Technical Report No. 11-07

Tributary Creek Fish Population Estimates

by

Katrina M. Kanouse

November 2011

Alaska Department of Fish and Game **Division of Habitat**

Cover from left: Chris Wallace (Hecla Greens Creek Mining Company), Katrina Kanouse and Tess Quinn (Alaska Department of Fish and Game) at the mouth of Tributary Creek, Zinc Creek in the foreground. Photo by Katie Eaton.

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This document should be cited as:
Kanouse, K. M. 2011. Tributary Creek Fish Population Estimates. Alaska Department of Fish and Game, Technical Report No.11-07, Douglas, Alaska.

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TRIBUTARY CREEK FISH POPULATION ESTIMATES

by
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November 2011

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in reports by the Divisions of Habitat, Sport Fish and of Commercial Fisheries. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ACKNOWLEDGEMENTS

The Alaska Department of Fish and Game (ADF&G) thanks Hecla Greens Creek Mining Company (Hecla) for their financial, logistical, and field support for this special project, particularly Jennifer Saran, Chris Wallace and Ted Morales. We also thank Fisheries Biologist Ryan Kreiner and Fisheries Technician Thor Eide of the U.S.D.A. Forest Service who assisted with field sampling in 2010 and 2011.

Several staff of the ADF&G Division of Habitat assisted with project design and field data collection. Habitat Biologist Katie Eaton researched previous fisheries studies, authored the project proposal to Hecla, and led the field crew in 2010. Fish and Wildlife Technician Tess Quinn assisted with field sampling in 2010 and 2011, and led the field crew in 2011. Habitat Biologists Jackie Timothy and Joe Hitselberger assisted with field sampling in 2011. Finally, Al Ott and Jackie Timothy provided technical review and editing.

EXECUTIVE SUMMARY

Hecla Greens Creek Mining Company (Hecla) proposes to expand their existing dry-stack tailings disposal facility south into Tributary Creek, a lowland stream that provides habitat for several species of anadromous and resident fish. In preparation for government review of the proposed project, Hecla requested the ADF&G Division of Habitat estimate the abundance and composition of coho salmon *Oncorhynchus kisutch*, Dolly Varden char *Salvelinus malma*, and cutthroat trout *O. clark*i, in three reaches of Tributary Creek and compare the results to those of a baseline survey conducted in 1981 prior to mine development. Generally, salmonid populations in Tributary Creek appear to be similar to populations documented 30 years ago, though species composition appears to have changed within each of the reaches.

INTRODUCTION

Hecla operates an underground polymetallic mine on Admiralty Island in southeast Alaska. Mineral claims for the project were staked in the 1970s within the U.S. Forest Service (USFS) Admiralty National Monument. Mine operations began in 1989 and have continued to date, interrupted once between 1993 and 1996 due to low metal prices. Hecla currently produces more than 2,000 tons of ore concentrate per day containing silver, lead, zinc, and gold, which is shipped to smelters worldwide for processing.

In 2010, Hecla proposed to expand the existing dry-stack tailing disposal facility (TDF) to accommodate additional tailing as exploration results and improved metals prices have extended the projected mine life 30–50 years. Hecla's proposed TDF expansion would hold 10–15 million tons of tailings and expand 50–60 acres (20–24 hectares) to the south into Tributary Creek. The USFS, in cooperation with state agencies, is currently reviewing the proposal among other alternative TDF designs. To provide additional fisheries information for the project review, Hecla requested that we estimate the abundance and composition of fish in Tributary Creek and compare the results with the previous results from a baseline study conducted prior to mine development.

PURPOSE

The objective of this study is to provide additional fisheries information for project review by estimating abundance and composition of salmonid populations in three reaches of Tributary Creek and compare the results with a premine baseline study to detect any change in fish abundance or composition since mine development and operations.

LOCATION

Greens Creek Mine is located about 29 km (18 mi) west of Juneau, Alaska, on Admiralty Island in the USFS Tongass National Forest. The TDF and associated facilities are located in the historical headwaters of Tributary Creek. Tributary Creek is a shallow, low-energy, lowland stream with annual flows ranging from 1 to 5 cfs. The creek is about 1.6 km long, gradient varies from 1% to 2%, and wetlands and inactive beaver ponds south of the TDF are the primary sources for base flow. Water flow is flashy as the creek is largely fed by precipitation and drainage from adjacent hillsides.

Tributary Creek is included in the *Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes* and provides habitat for coho salmon *Oncorhynchus kisutch*, pink salmon *O. gorbuscha*, and Dolly Varden char *Salvelinus malma* (Johnson and Blanche

2011). Cutthroat trout *O. clarki*, rainbow trout *O. mykiss*, and sculpin *Cottus* sp. also have been observed in the creek (Kanouse 2011).

METHODS

Sample design and methods followed the protocol used during the baseline fish populations survey to the extent practicable (Buell 1981). Deviations from Buell's protocol and data analyses are described below.

SAMPLE SITES

In the 1981 study, Buell sampled three reaches in Tributary Creek:

- Reach B located between 244 m and 349 m upstream from the mouth (105 m)
- Reach C located between 754 m and 847 m upstream from the mouth (94 m); and
- Reach D located between 1,128 m and 1,205 m upstream from the mouth (77 m).

In 1981, the upper and lower extents of each reach were marked with yellow and orange/white flagging tape and tin shiners that were nailed to trees nearby. We found three tin shiners during our field surveys in 2010 and 2011. We used a hip chain and walked the centerline of the creek upstream from the mouth to reestablish each reach. Our measured reaches were similar to those used by Buell (1981) and we designated the reaches based on our measurements. Changes in stream morphology could explain differences in stream reach locations among years. We marked the upper and lower ends of the reaches in 2010 with blue/white flagging, which were still present in 2011.

DATA COLLECTION

We used the Petersen mark–recapture method to estimate abundance of fish in each reach. Block nets made of 3.175 mm (1/8 in) mesh with cork and lead lines were installed at the lower and upper ends of each reach to prevent fish movement, and left in place throughout the entire study. Using a backpack electrofisher (Smith-Root LR-24 Electrofisher[1], Vancouver WA), we fished each reach beginning with the downstream-most reach on the downstream end in a single pass. Voltage, pulse, and frequency were adjusted to maximize capture probability without causing fish injury. Two biologists followed the electrofishing wand and captured stunned fish with hand nets. Fish were removed from the creek and retained in a large plastic bucket equipped with an aerator.

After fishing each reach, captured fish were anaesthetized with clove oil, identified to species, measured to fork length, and marked by clipping the dorsal tip of the caudal fin during the 2010 sampling event, or clipping the dorsal tip of the dorsal fin during the 2011 sampling event. Fish measuring less than 45 mm were not included in the 2010 or 2011 study as their fins were too small to effectively mark without removing a substantial portion of the fin, which could cause mortality and violate a condition of the Petersen mark–recapture method. After recovering from the clove oil treatment in fresh, aerated water, marked individuals were returned to the sample reach throughout the length of the reach sampled.

After 24 hours, we electrofished each reach in the same manner. Captured fish were identified to species, measured to fork length, evaluated for marked fins, and returned to the creek. Block nets

[1] Product names used in this publication are included for completeness but do not constitute product endorsement.

were removed following the second sampling. A cross section flow survey to determine discharge was conducted for each sample reach.

During the 2010 survey, the electrofisher did not function properly and each of our four batteries only lasted 10–20 minutes. We ordered new batteries for the 2011 survey and the electrofisher functioned as designed.

DATA ANALYSES

Data analyses of the 1981 baseline data used the Bailey modification of the Petersen single census method to estimate fish populations (Buell 1981). Bernard and Hansen (1992) suggest the Bailey modification is appropriate when sampling during the second event is done with replacement. The methods described in the 1981 report do not specify if fish were removed or replaced during the second event.

