River can be considered an isolated upstream refuge where genetically pure Westslope Cutthroat Trout are present (Carscadden and Rogers 2011). Previous studies have identified the upper Fording River Westslope Cutthroat Trout population as one of a limited group to qualify as genetically pure (Rubidge and Taylor 2005, Rubidge *et al.* 2001), thus making them an important population in the context of Westslope Cutthroat Trout conservation.

The Fording River is a tributary to the Elk River located within the Regional District of East Kootenay, in southeastern British Columbia. The Fording River drainage basin is located on the west slope of the Rocky Mountains and encompasses an area of approximately 621 km^2 with a mean annual discharge of 7.93 m^3/s (Water Survey Canada, Stn 08NK018, 1970-2010). The river flows 78 km in a southerly direction from its headwaters immediately west of the British Columbia – Alberta boundary and the continental divide to its confluence with the Elk River near Elkford, B.C. Josephine Falls represents a natural fish barrier in a steep-walled canyon and is located at river kilometer (rkm) 20.51.

The Fording River is a tributary to the Elk River, which is one of seven major streams (Bull, Elk, Skookumchuck, St. Mary, Upper Kootenay, Wigwam and White Rivers) and their tributaries in the upper Kootenay River watershed that were designated as Class II Classified Waters in 2005 (Anon. 2006). The classified waters licensing system was created to preserve the unique fishing opportunities provided by these waters, which contribute substantially to the province’s reputation as a world class fishing destination (Heidt 2007).

These seven streams within the upper Kootenay River watershed in the Rocky Mountains of southeast British Columbia are recognized as range-wide strongholds for Westslope Cutthroat Trout and currently support an intensive, high quality recreational fishery. It is generally recognized that this is due to the fact that these watersheds are some of the most pristine and diverse landscapes within the species range (Isaak *et al.* 2012, Muhlfeld *et.al.* 2009). Although there are many healthy populations of Westslope Cutthroat Trout in the East Kootenay, Westslope Cutthroat Trout are a blue-listed species (*i.e.,* species of concern; formerly vulnerable) in British Columbia (Conservation Data Centre (CDC) 2004) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the British Columbia population of Westslope Cutthroat Trout as Special Concern in November 2006 (COSEWIC 2006). Currently, the federal Species at Risk Act (SARA) lists the British Columbia population of Westslope Cutthroat Trout as Special Concern under Schedule 1 of SARA. If a project is subject to an assessment under the Canadian Environmental Assessment Act, measures must be taken to avoid or lessen any adverse effects of the project on the species. Additionally, fisheries protection and pollution prevention provisions of the Fisheries Act provide protection to this species. DFO in cooperation with the British Columbia Ministry of Environment (MOE) has developed a Management Plan for Westslope Cutthroat Trout (British Columbia population) adopted under Section 69 of SARA (DFO 2017).

1.2 Regulatory Context and Connection to Other Programs

The Environmental Assessment Certificate (EAC) for the Fording River Operations (FRO) Swift Project, a legally binding document for Teck, was issued in September 2015. The Swift Project will develop new operating areas adjacent to existing Fording River operations to provide a mine life extension of 25 years. Condition 12 of the EAC requires Teck to develop and implement a plan to address the final recommendations of the population assessment project. The population monitoring project addresses one of the recommendations.

The population monitoring project also provides supporting information to the following Teck monitoring programs;

1. The Elk Valley Water Quality Program (EVWQP) under Permit #107517 issued under the *Environmental Management Act*. Programs developed as part of the EVWQP include the Regional Fish Habitat Management Plan, Tributary Management Plan, FRO Local Aquatic Effects Monitoring Program, Regional Aquatic Effects Monitoring Program, and Adaptive Management Plan,
2. The FRO Operating Parameters and Procedures Report and Operational Environmental Monitoring Plan for Consumptive Water Licences C133241, C133242, C133243, and,
3. The effectiveness monitoring programs for the LCO Phase II and Swift Project Fish and Fish Habitat Offsetting and Effectiveness Monitoring Plans.

1.3 Consultation

The 2017 population monitoring project was completed considering input from the EVFFHC. The EVFFHC consists of representatives of the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR), the Ktunaxa Nation Council (KNC), Fisheries and Oceans Canada (DFO) and Teck.

An initial kick-off meeting was held with the EVFFHC on October 24, 2016 to review the population recommendations from the population assessment project (Cope *et al.* 2016) and gather input prior to developing the population monitoring project. The population monitoring project was developed based on the study objectives and goals, recommended methodologies and options identified in this meeting. Ensuring consistency in population monitoring provides benefits in regards to ensuring identification of a population trend with sufficient power. Population monitoring data can be used to detect trends (*i.e.,* stable, increasing, decreasing) and as the data set grows, the ability to detect trends improves. This was considered important by the EVFFHC given the relatively low population densities and broad confidence limits currently estimated for this population (Cope *et al.* 2016).

Subsequent meetings were held with the EVFFHC in June 2017 to ensure the population monitoring project was aligned with the data requirements for the habitat offsetting effectiveness monitoring.

Consultation with the EVFFHC will continue throughout the implementation of the population monitoring project. Continued consultation will include input on the methods, results and recommendations. A draft report will be provided to the EVFFHC on March 1 for review with input requested by March 31 and the final report will be completed by April 30 the year after data collection.

1.4 Scope

The 2017 population monitoring project addresses the recommendation of the population assessment project final report for a long-term population monitoring strategy. The 2017 monitoring project is the first year of a proposed monitoring plan to continue snorkel counts and extend the current sub-adult and adult population trend monitoring data (2012, 2013, 2014) to a 6 year data set (2012, 2013, 2014, 2017, 2019, 2021) over a 10 year period. Similarly, continuation of the fry and juvenile density monitoring program will extend the current trend monitoring data (2013, 2014, 2015) to a 6 year data set (2013, 2014, 2015, 2017, 2019, 2021) over a 9 year period. This will reduce uncertainty regarding the population trend and the long-term viability and sustainability of the upper Fording River Westslope Cutthroat Trout population above Josephine Falls.

The 2017 population monitoring project also collects detailed fish distribution, habitat utilization and trend monitoring data for habitat offsetting effectiveness evaluation. In 2016, fish habitat offsetting works began within FRO (River Segments S7, S8, S9 and Henretta Creek). Additional offsetting works are scheduled within these river segments in upcoming years. In 2017, these river segments and Henretta Creek were further sub-divided into a total of 23 treatment and control sub-sections and these data are forwarded to the habitat offsetting monitor.

2 Methods

This section describes the study area, sample locations and the study methods used for the population monitoring project. Population monitoring data can be used to detect trends (*i.e.,* decreasing, stable, increasing) and monitor population sustainability (*i.e.,* does not decrease over time). However; assessing a population's sustainability represents a present day snapshot in time of the current status of a population and should be reassessed if the severity of population threats change, as new threats appear, or as management actions change.

Telemetric methods used to support the 2017 population monitoring project were supported by 24 years of implementation and interpretation by the principle biologists and field crew within British Columbia watersheds on threatened or endangered populations for a variety of species such as Westslope Cutthroat Trout (Cope *et al.* 2016, Cope and Prince 2012, Morris and Prince 2004, Prince and Morris 2003), Mountain Whitefish (*Prosopium williamsoni*) (Cope and Prince 2012), Bull Trout (*Salvelinus confluentus*) (Prince 2010), Rainbow Trout (*Oncorhynchus mykiss*) (Prince *et al.* 2000), Pacific salmon (Sockeye (*Oncorhynchus nerka*), Hinch *et al.* 1996; Coho (*Oncorhynchus kisutch*), Healey and Prince 1998), White Sturgeon (*Acipenser transmontanus*) (Prince 2004, R.L.&L. Environmental Services Ltd. 1996) and Burbot (*Lota lota*) (Kang *et al.* 2015, Cope 2011).

Similarly, juvenile removal-depletion electrofishing methods for a variety of species including Westslope Cutthroat Trout were supported by over 10 years of implementation and interpretation by the principle biologists (Cope *et al.* 2016, Cope 2008, 2007, 2001, Cope and Morris 2006, Bisset and Cope 2002).

2.1 Study Period

The population monitoring project has been designed to encompass up to a 10 year monitoring period. The 2017 population monitoring project is the first year of a proposed monitoring plan to continue snorkel counts and extend the current sub-adult and adult population trend monitoring data (2012, 2013, 2014) to a 6 year data set (2012, 2013, 2014, 2017, 2019, 2021) over a 10 year period. Similarly, continuation of the fry and juvenile density monitoring program will extend the current trend monitoring data (2013, 2014, 2015) to a 6 year data set (2013, 2014, 2015, 2017, 2019, 2021) over a 9 year period.

In 2017, field studies were conducted between August 20 and September 30 to be consistent with the sampling period in previous years. Timing of field studies (*i.e.,* Aug 20 – September 30) will be consistent for 2019 and 2021.

A review of the population monitoring program after the 10 year monitoring period was recommended to ensure monitoring is achieving the desired objectives. At that time, based on the current state of knowledge, the population monitoring project could be ended, renewed, modified, or re-designed.

2.2 Study Area

The spatial boundary of the Project was defined as the upper Fording River watershed (including tributaries) above Josephine Falls (Figure 1.1). The upper Fording River mainstem was sub-divided into 11 population assessment river segments of similar character to facilitate sub-adult and adult population monitoring and distribution assessment using snorkel methods (Figure 1.1; Table 2.1). Henretta Creek was also subdivided into three river segments. River "segments" represent "strata" replicated from the randomly stratified approach used for population assessment (Cope *et al.* 2016). River segments were delineated principally based on the requirement to include enough stream length (lineal river km) to facilitate the recaptures necessary to generate population estimates while restricting the total segment length to a distance that could be snorkeled and traversed on foot within a day. As such, each river segment was not a river “reach” of similar geomorphological characteristics since some segments contain several reaches.

Table 2.1. Upper Fording River segments (*i.e.,* strata) used for population monitoring and distribution assessments (2012, 2013, 2014, 2017). River kilometers (rkm) are upstream from the confluence with the Elk River. The study area extends from 20.51 rkm at Josephine Falls to approximately 78.00 rkm (headwaters greater than 20% gradient). Fording River Operations extend from approximately 51 to 65 rkm.

River Segment	River Km	Length (km)	Location
1	20.51–25.00	4.49	Josephine Falls to GHO
2	25.00-29.00	4.00	GHO to above Fording Bridge
3	29.00-33.16	4.16	Above Fording Br. To Ewin Creek
4	33.16-37.59	4.40	Ewin Cr. To S-bends
5	37.56-41.96	4.40	S-bends to Chauncey Creek
6	41.96-48.96	7.00	Chauncey Cr. to F2 side road
7	48.96-54.00	5.04	F2 side road to Diversion Reach
8	54.00-59.75	5.75	Diversion reach to Turnbull Br.
9	59.75-63.40	3.65	Turnbull Br. to above Henretta
10	63.40-67.75	4.35	Above Henretta
11	67.75-78.00	10.25	Headwaters
H1	00.00-1.00	1.00	Henretta Creek Below Henretta Lake
H2	1.00-1.50	0.50	Henretta Lake
H3	1.50-4.00	2.50	Henretta Creek above Henretta Lake
		61.49	N = 14

The elevation of the study area ranges from 1,400 m at Josephine Falls to 2,740 m at the headwaters (78.0 rkm). For context, the FRO processing plant and dryer were located at 57.0 rkm and 1,650 m elevation. As Josephine Falls represents a natural barrier, the Westslope Cutthroat Trout population of concern was considered a fluvial, headwater population restricted to the approximately 57.5 km portion of the upper Fording River (plus tributaries) between Josephine Falls at 20.5 rkm and the upstream limit of fish distribution in the headwaters somewhere between 73.0 and 78.0 rkm.

Recruitment is typically the strongest determinant influencing populations (Maceina and Pereira 2007). Recruitment (fry) and juvenile (fish less than 200 mm) population monitoring of the upper Fording River Westslope Cutthroat Trout was examined through density estimates generated using three pass removal depletion electrofishing methods. The current monitoring replicates the 2015 representative locations of the previous population assessment sampling (Cope *et al.* 2016). The location of the sampling sites was summarized below in Table 2.2 and illustrated in Figure 2.1.

