Technical Report No. 24-09

Baseline Aquatic Biomonitoring at Illinois Creek and Associated Prospects, 2023

by

Lauren E. Yancy and Olivia N. Edwards

April 2024

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Habitat Section, as well as the Divisions of Sport Fish, and Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, Technical Reports and Special Publications. 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)

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. 24-09

BASELINE AQUATIC BIOMONITORING AT ILLINOIS CREEK AND ASSOCIATED PROSPECTS, 2023

By

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April 2024

Cover: Aerial view of the Colorado Creek drainage with abundant beaver ponds. Photograph by Lauren Yancy.

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ACKNOWLEDGEMENTS

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Olivia Edwards (ADF&G Habitat) led field sampling. Chelsea Clawson (ADF&G Habitat), Olivia Edwards, and Lauren Yancy processed the laboratory samples. Nora Foster (NRF Taxonomic Services) was responsible for the sorting and identification of aquatic macroinvertebrates. Chelsea Clawson and Al Ott (ADF&G Habitat) provided constructive reviews for this report.

EXECUTIVE SUMMARY

Western Alaska Copper & Gold has been operating an exploration program in the Illinois Creek Mining District for the past decade. Over the last five years, exploration expansion has warranted implementation of a biomonitoring program to document baseline aquatic conditions. Since 2020, the Alaska Department of Fish and Game (ADF&G) Habitat Section has conducted annual biomonitoring focused on identifying fish presence in surrounding streams. Additionally, juvenile fish whole body element analysis, periphyton, and benthic macroinvertebrates have been sampled in Illinois Creek. The purpose of this report is to document 2023 results and compare them to previous years' data.

In June 2023, ADF&G Habitat biologists sampled streams in the Little Mud River and Khotol River drainages near the historic Illinois Creek Mine. Resident fish catches from minnow trapping efforts were generally similar to past years. Juvenile coho salmon catches have greatly declined since 2020 and remained low in 2023. In general, catch per unit effort (CPUE) of all fish (resident and anadromous) has remained relatively unchanged for most sites, but a small number of sites have substantially differing CPUE between years, primarily due to decreases in juvenile coho salmon catch. Chlorophyll-a mean concentration was the highest on record in 2023 at 24.73 ± 10.14 SD mg/m^2. Aquatic macroinvertebrate densities in 2023 were substantially higher than past years averaging 46,441 ± 20,139 SD individuals/m^2 of stream bed. Benthic macroinvertebrate samples were composed of 80% Diptera and 13% Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa. Mean whole body element concentrations of juvenile coho salmon in Illinois Creek were similar to past years with slight increases in arsenic and cadmium concentrations. These arsenic and cadmium concentrations are well within the ranges reported in juvenile Dolly Varden around the Pebble Prospect (Brekken et al. 2022).

ADF&G Habitat Section recommends continuing this annual biomonitoring program with additional periphyton and benthic macroinvertebrate sampling near deposits of interest. Additional recommendations include conducting aerial surveys in August and/or September to determine adult fish presence and spawning areas.

INTRODUCTION

The historic Illinois Creek gold and silver mine and associated prospects are located in the southern Kaiyuh Mountains approximately 90 km southwest of Galena, Alaska. An open pit mine was operated in the area by USMX Incorporated from 1996 to 1998 and Viceroy Resources Corporation from 1998 to 2000. American Reclamation Group leased the mine from the State of Alaska until 2002, and fees from their operation were used for reclamation. The operation has since been acquired by Western Alaska Copper and Gold (WAC&G) and there is no active mining at this time. There are five main exploration targets held by WAC&G in the Illinois Creek Mining District (Figure 1). The historic Illinois Creek Mine gold and silver deposit is southwest of camp. The Waterpump Creek and Last Hurrah silver, zinc, and lead deposits are adjacent to the Illinois Creek deposit. Northwest of these deposits is the Honker gold vein. To the northeast are the Round Top copper and silver deposits and the TG North silver, zinc, and lead deposits. Plans for development include two proposed roads which would cross drainages that support resident and anadromous fish populations.

The ADF&G Habitat Section collected fish presence data and relative abundance in streams near the mine between 1995 and 1998 (Winters 1996-1998b). During this period, sampling focused on Illinois Creek using minnow traps for juvenile salmon, and visual surveys on foot for adult salmon. Whole body element and histological analyses were performed on juvenile coho salmon from Illinois Creek in 1995. Limited minnow trapping was done in California Creek in 1995. Annual biomonitoring sampling resumed in 2020 and expanded to include additional sampling protocols and sites.