We used the Chapman modification to the Petersen single census method to estimate fish populations in 2010 and 2011. This approach is appropriate when sampling during the second event is done without replacement; we did not replace fish during the second event. Please note that fish less than 45 mm long were not included in our studies. The 1981 study included all fish captured regardless of size.

Fish population estimates calculated using the Chapman modification reduces the likelihood of overestimating a small population when few marked fish are recaptured in the second event (Vincent 1971). We used a slight modification to the Chapman equation recommended by Ricker (1975) to calculate fish population estimates for the 2010 and 2011 data, where the fraction portion of the equation is not reduced by 1. To calculate the population estimate, N, let M represent the number of fish marked during the first event, let C represent the combined number of unmarked and marked fish captured during the second event, and let R represent the number of recaptured marked fish in the second event.

$$N = \frac{(M+1)(C+1)}{(R+1)} \tag{1}$$

Confidence intervals of 95% were calculated by treating R as a Poisson variable, using upper and lower values from a Poisson frequency distribution table and substituting those in Equation (1) for each population estimate (Ricker 1975). These intervals are usually asymmetrical and measure variability more accurately than calculating variance and standard error to determine 95% confidence intervals, particularly for single population estimates (Bryant 2000).

Data analyses were performed using hand calculators and spreadsheets. Significant differences ($\alpha \leq 0.05$) among populations were determined using the 95% confidence intervals.

EVALUATION OF STUDY DESIGN AND DATA ANALYSES

Sample reaches designated by Buell (1981) may have been too small to ensure accuracy of fish population estimates. Vincent (1971) suggests that sample reaches for mark–recapture studies should be determined by sample size, and generally greater than 305 m (1000 ft) to guarantee a minimum sample size of 150 fish. The stream reaches designated by Buell (1981) and sampled in 2010 and 2011 were 25–35% of the recommended reach lengths, and the total number of fish captured in a single event was 102. The median number of fish captured per sample event in 2010 and 2011 was 7 fish. The small sample size in the 2010 survey, and particularly in the 2011 survey, negatively affected the reliability of the fish population estimates. Additional sampling time during the census event (Ricker 1975) and longer sample reaches may have improved accuracy and precision of population estimates.

Catch rates were less than expected during the 2010 and 2011 surveys. The 2010 survey may have been adversely affected by discharge and faulty electrofisher batteries. High discharge during the sampling period afforded more fish habitat, particularly habitats difficult to thoroughly electrofish (e.g., large woody debris and undercut banks). In addition, malfunctioning electrofisher batteries may not have transmitted adequate electrical currents to stun fish. Catch rates during the 2011 survey may also have been adversely affected by discharge, where low water levels reduced available habitat and number of fish present (i.e., sample size). Raw data from the 1981 survey is not available to evaluate catch rate success, though the large confidence intervals provided for each population estimate suggest low catch rate success.

Numbers of marked fish recaptured during the census event were low during the 2010 and 2011 surveys, also weakening the reliability of population estimates. In 2010, marked fish captures ranged from 0% to 18.2% (median 7.3%) of the total captures. In 2011, marked fish captures ranged from 0% to 25.5% (median 8.0%) of the total captures. The modified Chapman equation provides an unbiased population estimate if the total of the number of fish captured during the first and second sampling events is greater than the population estimate (Robson and Regier 1964). Of all the species sampled in the 3 reaches in 2010 and 2011, this condition is only valid for the 2011 coho salmon population estimate in Reach B. In addition, Ricker (1975) suggests that population estimates derived are unbiased if the number of recaptures is greater than four, which was not the case for many species estimates. Finally, Jensen (1992) suggests that population estimates derived from the mark–recapture method have low bias if more than 50% of the population is marked, which could not have been possible for many of the populations sampled. Therefore, many of the population estimates derived from the 2010 and 2011 surveys are negatively biased.

RESULTS AND DISCUSSION

Stream discharge during the 2010 field survey was higher than during the 2011 survey, typical of the fall and spring seasons in southeast Alaska (Table 1). Hecla's rain gage at the Hawk Inlet terminal recorded nearly 17 cm of rainfall during the 3 weeks prior to sampling in 2010, and only 4 cm of rainfall during the 3 weeks prior to sampling in 2011 (C. Wallace, Hecla Environmental, Juneau, personal communication). These rainfall amounts were similar to preliminary climatology data collected in Juneau by the National Weather Service, which reports that 20 cm of rain fell during the three weeks prior to sampling 2010 and and 3 cm of rain fell during the three weeks prior to sampling in 2011.

Table 1.–Field-measured discharge in Tributary Creek during sampling in 2010 and 2011.

Year	Reach	Discharge (cfs)[a]	Discharge (cms)[a]
2010	D	1.16	0.033
2010	C	1.94	0.055
2010	B	3.42	0.097
2011	D	0.32	0.009
2011	C	0.59	0.017
2011	B	0.42	0.012

[a] Field measuring discharge in Tributary Creek during low flow is difficult because of shallow water. Field measurements collected in 2011 may not be accurate, particularly in Reach B where discharge should have measured the highest.

Habitat availability, fish distribution, and vulnerability of fish for capture can be influenced by discharge in small streams such as Tributary Creek. High discharge periods provide more fish habitat than low discharge periods, which may influence the number of fish present. Changes in species density between seasons and years may be attributed to different habitat conditions during sampling, as the distribution of juvenile salmonids is determined by species-specific habitat requirements (Quinn 2005). Finally, fish hiding in complex habitats and cover can reduce fish vulnerability to electrofishing capture (Rodgers et al. 1992).

2010 Fish Population Estimates

The first sampling event occurred on October 14, 2010 and the census event occurred about 24 hours later on October 15, 2010. Water temperature during this period was about 7.5°C, and light rain fell throughout both days. Stream level was less than bankfull, though higher than observed in July during sampling for the Fresh Water Monitoring Program (Kanouse 2011).

Coho salmon were most abundant among species in all reaches—significantly more abundant in Reach B than other species, and significantly more abundant in Reach C than cutthroat trout (Table 2, Figure 1).[2, 3] No cutthroat trout were captured in Reach B. No marked Dolly Varden char were recaptured in Reach C or D so only the number of captures is presented. Length

[2] No significant differences between coho salmon and Dolly Varden char populations were found in within any of the reaches. No marked cutthroat trout were recaptured during the census event in any of the reaches; therefore no population estimate can be calculated, Only the total number of captured fish are presented. Dolly Varden char and cutthroat trout were equally dense and more dense than coho salmon in Reach D, while Dolly Varden char were more dense than other species in Reaches B and C.

[3] Large confidence intervals are attributable to low recaptures of marked fish, which reduces the precision of the estimates.

frequencies of captured fish suggest more than one age class was present for each species (Appendix A).

Table 2.–2010 fish mark–recapture data by reach and species.

Reach	Species[a]	Number of fish marked and released	Total recaptured	Number of marked fish recaptured	Population Estimate (*N*)	Upper 95% CI (+)	Lower 95% CI (-)	Est. Fish Density (fish/m)
D	DV	5	5	0	10	N/A	N/A	0.47
D	CO	5	8	1	27	49	8	0.35
D	CT	4	7	2	13	33	5	0.17
C	DV	1	10	0	11	N/A	N/A	0.23
C	CO	18	59	4	228	570	102	2.43
C	CT	7	6	2	19	47	7	0.20
B	DV	68	61	18	225	366	146	2.14
B	CO	88	102	13	655	1160	393	6.24
B	CT	0	0	0	0	N/A	N/A	0.00

[a] Species codes: DV=Dolly Varden char, CO=coho salmon and CT=cutthroat trout.