Table 2.2. Summary of upper Fording River recruitment and juvenile sample locations 2013, 2014, 2015 and 2017.

Location	Strata	River Segment	River Km	Sample Years
Fording River	Mainstem Headwaters	11	68.0	2013, 2014, 2015, 2017
Fording River	Mainstem Headwaters	10	65.6	2013, 2014, 2015, 2017
Fording River	Mid-Mainstem (FRO Onsite)	8b	59.3	2015, 2017
Fording River	Mid-Mainstem (FRO Onsite)	8a	58.1	2013, 2014, 2015, 2017
Fording River	Mid-Mainstem (FRO Onsite)	7	52.4	2013, 2014
Fording River	Lower Mainstem	6	48.5	2015, 2017
Fording River	Lower Mainstem	5	34.4	2013, 2014
Fording River	Lower Mainstem	3	32.5	2015, 2017
Fording River	Lower Mainstem	2	27.2	2013, 2014, 2015, 2017
Henretta Creek	Lower Tributary	1	0.2	2013, 2014, 2015, 2017
Henretta Creek	Upper Tributary	3	2.4	2013, 2014, 2015, 2017
Fish Pond Creek	Lower Tributary	1	0.4	2013, 2014, 2015, 2017
Lake Mountain Cr.	Lower Tributary	1	0.1	2015, 2017
Chauncey Creek	Lower Tributary	1	0.4	2013, 2014, 2015, 2017
Chauncey Creek	Upper Tributary	2	1.3	2013, 2014
Ewin Creek	Lower Tributary	1	0.7	2013, 2014
Ewin Creek	Upper Tributary	2	3.3	2013, 2014, 2015, 2017
Dry Creek	Lower Tributary	1	0.2	2013, 2014, 2015, 2017
Greenhills Creek	Lower Tributary	1	0.3	2015, 2017

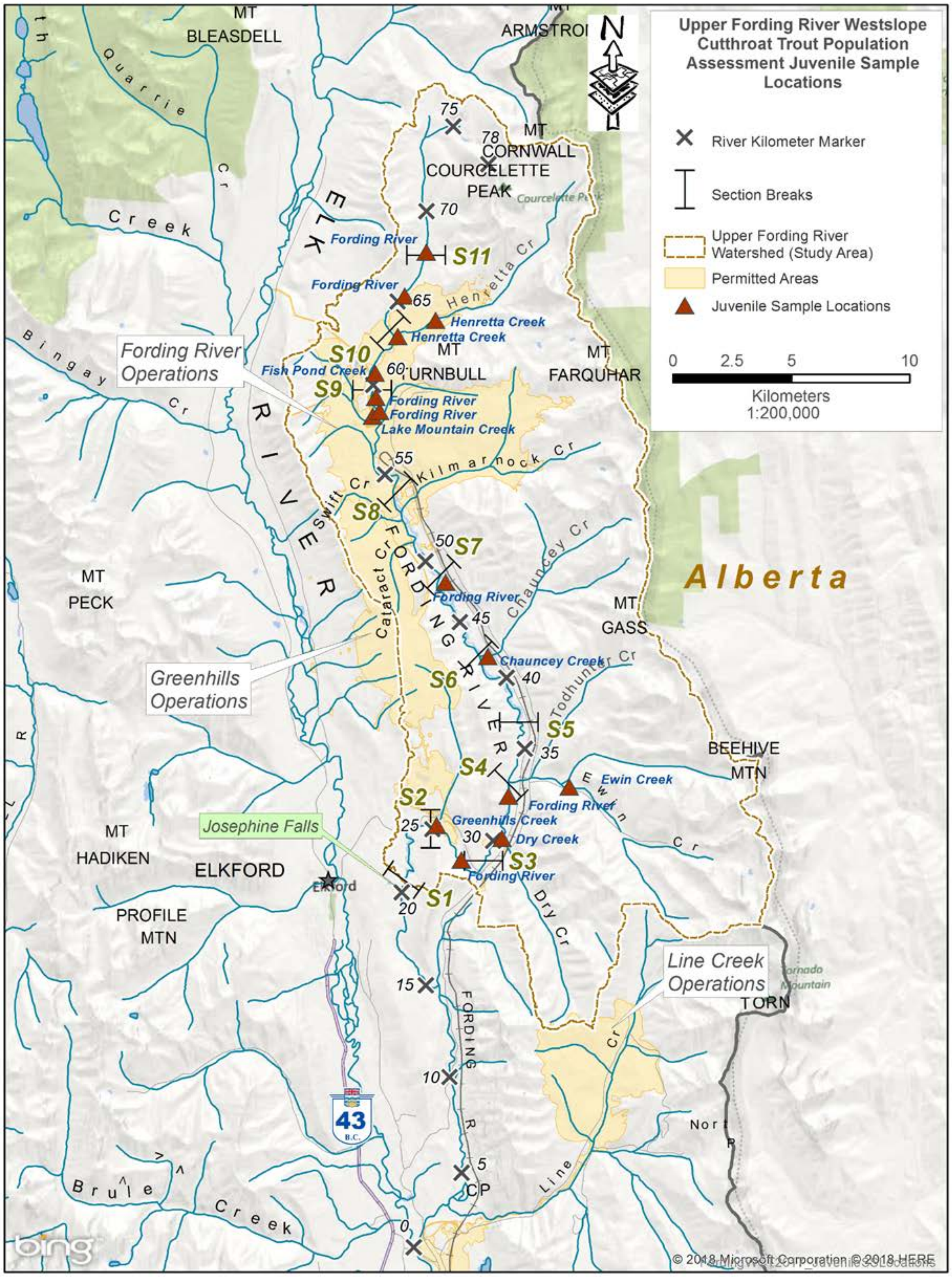


Figure 2.1. Upper Fording River 2017 recruitment and juvenile sample locations.

2.3 Population Monitoring

The methodology for the population monitoring project employs two independent estimation methods;

- Snorkel count of all Westslope Cutthroat Trout within at least 80% of the available habitat within the upper Fording River mainstem and the lowermost 4.0 km of Henretta Creek. The 2017 sub-adult and adult count data (fish greater than 200 mm) was then input into a Pooled Peterson model that addressed the observer efficiency issue (not estimated in 2017) by using the range of observer efficiencies estimated through a mark-recapture calculation in previous years (2012, 2013, 2014), and
- Three pass removal depletion electrofishing methods to estimate densities within three meso-habitat sites at 15 representative locations (represents a total of 43 meso-habitat unit enclosures as Lake Mountain Creek location was represented by one site). This includes Passive Integrated Transponder (PIT) tagging and scanning of all electrofishing captures for supplemental data on survival, longevity, growth and movement estimates from previous years sampling events. Depending on how the fish mix with each other across years, the multiple years of data can also be modeled and analysed to generate population estimates for the entire stream from recapture of PIT tagged fish and from the unmarked fish captured during each electrofishing event (year).

Two independent trend-monitoring approaches increase confidence in the interpretation of population trends. This is an important consideration given the selection of relative indices (*i.e.,* snorkel count CPUE data) as the population estimator and their weakness in regards to being a misleading indicator of abundance when not applied properly or meeting underlying assumptions (Hubert and Fabrizio 2007). As such, it was imperative in 2017 to standardize sample methods and environmental conditions (*i.e.,* timing, flow, visibility conditions, spatial extent and consistency in qualified trained observers) as much as possible amongst all years of data collection. These standardization measures are outlined in the respective sample methods sections below.

As the data set grows (for example, estimates in Years 1, 2, 3, 5, 8 and 10), the ability to detect trends (*i.e.,* stable, increasing, decreasing) improves. Therefore, long term population monitoring using such a study design is possible. Data quality objectives for sub-adult and adult population monitoring were to detect +/-25% change in abundance per year. After completion of the 6 year data set it is hoped this would improve to +/- 10%.

2.3.1 Snorkel Enumeration Methods

As a general rule, a relative abundance estimator (*i.e.,* snorkel count or CPUE) can be used to track trends in actual population abundance provided underlying assumptions are not seriously violated and sources of variation are minimized to the extent possible (Hubert and Fabrizio 2007). CPUE indexing methods such as snorkel counts are extremely sensitive to methodology deviations that affect catchability (*i.e.,* observer efficiency). Therefore, it was imperative to standardize sampling design (*i.e.,* timing, visibility conditions, spatial extent and consistency in qualified trained observers) as much as possible between sample years to ensure consistency in observer efficiency. Consequently, the following practices were standardized to ensure snorkel count catchability remained reasonably constant across years (*i.e.,* +/- 25%) and that counts were representative of trends in actual abundance;

1. Spatial extent remain consistent among years (*i.e.,* greater than 48 km or 80% of available mainstem upper Fording River and Henretta Creek Habitat). As replicated from previous years, a crew of four to six experienced snorkel observers enumerated river Segments S1 through S10, Henretta Pit Lake and Henretta Creek below Henretta Pit Lake over a seven day period. The counts were summed by river Segment and their number and distribution compared from year to year. This ensured consistency in effort among years and ensures potential changes in the spatial distribution of the population does not go unnoticed or bias results,

2. To ensure consistency, the same trained and qualified observers (snorkelers) were used in all years. Although some staff turnover was expected, in 2017 at least 50% of the snorkel observers (*i.e.,* one individual in each snorkel pair of observers) have participated in all snorkel counts (2012, 2013, 2014, 2017), and

3. Timing (*i.e.,* Aug 25 – September 15) must be consistent and flow and visibility based (*i.e.,* ensure no precipitation in preceding days and no instream works activities). If in the opinion of project biologists present in all four years (*i.e.,* 2012, 2013, 2014, 2017), flow and/or visibility conditions during the timing window are outside the range of previous years, the snorkel survey will be deferred to the next year. In the event of a cancellation the snorkel survey will proceed in the subsequent year and would result in a data gap of two years rather than one year.

In 2017, snorkel counts of Westslope Cutthroat Trout within the 12 river or tributary population index strata or “Segments” established for the population assessment project were replicated (Table 2.1, Figure 1.1). The 12 population segments include 11 mainstem upper Fording River segments plus one tributary segment (Henretta Pit Lake including lower Henretta Creek to the confluence with the upper Fording River). In 2016, fish habitat offsetting works were begun within FRO (River Segments S7, S8, S9 and Henretta Creek). Additional offsetting works are scheduled within these river segments in upcoming years. In 2017, these river segments and Henretta Creek (including upper Henretta Creek above the lake) were further sub-divided into a total of 23 treatment and control sub-sections to facilitate more detailed fish distribution, habitat utilization and trend monitoring data for offsetting effectiveness evaluation. These data were summarized in Appendix A and forwarded to the habitat offsetting monitor completing the effectiveness monitoring (Lotic Environmental Ltd. 2017).

The following exceptions were not snorkelled in 2017 or in previous years. The uppermost headwater population river segment (S11) representing 11 km of headwater stream channel habitat. This was not snorkeled due to the low water volume, small stream size and high gradients. As well, the lowermost 370 m of river Segment S1 above Josephine Falls was not snorkeled due to obvious safety concerns. The remaining potential fish bearing tributaries (*i.e.,* Chauncey, Ewin, Dry Creeks) were not snorkelled due to the low water volume and small stream size. These tributaries are sampled as juvenile rearing tributaries using three pass removal depletion electrofishing.

Snorkel surveys were conducted using a team of four observers with the exception of Henretta Pit Lake where five observers were employed. Where possible, a snorkeler’s lane extends 3-5 metres towards shore, with the offshore observer looking both ways towards the near shore observer. Where the stream width was less than 15 m the snorkel team formed two person teams to cover the distance in a more efficient manner. Frequent stops occur to discuss whether duplication has occurred. Whenever necessary, a habitat unit was re-surveyed if there was uncertainty or obvious discrepancies. Observed Westslope Cutthroat Trout were identified to 100 mm size class (e.g., 0 – 100 mm, 100 – 200 mm, etc.).

