Technical Report No. 20-08

Baseline Aquatic Biomonitoring: Illinois Creek Mine and Associated Prospects, 2020

by

Justin M. Burrows

December 2020

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

Symbols and Abbreviations

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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)

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

TECHNICAL REPORT NO. 20-08

BASELINE AQUATIC BIOMONITORING: ILLINOIS CREEK MINE AND ASSOCIATED PROSPECTS, 2020

By

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Cover: Illinois Creek juvenile coho salmon, July 2020, photograph by Chelsea Clawson.

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Acknowledgements

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Chelsea Clawson (ADF&G Habitat) assisted with both field work and laboratory processing of periphyton samples. Nora Foster (NRF Taxonomic Services) was responsible for the sorting and identification of aquatic macroinvertebrates. Audra Brase and Al Ott (both ADF&G Habitat) provided constructive reviews for this report.

Executive Summary

This report summarizes the results of biomonitoring work performed in July of 2020 in streams potentially impacted by the Illinois Creek Mine, as well as the development of the adjacent Honker and Round Top prospects.

Biomonitoring efforts included surveys of periphyton (measured by chlorophyll-a) and aquatic macroinvertebrates in Illinois Creek. Juvenile fish were captured in minnow traps in Illinois Creek, as well as streams in the nearby Dome, Minnesota, Colorado, California, and Eddy Creek drainages. One unnamed tributary of the Little Mud River was also trapped. Juvenile coho salmon from Illinois Creek were analyzed for whole-body concentrations of several metals, and their length frequencies described. Juvenile coho population characteristics and metal concentrations in 2020 were compared to historical data.

Baseline periphyton standing crop and aquatic macroinvertebrate population characteristics were described and can be used as an indicator of future environmental changes.

Metal concentrations found in juvenile coho salmon captured in Illinois Creek were generally comparable to those found in the 1990s. The exception was mercury, which was notably elevated compared to previous the collection, though they are still below FDA action levels. Other metal concentrations differed only slightly from those found 1990s samples. Catches and length-frequency distributions of juvenile coho salmon in Illinois Creek were comparable to the historical data.

Streams in the area vary considerably in physical characteristics but tend to rapidly transition from steep upland streams to lower gradient meandering incised streams. The dominant rock type in the area is schist, which decomposes rapidly, and stream substrate transitions from small boulders to sand and silt in just a few km.

Fish communities vary depending on stream characteristics, consisting primarily of resident Dolly Varden and slimy sculpin in high-gradient headwater streams, and mixed communities of Alaska blackfish, slimy sculpin, Arctic grayling, and juvenile salmon in the lower reaches. Abundant large beaver dam complexes in these drainages alter fish distribution on a decades-long timescale.

Introduction

The Illinois Creek gold-silver mine is located in the southern Kaiyuk Mountains about 90km southwest of Galena. The open pit mine was operated by USMX Inc. from 1996 to 1998, and Viceroy Resources Corp. from 1998 to 2000. ARG Group leased the mine from the State of Alaska until 2002, and fees from their operation were used for reclamation. The project has since been taken over by Western Alaska Copper and Gold, and there is no active mining at this time. The Honker and Round Top prospects are located nearby (Figure 1) and currently are undergoing mineral exploration. Two proposed winter trails connect each prospect to the existing mine road.