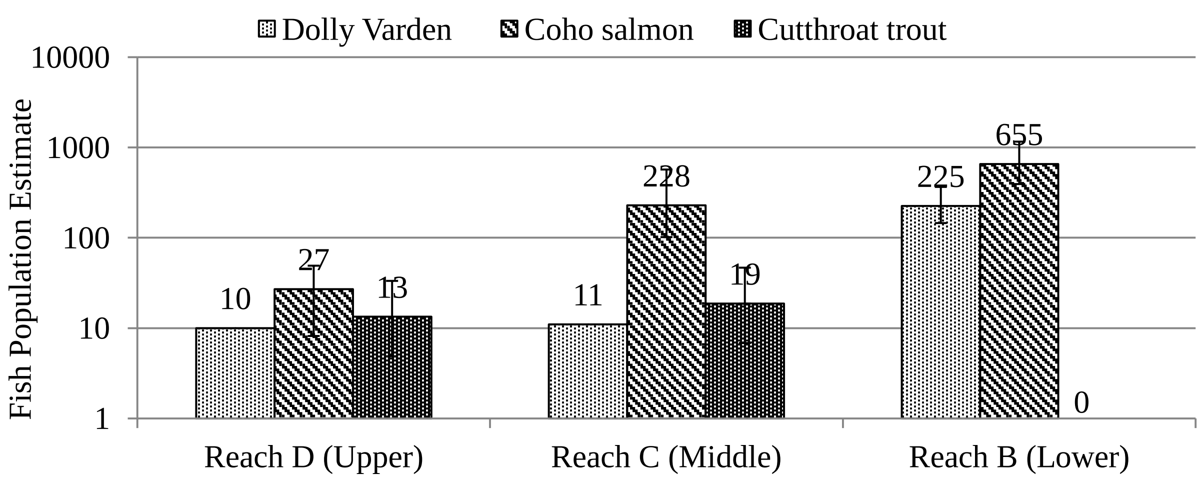

Figure 1.–2010 fish population estimates by reach and species.

2011 Fish Population Estimates

The first sampling event occurred on May 10, 2011 and the census event occurred about 24 hours later on May 11, 2011. Water temperature during this period was about 4.5°C and the weather was cloudy with drizzle throughout both days. Stream level was lower than during the October field survey, and lower than usually observed in July during sampling for the Fresh Water Monitoring Program (Kanouse 2011).

In 2011, Dolly Varden char and coho salmon were similarly abundant in Reaches C and D, and cutthroat trout were nearly absent in Reaches B and C (Table 3, Figure 2).[4,5] No marked

[4] No significant differences between coho salmon and Dolly Varden char populations were found in within any of the reaches. No marked cutthroat trout were recaptured during the census event in any of the reaches; therefore no population estimate can be calculated, Only the total number of captured fish are presented. Dolly Varden char and

cutthroat trout were recaptured in any of the reaches so only the number of captures is presented. Length frequencies of captured fish suggest more than one age class was present for each species (Appendix A).

Table 3.–2011 fish mark–recapture data by reach and species.

Reach	Species[a]	Number of fish marked and released	Total recaptured	Number of marked fish recaptured	Population Estimate (*N*)	Upper 95% CI (+)	Lower 95% CI (-)	Est. Fish Density (fish/m)
D	DV	11	5	2	24	60	9	0.31
D	CO	8	5	2	18	45	7	0.23
D	CT	4	4	0	8	N/A	N/A	0.32
C	DV	12	13	2	61	152	22	0.65
C	CO	22	10	5	42	97	20	0.45
C	CT	1	0	0	1	N/A	N/A	0.01
B	DV	15	7	1	64	116	19	0.61
B	CO	20	27	12	45	82	27	0.43
B	CT	0	1	0	1	N/A	N/A	0.01

[a] Species codes: DV=Dolly Varden char, CO=coho salmon and CT=cutthroat trout.

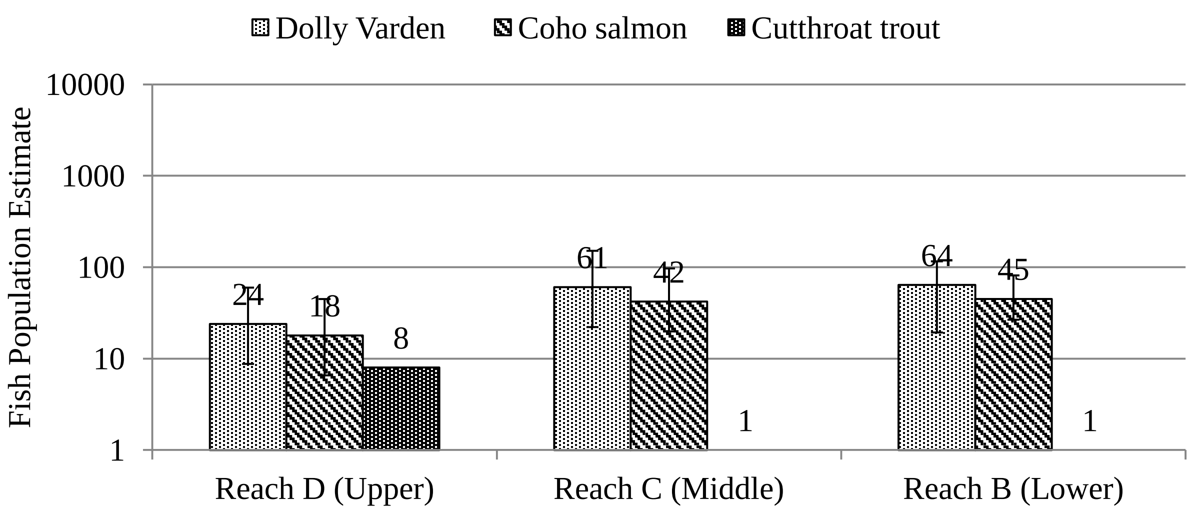

Figure 2.–2011 fish population estimates by reach and species.

COMPARISON AMONG YEARS

Table 4 shows results from Buell's (1981) baseline survey conducted in July 1981, when summer water levels are expected to be lower than spring or fall. Figure 3 illustrates the estimated populations. Dolly Varden char, coho salmon and cutthroat trout population estimates

cutthroat trout were equally dense and more dense than coho salmon in Reach D, while Dolly Varden char were more dense than other species in Reaches B and C.

[5] See note 3 above.

were similar within and between reaches and no significant differences were found. Coho salmon were most abundant.[6]

Table 4.–1981 fish mark-recapture data by reach and species (Buell 1981).

Reach	Species[a]	Population Estimate (*N*)	Upper 95% CI (+)	Lower 95% CI (-)	Est. Fish Density (fish/m)
D	DV	15.0	37.5	5.5	0.19
D	CO	30.9	65.0	20.1	0.40
D	CT	17.3	31.9	11.3	0.22
C	DV	28.5	67.0	16.0	0.30
C	CO	33.1	75.0	18.5	0.35
C	CT	24.0	55.4	11.3	0.26
B	DV	24.8	61.9	10.1	0.24
B	CO	34.6	70.0	19.5	0.33
B	CT	27.0	67.5	11.0	0.26

[a] Species codes: DV=Dolly Varden char, CO=coho salmon, and CT=cutthroat trout.