In an effort to document consistency of conditions and ensure standardization of practices, at the start of each survey day horizontal Secchi distance, a measurement of water clarity and an index of visibility, was taken from each observer and then averaged. Spot water temperatures were also taken. Any variations in sample effort (river kilometers surveyed) are documented and upper Fording River flows (mean daily discharge, Water Survey Canada Station 08NK018 at the mouth) for the survey period are summarized for comparison.

Given suitable watershed conditions, snorkel counts have proven to be a reliable and efficient means of obtaining indices of relative abundance for salmonid populations in British Columbia streams (Korman *et al.* 2002, Slaney and Martin 1987, Northcote and Wilkie 1963) and for Cutthroat Trout throughout their range including the East Kootenay (Cope *et al.* 2016, Cope and Prince 2012, Baxter 2006a, 2006b, 2005, 2004, Baxter and Hagen 2003, Oliver 1990, Zubick and Fraley 1988, Slaney and Martin 1987, Schill and Griffith 1984). However, snorkel counts are typically underestimates of true abundance because individuals are routinely missed due to the impacts of visibility, fish behaviour, and stream channel complexity.

In previous years (2012, 2013, 2014), to address the observer efficiency issue, fish were marked (Floy tags and radio tags) within the section of stream for which the estimate was conducted and the population estimate was generated with associated variability through a mark-recapture calculation (Schwartz *et al.* 2013). Previous population estimates applied a “blended” approach to uncertainty and were based on the pooled set of radio tags and Floy tags combined to generate a single mark-recapture population estimate for each year.

In 2017, only the count data (*i.e.,* observed fish within each stream segment) was collected. There was no mark-recapture program and hence no estimate of observer efficiency in 2017. Instead, an estimate of abundance relied on the previous years (2012, 2013, 2014) calculation of observer efficiency. Using the previous year’s observer efficiencies (Cope *et al.* 2016), a Pooled Peterson model was used to expand the 2017 count data into an estimate of abundance. This model estimate for 2017 assumes consistency in observability was met (*i.e.,* spatial extent and effort, same seasonal timing, flow, visibility, consistency in snorkel observers and observer search patterns) and that observer efficiency was within the values estimated in the years 2012 (42%), 2013 (25%), and 2014 (32%). This was a reasonable assumption given the measures outlined above that were employed to standardize snorkel methods. The rationale for the change in methods was previously outlined (Cope *et al.* 2016).

The three observer efficiencies for 2012, 2013 and 2014 were applied to the 2017 catch data and the median, minimum and maximum values were plotted as a relative index of abundance for comparison with previous population estimates and their 95% confidence interval from 2012 to 2014. Finally, a biological opinion or ranking of previous years observability conditions (flow, visibility) compared to the current year was provided for context on the most likely estimate or range of estimates among the three outcomes of the model.

2.3.2 Removal Depletion Electrofishing Methods

In order to PIT tag juveniles and generate density estimates, fry and juvenile Westslope Cutthroat Trout (fish less than 200 mm) were captured using three pass removal depletion electrofishing late August through early October 2013, 2014, 2015 and 2017 when water temperatures were greater than 5.0 ^{o}C. Depletion sampling in combination with multiple-pass electrofishing is an important fisheries management tool for wadeable streams and this combination of techniques has been used routinely for several decades as a reliable means to obtain quantitative data on trout populations (Hilborn and Walters 1992, Van De-venter and Platts 1983).

Locations were selected to represent the available river strata or segments (*i.e.,* reach based methods) to facilitate population estimation, although access considerations (light truck and/or ATV) also factored into the selection process. Five primary strata were delineated; the lower, mid (FRO onsite) and upper (headwater) mainstem river segments and both lower and upper tributary sites. In total, nineteen representative juvenile locations were sampled in 2013, 2014 and 2015. Fourteen locations were sampled in 2013 and 2014; fifteen locations were sampled in 2015. In 2013 and 2014 the same 14 locations were replicated; in 2015, 10 locations were replicated and 5 new locations were sampled (Table 2.2). Location changes in 2015 were designed to test fry and juvenile densities within areas of observed high density spawning. The 2015 locations were replicated in 2017. Figure 2.1 and Table 2.2 illustrate and summarize the monitoring locations and their distribution within the study area.

Each location was sub-divided into three meso-habitat sites of approximately 100 m^2 each. The one exception was Lake Mountain Creek, which only had one meso-habitat site at that location (Cope *et al.* 2016). Using shore-based or backpack electrofishing, depending on site characteristics, the three meso-habitat units in each sample location were sampled using three-pass removal depletion methods for a total meso-habitat effort of 43 sites and at least 4,200 m^2 habitat. These sampling methods were adapted from Ptolemy *et al.* (2006) and replicated from the 2013 to 2015 assessments (Cope *et al.* 2016); with specific measures designed to ensure consistency.

Westslope Cutthroat Trout fry and juveniles were captured using a 3-person crew, a DC backpack electrofishing unit (Smith Root LR24), and three-pass removal depletion methods that requires three successive passes of declining catch for population estimation methods. As described in Ptolemy *et al.* (2006), wadeable meso-habitat units (*i.e.,* <1.5 m deep) within the selected locations were sampled using three sided shore sites. Where possible full span upstream and downstream stop nets were used (*i.e.,* wetted widths < 8.0 m). Upstream and downstream stop nets were placed perpendicular to the shore and the off-shore side of the site (if required) followed depth and velocity contours to enclose the area between the upstream and downstream stop nets. Sites offering natural physical barriers such as mid-channel bars or braids were preferred since upstream-downstream barriers are easier to install thus requiring less site disturbance prior to sampling. Fry are typically bounded by high velocities close to shore; barrier nets extend well beyond their distribution with the bottom net angled with mid-channel position about 4 m upstream of the shore reference point. This was done to maximize capture of drifting animals by shunting and collection of fry and juveniles near shore. Nets were configured into stable position with guy ropes, bipod stays, and anchors to a distance of up to 8.0 m from shore. The lead line was knitted to the bottom contours with boulders placed as weights along the lead line. Stop nets were 4 mm stretch mesh (square).

At each site, electrofishing was initiated at the downstream net, and consists of a thorough surprise/ambush search in an upstream direction, followed by a systematic sweep back towards the downstream net. Each “catch” (c1, c2, c3) effort involves multiple passes and the same search pattern was replicated in “catch 2”. Electrofishing seconds (*i.e.,* time) was monitored and recorded to ensure each successive depletion or “catch” utilized similar effort. At three-sided shore sites, electrofishing always proceeds from the fast water forming the offshore boundary towards the shore, to avoid chasing larger juveniles into the outside net where they may find a hole and escape from the site. Both the upstream and downstream nets were monitored to ensure any fish that drifted into the nets that were not captured by the netters were collected and included in that catch.

All fish captured during electrofishing were anaesthetized, weighed (g), measured (fork length mm), examined externally for any signs of deformity (including the most common deformity, shortened opercula whose frequency of occurrence is tracked) or injury, and all juveniles (fish greater than 60 mm) not previously PIT tagged were implanted with a Passive Integrated Transponder (PIT) tag (Biomark HPT8 134.2 PIT Tag, Biomark, Boise, Idaho). Previously PIT tagged fish had their number recorded. Captured fish were allowed to recover their oxygen deficit (created during capture) in 20 litre capture buckets prior to being anaesthetized and processed. Fish were anaesthetized in a 40 L bath of river water containing 2.0 ml clove oil yielding bath concentrations of 50 ppm. Clove oil is a safe, inexpensive, and effective anaesthetic suitable for invasive procedures in the field (Prince and Powell 2000, Peake 1998, Anderson *et al.* 1997). The lowest effective dose of clove oil is recommended as time to recovery of equilibrium and fear response in salmonids has been shown to increase exponentially with exposure time (Keene *et al.* 1998). Because of its low solubility in water, the clove oil was first dissolved in 10-ml of ethanol (95%) before being added to the river water. The five stages of anaesthesia referred to in this investigation are: level one, partial loss of equilibrium with normal swimming motion; level two, total loss of equilibrium with normal swimming motion; level three, partial loss of swimming motion; level four, total loss of swimming motion and weak opercula motion; level five, no opercula motion (Yoshikawa *et al.* 1988). For PIT tagging procedures level three anaesthesia was all that was required to ensure immobility. To prevent immigration during multiple-pass depletion all fish from successive depletions were allowed to recover within fish sleeves, totes or 20 litre buckets placed downstream. Upon completion of sampling, fish were released back into their respective meso-habitat units.

Capture, effort (area and electrofishing time for each pass), life history data (length, weight, life stage) and individual tag identification are input using the FLNR Microsoft Excel tool, “Fish Data Submission (FDS) Spreadsheet Template V2.0”. Physical site attributes were recorded each year during site layout. Repeat habitat inventories at each site include meso-habitat classification (riffle, cascade, glide, run, pool or side-channel), descriptions of depth-velocity profile at 0.25-0.5 m intervals perpendicular to flow with shorter intervals over high velocity gradients (*i.e.,* a representative discharge transect), riparian vegetation, bed material composition, dominant particle size, Dmax, D_{90}, large woody debris content, substrate embeddedness, site length, site wetted width, estimated available cover, and maximum depth. Photographs and UTM coordinates are taken of each site for future reference. These data are captured through the use of three standard data forms plus notes and a site sketch that the surveyor produces. The data forms are; 1) the Fish Data Submission (FDS) Spreadsheet Template V2.0, 2), Level 1 Habitat Survey Data Form, and 3) Hydrometric Survey Data Notes.

The catch data for the three passes (*i.e.,* c1, c2, c3) are input using the “Microfish” software package to calculate population estimates (Van Deventer and Platts 1990). Population estimates and the 95% confidence interval were reported as a standard numerical density (number fish/100 m^2) and biomass (g/100 m^2) by life stage (*i.e.,* fry, juveniles) for each meso-habitat site. Data were then compared to the previous data within the upper Fording River (2013, 2014, 2015). Recaptures were added to the existing database used to validate growth rates, survival and age classes as data becomes available from recaptures. Recapture data was also examined for movement patterns.

Subsequently, the data were pooled in various ways to explore potential temporal and spatial trends within the 15 representative locations within the upper Fording River. First, age data was pooled from at least five age classes (0+, 1+, 2+, 3+, 4+) to two life stages (fry and juvenile). Pooling of age classes into two life stages was necessary due to the low densities reported and was consistent with previous sample events (Cope *et al.* 2016) and comparative studies elsewhere (Robinson 2014).

The catch data for the three passes (*i.e.,* c1, c2, c3) was subsequently pooled in a variety of ways to explore spatial and temporal patterns across locations and watershed strata. The three meso-habitats within each location were pooled to provide a composite location density estimate and biomass estimate for fry and juveniles and both life stages combined for the 15 locations within the upper Fording River watershed. This is important because increased densities across a majority of sites during trend monitoring timelines suggest population increases are broad based and indicative of an increasing population trend. Location based data can often be useful in evaluating specific habitat offsetting measures at a later date; despite its lower precision compared to the pooled watershed strata.

2.3.2.1 PIT Tagging

All captures were scanned for PIT tags during electrofishing, therefore, growth rates, age classes, survival and longevity can be estimated in subsequent years (*i.e.,* 2019, 2021). PIT tagged fish have been at large since 2013 and depending on how the fish mix with each other across years, the multiple years of data can also generate a second independent population estimate for the entire population from recapture of PIT tagged fish and from the unmarked fish captured during each electrofishing event (year). Recapture data are also examined for movement patterns.

A key assumption to PIT tagging is that fish implanted with electronic tags have similar fates and behavior relative to untagged conspecifics. However, fish that survive electrofishing injuries (hemorrhagic trauma, spinal compressions, misalignments and fractures) are more likely to suffer short and long term adverse effects to their behavior, health, growth, or reproduction. In addition to injury, electrofishing can result in a variety of stress related effects that result in physiological and behavioral changes. Panek and Densmore (2011) can be consulted for one of many reviews on the subject. Because of these known impacts to fish, electrofishing (especially multiple pass methods) is the capture method of last resort in the implantation of electronic transmitting devices in fish for behavioral studies. Since it is well known that the capture method (electrofishing), PIT tagging methods, PIT tag placement and the experience of the technician or biologist applying PIT tags influence both tag retention and fish survival (Mamer and Meyer 2016, Cook *et al.* 2014, Panek and Densmore 2011), it is critical to ensure that the best practices are being used. There are trade-offs and rationale to be considered for PIT tagging methods and these are outlined below.