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

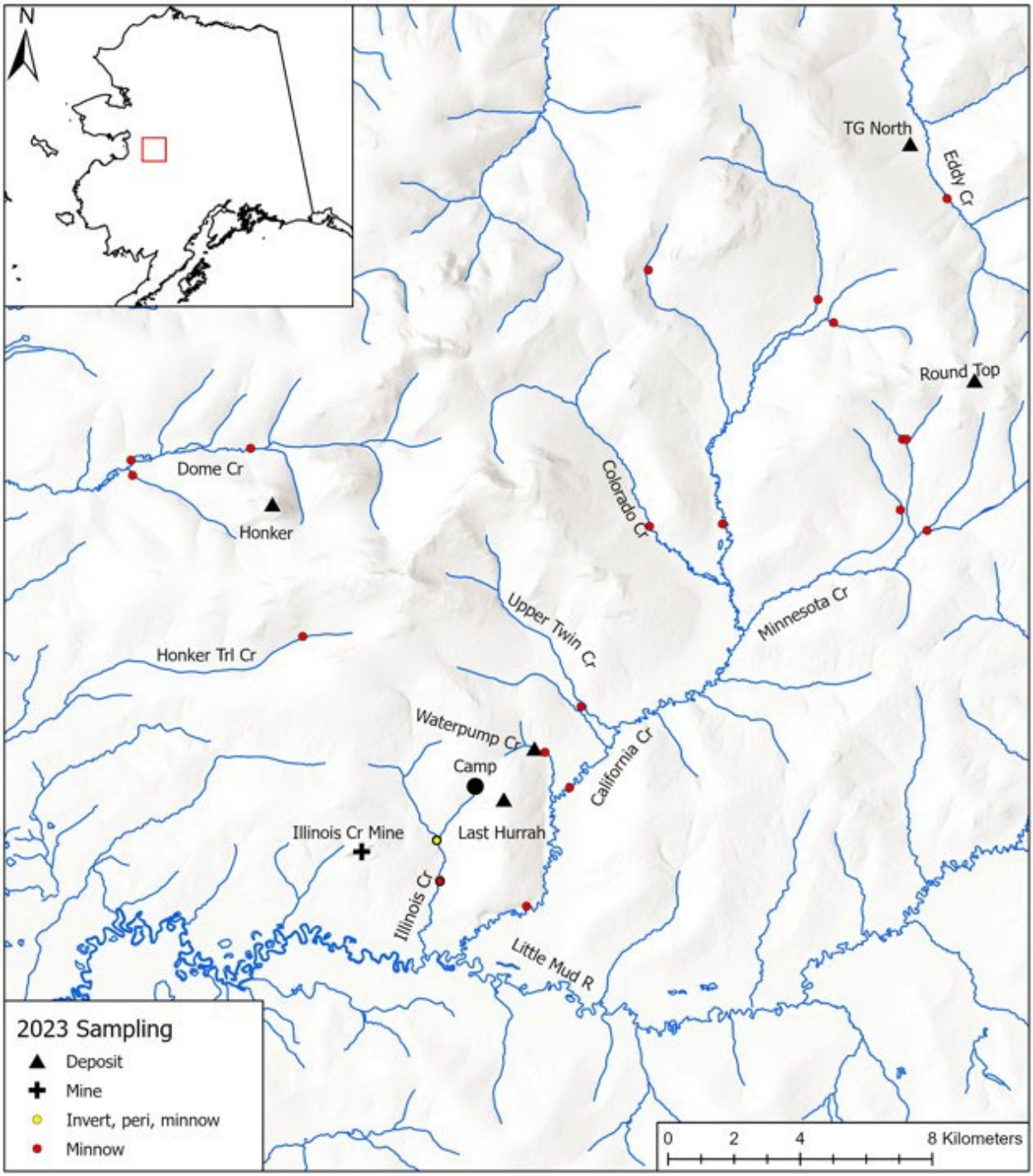

Figure 1. June 2023 sample sites surrounding the historic Illinois Creek Mine and target deposits.

Fish communities vary depending on stream characteristics. The high gradient headwater streams are primarily inhabited by resident Dolly Varden, and mixed communities of Alaska blackfish, slimy sculpin, Arctic grayling, and juvenile salmon occupy the lower reaches. Abundant large

beaver dam complexes in these drainages impact fish distribution by creating fish passage barriers which can fragment habitat and exclude species previously present in upper stream reaches. Conversely, when dam complexes are destroyed via high water events or structural failure, fish recolonize previously fragmented areas.

The goal of annual biomonitoring is to quantify baseline biological conditions in Illinois Creek and nearby watersheds. Parameters for biomonitoring include periphyton, benthic macroinvertebrates, and fish presence. Collecting baseline biomonitoring data at established monitoring locations makes it possible to assess naturally variable biological conditions and identify changes over time.

Location and Description of Monitoring Sites

Biomonitoring was performed at 20 sites around the Illinois Creek Mining District. Site names with an asterisk (*) are unnamed streams with locally recognized names.

- **Illinois Creek**
    - **Lower Illinois Creek** is a low-gradient, incised stream characterized by a silty mud bed with abundant decayed organic matter and deciduous shrubs lining the banks.
    - **Upper Illinois Creek** is approximately 1.35 km upstream of the lower Illinois Creek site. This site is characterized by pool/riffle habitat with silt, cobble, and small boulder substrate. Wet grassy meadows and deciduous shrubs line the stream banks. A warm groundwater spring enters approximately 200 m upstream of our sampling reach.
- **California Creek and Tributaries**
    - **Lower California Creek 1** is the downstream-most site in the California drainage. Here, the creek is approximately 12 to 20 m wide meandering through low lying grassy wetlands with mature spruce trees along parts of the riverbanks. The creek is low gradient with deep pools and large woody debris built up at river bends. Silt and gravel are the predominant substrate and wadable riffle sections are sparse.

- **Lower California Creek 2** is 5 km upstream of the lower California Creek 1 site and has similar characteristics, but the substrate is comprised of more gravel and sand, and less silt.

- **Waterpump Creek*** is a small, approximately 2.5 km long tributary of California Creek with headwaters just north of the camp and airstrip (Figure 1). The site is characterized by moderate gradient, cobble and gravel substrate, cut banks, and woody debris in the stream. Spruce, alder, and willow vegetation line the stream banks.

- **Upper Twin Creek*** formerly referred to as "California Creek unnamed tributary 3" (Burrows 2020), is below a series of beaver complexes (Figure 2). The creek is characterized by riffle/run/pool habitats with small cobble, gravel, and sandy substrate. There is dense willow and alder growth along the banks.

- **Colorado Creek** is characterized by moderate gradient riffle/runs with sand and gravel substrate. The adjacent banks are dominated by deciduous shrubs. There are abundant off-channel beaver complexes that do not impede the main channel flow (Figure 2).

- **California Creek upstream Colorado Creek** is approximately 2.5 km upstream of the mouth of Colorado Creek. It is characterized by shallow, swift reaches with occasional deeper pools and cobble substrate. The site is surrounded by black spruce bog with mature willows along the banks.

- **California Creek Headwaters** is the most upstream site on California Creek. There is a large beaver complex downstream of the sample site, but at the site the stream is wide with shallow riffle/pool habitat and cobble and gravel substrate. The riparian vegetation consists of white spruce and mature willows.

- **California Creek Tributary 1** is a small stream, approximately 2 m wide and has a medium gradient with cobble and small boulder substrate. Cutbanks are abundant and riparian vegetation consists of alder and willows.

- **California Creek Tributary 2** is characterized by high gradient cascading step pools with vertical drops up to 1.5 m. There is dense alder and willow canopy intertwining across the stream with boulder and some cobble substrate.

- **Upper Minnesota Creek** is characterized by riffle/run/pool habitats with cobble and gravel substrate. Thick deciduous shrubs and tall grasses line the banks.

- **Minnesota Creek Tributary 1** is a narrow and braided stream with intermittent sections of subsurface flow. Step pools formed by large boulders are sparsely present. Some sections of the stream are only 1 m wide, and the riparian vegetation is dense, intertwining across the stream.

- **Minnesota Creek Tributary 2** is approximately 150 m east of Minnesota Tributary 1 and converges 100 m below the sample sites. The creek has red precipitate accumulation on the gravel substrate, with deciduous shrubs along the bank.

- **Minnesota Creek Tributary 3** is approximately 1.5 m wide with cut banks, gravel substrate, and silty pools. There is intermittent dense overhanging vegetation along the banks.

- **Eddy Creek** is a tributary of the Khotol River and is the only sample site not in the Little Mud River drainage. The site is characterized by moderate gradient with swift riffles, and interspersed deeper pools and runs with gravel and cobble substrate. There is thick grassy and deciduous vegetation along the banks. There is a large established beaver dam downstream of the sample site.

- **Honker Trail Creek*** is a tributary of the West Fork Mud River. It is a high gradient tundra stream with abundant step pools and rapids. Boulder and cobble are the dominant substrate, and dense alder and willows shade the stream.

- **Dome Creek**

    - **Dome Creek Tributary** is a small tundra stream with cut banks and fine gravel substrate. Alder and willow shade significant portions of the stream.