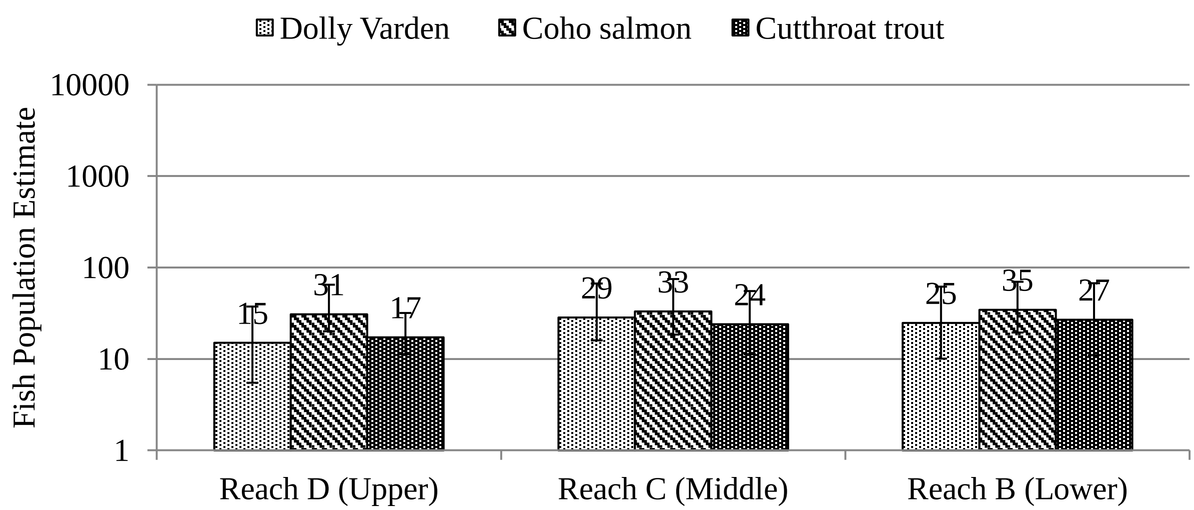

Figure 3.–1981 fish population estimates by reach and species.

Comparing all 3 years of fish population estimates, no significant differences were found between species or years in Reach D (Figure 4). Generally, Dolly Varden char were most abundant in 2011, coho salmon were most abundant in 1981, and cutthroat trout were most abundant in 1981. No marked Dolly Varden char were recaptured during the 2010 census event, or cutthroat trout in the 2011 census event, so population estimates could not be calculated.

[6] The large confidence intervals for each estimate suggest Buell had low recapture success of marked fish.

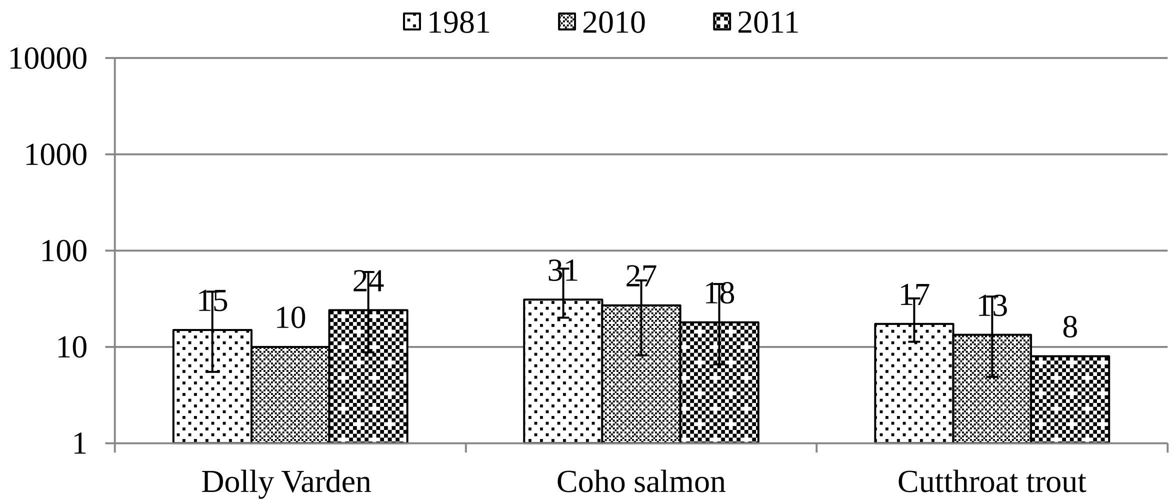

Figure 4.–Fish population estimates by species and year in Reach D.

In Reach C (Figure 5), Dolly Varden char were most abundant in 2011, coho salmon were significantly more abundant in 2010 than in 1981 and 2011, and cutthroat trout were significantly less abundant in 2011, when only 1 cutthroat trout was observed. The high coho salmon abundance may be attributed to the higher water level providing additional habitat during the fall sampling event. No marked Dolly Varden char were recaptured during the 2010 census event; therefore, a population estimate could not be calculated.

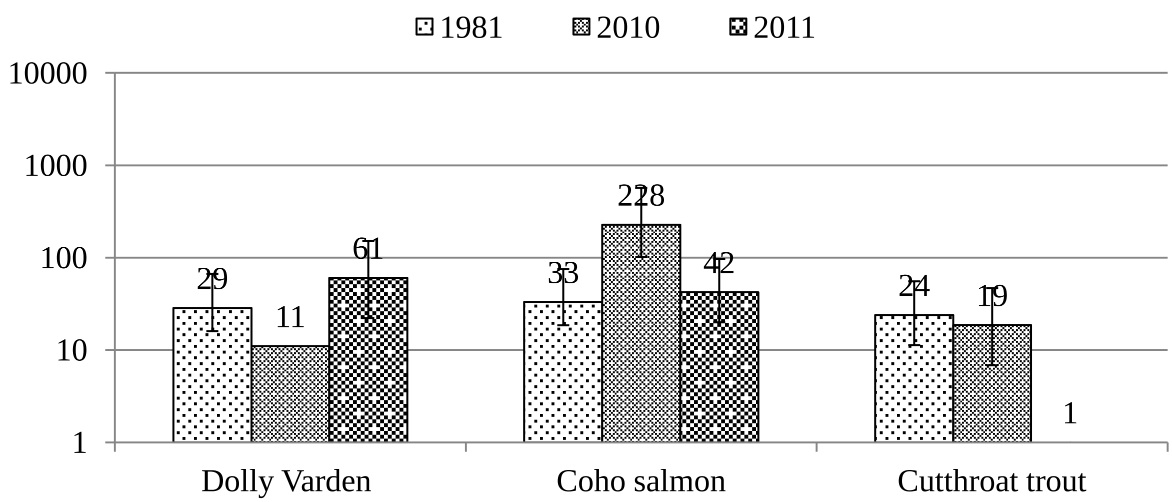

Figure 5.–Fish populations estimates by species and year in Reach C.

In Reach B, Dolly Varden char and coho salmon were significantly more abundant in 2010 than other years (Figure 6), which may again be attributed to the higher water level during the fall sampling event. Cutthroat trout were absent in 2010 and nearly absent in 2011, significantly less abundant than in 1981.