In addition to the above scientific study design concerns influencing tag retention and fish survival, there is an increasing need and desire for scientists to treat organisms with a higher standard of care and respect, rather than just as specimens; this is especially important for listed species (*i.e.,* threatened, endangered or species of special concern) in intensively sampled landscapes. This is something that the EVFFHC takes very seriously; it is also in response to the abundant feedback from Ktunaxa Nation citizens and other citizens.

The experience of the technician or biologist applying PIT tags has been demonstrated to influence tag retention and fish survival; especially when performing a laparotomy to insert tags intraperitoneally (*i.e.,* in the body cavity) in fish as small as 60 mm in length. This will influence the validity of the study results when inferring movement patterns and survival (Mamer and Meyer 2016, Lopes *et al.* 2016, Brown *et al.* 2010, 2011). This will result in trade-offs to be considered in the minimum fish size and the placement of the PIT Tag. In smaller fish (typically less than 250 mm, a laparotomy was performed (a needle used) to open the coelomic cavity and place the PIT tag intraperitoneally. In larger fish (*i.e.,* greater than 250 mm), these potential effects were eliminated by injecting PIT tags into the muscle tissue; but still require a detailed knowledge of their application (Cook *et al.* 2014). Muscle tissue placement has the benefit of having higher tag retention rates, especially for mature females. PIT tags applied in the musculature ventral to the dorsal fin report the highest retention rates (94.1% per year) compared to intraperitoneal (59.4% for females and 89.7% for males, Mamer and Meyer 2016). The difference between the sexes is due to females shedding the intraperitoneal tags during spawning. However, PIT tags in musculature have a higher retention (65%) in fillets than body cavity (4%). In some jurisdictions, human consumption concerns may prohibit the use of musculature implantation where angler harvest is possible. Angling is prohibited within the upper Fording River at this time.

To address the above concerns the following considerations were employed;

- An experienced removal depletion electrofishing crew was employed. Principle biologists and senior technicians had a minimum of 10 years' experience and have participated in all sample years (2013, 2014, 2015, 2017). Junior team members were employed under the direct supervision of experienced team members.

- Only biologists or technicians with multiple years of experience in specialized handling procedures designed to minimize stress, including anesthesia procedures, sterile techniques and the application of PIT tags were employed for PIT tagging. The Westslope Fisheries Ltd. study team has captured, Floy, PIT and radio tagged 3,228 Westslope Cutthroat Trout over a 12 year period between 2000 and 2017.

- Single use pre-loaded Biomark HPT8 PIT tags were used to minimize possible infection and handling stress. HPT8 PIT tags were used as they are the smallest tag available and minimize the needle size (coelomic cavity opening) and tag weight; considered important given the application (fish as small as 60 mm) and the 2% rule of biotelemetry (*i.e.,* the weight of the tag not to exceed 2% the weight of the fish in air; Winter 1983). All tools, equipment and surfaces that may come in contact with fish were cleaned with isopropyl alcohol before use. All crew members equipment was disinfected (*i.e.,* 100 mg/l chlorine bleach) before sampling to minimize the risk of disease transmission.

- PIT tags were inserted in the musculature for fish greater than 250 mm (ventral to the dorsal fin) and intraperitoneal for fish less than 250 mm.

- All fish were anesthetized and examined for deformities and injuries. Any deformed or injured fish were documented, concerns identified and released untagged. Captured fish were allowed to recover their oxygen deficit (created during capture) in an instream holding tank prior to being anaesthetized and processed. Processed fish were subsequently allowed to recover for at least 30 minutes in an instream holding tank before being released back into the capture meso-habitat.

3 Results

The results of the sub-adult and adult snorkel count and the juvenile removal depletion electrofishing are provided in this section. The 2017 results were also used to update the 2012, 2013 and 2014 adult population trend monitoring dataset (2012 – 2017) and the 2013, 2014 and 2015 juvenile population trend monitoring dataset (2013 – 2017).

3.1 Sub-Adult and Adult Snorkel Survey

The following outlines the rationale for the assertion that the 2017 survey was successful in minimizing the sources of variation and the assumption of equal catchability was met; particularly for the year 2012 and to a lesser extent 2014.

Table 3.1 summarizes the variables monitored to ensure consistency in potential sources of variation. The snorkel survey timing and effort (spatial extent) were consistent across all years. Similarly, at least 50% of snorkel observers in 2017 have participated in all four surveys to ensure consistent search patterns and observer efficiency. The 2017 flows were the lowest on record but were very similar to the 2012 flows which had the highest observer efficiency. In the opinion of project biologists who participated in all four snorkel surveys, visibility was within the range of previous years and was most similar to 2014 which had the median observer efficiency. This results in rating the 2017 visibility as moderate to excellent and observer efficiency was most consistent with the higher observer efficiencies of 2012 (42%) and to a lesser extent 2014 (32%). These higher efficiencies will equate to the lower two of the three model estimates (*i.e.,* a lower observer efficiency will expand the count higher).

Table 3.1. Summary of snorkel survey timing and environmental conditions for the four years of population monitoring in the upper Fording River.

	2012	2013	2014	2017
Snorkel Survey	Sept 16 – 22	Sept 4 – 9	Sept 2 - 8	Sept 5 - 12
Snorkel Kilometers (% mainstem)	47.62 (83%)	48.37 (84%)	46.62 (81%)	48.37 (84%)
Mean Daily Water Temperature (^oC)	7.0 – 7.8	9.4 – 10.2	7.0 – 7.9	6.5 – 8.5[a]
Mean Daily Discharge (m^3/s)[b]	3.9 – 4.3	5.2 – 6.0	5.6 – 10.0	3.5 – 3.7
Visibility	Excellent	Mod. to Poor	Moderate	Mod. to Excellent
Observer Efficiency[c]	42%	25%	32%	Not Estimated

[a] – spot temperature not mean daily.

[b] – Water Survey of Canada Station 08NK018 at the mouth of the Fording River.

[c] – Floy and Radio tags combined (Cope *et al.* 2016).

Table 3.2 summarizes the snorkel count data for the enumeration years (2012, 2013, 2014, 2017). The 2017 snorkel program enumerated 3,672 fish. This was more than double the previous survey counts in 2012, 2013 and 2014. Since the previous snorkel count (2014), the adult count has increased by 46% (497 fish) and the juvenile count increased by 407% (five times increase or 1,685 fish). The majority of the increase was located in the FRO onsite river segments 7 to 9 and the upstream headwaters (river segment 10; Table 3.2).

Table 3.2. Snorkel count data for mainstem river segments S1 through S10 upper Fording River and lower Henretta Creek. Data has been summarized to represent juvenile age classes (0-200 mm) and sub-adult and adult age classes (200-500 mm). Subsequent population modelling applies to the 200 – 500 mm size classes. For a full breakdown by 100 mm size classes see Appendix A.

	Snorkel Count							
River	2012		2013		2014		2017	
Segment	0-200	200-500	0-200	200-500	0-200	200-500	0-200	200-500
1	0	46	0	29	0	22	1	25
2	81	329	4	51	32	186	12	36
3	1	37	1	12	0	51	4	11
4	20	68	75	126	17	143	5	77
5	5	34	0	1	0	41	9	36
6	33	160	10	45	4	121	24	140
7	4	18	148	154	16	39	1002	458
8	1	33	146	167	89	192	487	195
9	39	82	29	44	101	143	275	309
10	14	24	15	26	126	77	273	256
H1[a]	7	165	1	12	14	19	7	5
H2[b]	0	0	38	101	15	42	0	25
Total	205	996	467	768	414	1076	2099	1573
	1201		1235		1490		3672	

[a] – Henretta Creek below Henretta Lake.

[b] – Henretta Lake.

Table 3.3 summarizes the data used in the pooled Peterson model for the estimation of population abundance using the previous years' mark – recovery calculation and observer efficiency estimates (2012, 2013, 2014). These three observer efficiency estimates were then applied to the 2017 count data and the resulting three 2017 abundance estimates output from the model were summarized (Table 3.3). Note that while all three 2017 model estimates are presented, these estimates are not a range but represent a measure of sensitivity to CPUE (catchability or observer efficiency) depending on which of the three previous years observer efficiencies are input into the 2017 pooled Peterson model. This was done to extrapolate the 2017 count data into a relative index of population abundance for context in trend monitoring and for comparison of regional data and reference populations (*i.e.,* FLNR index of large WCT defined as fish greater than 300 mm/km).

Although the 2017 median model estimate was 4,908 fish greater than 200 mm and the three model estimates ranged between 3,690 to 6,240, the median and range of model estimates in Table 3.3 most likely over-estimate the 2017 population abundance based on the flow and visibility conditions in 2017. The 2017 environmental conditions (flow) were most consistent with the highest of the three model estimates for observer efficiencies (42% in 2012) and visibility ratings (*i.e.,* catchability) were most

Table 3.3. Summary of data used for population model estimates.

	2012	2013	2014	2017
Radio Tags	59	57	58	-
Floy Tags	151	164	178	-
Combined Tags	210	221	236	-
Observed Radio Tags	35	22	23	-
Observed Floy Tags	54	33	52	-
Combined Observed Tags	89	55	75	-
% Recovery	42.38	24.89	31.78	25 – 42
Unmarked Count > 200 mm	996	768	1076	1573
Unmarked Count > 300 mm	489	283	366	461
Previous Years Marks Observed	-	13	23	-
Population Estimate (>200 mm)	2,546	3,318	3,664	4,908$_{(2014)}$[a] 3,690$_{(2012)}$[a] 6,240$_{(2013)}$[a]

[a] - subscript year refers to the mark – recovery data for that year utilized in combination with the 2017 count data to generate the Pooled Peterson estimate.

consistent with the higher two of the three model estimates for observer efficiencies (42% in 2012, 32% in 2014). This would provide weight to the lower two model estimates of 3,690 and 4,908 Westslope Cutthroat Trout greater than 200 mm. This was consistent with the professional judgement of the biologists who were snorkel observers in all four surveys who indicated the expected value should be consistent with the 2012 conditions and observer efficiencies.

Therefore, given the above rationale (flow and visibility and their effect on observer efficiency) and based on a recommended precautionary Westslope Cutthroat Trout management approach when faced with uncertainty (DFO 2017), the estimate of 3,690 Westslope Cutthroat Trout greater than 200 mm was used for further trend and regional comparisons. Recall the CPUE indexing methods (*i.e.,* the underlying model data, the snorkel count) are extremely sensitive to methodology deviations that affect catchability (observer efficiency) and this assumes underlying assumptions of flow and visibility conditions were best represented by the 2012 conditions and the highest observer efficiency. This assumption was supported by; 1) the lowest flows observed to date, 2) drought conditions (no precipitation long before or during snorkel survey), 3) the time since the 2013 flood event for fines and disturbance effects to stabilize (4 years), and 4) professional judgement.

Figure 3.1 illustrates the adult Westslope Cutthroat Trout count data (*i.e.,* fish greater than 200 mm) for the four years (2012, 2013, 2014 and 2017) as well as the model estimates for the Pooled Peterson population estimates (2012, 2013, 2014, 2017). The 2017 data point represents a relative index of count data input into the Pooled Peterson model using the 2012 mark-recapture observer efficiency calculation. The resulting three estimates of the 2017 Pooled Peterson Model were plotted in Figure 3.1 as the range representing model variation in estimates in lieu of confidence intervals for 2017.