    - **Lower Dome Creek** is characterized by shallow riffle/run habitat and deep pools with gravel and cobble substrate. There is abundant beaver activity above and below this site. The sample reach contains a breached beaver dam with some regrowth of vegetation in the previously submerged flood plain (Figure 3).

    - **Upper Dome Creek** is a fast-flowing shallow stream with interspersed pools. Adjacent beaver complexes overflow into the creek and active dams create a series of potential fish barriers from the lower to the upper Dome Creek sites (Figure 3). Riparian vegetation varies along the sample reach ranging from tall grasses and sedges to large birch trees.

Figure 2. Aerial view of Twin Creek (left) and Colorado Creek (right).

Figure 3. Dome Creek active beaver dam (left) and remnants of historically dammed and flooded area of Lower Dome Creek (right).

METHODS

Sampling Overview

The objective of the Illinois Creek biomonitoring program is to document in-situ productivity of the aquatic communities and quantify whole body elements and metal concentrations in juvenile coho salmon.

In 2023 biologists performed one sampling trip in the Illinois Creek area from June 22–29. Water levels were normal and ideal for sampling protocols, with intermittent rain and thunderstorms throughout the trip. Heavy rains arrived on the last day, after sampling was completed.

Illinois Creek

Periphyton

Periphyton sample collection and lab analyses follow the rapid bioassessment techniques of Barbour et al. 1999. At Upper Illinois Creek ten completely submerged rocks were selected for periphyton sampling, each with an appropriately sized flat surface exposed to sunlight. A 5-cm by 5-cm square of flexible foam was placed on the flat surface, and all material outside of the square was 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. Material trapped on the brush was also rinsed onto 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 absorb any remaining water, then were immediately wrapped in aluminum foil to prevent chlorophyll degradation and stored in a cooler with ice. Samples were stored frozen until chlorophyll-a concentration of each sample was measured in the ADF&G lab in Fairbanks. Results are reported as mean chlorophyll-a concentration ($mg/m^2 \pm 1$ SD). These concentrations are a metric for estimating periphyton standing crop and primary productivity in the stream. Additional details regarding periphyton sampling and analysis methods can be found in ADF&G Technical Report No. 17-09 (Bradley 2017).

Benthic Macroinvertebrates

At the Upper Illinois Creek site, approximately 100 m downstream of the minnow trapping reach, a Hess sampler was used to collect five benthic macroinvertebrate (BMI) samples. The Hess stream bottom sampler has a 0.086 m^2 sample area and material is captured in a 200 mL cod end – both constructed with 300 μm mesh net. For each replicate, the Hess sampler was set in place and all rocks within the circular sampling area were dislodged from the stream bed and thoroughly agitated to dislodge BMI into the net. The cod end contents were then removed and placed in individual pre-labeled Nalgene bottles with denatured ethyl alcohol to preserve the samples lab analysis. NRF Taxonomic Services in Fairbanks, Alaska identified and enumerated the samples.

Samples were sorted and invertebrates identified to the lowest taxonomic level, typically family or genus. Invertebrates belonging to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (collectively known as EPT) are more sensitive to water quality, the total percent of EPT composition was calculated and compared to groups of other invertebrates, which are less sensitive. BMI density was calculated for each sample by dividing the number of macroinvertebrates by 0.086 m^2, the Hess sampling area. Mean density was estimated for each site by calculating the mean density among the five samples. Taxa richness is reported as the number of taxonomic groups identified to the lowest practical level.

A Surber sampler was used in 2020 for aquatic macroinvertebrates, which adds a component of drift collection to the benthic sampling. While Surber and Hess samples are not directly comparable due to the added drift component with the Surber sampler, the Surber results are still included in comparisons because both methods sample benthic macroinvertebrates in a fixed area.

Juvenile Coho Salmon Whole Body Elements

At the Lower Illinois Creek site, nine juvenile coho salmon between 80 to 110 mm FL were retained for whole body element analysis. Fish were handled with class 100 nitrile gloves, which were changed between sites and whenever they contacted soil, metal, clothing, or vegetation. Retained fish were euthanized immediately via cranial concussion and placed individually in labeled zip-loc bags. Samples were kept frozen until lab analyses were performed.

Retained juvenile coho salmon were analyzed for arsenic, cadmium, copper, lead, mercury, selenium, zinc, and silver by ACZ Laboratories in Steamboat Springs, Colorado. Mercury was measured using direct combustion, and other elements by inductively coupled plasma mass spectroscopy. When an element was measured at concentrations below the Method Detection Limit (MDL), the MDL was reported as the concentration of the element for that fish. Results are reported as mean concentration (dry weight; mg/kg ± 1 SD) of all fish collected for each element.

Mean element concentrations were compared with past values from juvenile coho in Illinois Creek. In addition, concentrations from other Alaskan fish species of a similar life stage and trophic level were used to draw comparisons across the state in historically mined areas and exploration prospects.

Fish Presence

Ten minnow traps baited with cured salmon roe in perforated plastic bags were set at each sample site for approximately 24 hours. When traps were collected, the species and fork length (FL; mm) of every captured salmonid were recorded. Total length (TL; mm) was recorded for species with round caudal fins, such as slimy sculpin and Alaska blackfish. Results are reported as catch per unit effort (CPUE) which is the total number of fish caught at a site divided by the number of hours the trap was set for (number of fish caught/24 hrs). Length-frequency histograms are presented for juvenile coho salmon.

RESULTS AND DISCUSSION

Illinois Creek

Periphyton

In 2023, mean phaeophytin corrected chlorophyll-a concentration in Upper Illinois Creek was higher than previously recorded (24.73 ± 10.14 SD mg/m^2; Figure 4). High values recorded in 2022 and 2023 are similar to highly productive streams (e.g., Upper Ruby Creek) sampled near the Arctic-Bornite prospects in the southern end of the Brooks Range (Clawson 2022). All values recorded since 2020 are presented in Appendix 2.

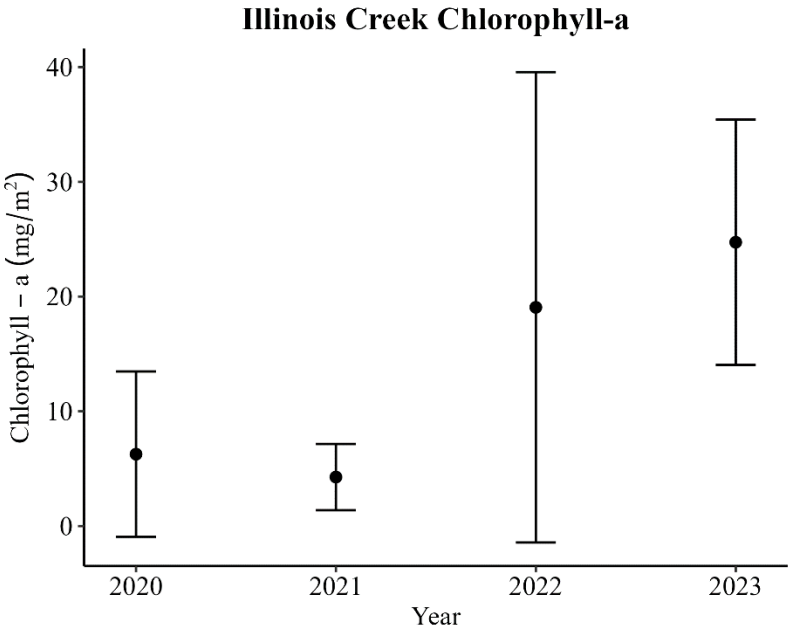

Figure 4. Phaeophytin corrected chlorophyll-a mean concentrations ± 1 SD in Illinois Creek, 2020–2023.