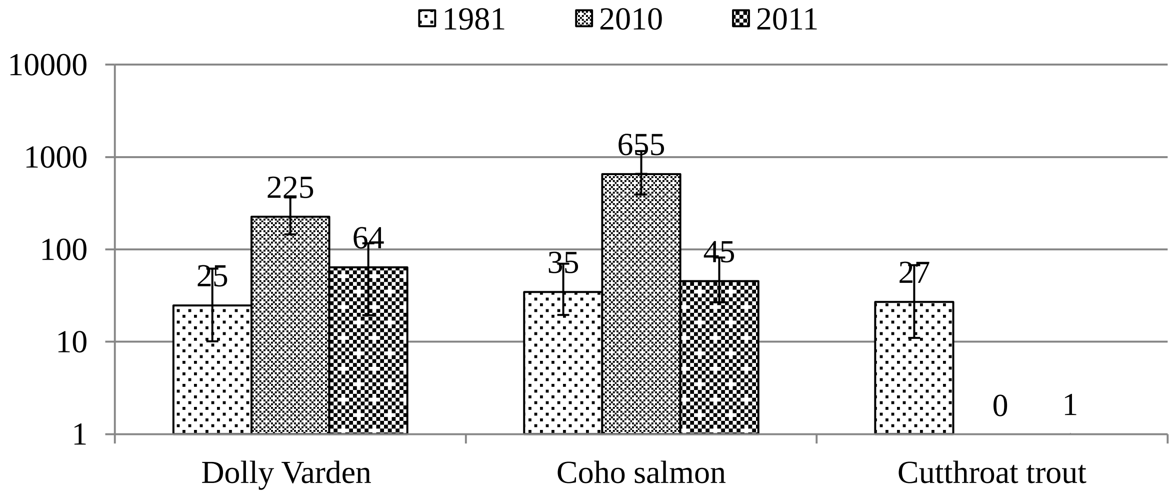

Figure 6.–Fish population estimates by species and year in Reach B.

Fish densities provide a way to directly compare fish presence between reaches. The bolded numbers in Table 5 show the species with the highest density observed in each reach, each year. Coho salmon were most dense in all reaches in 1981, and most dense in reaches B and C in 2010. Dolly Varden char were most dense in Reach D in 2010 and in reaches B and C in 2011, and cutthroat trout were most dense in Reach D in 2011.

Table 5.–Estimate fish densities (#fish/50m) by species and reach in 1981, 2010 and 2011.

Reach	Species[a]	1981	2010	2011
D	DV	9.74	23.4	15.6
D	CO	20.0	17.5	11.7
D	CT	11.2	8.7	16.2
C	DV	15.2	11.7	32.2
C	CO	17.6	121.3	22.4
C	CT	12.8	9.9	0.5
B	DV	11.8	107.2	30.5
B	CO	16.5	311.8	21.5
B	CT	12.9	0.0	0.5

[a] Species codes: DV=Dolly Varden char, CO=coho salmon and CT=cutthroat trout.

Figure 7 shows the total fish population in each reach each year, calculated by summing all species population estimates and confidence intervals within each reach. Fish population estimates using raw data would have been more accurate, however raw data from the 1981 survey was not available. The total fish population estimate in Reach B in 2010 was significantly higher than in 1981 and 2011. No other statistical differences were identified within the other reaches. One possible statistical difference could exist between the approximate fish populations in Reach C as the population in 1981 was lower with a larger confidence interval.

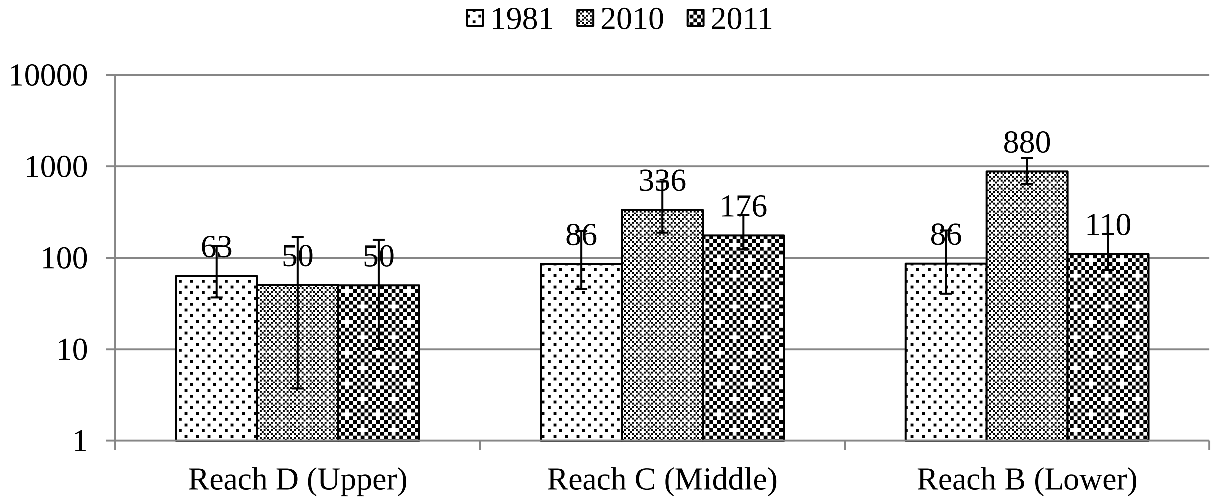

Figure 7.–Total fish populations by reach in 1981, 2010 and 2011.

In 2001, Hecla began aquatic biomonitoring studies under the Fresh Water Monitoring Program in Tributary Creek at Site 9, downstream of Reach C. These annual studies occur in July and include estimating salmonid populations within a 50 m reach, allowing comparison of additional data to examine changes in species composition in the middle portion of Tributary Creek. Figure 8 shows the percent species composition among years in Reach C, and the average species composition observed at Site 9 during the years 2011 through 2010 (Kanouse 2011). Buell's (1981) results indicate the middle portion of Tributary Creek (Reach C) was used similarly by Dolly Varden char, coho salmon and cutthroat trout. The 2010 data suggests coho salmon use the middle reach heavily during periods of high flow, while the 2011 and Site 9 data indicate Dolly Varden char and coho salmon codominate during periods of low-moderate flows.

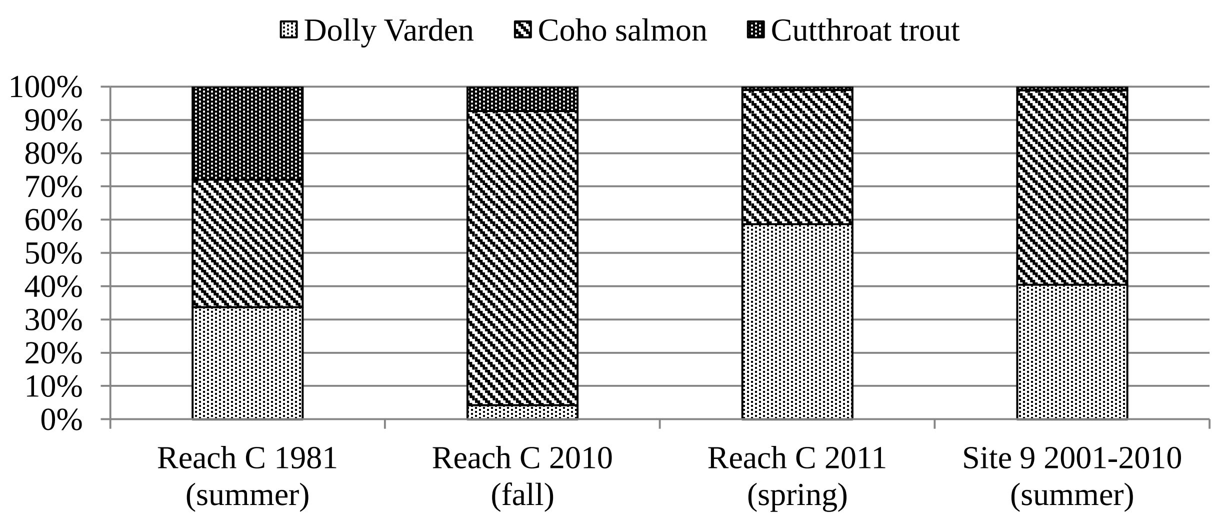

Figure 8.–Comparison of species composition between years in Reach C, and Site 9 (Kanouse 2011).