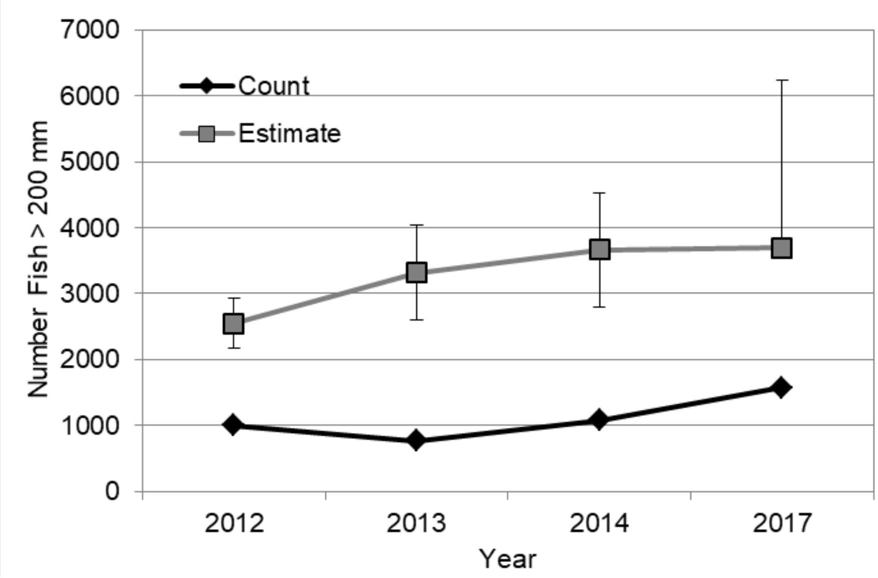


Figure 3.1. Adult Westslope Cutthroat Trout snorkel counts and associated population estimates for the upper Fording River, 2012, 2013, 2014 and 2017. Error bars in 2012, 2013, and 2014 represent 95% confidence intervals for the estimated number of fish. Error bars in 2017 represent model variation (due to the different estimates of observer efficiency in 2012, 2013 and 2014).

Based on the 2017 model estimate of 3,690 fish greater than 200 mm (*i.e.,* sub-adult and adult population) the point estimates appear to be increasing in the first three years (2012 to 2014) and stable since 2014, but the evidence of an increase in population size among the years was weak (95% confidence intervals overlap). The 2017 estimate (3,690 fish greater than 200 mm) represents an increase of 45% since 2012 and was essentially equal to the 2014 estimate.

The metric most often used for population estimation and comparison within the literature was fish per lineal river kilometer. Using the 2017 model estimate of 3,690 Westslope Cutthroat Trout greater than 200 mm over the snorkel distance of 48.37 km yields a 2017 density estimate of 76.3 fish/km greater than 200 mm (range of model estimates 76.3 – 129.0 fish/km) and 22.4 fish/km greater than 300 mm (range of estimates 22.4 – 37.8 fish/km). These densities were lower than the last (2014) density estimates calculated (78.6 fish greater than 200 mm and 28.2 fish greater than 300 mm) but within the range since 2012 (Table 3.4). The upper Fording River density of large Westslope Cutthroat Trout greater than 300 mm has not increased as the density of fish greater than 200 mm metric has; however, this was expected given the timeframe since angling prohibition (7 years), since monitoring began (5 years) and the time lag expected to reach a length greater than 300 mm (7 years). Mark-recapture growth data has confirmed upper Fording River Westslope Cutthroat trout of 283 mm to be 7 years old (*See* Section 3.3 Mark – Recapture and Growth Update).

Density estimates for mature Westslope Cutthroat Trout (fish greater than 200 mm or fish greater than 300 mm) have been collected using similar snorkel methods for a few priority Westslope Cutthroat Trout streams in the upper Kootenay drainage (Elk mainstem, Elk tributaries (Wigwam River, Michel Creek), St. Mary, White (Middle, East and North Forks) and Bull Rivers). These estimates have been used to place upper Fording River estimates in context regionally (Table 3.4). In 2008 and 2010 Michel Creek and the

Elk, upper Bull, Wigwam and St. Mary Rivers all exceeded the upper Fording River fish greater than 300 mm metric.

Table 3.4. Summary of recent density estimates (snorkel) for Westslope Cutthroat Trout greater than 300 mm in Classified Waters from the upper Kootenay River watershed.

Population Group	Year	Fish/km (> 200 mm)	Fish/km (> 300 mm)	Reference
Upper Bull River	2010	108	55	Cope and Prince 2012
Michel Creek	2008		46	Hagen and Baxter 2009
Lower St. Mary River	2008		44	Hagen and Baxter 2009
Upper Bull River	2005		40	Baxter 2006a
Elk River	2008		39	Hagen and Baxter 2009
Middle Fork White River	2011		37.5	Heidt 2013, *pers. comm.*
Upper Fording River	2017	76.3	22	
Upper Fording River	2014	78.6	28	Cope *et al.* 2016
Upper Fording River	2012	68.6	27	Cope *et al.* 2016
Upper Fording River	2013	53.4	23	Cope *et al.* 2016
Wigwam River	2008		12-24	Hagen and Baxter 2009
Upper St. Mary River	2011		19	Heidt 2013, *pers. comm.*
Upper St. Mary River	2008		14	Hagen and Baxter 2009
North Fork White River	2011		9.7	Heidt 2013, *pers. comm.*
East Fork White River	2012		3.7	Heidt 2013, *pers. comm.*

The upper Bull River population was selected as the most similar population of the reference populations (above barrier, pure strain, adjacent watershed, same assessment methods). Westslope Cutthroat Trout within the upper Bull River yielded an estimate (2010) of 108 fish/km greater than 200 mm and 55 fish/km greater than 300 mm (Table 3.4). This represents 2.5 times the observed density of large adult Westslope Cutthroat Trout within the upper Fording River (fish greater than 300 mm/km). The upper Bull River also supports a Mountain Whitefish (*Prosopium williamsoni*) population with an estimated density (2010) of 165 fish greater than 200 mm/km. However, there is a substantial difference in river size (volume) between the upper Bull River and the upper Fording River (the mean annual discharge of the upper Fording River is approximately 25% that of the upper Bull River).

Michel Creek was another tributary to the Elk River of similar size (mean annual discharge) to the upper Fording River that was used as a reference population. In 2008 the Michel Creek average density of Westslope Cutthroat Trout greater than 300 mm was estimated to be 46 fish/km or just over double the observed density within the upper Fording River (Table 3.4). Although Michel Creek is of similar size to the upper Fording River, naturally occurring phosphorus sources are known to exist within Wheeler Creek, and to a lesser extent Leach Creek (tributaries to Michel Creek), and is large enough to significantly increase biological production, fish included, in Michel Creek and the Elk River downstream (McDonald 2008).

The St. Mary River and Elk River also report similar higher estimated densities of large adult Westslope Cutthroat Trout (Table 3.4). The lower St. Mary River, at a time when fishing effort was much lower, had an estimated 75 fish greater than 300 mm/km (Oliver 1990 in DFO 2017). Based on the viability population estimate of 4,600 adults (90% probability estimate, DFO 2009), this suggest a target density of 95 adult fish/km. While the adult population trend appears to be stable, the current range of density estimates (22 to 28 fish greater than 300 mm/km) was less than reference targets of between 46 and 95 Westslope Cutthroat trout greater than 300 mm/km.

This suggests the upper Fording River Westslope Cutthroat Trout population is not achieving its full productive potential. This is most likely due to; 1) the cumulative impacts of mining operations over the last 40 plus years and the perceived threats to population resilience and sustainability that have been identified (Cope *et al.* 2016), and 2) natural limitations resulting from the isolated, headwater, tributary nature of the habitat they occupy (*i.e.,* high elevation stream with restricted geographic distribution and a short summer rearing season and low productivity).

3.2 Recruitment and Juvenile Density Estimates

In 2017, a total of 714 Westslope Cutthroat Trout were captured in 43 meso-habitat units of approximately 100 m^2 each within 15 representative locations between August 19 and 28, 2017.

Shortened opercula (gill cover defects) are tracked and there was no evidence of an increase in 2017 (9/714 or 1.3%) as results were within the range of the 2013 to 2015 data (range 0.4% - 2.5%).

Population Estimate

Annual density estimates of both life stages combined (fry and juvenile) for all representative locations sampled in all four years (n=10) have demonstrated a statistically significant increase every year of the study (Figure 3.2).

In 2017, of the 10 locations sampled in all four years, four locations increased, five locations decreased and one site was stable (Table 3.5). Table 3.5 illustrates the 2017 increase was a result of the continued increase in fry and juvenile densities within tributary habitat (Henretta, Fish Pond and Chauncey Creeks) and the Fording River headwaters (River Segment 11). These increases were countered somewhat by smaller decreases within lower Henretta Creek, Dry Creek and the Fording River mainstem segments (2, 8, 10). Increases appeared to be associated with improved habitat characteristics within the main channel (*i.e.,* channel down-cutting and scour combined with large woody debris recruitment) at these sites since the 2013 flood. The decrease in Fording River segments 2, 8 and 10 were attributed to channel down-cutting and the loss or siltation of early rearing side-channel (or braided channel) habitats at those locations since the flood event of 2013. Although the lower Henretta location decreased it was still a high density site.

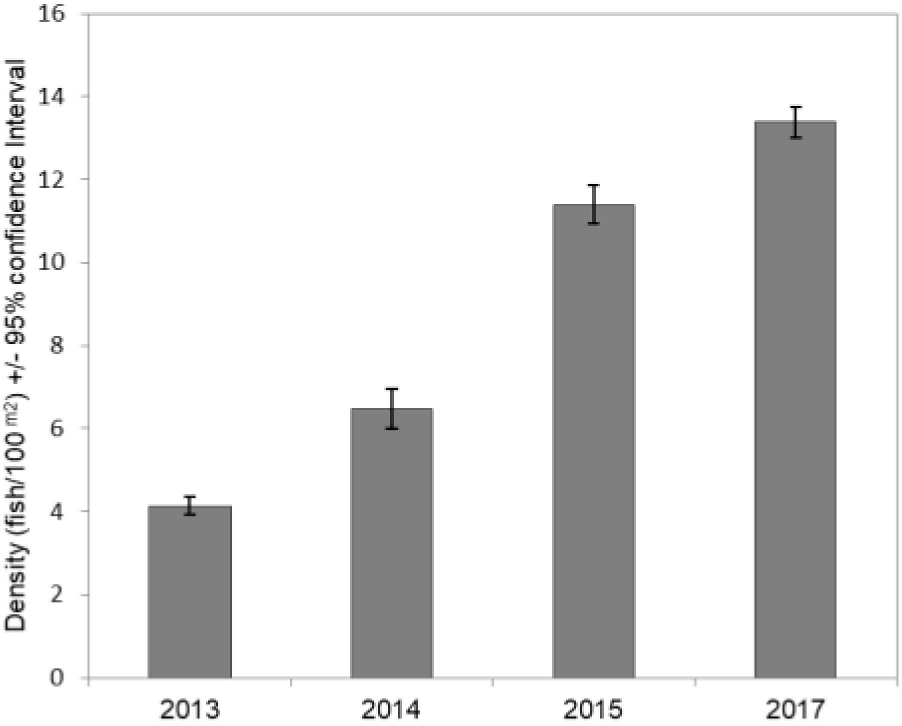


Figure 3.2. Average density estimates (fish/100 m^2) for both fry and juvenile life stages combined within sites sampled in all four years (n=10), upper Fording River, 2013, 2014, 2015 and 2017.

Table 3.5. Summary of density estimates for locations (n=10) sampled in all four years.

	Density (Fish/100 m^2)			
Site	2013	2014	2015	2017
Henretta-1	0.80	3.96	33.73	26.91
Henretta-3	0.00	0.25	0.88	5.62
Fish Pond-1	11.40	42.25	19.76	27.47
Chauncey-1	4.90	5.77	7.46	30.39
Ewin-2	0.30	1.62	2.90	2.93
Dry-1	2.50	2.25	16.50	3.82
Fording-2	2.90	3.00	3.60	0.42
Fording-8a	5.30	1.76	11.73	6.30
Fording-10	11.10	10.10	13.64	7.14
Fording-11	0.50	6.30	15.18	27.48

The June 2013 flood appears to have impacted fry and juveniles with resulting low recruitment and juvenile densities during the first year of sampling (September 2013). Subsequent increases in 2014 and 2015 were likely influenced by post flood recovery and study design changes in the final year (2015). Nevertheless, the following sections illustrate the increasing trend over the years of study has been broad based and consistent.