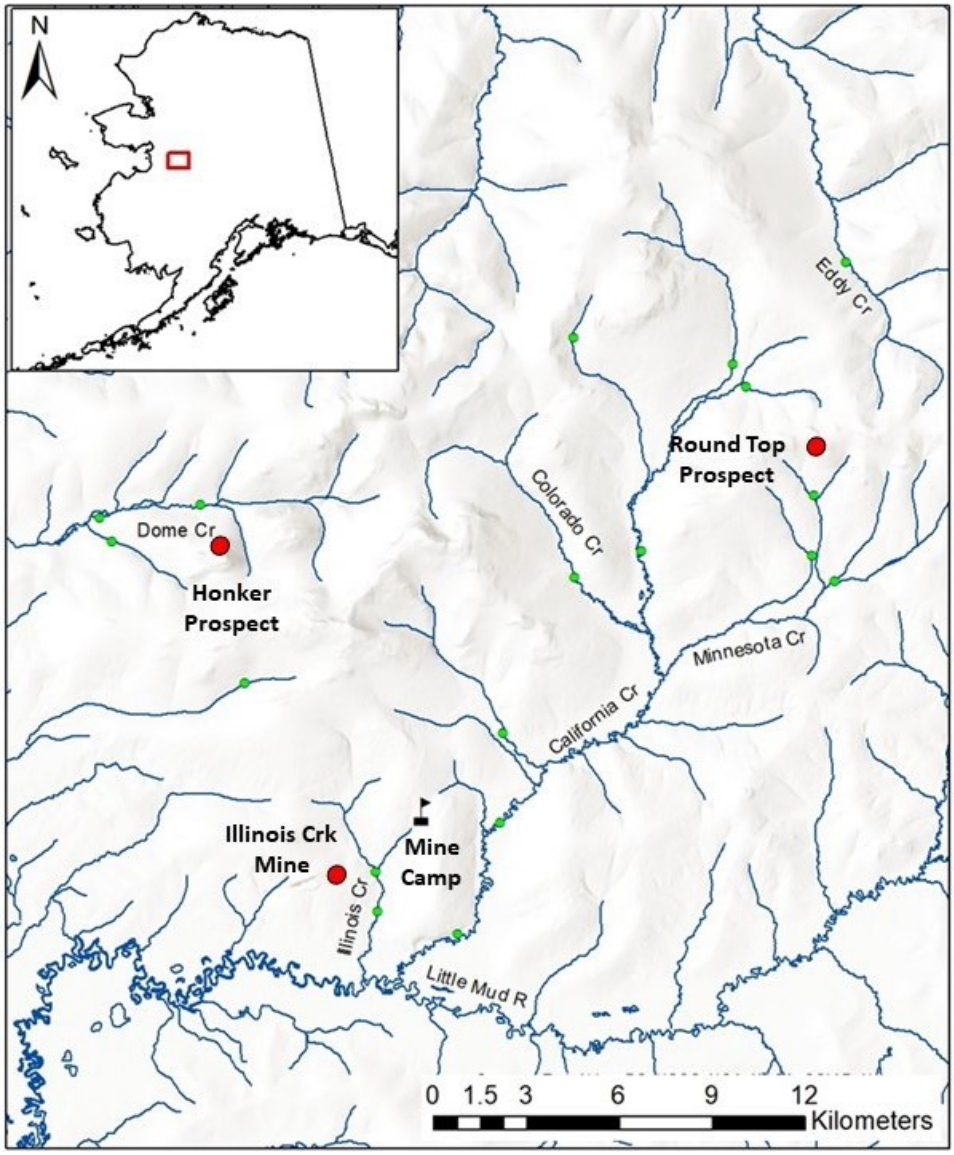

Figure 1: Sample sites (green circles) surrounding the Illinois Creek Mine, Honker deposit, and Round Top deposit, July 2020.

The ADF&G Habitat Section collected baseline fish data at the mine between 1995 and 1998 (Winters 1996, 1997, 1998a, 1998b). During this period, sampling work focused on Illinois Creek. Juvenile salmon were captured using minnow traps, and visual surveys were performed on foot for adult salmon. Limited minnow trapping was done in California Creek in 1995 but was not continued from 1996-1998. Full-body element analyses, as well as histological analyses, were performed on juvenile coho salmon from Illinois Creek in 1995.

The goal of this project was to capture juvenile coho salmon from Illinois Creek, and to compare catch sizes, size distributions, and whole-body element concentrations to historical data.

Additionally, we collected periphyton and aquatic macroinvertebrates to form a baseline dataset in Illinois Creek, and collected fish-presence data in streams that would be impacted by the development of the Honker and Round Top prospects and their related infrastructure.

Methods

Fish Presence

Minnow traps were baited with cured salmon roe in perforated plastic bags. Ten traps were set at each sample site and allowed to fish for approximately 24 hours. When traps were collected, the species and fork-length of every captured salmonoid were recorded. Total length was recorded for species with round caudal fins, such as slimy sculpin and Alaska blackfish.

Fish Tissue Elements

In Illinois Creek, 15 juvenile coho salmon with fork-lengths of 80-110mm were retained for whole-body element analysis. Retained fish were handled with class 100 nitrile gloves, and care was taken to not touch any metallic objects that could contaminate the gloves. Gloves were changed regularly to avoid cross-contamination. Retained fish were euthanized with a blow to the head and placed individually in labeled zip-loc bags. Samples were frozen upon returning from the sample site and kept frozen until analysis was performed.

Retained juvenile coho salmon were analyzed for arsenic, cadmium, copper, lead, mercury, selenium, zinc, and silver concentration. The whole-body element analyses were performed by ACZ Laboratories located in Steamboat Springs, Colorado. Mercury was measured using direct combustion, and other elements by inductively coupled plasma mass spectroscopy.

Periphyton

In upper Illinois Creek, ten flat rocks with a flat surface larger than 25 cm^2 were collected. Only completely submerged rocks with a flat surface exposed to sunlight were selected for sampling. A 5-cm x 5-cm square of flexible foam was placed on the flat rock surface, and all material outside of that square removed with a toothbrush. The scrubbed area and brush were then thoroughly rinsed with freshwater. The foam square was removed, the remaining section brushed, and the periphyton rinsed onto a 0.45 μm glass fiber filter receptacle. Material trapped on the brush was then rinsed into the filter, and water was removed with a hand vacuum pump. Two drops of magnesium carbonate ($MgCO_3$) solution were added to the water near the end of the evacuation process to prevent acidification and chlorophyll degradation.

Filters from each rock were folded in half, with sample material facing inwards, and placed in individual dry paper coffee filters. All ten coffee filters were placed in a zip-lock bag with desiccant to remove any remaining water and were immediately wrapped in aluminum foil and kept on ice. Upon removal from the field, samples were stored frozen wrapped in aluminum foil to prevent chlorophyll degradation. In the lab, the chlorophyll-a area-density of each sample was measured using the methods of Barbour et al. (1999).

Aquatic Macroinvertebrates

In upper Illinois Creek, 0.093 m^2 Surber nets were used to collect five invertebrate samples. For each sample, the net was set in place and all rocks within the Surber square were dislodged from the stream bed and thoroughly agitated to release invertebrates downstream into the net. Insect samples were preserved in 90% ethanol and stored at room temperature until identification could be performed. NRF Taxonomic Services located in Fairbanks, Alaska identified and enumerated the samples.

Aquatic macroinvertebrates were expressed as the average number of individuals/m^2 of stream bed, as well as the percent belonging to orders Ephemeroptera, Plecoptera, Tricoptera, Aquatic Diptera, and other.

The combined percentage of Ephemeroptera, Plecoptera, and Tricoptera (EPT) and percent Chironomidae (a subset of aquatic Diptera) were compared. Chironomidae generally are tolerant to pollution, whereas EPT are more sensitive. Changes in this ratio can be used as a baseline for comparison to future sampling events to determine potential changes in the stream system.