CONCLUSIONS

Estimate fish populations were generally similar within reaches and between years for the 1981, 2010 and 2011 surveys with few statistical differences identified. Undersized sample reaches and insufficient study design likely influenced catch rates, particularly recaptures of marked fish. Few recaptures of marked fish from small populations reduced the reliability of the accuracy and precision of population estimates, potentially masking additional statistical differences within reaches and among years. However, many of the population estimates were similar, thereby affording somewhat confident comparisons within reaches and between years. Generally, fish populations in Tributary Creek appear to be similar to populations documented 30 years ago during baseline surveys prior to development of the Greens Creek Mine, with the exception of fewer cutthroat trout observed recently in Reaches B and C. In addition, species composition appears to have changed somewhat within each of the reaches sampled, though some of these differences may be explained by discharge and season, and subsequently competition for habitats during the sampling period.

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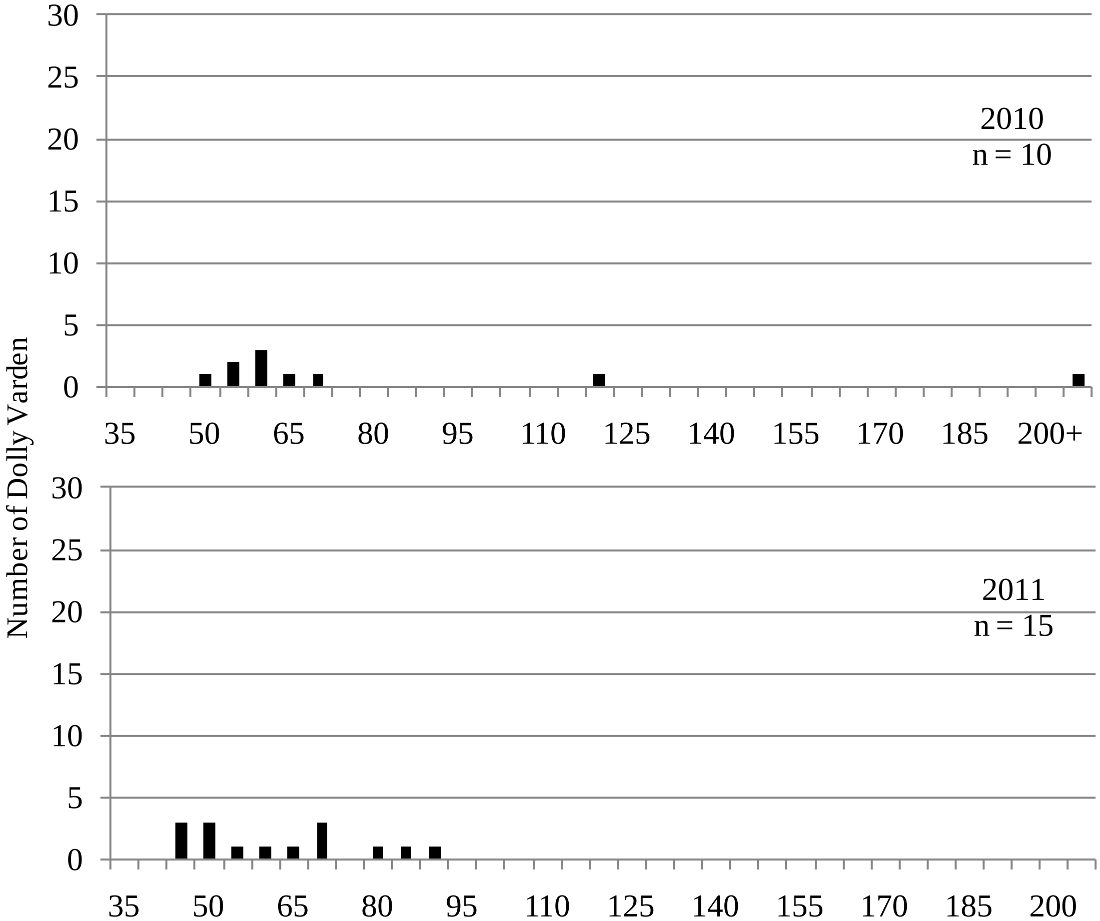
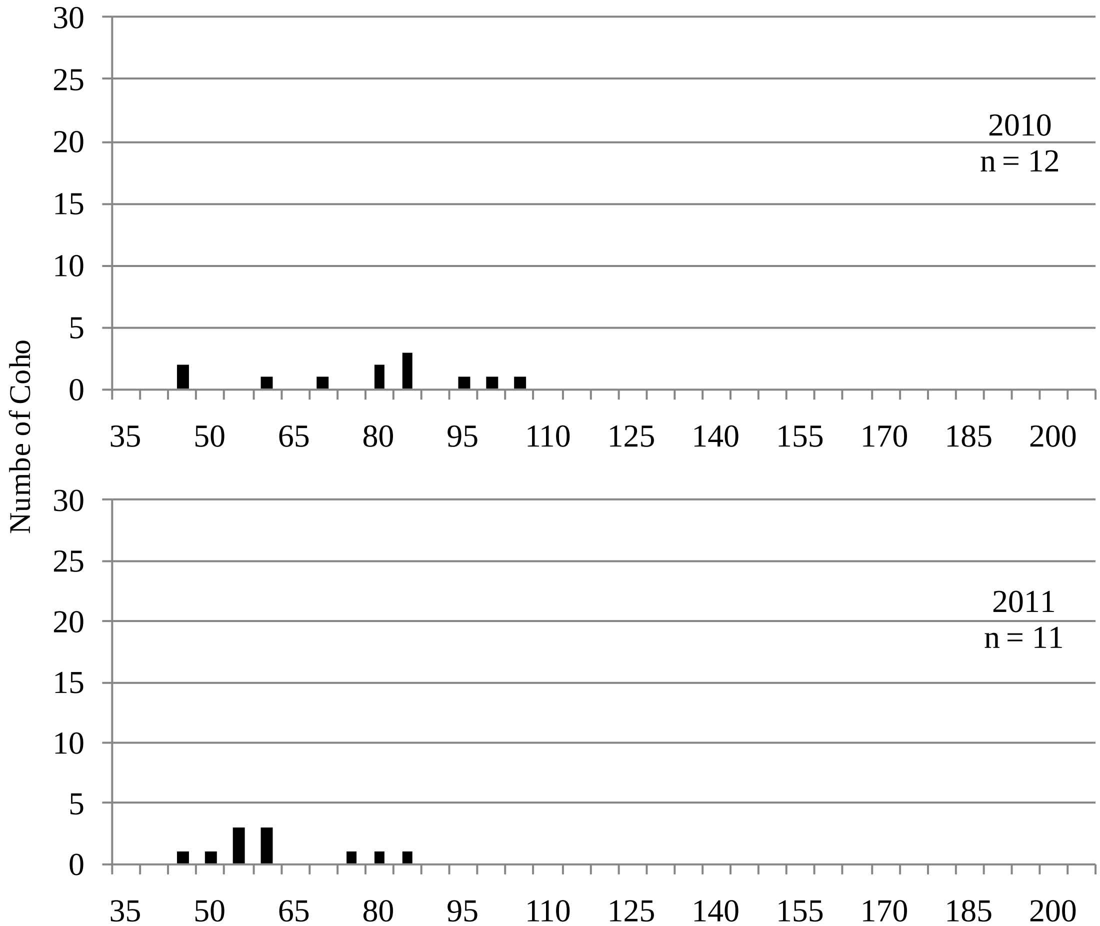
APPENDIX A: LENGTH FREQUENCY PLOTS OF CAPTURED FISH