Benthic Macroinvertebrates

Mean BMI density in Illinois Creek in 2023 was 46,441 ± 20,139 SD individuals/m^2 of stream bed, which is substantially higher than previously recorded averages (Figure 5). Mean 2023 density is less than but within the standard deviation of the highly productive Upper Ruby Creek near the Arctic-Bornite prospects (72,732 ± 37,940 SD individuals/m^2; Clawson 2022).

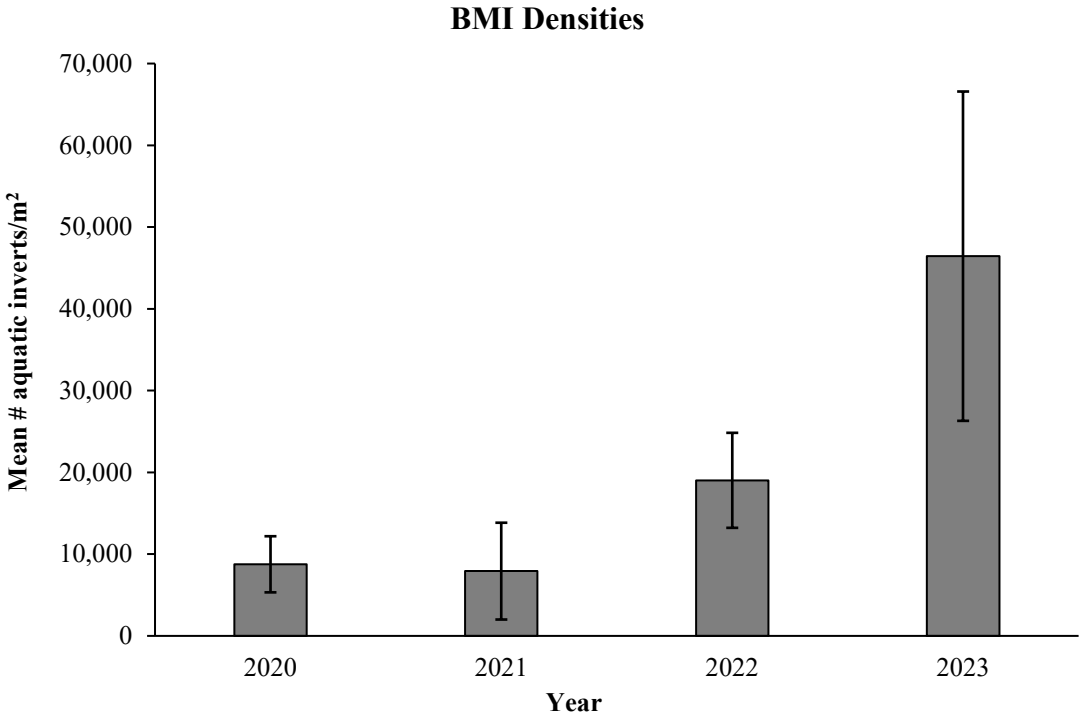

Figure 5. Mean benthic macroinvertebrate densities (± 1 SD), 2020–2023.

BMI taxonomic composition has varied from 2020–2023 (Figure 6). Aquatic Diptera (primarily chironomids) were the dominant taxa in 2023 at 80% of the sample. The EPT taxa comprised 13% of the sample in 2023. Of the EPT taxa, 10.4% were Ephemeroptera, 2% were Plecoptera, and 0.6% were Trichoptera. The remaining 7% of the sample are categorized as "other" which includes Acarina (mites), Ostracods (seed shrimp), Platyhelminthes (flatworms), and miscellaneous invertebrates. The change in taxa composition seen after 2020 is potentially due to the switch from Surber to Hess samplers in 2021.

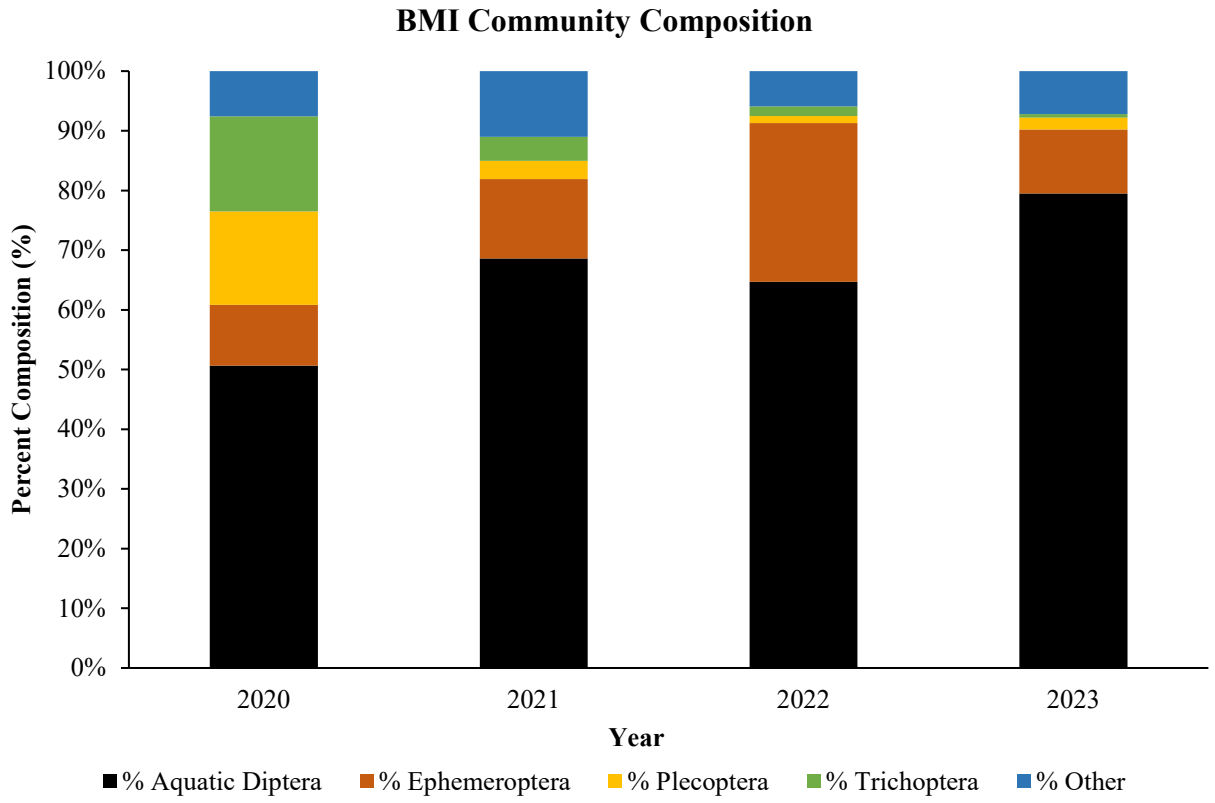

Figure 6. Benthic macroinvertebrate community composition in Illinois Creek, 2020–2023.