Results and Discussion

Illinois Creek: Illinois Creek is located directly between the mine pit and mine camp (Figure 1), which are across the drainage from each other and are connected by a gravel road. We sampled two locations in this stream.

Lower Illinois Creek: This stretch of Illinois Creek has a silt and mud bed with abundant decayed organic matter. It is an incised, low-gradient meandering stream with deciduous shrubs lining the banks (Figure 2). In 2020, 304 juvenile coho salmon and seven slimy sculpin were caught. Catches here have been historically variable, ranging from 11 to 655 juvenile coho salmon (Winters 1996-1998). Previous work also found Alaska blackfish and juvenile, however the drainage had multiple beaver dams during that period, which have since washed out (Winters 1996-1998). Seven juvenile coho salmon were kept from this reach of Illinois Creek for whole-body element analysis.

Figure 2: Lower Illinois Creek, downstream of the historical trail crossing.

The length-frequency distribution of juvenile coho salmon from lower Illinois Creek is depicted in Figure 3. Juvenile coho salmon were present in two age classes. Age-0 fish ranged from

approximately 42 to 75mm, while age-1 fish ranged from 92 to 104mm (Figure 3). Several fish were in an intermediate size range of 75 to 90mm.

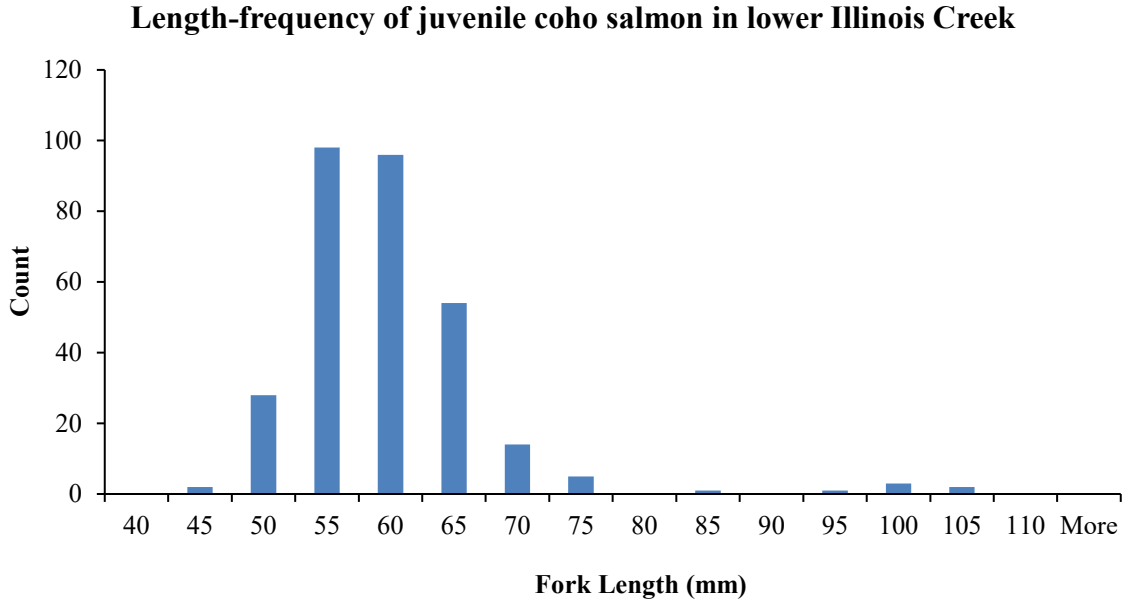

Figure 3: Length-frequency distribution of juvenile coho salmon in lower Illinois Creek, July 2020.

Upper Illinois Creek: The stream bed in this location consists of gravel and cobble, with some boulder-sized pieces of schist and quartz. This reach of the stream is surrounded by a mixture of wet meadows and deciduous shrubs (Figure 4). A warm spring enters the stream approximately 200m upstream of the upper limit of the minnow traps. Sixty-two juvenile coho salmon and six slimy sculpin were caught. These catches were slightly higher than during the 1990s, when catches ranged from 14 to 53 coho salmon (Winters 1996-1998). Eight fish were the appropriate size for whole-body element analysis and were kept.

Periphyton samples were collected immediately downstream of the minnow traps on upper Illinois Creek, where the stream bed had enough flat, sediment-free rocks for collection.

Figure 4. Upper Illinois Creek, immediately downstream of the warm springs, July 2020.

Similar to lower Illinois Creek, two distinct age classes of juvenile coho salmon were present in upper Illinois Creek, but there were more fish in the intermediate 75-90mm range (Figure 5). A spring-fed pool was connected to the creek near our trapping activity, and hundreds of juvenile coho salmon were observed feeding (cover photo).