Location Estimates

The three meso-habitats within each location were pooled to provide a composite location and Figure 3.3 illustrates the density estimates (fry and juveniles combined) for the 19 locations sampled within the upper Fording River watershed in 2013, 2014, 2015 and 2017. Location results illustrate the 2017 increase was attributed to substantial and significant density increases within Fording River Segment 6, the headwaters (Segment 11) and lower Chauncey and Greenhills Creeks.

Table 3.6 summarizes the density and biomass results by location for fry and juveniles illustrating trends for these two life stages. There were significant increases to fry recruitment within lower Greenhills Creek and Fording River Segment 6 immediately below FRO. The increases in juvenile density and biomass within Chauncey and Greenhills Creeks and Fording River Segment 11 suggest intervening years were also strong recruitment years. This data was consistent with the juvenile snorkel count data. The count data provides evidence of an increasing population response in the form of the substantial increase in juvenile counts (407% or five times increase) within FRO onsite reaches (River Segments 7 to 9) and the headwaters upstream of FRO (River Segment 10; Table 3.2). These size classes are not included in the adult population abundance model but were consistent with juvenile density results providing further evidence of a broad based (mainstem and tributary habitats) increasing population response following the 2013 flood event.

The majority of these juveniles (60 to 200 mm) were in the 1^+ to 3^+ age classes spawned in 2014, 2015, and 2016 after the 2013 flood year. This may represent high egg to fry survival conditions and strong year classes in the moderate to low freshet flows in the years immediately following the 2013 flood event. The extreme flows of this event likely represent a flushing event. Flushing flows refers to flood flows of sufficient force to result in bedload (*i.e.,* particles such as gravels and cobbles transported in water through rolling, sliding or saltating) that “flush” fines from streambed substrates with subsequent benefits to incubating embryo, alevin and rearing juvenile interstitial habitats. Regardless, if the snorkel count data was accurate this large cohort of juveniles will recruit into the adult population over the next three years (2018, 2019 and 2020), resulting in further increases in snorkel counts and additional power in interpreting an increasing population trend.

Note that there was no or at best extremely limited spawning habitat within lower Chauncey Creek and Lake Mountain Creek. These lower tributary habitats adjoin documented high density mainstem spawning habitats (Cope *et al.* 2016). The large increases in juvenile densities in these locations reflect movement patterns and habitat preferences of juvenile Westslope Cutthroat Trout for tributary habitat with coarse substrate, gradients of 1 to 3% and abundant overhead cover in the form of coarse substrate interstices and large woody debris.

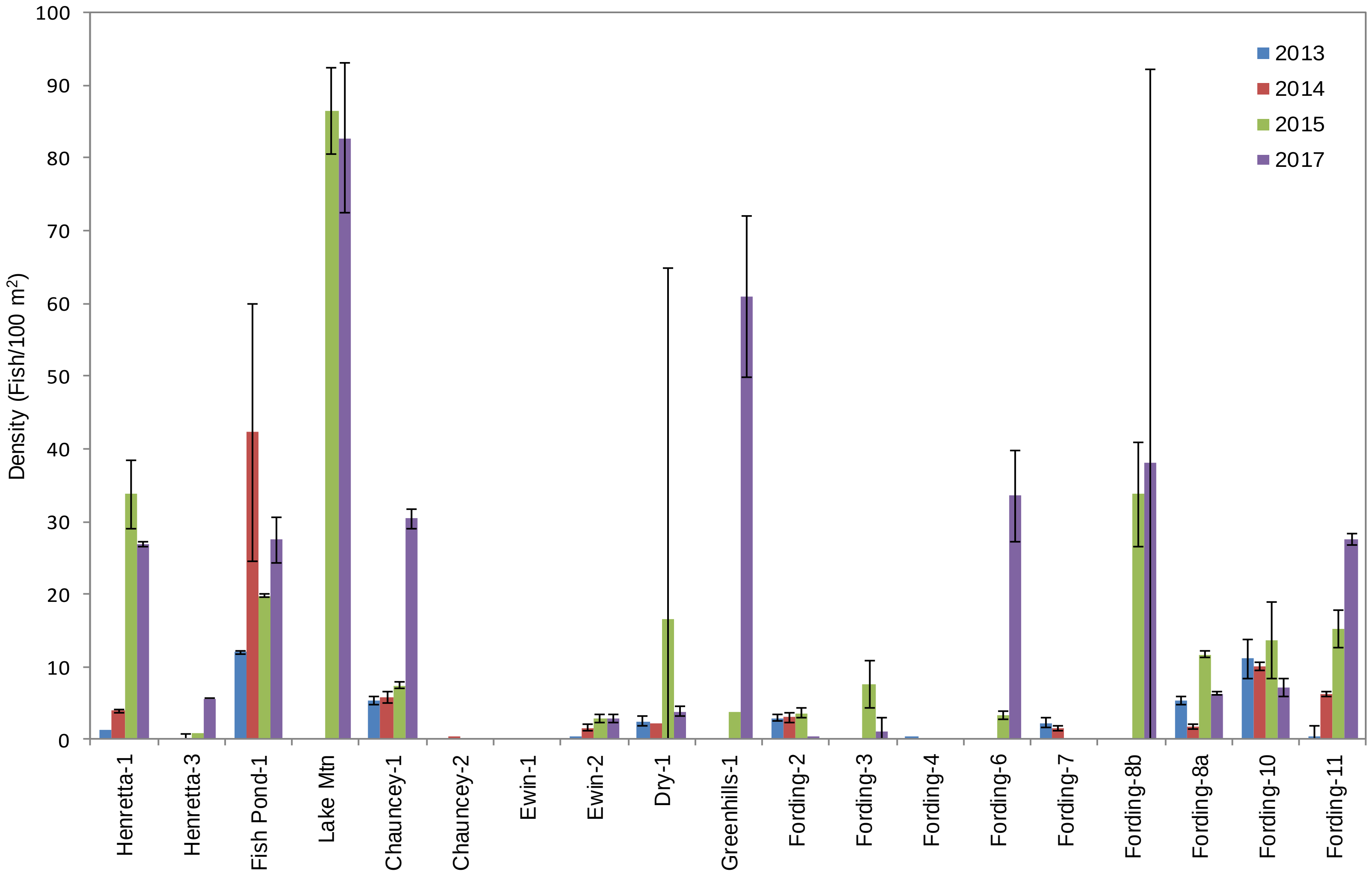


Figure 3.3. Density estimates (fry and juvenile life stages combined) for the 19 locations within the upper Fording River watershed sampled in 2013, 2014, 2015 and 2017.

Table 3.6. Summary of fry and juvenile density and biomass estimates by composite location, upper Fording River, 2013-2015 and 2017.

Year	Stream	Segment	Area (m^2)	Density (Fish/100 m^2) Fry	Juv	Comb.	Biomass (g/100 m^2) Fry	Juv	Comb.
2013	Henretta	1	370.8	0.00	1.35	1.35	0.00	35.27	20.90
2014	Henretta	1	505.0	0.00	3.96	3.96	0.00	136.20	136.20
2015	Henretta	1	293.6	1.02	33.38	33.73	0.77	691.97	692.74
2017	Henretta	1	293.5	0.00	26.91	26.91	0.00	2179.87	2179.87
2013	Henretta	3	307.4	0.00	0.00	0.00	0.00	0.00	0.00
2014	Henretta	3	810.0	0.00	0.25	0.25	0.00	33.48	33.48
2015	Henretta	3	342.8	0.00	0.88	0.88	0.00	24.12	24.12
2017	Henretta	3	352.9	0.00	5.62	5.62	0.00	305.96	305.96
2013	Fish Pond	1	375.5	0.50	11.48	11.98	0.20	296.37	296.57
2014	Fish Pond	1	374.0	3.74	37.17	42.25	0.85	911.23	1035.79
2015	Fish Pond	1	359.4	0.83	18.92	19.76	0.63	326.01	326.64
2017	Fish Pond	1	382.3	4.19	23.28	27.47	3.35	824.80	828.16
2015	Lake Mtn.	1	100.5	26.87	59.70	86.57	20.15	966.39	986.54
2017	Lake Mtn.	1	107.5	38.14	43.72	82.79	38.14	1505.31	1535.82
2013	Chauncey	1	319.7	0.00	5.32	5.32	0.00	137.34	137.34
2014	Chauncey	1	277.3	0.00	5.77	5.77	0.00	282.77	282.77
2015	Chauncey	1	281.4	0.00	7.46	7.46	0.00	98.67	98.67
2017	Chauncey	1	286.2	0.00	30.39	30.39	0.00	641.31	641.31
2013	Chauncey	2	300.4	0.00	0.00	0.00	0.00	0.00	0.00
2014	Chauncey	2	320.9	0.00	0.31	0.31	0.00	40.95	40.95
2013	Ewin	1	334.5	0.00	0.00	0.00	0.00	0.00	0.00
2014	Ewin	1	283.4	0.00	0.00	0.00	0.00	0.00	0.00
2013	Ewin	2	325.5	0.00	0.31	0.31	0.00	8.10	8.10
2014	Ewin	2	247.5	0.81	0.80	1.62	0.08	22.26	22.35
2015	Ewin	2	413.3	0.00	2.90	2.90	0.00	63.96	63.96
2017	Ewin	2	341.8	0.59	2.34	2.93	0.47	29.26	29.73
2013	Dry	1	294.9	0.00	2.71	2.71	0.00	70.79	70.79
2014	Dry	1	266.5	0.00	2.25	2.25	0.00	71.14	71.14
2015	Dry	1	163.6	6.11	3.06	16.50	4.58	22.89	27.47
2017	Dry	1	287.8	0.00	3.82	3.82	0.00	66.00	66.00
2015	Greenhills	1	187.6	0.53	3.20	3.73	0.40	23.96	24.36
2017	Greenhills	1	208.4	38.87	21.11	60.94	31.09	296.43	327.52

continued

Table 3.6. Concluded.

			Area	Density (Fish/100 m^2)			Biomass (g/100 m^2)		
Year	Stream	Segment	(m^2)	Fry	Juv	Comb.	Fry	Juv	Comb.
2013	Fording	11	373.5	0.00	0.54	0.54	0.00	13.30	13.30
2014	Fording	11	332.5	0.30	6.00	6.32	0.10	304.00	304.00
2015	Fording	11	263.5	0.38	14.42	15.18	0.28	207.55	207.83
2017	Fording	11	272.9	0.00	27.48	27.48	0.00	1122.11	1122.11
2013	Fording	10	299.0	9.73	0.30	10.03	3.87	8.70	12.57
2014	Fording	10	374.9	6.90	3.20	10.14	2.30	445.20	239.30
2015	Fording	10	308.0	1.30	12.01	13.64	0.97	943.74	944.71
2017	Fording	10	322.1	0.00	7.14	7.14	0.00	584.82	584.82
2015	Fording	8b	278.5	27.30	5.75	33.75	20.47	426.15	446.62
2017	Fording	8b	243.7	43.49	2.05	38.16	34.79	89.61	124.00
2013	Fording	8a	338.2	0.30	5.02	5.32	0.10	129.40	129.50
2014	Fording	8a	401.1	0.00	1.76	1.75	0.00	62.00	62.00
2015	Fording	8a	400.8	5.74	5.99	11.73	4.30	329.52	333.83
2017	Fording	8a	381.1	0.52	5.77	6.30	0.42	366.15	366.57
2013	Fording	7	300.0	0.00	2.33	2.33	0.00	60.40	60.40
2014	Fording	7	392.0	0.00	1.53	1.53	0.00	50.82	50.82
2015	Fording	6	336.8	3.27	0.00	3.27	2.45	0.00	2.45
2017	Fording	6	271.6	33.51	0.74	33.51	26.81	6.81	33.62
2013	Fording	4	366.0	0.00	0.27	0.27	0.00	7.00	7.00
2014	Fording	4	508.8	0.00	0.00	0.00	0.00	0.00	0.00
2015	Fording	3	275.1	7.63	0.00	7.63	5.72	0.00	5.72
2017	Fording	3	257.9	0.78	0.39	1.16	0.62	19.39	20.01
2013	Fording	2	446.1	2.02	0.00	2.02	0.84	0.00	0.84
2014	Fording	2	268.4	2.98	0.00	2.98	1.79	0.00	1.79
2015	Fording	2	305.7	3.27	0.33	3.60	2.45	2.45	4.90
2017	Fording	2	240.1	0.00	0.42	0.42	0.00	2.92	2.92