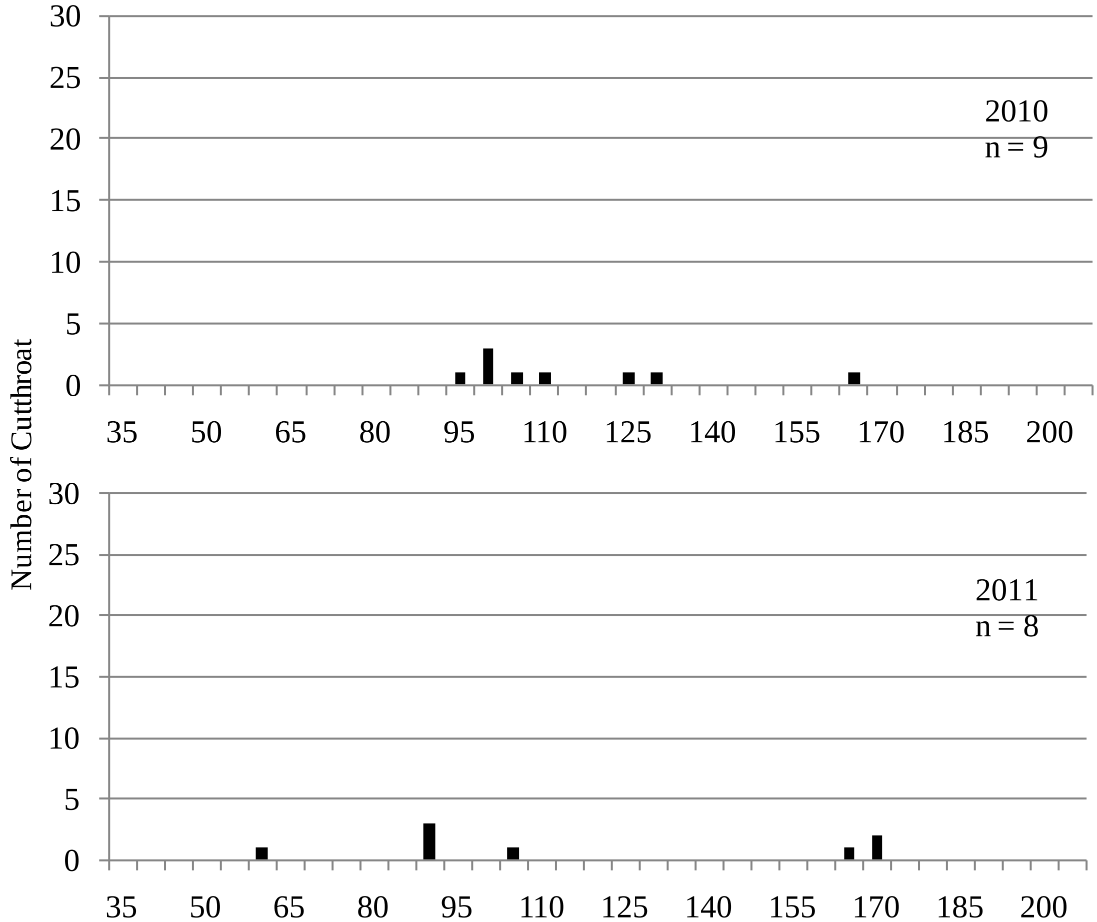
Appendix A 1.–Length frequency plots for Dolly Varden char captured in Reach D, less recaptures.



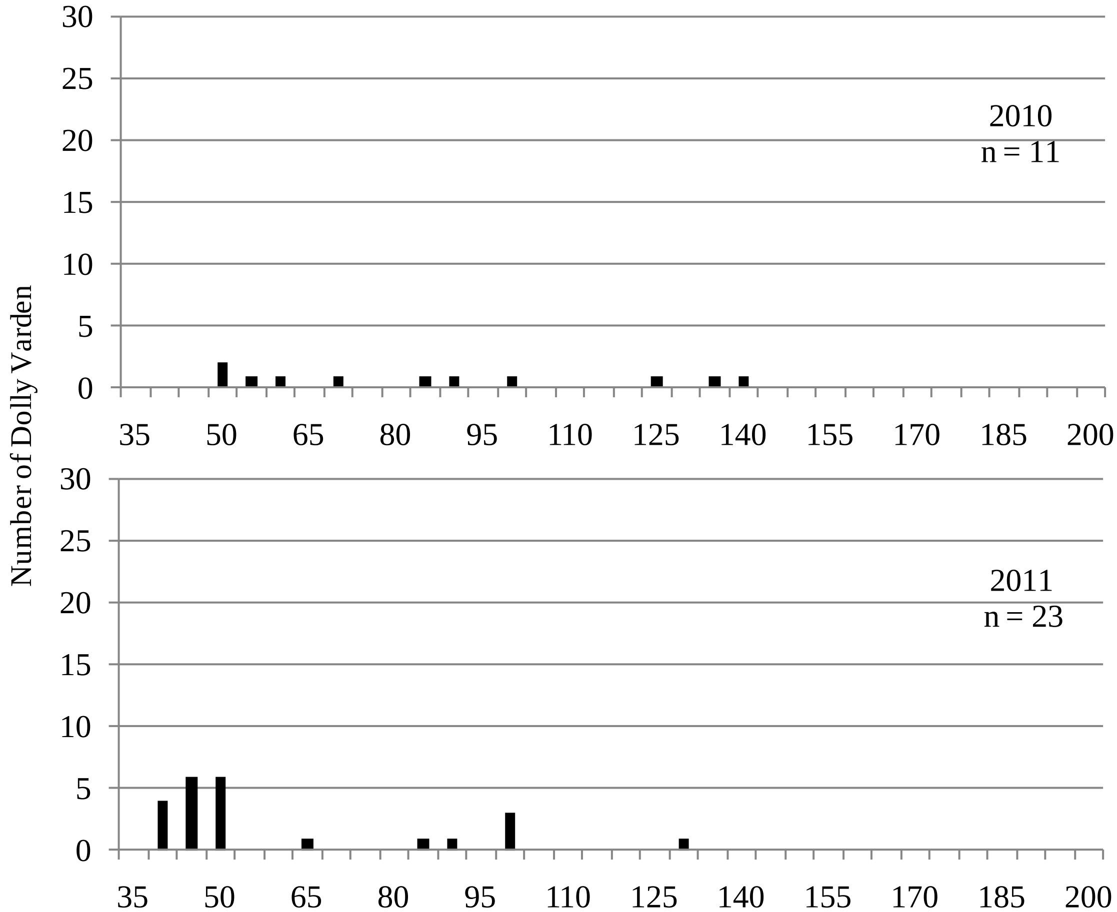
Appendix A 2.–Length frequency plots for coho salmon captured in Reach D, less recaptures.