Juvenile Coho Salmon Whole Body Elements

Mean whole body element concentrations (dry weight; mg/kg ± 1 SD) from 2020–2023 are displayed in Figure 7. Fifteen juvenile coho salmon were retained for element analysis each year in 2020–2022 and nine were retained in 2023. Whole body element concentrations of analyzed fish to date are reported in Appendix 3 (Winters 1996; Burrows 2020; Burrows and Edwards 2022; Yancy and Edwards 2023).

Silver concentrations were below the MDL in all samples in 2023 (Figure 7). The MDL concentrations range from 0.06 to 0.10 mg/kg due to differing moisture content in each processed juvenile fish. Concentrations have been at or below the MDL for all years, except for nine samples in 1995 (Appendix 3; Winters 1996).

The mean arsenic concentration was 4.82 mg/kg in 2023 (Figure 7). This is slightly elevated compared with past years, but comparable to values found in juvenile Dolly Varden from streams around the Pebble Prospect (Brekken et al. 2022).

The mean cadmium concentration was 0.17 mg/kg in 2023 (Figure 7). The mean has nearly doubled over the last four years (0.09 mg/kg in 2020), but the range of values fall within values found in juvenile Dolly Varden from streams around the Pebble Prospect (Brekken et al. 2022).

The mean copper concentration was 3.74 mg/kg in 2023 (Figure 7). This is comparable to previous years as well as concentrations found in juvenile Dolly Varden from streams around the Pebble Prospect (Brekken et al. 2022). These copper concentrations are on the low end of those found in juvenile Dolly Varden captured in streams in the vicinity of active mines throughout the state of Alaska (Legere and Timothy 2016).

The mean mercury concentration was 0.22 mg/kg in 2023, which is similar to concentrations reported in the previous three years (Figure 7). This is similar to those found in juvenile coho salmon in historically mined areas in Resurrection Creek on the Kenai Peninsula (MacFarlane 2004) but are slightly higher than values in juvenile Dolly Varden near the Pebble Prospect (Brekken et al. 2022).

The mean lead concentration was 0.10 mg/kg in 2023, which is similar to concentrations reported in the previous three years (Figure 7). Six of the concentrations were below the MDL and are reported as the MDL (Appendix 3). These lead values are within the range found in juvenile Dolly Varden near the Pebble Prospect (Brekken et al. 2022).

The mean selenium concentration was 1.25 mg/kg in 2023, which is similar to concentrations reported in the previous three years (Figure 7). These selenium values are on the low end of those found in juvenile Dolly Varden near the Pebble Prospect (Brekken et al. 2022).

The mean zinc concentration was 143.95 mg/kg in 2023, which is similar to concentrations reported in the previous three years (Figure 7). These zinc values are consistent with those found across Alaska in juvenile Dolly Varden (Legere and Timothy 2016).

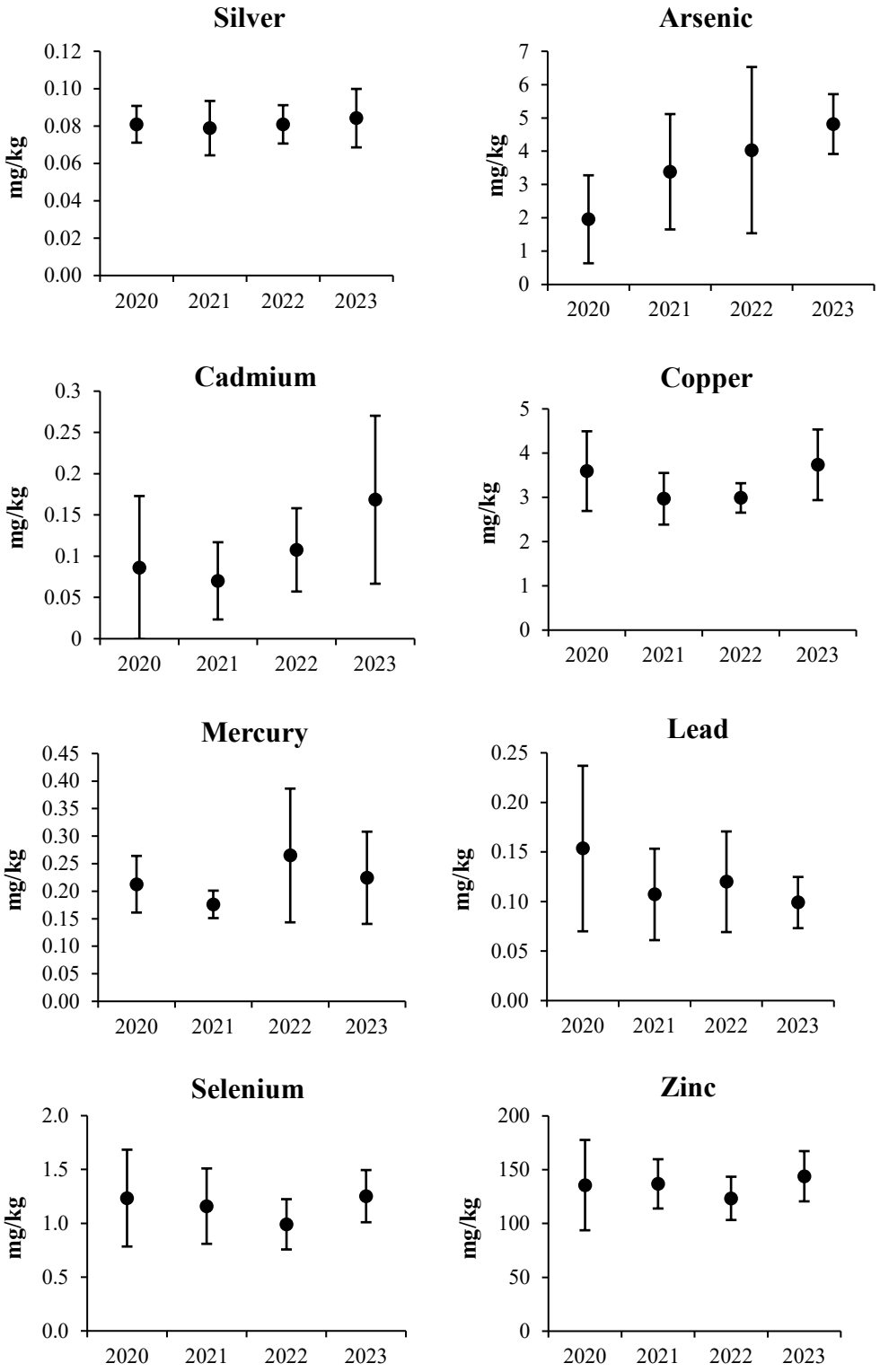

Figure 7. Juvenile coho salmon whole body mean element concentrations (dry weight; mg/kg ± 1 SD) in Illinois Creek 2020–2023. Note: n = 15 for 2020–2022, n = 9 for 2023.