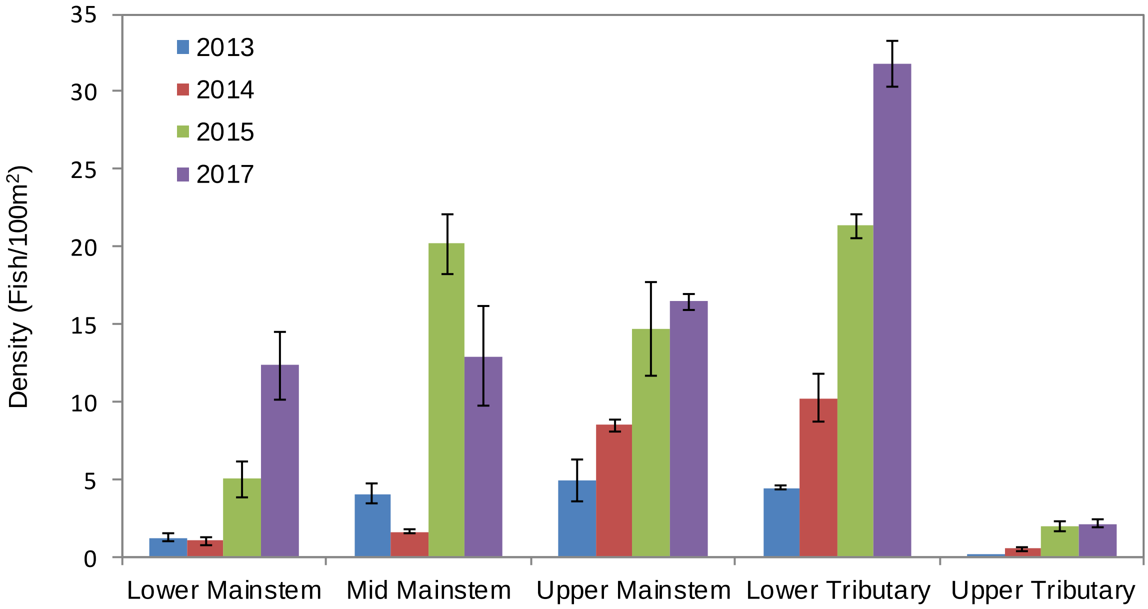
Pooled Segments

Spatial trends were illustrated further through pooling of location estimates into five watershed areas or strata; lower, mid and upper (headwaters) Fording River mainstem plus lower and upper tributary (Table 2.2). Figure 3.4 illustrates the increase in population densities (fry and juveniles combined) have been broad based across all mainstem strata and the lower tributary strata. The much larger biomass increases within the headwater (upper mainstem) and lower tributary strata are reflective of the increased juvenile densities and increases in mean weight (*i.e.,* a larger proportion of 2^+ to 4^+ age classes).

The lack of population response within upper tributary locations compared to remaining watershed strata was attributed to lost connectivity. Both upper tributary locations have full or partial culvert barriers to mainstem connectivity (Cope *et al.* 2016) with low densities of Westslope Cutthroat Trout within fragmented habitat segments upstream.

Figure 3.5 illustrates density trends for fry and juveniles separately across watershed strata and the relative importance of these areas to these life stages. Fry have a more ubiquitous distribution suggesting spawning occurs within all strata, whereas juveniles migrate into preferred habitats represented by the headwaters and lower tributaries.

A. Density



B. Biomass

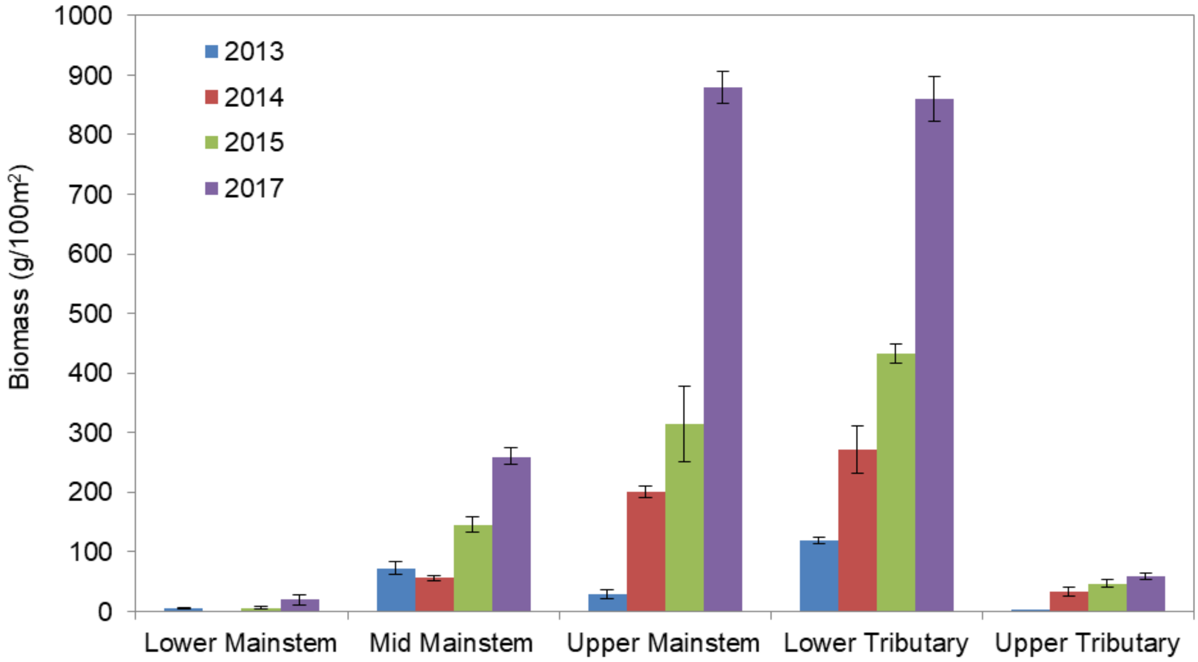
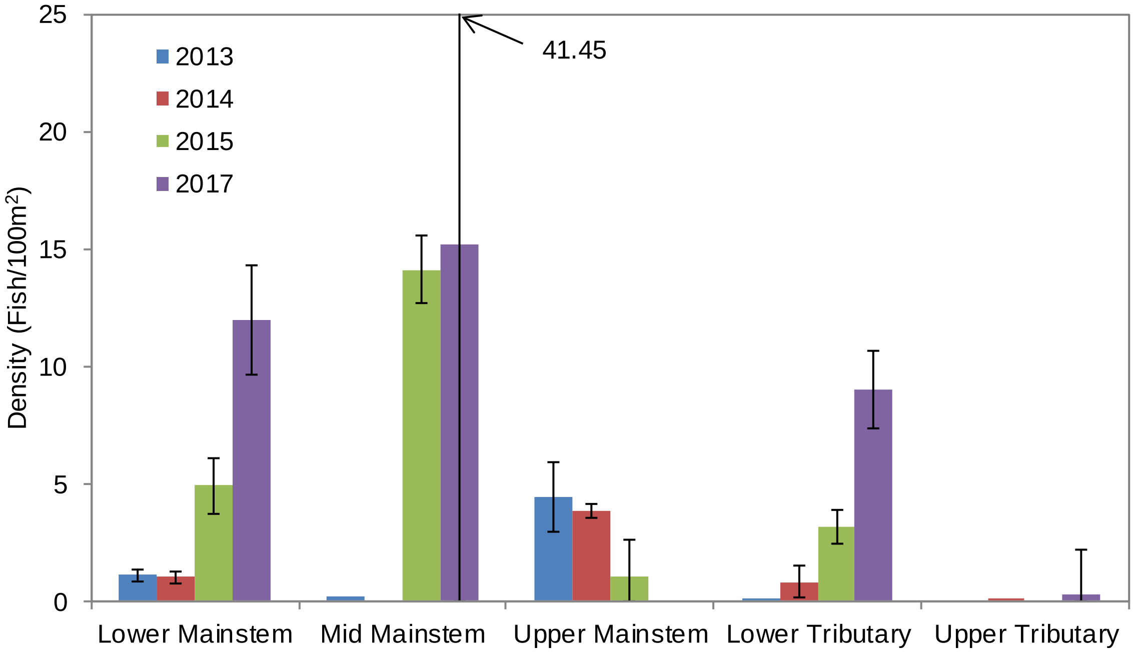


Figure 3.4. Density and biomass estimates for fry and juveniles combined by pooled river segments or watershed area, upper Fording River, 2013, 2014, 2015 and 2017.

B. Fry



B. Juveniles

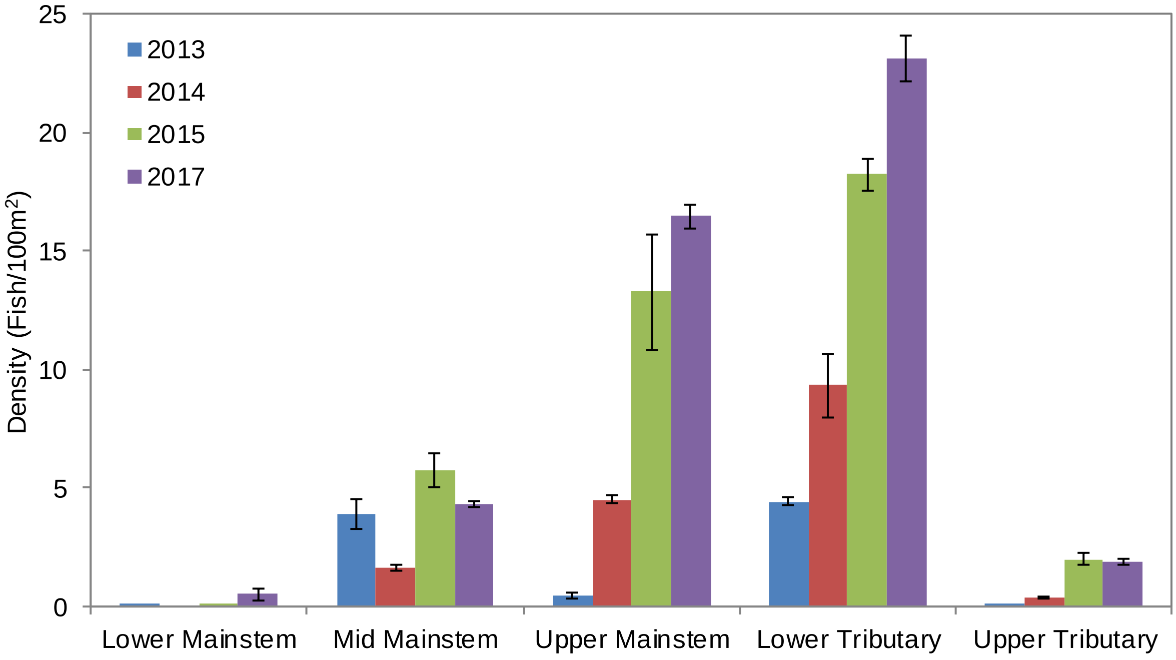


Figure 3.5. Fry and Juvenile density estimates for pooled river segments or watershed area, upper Fording River, 2013, 2014, 2015 and 2017.

3.3 Mark - Recapture and Growth Update

An additional 355 PIT Tags were applied to the 2017 catch. There were three recaptures from the 340 PIT Tags applied previously (2013 – 2015; Cope *et al.* 2016). In addition, there was one Floy Tag recapture from the 495 Floy Tags applied previously (Cope *et al.* 2016). This data has been added to the mark – recapture growth dataset (Cope *et al.* 2016) and are summarized below in Table 3.7. The 2013 Floy Tag recovery has confirmed an upper Fording River Westslope Cutthroat trout of 283 mm to be 7 years old.

Table 3.7. Summary of mark – recapture data for 2017 electrofishing captures.