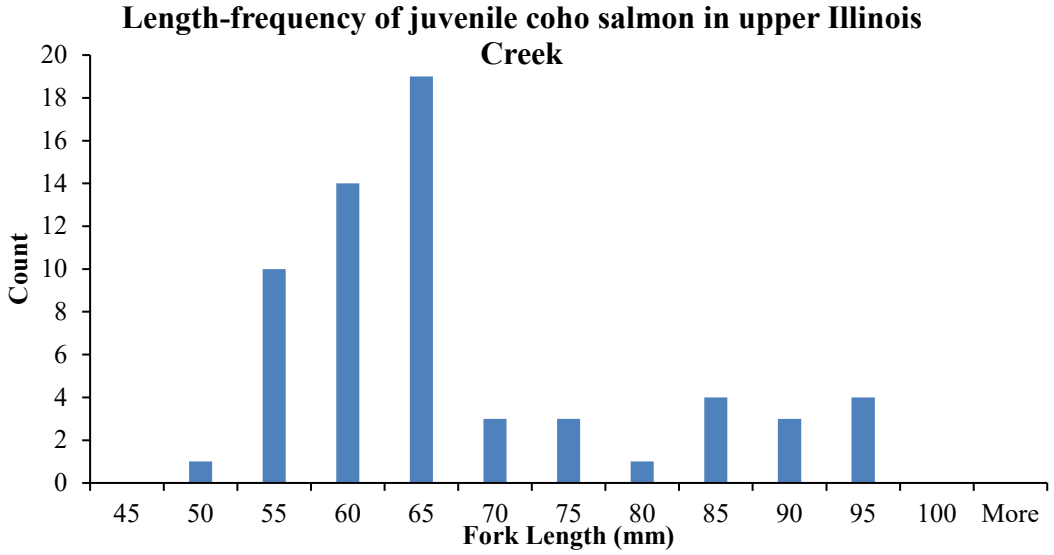

Figure 5. Length-frequency distribution of juvenile coho salmon in upper Illinois Creek, 2020.

Aquatic Invertebrates

Aquatic macroinvertebrates averaged 8,757 (±3,070) individuals/m^2 of stream bed. Of the taxa sampled, 10% were Ephemeroptera, 16% were Plecoptera, 16% were Trichoptera, 51% were aquatic Diptera (primarily chironomids), and 8% belonged to other groups (Figure 6). Two larval slimy sculpin were identified in the samples. A summary of the aquatic macroinvertebrate data is included in Appendix 2.

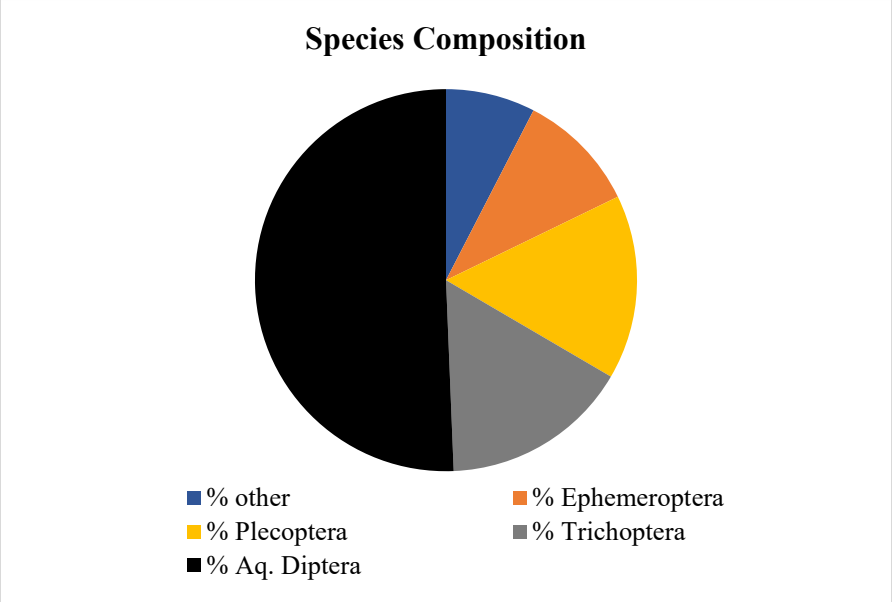

Figure 6: Species composition of aquatic macroinvertebrates in upper Illinois Creek, 2020.

The macroinvertebrates sampled in upper Illinois Creek consisted of 42% EPT and 49% Chironomidae (Figure 7).

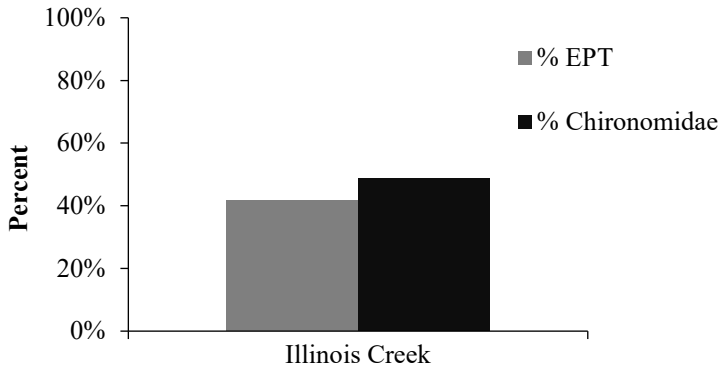

Figure 7: Percent EPT and Percent Chironomidae in Illinois Creek, July 2020.

Periphyton

Chlorophyll-a concentrations in upper Illinois Creek had a median area density of 3.68 mg/m^2 (Figure 8), this is similar to levels seen in fish bearing streams in the vicinity of the Red Dog Mine (Clawson and Ott 2020). Chlorophyll-a area density data are included in Appendix 3.