Fish Presence

Total fish (resident and anadromous) CPUE varies among sites and years (Figures 8 and 9). The number of resident fish captured has not varied substantially from year to year but there has been a general decline in juvenile coho salmon catches (Appendix 1, Figure 10). There are data gaps at some sites due to limited sampling in 2021 and the addition of new sites in 2022 and 2023.

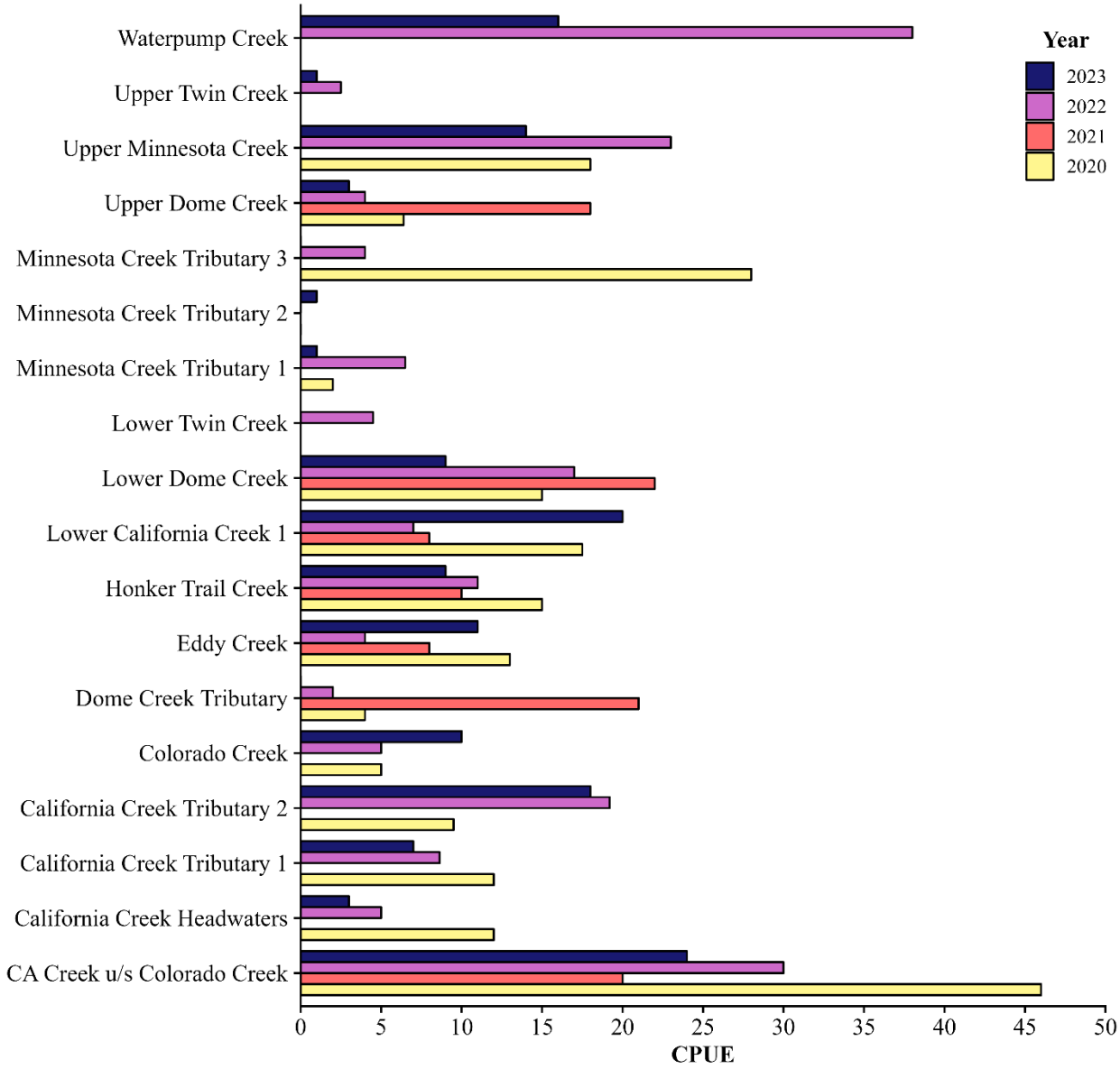

Figure 8. Catch per unit effort (number of fish caught/24 hrs) for all fish species, excluding three high CPUE sites, from 2020–2023.

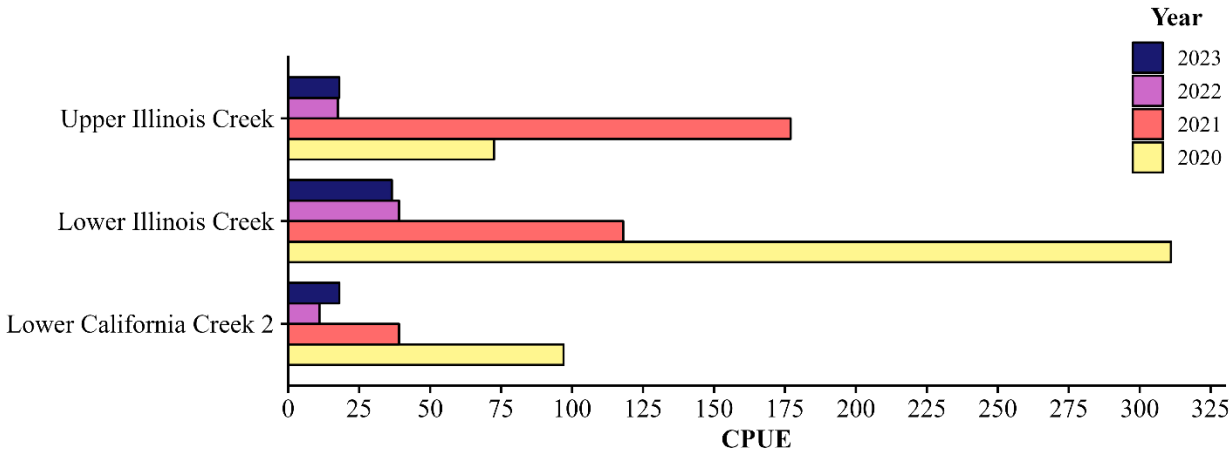

Figure 9. Catch per unit effort (number of fish caught/24 hrs) for all fish species from 2020–2023 for the Illinois Creek sites and Lower California Creek 2.