Original Capture				Recapture			
Year	Length (mm)	Weight (g)	Age	Year	Length (mm)	Weight (g)	Age
2015	92	8.1	1	2017	191	86.0	3
2015	126	22.4	2	2017	208		4
2015	150	37.7	2	2017	249	245.0	4
2013	201	100.0	3	2017	283	300.0	7

4 Discussion

The upper Fording River Westslope Cutthroat Trout population monitoring program recognizes CPUE indexing methods are extremely sensitive to methodology deviations that affect catchability. For this reason, trend monitoring included two independent population metrics to increase confidence in the interpretation of population trends. These included; 1) adult snorkel counts and a Pooled Peterson Model that used previously calibrated observer efficiencies, and 2) juvenile three pass removal-depletion density estimates.

The 2017 snorkel program enumerated 3,672 fish. This was more than double the previous surveys (2012, 2013 and 2014). Since the previous snorkel count (2014), the sub-adult and adult count (fish greater than 200 mm) increased by 46% and the juvenile count (fish less than 200 mm) increased by 407% (five times). The majority of the increase was located in the FRO onsite river segments and the upstream headwaters (Table 3.2).

Based on the 2017 model estimate of 3,690 fish greater than 200 mm the sub-adult and adult population trend appears to be increasing in the first three years (2012 to 2014) and stable since 2014; but the evidence of an increase in population size among the years was weak (95% confidence intervals overlap). The sub-adult and adult population estimate in 2017 was based on snorkel count CPUE data and was extremely sensitive to methodology deviations that affect catchability (observer efficiency). The streamflow and visibility conditions in 2017 were most consistent with the 2012 conditions and the highest observer efficiency. As a result, the median model estimate (4,908 fish greater than 200 mm) and range (3,690 to 6,240 fish greater than 200 mm) most likely over-estimate the 2017 population abundance. This assumption was supported by the low flows, drought conditions (no precipitation before or during snorkel survey), time post 2013 flood event for fines and disturbance effects to stabilize (4 years), and professional opinion. For this reason and based on a recommended precautionary Westslope Cutthroat Trout management approach when faced with uncertainty (DFO 2017), the lower estimate (*i.e.,* highest observer efficiency) of 3,690 Westslope Cutthroat Trout greater than 200 mm was used.

It has been suggested that 45 fish greater than 300 mm/km from systems that are almost entirely catch and release (Hagen and Baxter 2009) may represent an approximation of the unfished equilibrium abundance ($N_{equilibrium}$) for large productive systems (DFO 2017). The 2017 upper Fording River density estimate was approximately half that (22 fish greater than 300 mm/km, Table 3.4). In 2010 the upper Bull River reference population had an estimated 55 fish greater than 300 mm/km. The lower St. Mary River, at a time when fishing effort was much lower, had an estimated 75 fish greater than 300 mm/km (Oliver 1990 in DFO 2017). This was in contrast to the 44 fish greater than 300 mm/km estimated in 2008 (Hagen and Baxter 2009).

Based on the viability population estimate of 4,600 adults (90% probability estimate, DFO 2009), this suggest a target density of 95 adult fish/km. The length at maturity was estimated to be between 233 and 290 mm (Cope *et al.* 2016), so this would equate to something less than 95 fish greater than 300 mm but higher than 45 fish greater than 300 mm. While the adult population trend appears to be stable, the current range of density estimates of between 22 to 28 Westslope Cutthroat trout greater than 300 mm/km was much less than reference targets of between 45 and 95 Westslope Cutthroat trout greater than 300 mm/km.

Target densities derived from reference populations (*i.e.,* Bull River, St. Mary River, Michel Creek) suggest the upper Fording River Westslope Cutthroat Trout population is not achieving its full productive potential. This is most likely due to; 1) the cumulative impacts of mining operations over the last 40 plus years and the perceived threats to population resilience and sustainability that have been identified (Cope *et al.* 2016), and 2) natural limitations resulting from the isolated, headwater, tributary nature of the habitat they occupy (*i.e.,* high elevation stream with restricted geographic distribution and a short summer rearing season and low productivity).

The mean overall density of fry and juveniles combined have shown a significant statistical increase every year since monitoring began. The 2017 mean density (13.38 fish/100 m^2) represents a 223% (3.23 times) increase since 2013 (4.14 fish/100 m^2). The data illustrates the increases in fry and juvenile densities have been broad based across all mainstem strata (lower, mid-, upper watershed) and the lower tributary strata. Upper tributary locations have not increased proportionally with the rest of the watershed strata and was assumed to be due to lost connectivity (*i.e.,* impassable culvert barriers or size based life stage limits to culvert passage) and resulting habitat fragmentation. This result underscores the importance of the habitat off-setting focus on connectivity. The monitoring data to date provide the necessary baseline for success or performance measure monitoring of habitat off-setting options designed to restore connectivity and increase upper tributary Westslope Cutthroat Trout densities.

The fry and juvenile density data generated using three pass removal – depletion methods was further supported by the snorkel count data. The count data also documented a large increase in juvenile counts (407% since 2014). The majority of the juveniles (60 to 200 mm) were 1^+ to 3^+ age classes spawned in 2014, 2015, and 2016 after the 2013 flood event. This may represent high egg to fry survival conditions and strong year classes in the moderate to low freshet flows in the years following the 2013 flushing event. A flushing event refers to flood flows of sufficient force to result in bedload (*i.e.,* particles such as gravels and cobbles transported in water through rolling, sliding or saltating) that “flush” fines from streambed substrates to the benefit of salmonid embryo, alevin, fry and juvenile interstitial habitats.

In summary, fry and juvenile densities have increased significantly in the last 5 years since the June 2013 flood event. Sub-adults and adults (fish greater than 200 mm) and large Westslope Cutthroat Trout (fish greater than 300 mm) have remained stable or increased slightly but this was expected given the timeframe since angling prohibition (7 years), since monitoring began (5 years) and the time lag expected to reach a length greater than 300 mm (7 years). It is expected the large cohort of juveniles documented in the snorkel count and in removal depletion estimates will recruit into the adult population over the next three years (2018, 2019 and 2020), resulting in further increases in adult snorkel counts in future years and additional power in interpreting an increasing population trend.

Further increases should be possible and probable given; 1) the continued angling prohibition (since 2010), 2) improvements in juvenile densities due to post flood recovery, and 3) the habitat off-setting works targeting limiting factors and improvements to habitat carrying capacity.

5 Recommendations

The relative index methods were employed successfully and population monitoring objectives were achieved. It is recommended the upper Fording River Westslope Cutthroat Trout Population Monitoring Project proceed with the population monitoring as scheduled in 2019 and 2021. The large cohort of juveniles identified will allow further validation of methods (predicting will recruit to adults in next 3 years) and will provide additional power in interpreting a population trend.

Habitat off-setting effectiveness monitoring requirements have been incorporated into the upper Fording River Westslope Cutthroat Trout Population Monitoring Project to ensure consistency and cost efficiencies. Should there be a desire for annual monitoring of habitat offsetting, this could be completed in the interim years (2018, 2020) cost effectively as just the snorkel count data. This would also provide some back-up in case a future year gets “rained out”.

Population monitoring provides a unique opportunity to test assumptions regarding habitat off-setting effectiveness including the value of restoring connectivity and the assertion that habitat fragmentation may be limiting population productivity and abundance within preferred juvenile tributary rearing habitat. The upper Chauncey Creek location should be resampled in planning for culvert replacement. Continued monitoring could then document the population response and potential benefits within Chauncey Creek when an opportunity arises for culvert replacement with an appropriately designed stream crossing structure. Similar learning opportunities exists for Henretta Creek.

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Appendix A

Habitat Off-setting Sub-section Data

Appendix A. Snorkel Count Data for individual sub-sections used for habitat off-setting effectiveness evaluation and reaches used for population monitoring (shaded reach totals).

Date	Water Body	Reach	Section	Horizontal Secchi Visibility (m)	Snorkel Length (km)	Snorkel Count WCT (no Marks) 1-100	100-200	200-300	300-400	400-500	500+	Total > 200	Tag Observations Floy Yellow	Floy Pink	Radio Antenae
Sept 5 2017	Fish Pond Cr	1	FISH1-1T	7		20	59	87	9	0	0	96			
Sept 5 2017	Henretta Cr	3	HEN2-2C	7		0	9	20	5	0	0	25			
Sept 5 2017	Henretta Cr	3	HEN2-1T	7		0	0	0	0	0	0	0			
	Henretta Lake	2		6.5	0.50	0	0	11	12	2	0	25	2	1	
Sept 5 2017	Henretta Cr	1	HEN1-2T	7		0	0	0	0	0	0	0			
Sept 5 2017	Henretta Cr	1	HEN1-1	7		0	7	5	0	0	0	5			
	Henretta Cr	1			1.00	0	7	5	0	0	0	5			
Sept 6 2017	Fording River	10	10-1	8		20	224	217	17	0	0	234	1		
Sept 6 2017	Fording River	10	10-2C	8		1	21	15	1	0	0	16			
Sept 6 2017	Fording River	10	10-1T	8		0	7	6	0	0	0	6			
	Fording River	10			4.35	21	252	238	18	0	0	256			
Sept 6 2017	Fording River	9	9-6T	8		0	0	0	0	0	0	0			
Sept 6 2017	Fording River	9	9-5	8		0	13	8	1	0	0	9			
Sept 6 2017	Fording River	9	9-4T	8		0	10	16	0	0	0	16			
Sept 6 2017	Fording River	9	9-3C	8		30	63	23	1	0	0	24			
Sept 6 2017	Fording River	9	9-2	8		4	99	116	43	8	1	168			
Sept 6 2017	Fording River	9	9-1T	8		25	31	63	28	1	0	92			
	Fording River	9			3.65	59	216	226	73	9	1	309			
Sept 7 2017	Fording River	8	8-7T	6.5		0	40	37	24	4	0	65			
Sept 7 2017	Fording River	8	8-6C	6.5		4	6	11	3	2	0	16			
Sept 7 2017	Fording River	8	8-5T	7		0	0	11	6	6	2	25	1		
Sept 7 2017	Fording River	8	8-4T	7		0	0	0	0	0	0	0			
Sept 7 2017	Fording River	8	8-3C	7		0	0	4	2	0	0	6			
Sept 7 2017	Fording River	8	8-2T	7		0	0	1	1	0	0	2			
Sept 7 2017	Fording River	8	8-1C	7		345	92	59	15	2	5	81	1		
	Fording River	8			5.75	349	138	123	51	14	7	195			
Sept 8 2017	Fording River	7	7-3T	7		185	23	49	6	0	0	55			
Sept 8 2017	Fording River	7	7-2C	7		368	250	274	78	2	0	354			
Sept 8 2017	Fording River	7	7-1	7		12	164	47	2	0	0	49			
	Fording River	7			5.04	565	437	370	86	2	0	458			

Appendix A. Concluded.

						Snorkel Count WCT (no Marks)							Tag Observations		
Date	Water Body	Reach	Section	Horizontal Secchi Visibility (m)	Snorkel Length (km)	1-100	100-200	200-300	300-400	400-500	500+	Total > 200	Floy Yellow	Floy Pink	Radio Antenae
Sept 9 2017	Fording River	6	6-Top	8		0	11	38	17	0	0	55			
Sept 9 2017	Fording River	6	6-Bottom	8		0	13	33	42	7	3	85			1
	Fording River	6			7.00	0	24	71	59	7	3	140			
Sept 10 2017	Fording River	5		4	4.40	8	1	17	18	1	0	36		1	
Sept 10 2017	Fording River	4		7	4.40	0	5	50	21	6	0	77			
Sept 11 2017	Fording River	3		6.5	4.16	2	2	1	3	4	3	11			
Sept 11 2017	Fording River	2		4	4.00	0	12	0	24	11	1	36			1
Sept 12 2017	Fording River	1		4	4.12	0	1	0	5	15	5	25			2
Totals					48.37	1004	1095	1112	370	71	20	1573	5	2	4

▨ River Segments used for Population Monitoring (2012, 2013, 2014, 2017). Remaining sub-segments added in 2017 for habitat off-setting effectiveness monitoring (see Lotic Environmental 2017).