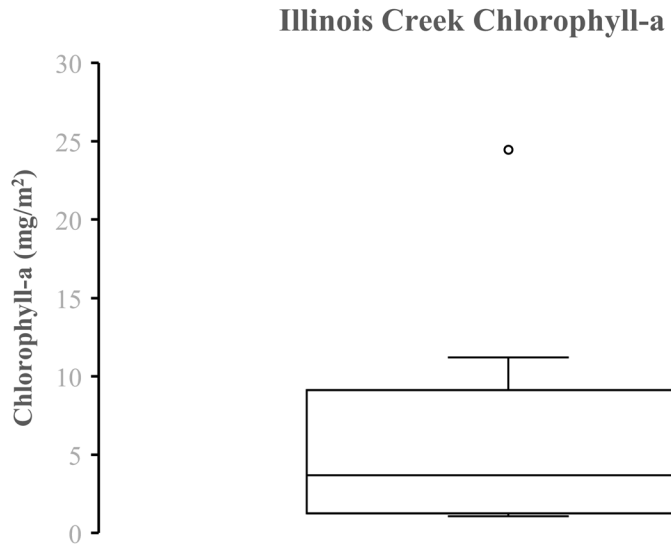

Figure 8: Chlorophyll-a area-density in Illinois Creek, July 2020. Line represents median. Box indicates first and third quartiles, whisker max and min, dot outliers.

Juvenile Coho Elements

Fish retained for element analysis are listed in Appendix 1 and results for element concentrations of each fish are listed in Appendix 4. Metals concentrations in juvenile coho salmon in Illinois Creek were similar to or less than concentrations of the same metals found in other Alaskan fish species of a similar life stage and trophic level. Metal concentrations are expressed on a dry mass basis in this section. All references to historic metals data in this section refer to data presented by Winters (1996). Data from Winters' 1996 report are included in Appendix 4 for comparisons. When an element was measured at concentrations below the Method Detectable Limit (MDL), the MDL was reported as the concentration of the element for that sample.

Zinc (Zn), Copper (Cu), and Arsenic (As) were found in the highest whole-body concentrations (Figure 9 and 10). Zinc was present at a median value of 135 mg/kg (Figure 10) which is similar to concentrations found in juvenile Dolly Varden in streams surrounding the Red Dog Mine, and is approximately double the levels found in Arctic grayling from Bons Pond (Clawson and Ott

2020). Previous samples from Illinois Creek were not tested for Zinc, and there are no historical data for comparison.

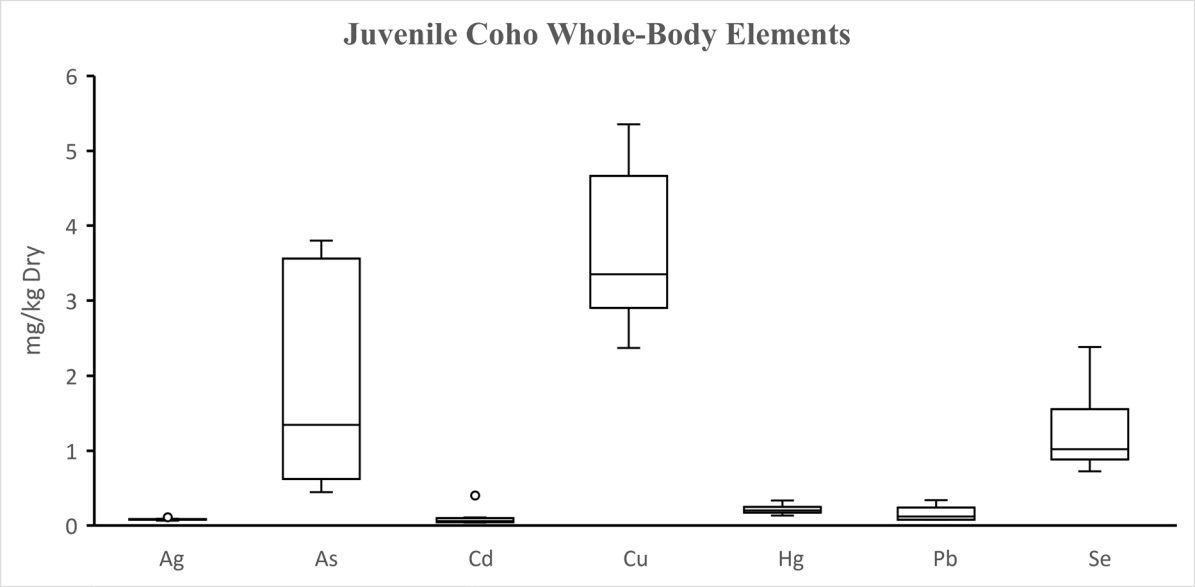

Figure 9: Whole-body concentration of silver, arsenic, cadmium, copper, mercury, lead, and selenium in juvenile coho salmon from Illinois Creek (n=15), July 2020. Line represents median. Box indicates first and third quartiles, whisker max and min, dot outliers.

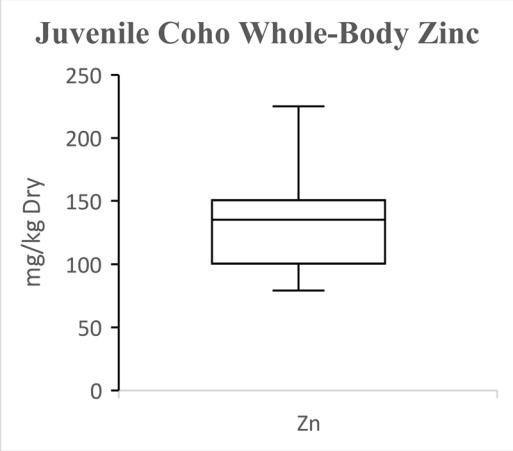

Figure 10: Whole-body zinc concentration of juvenile coho salmon from Illinois Creek (n=15), July 2020. Line represents median. Box indicates first and third quartiles, whisker max and min, dot outliers.

The median copper concentration in the juvenile coho salmon was somewhat higher in 2020 (3.35 mg/kg) than in 1996 (2.73 mg/kg). The 2020 concentration is comparable with copper

concentrations found in juvenile Dolly Varden captured in active mine drainages throughout the state of Alaska (Legere and Timothy 2016).