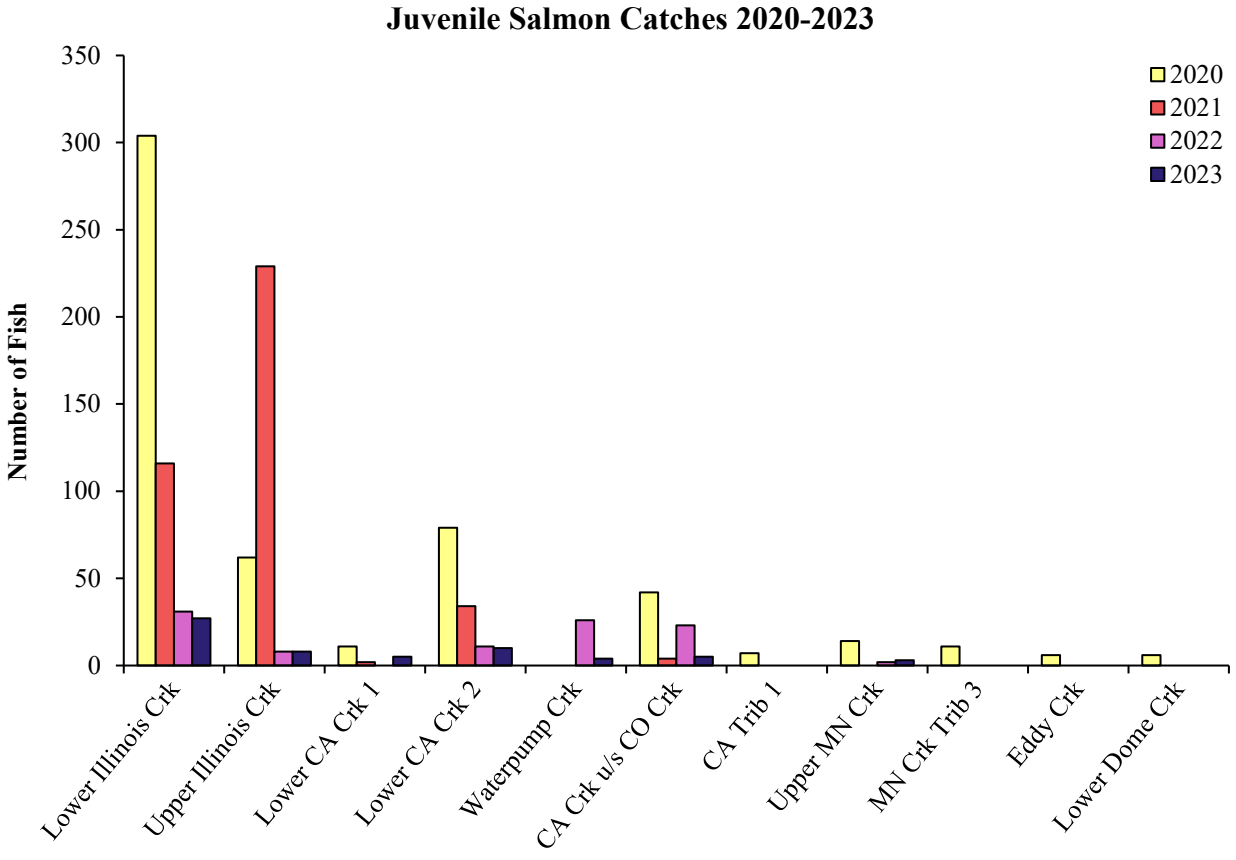

Figure 10. Juvenile salmon catches at a subset of sites from 2020–2023. The Waterpump Creek site was added in 2022. California Tributary 1, Upper Minnesota Creek, and Minnesota Tributary 3 were not sampled in 2021.

In the California Creek drainage, CPUE has slightly declined over the years at the headwaters site, California Tributary 1, California Creek upstream Colorado Creek, and Waterpump Creek. At Lower California Creek 2 CPUE declined from 97 in 2020 to 18 in 2023 (Figure 9). CPUE remained steady or slightly increased at California Creek Tributary 2, Colorado Creek, Lower California Creek 1, and Twin Creek (Figure 8). In the Minnesota Creek drainage, Minnesota Creek Tributary 3 went from a CPUE of 28 in 2020, to zero in 2023. The other Minnesota Creek sites have comparable CPUE among years. Minnesota Creek Tributary 2 went from a CPUE of zero in 2020 to one in 2023 when the first Dolly Varden was captured at the site. Dolly Varden are the most observed species in the Minnesota Creek drainage, with coho salmon rearing in the lower portions of the drainage (Appendix 1).

In Eddy Creek, CPUE was lower in 2022 but was similar in the other three years (Figure 8). In 2020, juvenile coho salmon were captured in Eddy Creek but have not been observed since (Appendix 1). In 2022 the sample site was moved upstream above a large beaver dam.

In the Dome Creek drainage, CPUE was high at Upper Dome Creek and Dome Creek Tributary in 2021, but in 2023 CPUE was three and zero, respectively (Figure 8). At the Honker Trail Creek site, located between the Dome Creek and Illinois Creek drainages, Dolly Varden is the only species present and CPUE is consistent among years. In Illinois Creek, slimy sculpin catches have remained steady over the last four years while juvenile coho catches and CPUE have declined by hundreds of fish since 2020 (Figure 9 and Figure 10).

In 2023, there were a total of 55 juvenile coho salmon captured across all sites; lengths ranged from 45 to 99 mm FL (Figure 10). The majority of individuals captured were between 65 and 75 mm FL, most likely age 1 fish (Figure 10).

Of the 55 juvenile coho salmon captured in 2023, half of the individuals (n = 28) were caught in Illinois Creek; lengths ranged from 45 to 99 mm FL (Figure 11). Lower Illinois Creek had a broader range of lengths recorded, whereas Upper Illinois Creek juvenile coho salmon ranged from 70 to 95 mm FL (Figure 11).