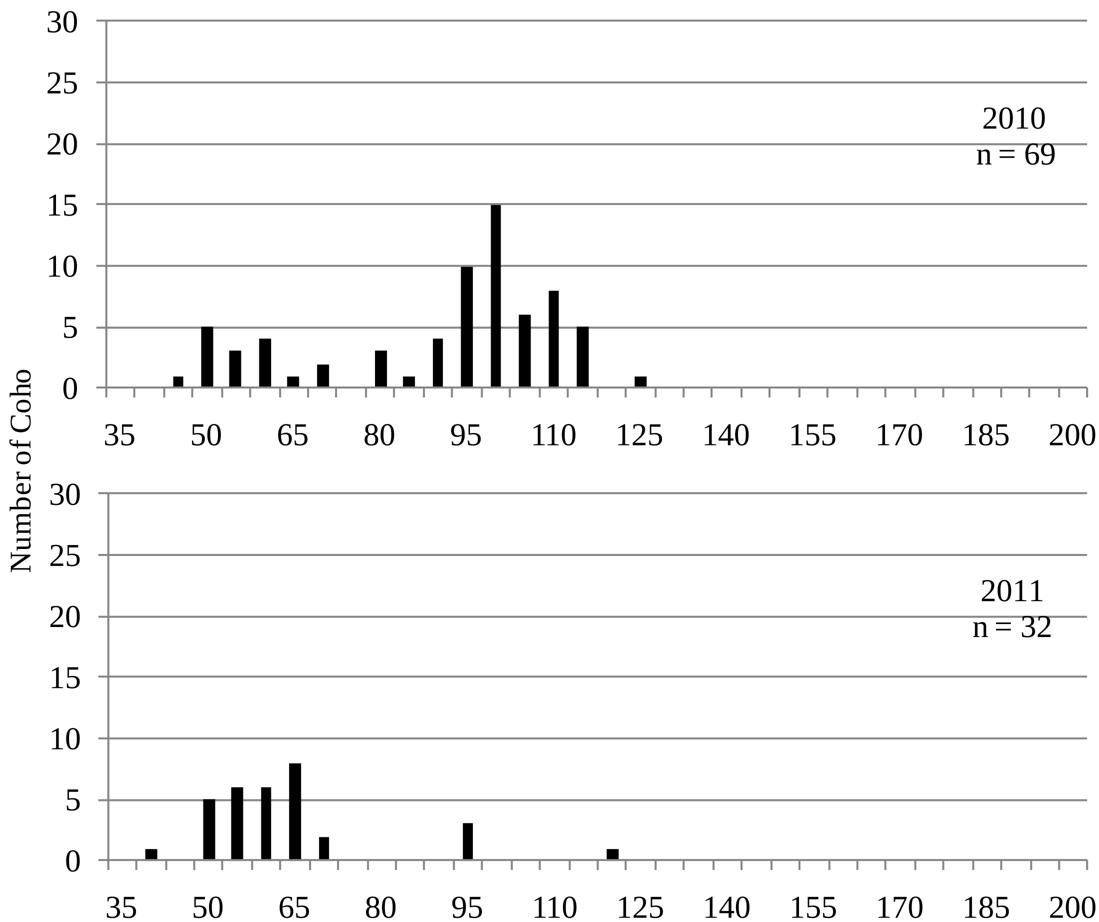
Appendix A 3.–Length frequency plots for cutthroat trout captured in Reach D, less recaptures.



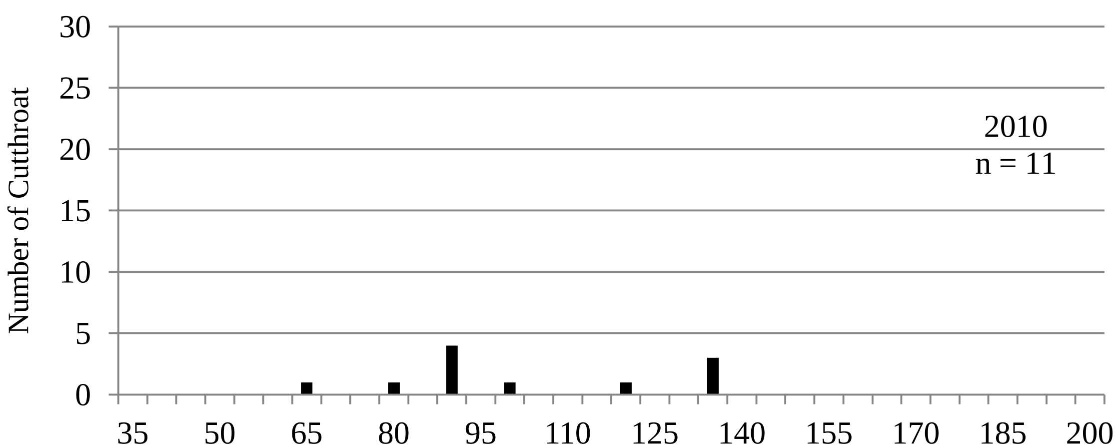
Appendix A 4.–Length frequency plots for Dolly Varden char captured in Reach C, less recaptures.



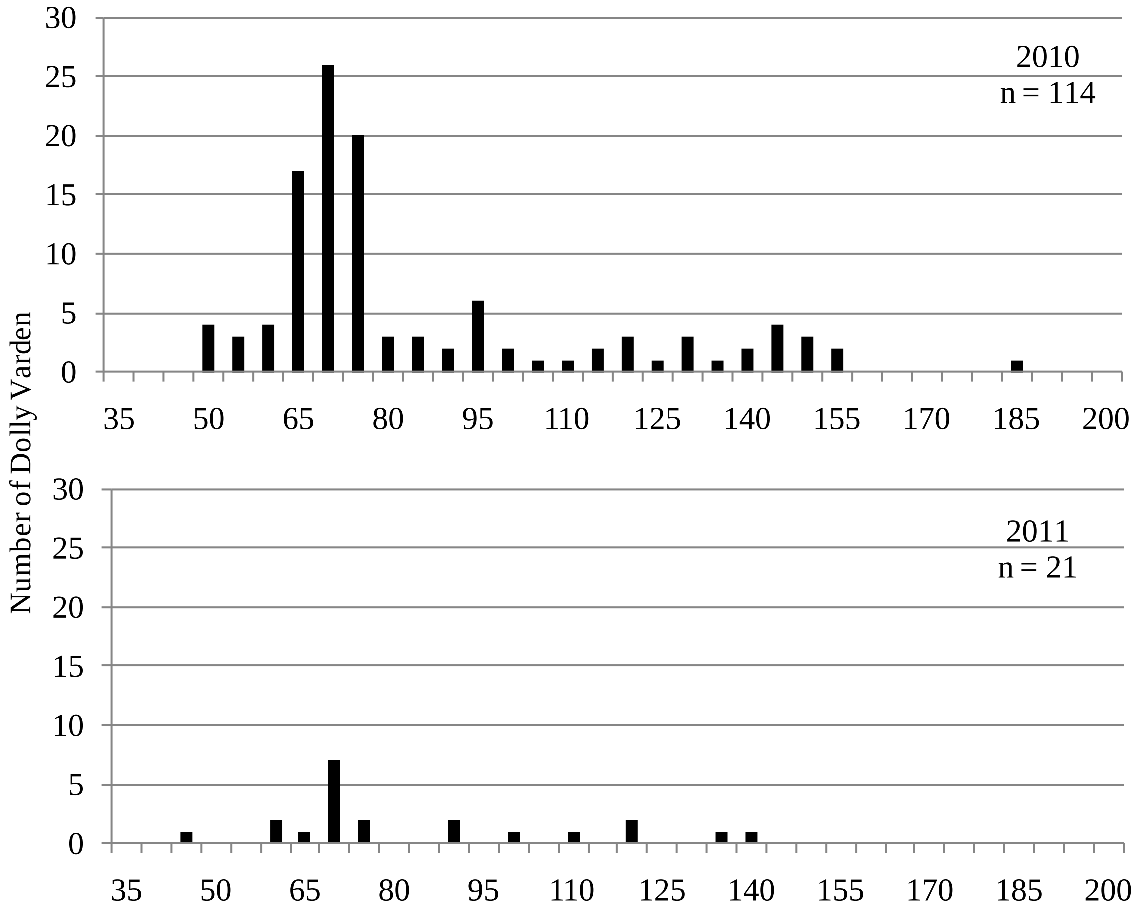
Appendix A 5.–Length frequency plots for coho salmon captured in Reach C, less recaptures.



Appendix A 6.–Length frequency plots for cutthroat trout captured in Reach C, less recaptures.



Appendix A 7.–Length frequency plots for Dolly Varden char captured in Reach B, less recaptures.



Appendix A 8.–Length frequency plots for coho salmon captured in Reach B, less recaptures.