Arsenic was present at a median concentration of 1.4 mg/kg, which is lower than the 1.75mg/kg seen in 1996. These concentrations fall between those found in juvenile Dolly Varden from streams near the Pebble Prospect (Legere and Timothy 2016) and multiple streams in the Middle Kuskokwim River Region (Matz et al. 2017).

Whole-body cadmium (Cd) concentrations had a median value of 0.06 mg/kg in 2020. This is double the 1996 median concentration, however in that year only five samples were analyzed versus 15 in 2020. These concentrations are an order of magnitude lower than those of juvenile Dolly Varden in Anxiety Ridge Creek near the Red Dog Mine (Clawson and Ott 2020).

Mercury (Hg) concentrations had a median value of 0.20 mg/kg in 2020. By contrast, the median concentration was 0.08 mg/kg in 1996. The mercury concentrations in 2020 are similar to those found in juvenile coho salmon in Resurrection Creek on the Kenai Peninsula (MacFarlane 2004). The concentrations observed in 2020, though somewhat elevated compared to historical data, are still well below the FDA action level of 1.0 mg/kg for consumed fish (Macfarlane 2004).

Lead (Pb) was slightly reduced in 2020, with a median concentration of 0.12 mg/kg, compared to 0.15 mg/kg in 1996. One sample was excluded from Figure 9, because the lead concentration was three orders of magnitude higher than the median (Appendix 4). These concentrations are comparable to those found in Arctic grayling in Fish Creek prior to the development of the Fort Knox Gold Mine (Weber Scanell and Ott 1994).

Selenium (Se) was present at a median value of 1.02 mg/kg in 2020. This was the first time that selenium was measured in juvenile coho salmon at this location. The median concentration is considerably lower than those found in juvenile Arctic grayling and Dolly Varden from drainages near the Red Dog mine from 2005 to 2019 (Clawson and Ott 2020).

Silver (Ag) was below the MDL in all samples (Figure 9). This is comparable to 1996 data, in which 21 out of 30 samples were below the MDL for silver (Appendix 4).

Fish Presence

In addition to the two sites sampled on Illinois creek, 17 additional sites were minnow trapped to determine fish presence. Total catches for each site are summarized in Appendix 1.

California Creek

The California Creek watershed drains much of the area that would potentially be impacted by development of the Round Top prospect (Figure 1).

Lower California Creek: Site 1

Figure 11: California Creek near its confluence with the Little Mud river, July 2020.

The lowest reach of California Creek is slow and meandering and is punctuated with mild riffles. Log jams and cut banks are common. The substrate is mixed sand and silt, and mature white spruce and birch forests shade much of the stream. Eleven juvenile coho salmon, four slimy sculpin, and one Alaska blackfish were caught at this location. Forty-seven chinook salmon juveniles were caught near this site in 1995, but none were caught in 2020.

Lower California Creek: Site 2

Figure 12: Lower California Creek, July 2020.

Located approximately 5km upstream of the previous site, this part of the stream has similar characteristics, though the substrate has more gravel and sand, and less silt. One Alaska blackfish, 79 juvenile coho salmon, and one small Arctic grayling were caught at this site. In 1995, there were 154 juvenile chinook salmon caught in this stretch of stream, however none were caught in 2020.

California Creek Headwaters

Figure 13: California Creek headwaters, July 2020.

This reach of the stream is fast flowing, approximately 2 meters wide, has abundant cut banks and a cobble and small boulder substrate. The sampling site is surrounded by tall grasses, scattered white spruce, and mature willow shrubs. At this site, three slimy sculpin and nine Dolly Varden were caught.

California Creek: upstream of Colorado Creek

This sampling site is approximately 3 km upstream of the mouth of Colorado Creek (Figure 1). It is a shallow, swift stream with occasional deeper pools. The proposed Round Top winter trail would cross the stream near this location. The site is surrounded by black spruce bogs with mature willows at the bank. Three slimy sculpin, 42 juvenile coho salmon, one Dolly Varden, three slimy sculpin, and one Alaska blackfish were caught at this sample site. No photos were taken of this stream in 2020.

California Creek: unnamed tributary 1

Figure 14: California Creek, unnamed tributary 1, July 2020.

This stream is approximately two meters wide and has a medium gradient with a cobble and small boulder bed. Cut banks are abundant, and the stream has medium density alder and willow cover. Fish captured at this location included seven juvenile coho, three slimy sculpin, and two Dolly Varden.

California Creek: unnamed tributary 2

Figure 15: California Creek, unnamed tributary 2, July 2020.

This stream is a high-gradient cascading stream with abundant plunge pools and hydraulic drops up to 1.5 meters. It has a very dense alder and willow canopy and a cobble and boulder substrate. Eight Dolly Varden were caught at this location.

California Creek: unnamed tributary 3

Figure 16: California Creek, unnamed tributary 3, July 2020.

This stream enters California Creek 8km upstream from its confluence with the Little Mud River. The drainage will be crossed by the winter trail to the Round Top prospect. It is 5 meters wide on average, and has a cobble and gravel substrate, and scattered cut banks. The sampling area was upstream of a beaver complex and flows through mixed beaver pond meadows and spruce forest. Three Dolly Varden were caught at this location.

Colorado Creek

Figure 17: Colorado Creek and associated beaver complexes, July 2020.

Colorado Creek is a tributary to California Creek. The drainage is located approximately halfway between the Illinois Creek Mine and the Round Top prospect (Figure 1) and would be crossed by the proposed Round Top winter trail near the minnow trapping location. The stream at the sampling location is up to 8 meters wide, has a sand and gravel substrate, and has abundant large beaver complexes. The stream channel primarily runs free, with complexes on the adjacent floodplain which is dominated by deciduous shrubs. Three Dolly Varden and two slimy sculpin were caught at this site.

Unnamed Stream

Figure 18: Unnamed stream, downstream of winter trail crossing, July 2020.

This tributary of the West Fork Mud River is a high-gradient stream with abundant step pools and rapids. It is located between Illinois Creek and the Honker Deposit (Figure 1), and the drainage would be crossed by the proposed Honker winter trail. The substrate consisted of gravel, cobble,

and small boulders, and the stream was shaded by dense alders and willows. Fifteen Dolly Varden were caught at this location.

Dome Creek: The Dome Creek watershed is a tributary to the West Fork of the Mud River and is immediately north of the Honker Prospect. Two locations were sampled on Dome Creek, and one location on an unnamed tributary.

Upper Dome Creek

Figure 19: Upper Dome Creek, July 2020.

This section of Dome Creek is fast-flowing with interspersed slow pools and has a gravel and cobble bed. Four slimy sculpin and four Alaska blackfish were caught here.

Lower Dome Creek

Figure 20: Lower Dome Creek, July 2020.

This reach of Dome Creek has a gravel and cobble bed, slightly incised beds, and deep pools. It is located between two large beaver dam complexes. Six juvenile coho salmon, six slimy sculpin, and one Dolly Varden were caught at this site.

Dome Creek: Unnamed Tributary

Figure 21: Dome Creek, unnamed tributary, July 2020.

This is a small tundra stream with frequent cut banks. The area experienced a wildfire in 2019, but stream-side deciduous shrubs survived in good condition and it has significant alder and willow cover. Four Dolly Varden were caught at this site.

Eddy Creek

Figure 22: Eddy Creek, July 2020.

Eddy Creek is a tributary of the Khotol River and drains the area north of the Round Top Prospect (Figure 1). The sample site has a gravel and cobble bed, a moderate gradient with swift riffles, and is interspersed by deeper pools and runs. There is thick deciduous bank cover and the banks are slightly incised. Six juvenile coho salmon, one slimy sculpin, and six Dolly Varden were caught at this site.

Minnesota Creek

Minnesota Creek is a tributary to California Creek, and drains the area to the southeast and South of the Round Top Prospect. The proposed Round Top winter trail would cross the top of this drainage. One site on Minnesota Creek, and three unnamed tributaries were sampled for fish presence.

Upper Minnesota Creek

Figure 23: Upper Minnesota Creek, July 2020.

This reach of Minnesota Creek is moderately incised with a cobble and gravel substrate. Thick deciduous shrubs line the banks. Fourteen juvenile coho and three Dolly Varden were caught here.

Minnesota Creek: unnamed tributary 1

Figure 24: Unnamed Minnesota Creek tributary 1, July 2020.

This tributary is narrow, deeply incised, and intermittently disappears into the roots of a thick deciduous plain with no visible surface flow. Two Dolly Varden were captured at this site. This tributary and tributary 2 merge approximately 300m downstream of the sample site.

Minnesota Creek: unnamed tributary 2

Figure 25: Unnamed Minnesota Creek tributary 2, July 2020.

This stream has abundant red and white precipitate on its bed, which is primarily gravel. The sample site flows through mixed deciduous shrubs and black spruce bog. No fish were captured at this site.

Minnesota Creek: unnamed tributary 3

This stream is approximately 1.5 meters wide, is deeply incised with a gravel bed and has dense overhanging vegetation. No photos were taken of this location. 11 juvenile coho, nine slimy sculpin, four Dolly Varden, and two Alaska blackfish were caught at this site.

CONCLUSION

If future aquatic sampling is planned, ADF&G recommends continuation of periphyton and aquatic invertebrate sampling, and juvenile fish whole body element analysis. Future fish work should be focused on developing a longer dataset to expand our understanding of what species utilize target areas around the deposits. For instance, juvenile Chinook salmon were documented in California Creek in 1995, however none were captured in 2020; determining which instance was an anomaly may be important. Additional recommendations include conducting aerial surveys to determine if there are adult Dolly Varden, coho and/or Chinook salmon spawning areas in the vicinity of the Illinois Creek mine and associated prospects.

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Appendix 1: Fish catches by species at each site, Illinois Creek biomonitoring project 2020.

Location	Lat	Long	Juvenile Coho	Slimy Sculpin	Dolly Varden	Alaska Blackfish	Arctic Grayling	Coho Retained for Elements
Lower Illinois Ck	64.0280	-157.8667	304	7	-	-	-	7
Upper Illinois Ck	64.0395	-157.8696	62	6	-	-	-	8
Lower California Ck: 1	64.0228	-157.8127	11	4	-	1	-	-
Lower California Ck 2	64.0557	-157.7892	79	-	-	1	1	-
California Ck Headwaters	64.1918	-157.6515	-	3	9	-	-	-
California Ck: US Colorado Ck	64.1363	-157.7487	42	3	1	1	-	-
California Ck Trib 1	64.1854	-157.6413	7	3	2	-	-	-
California Ck Trib 2	64.1967	157.7584	-	-	8	-	-	-
California Ck Trib 3	64.0816	-157.7903	-	-	3	-	-	-
Colorado Ck	64.1276	-157.7487	-	2	3	-	-	-
Unnamed Ck: Winter Trail	64.0917	-157.9635	-	-	15	-	-	-
Upper Dome Ck	64.1424	-157.9996	-	4	-	4	-	-
Lower Dome Ck	64.1368	-158.0659	6	6	1	-	-	-
Dome Creek Trib	64.1301	-157.0569	-	-	4	-	-	-
Eddy Ck	64.2231	-157.5799	6	1	6	-	-	-
Upper Minnesota Ck	64.1306	-157.5760	14	-	3	-	-	-
Minnesota Trib 1	64.1552	-157.5928	-	-	2	-	-	-
Minnesota Trib 2	64.1552	-157.5928	-	-	-	-	-	-
Minnesota Trib 3	64.1376	-157.5924	11	9	4	2	-	-

Appendix 2: Aquatic macroinvertebrate samples from upper Illinois Creek, 2020.

		Illinois Creek
Total aquatic invertebrate taxa per site		27
Total Ephemeroptera		83
Total Plecoptera		127
Total Trichoptera.		130
Total Aquatic Diptera		412
Miscellaneous Aquatic Species		62
	% other	8%
	% Ephemeroptera	10%
	% Plecoptera	16%
	% Trichoptera	16%
	% Aquatic Diptera	51%
Total EPT/Chironomidae percentage		
	% EPT	42%
	% Chironomidae	49%
Dominant taxon		
	% Dominant Taxon	48%
Average invertebrates/m^2 of stream bed		8,785
Average aquatic invertebrates/m^2 of stream bed		8,757
StDev of aquatic invertebrate/m^2 of stream bed		3,070
Total aquatic invertebrates in samples		4,072
Total terrestrial invertebrates in samples		13
Total invertebrates in samples		4,085
	% Sample aquatic	100%
	% Sample terrestrial	0%
	Average # aquatic invertebrates / sample	814
	St Dev of aquatic invertebrates / sample	319
	Average # terrestrial invertebrates / sample	3
	Average # invertebrates / sample	817
	StDev of invertebrates / sample	319
	Total larval fish	2

Appendix 3: Pheophytin-corrected chlorophyll-a area density (mg/m^2) in samples from Illinois Creek, 2020.

Sample	Chlorophyll-a
1	5.34
2	2.35
3	1.28
4	1.17
5	11.21
6	3.31
7	24.45
8	4.05
8	1.06
10	8.44
Median	3.68

Appendix 4: Element concentrations (mg/kg dry weight) in juvenile coho salmon from Illinois Creek in 2020 (top table) and 1996 (bottom table). In both data sets, each row represents one fish.

Element	Ag	As	Hg	Cu	Cd	Pb	Se	Zn
	0.09	3.6	0.27	3.4	0.064	0.18	1.5	163.3
	0.076	2.3	0.17	2.7	0.066	0.24	1.2	106
	0.064	3.6	0.19	3.4	0.1	0.09	1.8	138.1
	0.074	3.8	0.21	5	0.063	0.27	1.7	135.1
	0.073	3.3	0.2	3.1	0.064	0.12	0.96	119
	0.079	2.9	0.17	4.9	0.1	0.34	1.56	223.1
	0.11	3.6	0.24	5.3	0.4	0.24	2.39	225.2
	0.079	0.62	0.13	3.2	0.059	0.079	0.98	140.2
	0.082	0.44	0.15	2.9	0.041	0.082	0.82	131.1
	0.079	0.7	0.2	2.4	0.042	0.079	0.94	142.9
	0.078	0.84	0.25	3.5	0.11	0.078	1.2	150.7
	0.085	1.3	0.22	4.7	0.043	16.3	0.86	87.4
	0.088	0.49	0.34	3.7	0.044	0.12	0.88	100.5
	0.08	1.3	0.19	2.7	0.059	0.08	1	79.1
	0.077	0.57	0.26	3	0.038	0.15	0.72	93.9
Median	0.079	1.3	0.2	3.4	0.063	0.12	1	135.1

Element	Ag	As	Hg	Cu	Cd	Cr	Pb	Ni	Sb
	ND	0.5	0.12	3.96	0.04	8.7	0.15	1.2	0.06
	ND	0.6	0.03	2.85	0.09	0.5	0.11	0.3	0.13
	ND	ND	ND	2.27	0.03	0.6	0.07	0.3	0.09
	ND	0.7	0.14	2.32	0.03	0.7	0.27	0.4	0.34
	ND	0.6	0.07	2.65	0.03	0.6	0.15	0.3	0.14
	ND	1.6	0.07	4.01					
	ND	1.5	0.1	3.54					
	ND	ND	0.08	3.4					
	ND	1	0.08	3.17					
	ND	1.1	0.07	2.65					
	ND	1.6	0.07	3.26					
	ND	1	0.13	2.69					
	ND	1.3	0.08	2.75					
	ND	1.1	0.08	2.69					
	ND	3	0.1	2.84					
	ND	1.9	0.12	2.64					
	ND	3.5	0.08	3.32					
	ND	2.3	0.07	3.38					
	ND	3	0.07	2.77					
	0.02	2	0.06	2.71					
	0.08	1.6	0.06	2.44					

Appendix 4: Continued

Element	Ag	As	Hg	Cu	Cd	Cr	Pb	Ni	Sb
	0.03	2.0	0.08	3.06					
	0.11	1.9	0.11	2.23					
	0.04	2.4	0.08	2.31					
	0.02	1.9	0.08	3.52					
	0.03	2.7	0.06	2.55					
	0.03	2.1	0.07	2.23					
	0.03	1.2	0.07	2.61					
	0.08	3.1	0.1	2.46					
	0.03	1.9	0.07	5.92					
Median	0.03	1.75	0.08	2.73	0.03	0.6	0.15	0.6	0.13