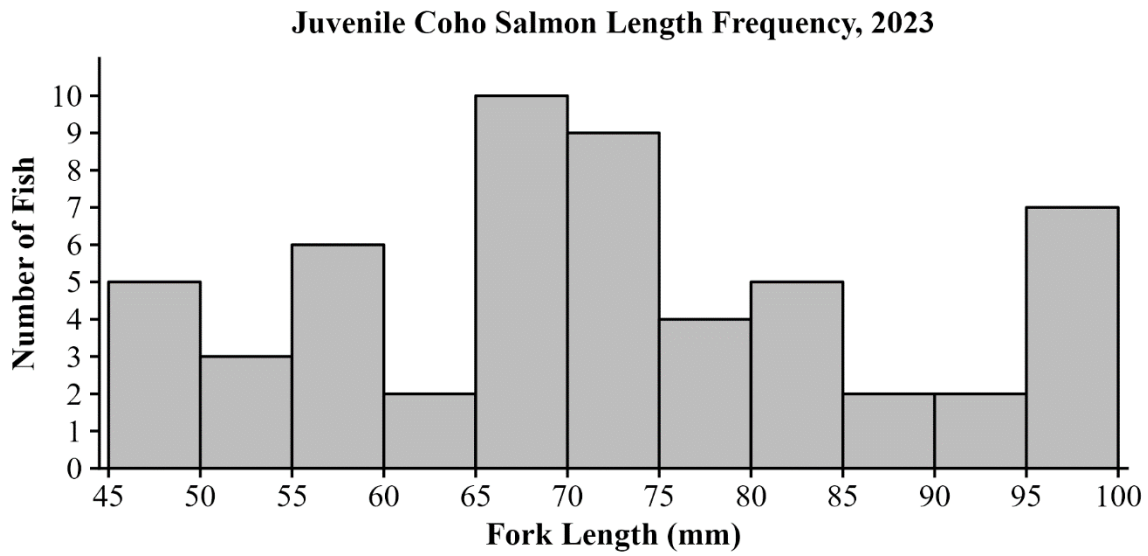

Figure 11. Length frequency plot of all juvenile coho salmon captured in 2023 (n = 55).

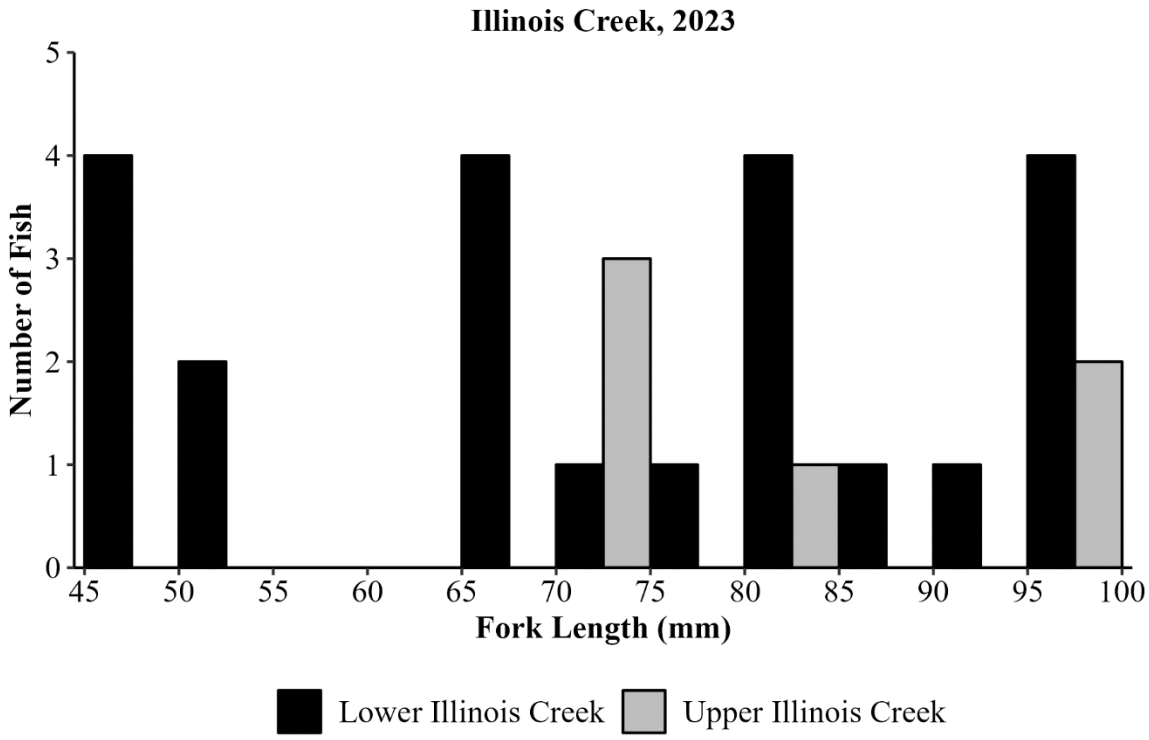

Figure 12. Length frequency plot of juvenile coho salmon from Illinois Creek, 2023 (n = 28).

In 2023, seven juvenile salmon captured in Illinois Creek, ranging from 82 to 107 mm FL, were tentatively identified as Chinook (Figure 12). Juvenile Chinook salmon were identified in Illinois Creek in 1995 (Winters 1996) but had not been observed in 2020 to 2022. No genetic fin clips were retained in 2023 to confirm identification, but future sampling efforts will include genetic sampling to confirm species identification.

Figure 13. Juvenile salmon caught in Illinois Creek, June 2023.

CONCLUSION

This report summarizes the current biological conditions in watersheds near the historic Illinois Creek Mine and surrounding prospects. While biomonitoring methods have been consistent for fish sampling since 2020, variability in the timing of sampling may contribute to differences in CPUE, length frequencies, and/or species composition. Many fish species move seasonally and juvenile salmon experience rapid growth during summer months. The number of juvenile coho salmon captured in Illinois Creek has decreased, mirroring the declines seen in adult coho salmon escapement estimates across the Yukon drainage (Donnellan and Munro 2023). Resident fish captures have remained relatively steady since 2020.

Chlorophyll-a concentrations in Illinois Creek were high in 2022 and 2023. Aquatic macroinvertebrate densities have also increased since 2021. This is potentially a bottom-up ecological trend, where the increase in chlorophyll-a concentrations, and therefore algal presence, provides more food for aquatic macroinvertebrates, resulting in an increase in macroinvertebrate population size. Environmental parameters such as water and air temperature are not currently monitored but may be correlated to fluctuations in periphyton abundance. Juvenile coho salmon

whole body element concentrations are similar among all years and comparable to concentrations found in other parts of Alaska.

Juvenile Chinook and coho salmon can be challenging to differentiate in the field due to regional differences in defining characteristics. Juvenile Chinook salmon were documented in Illinois Creek and California Creek in 1995 but have not been captured in minnow traps since. In 2023, seven juvenile salmon were tentatively identified as Chinook in Illinois Creek, although genetic samples were not collected. Fin clips from the fish collected for whole body element analyses in 2023 will be sent to the ADF&G Genetics Lab in spring 2024 to confirm coho salmon field identification. Future fish sampling will include collection of non-lethal fin clips from potential Chinook salmon juveniles for genetic testing.

Future work should be focused on continuing annual biomonitoring to expand the dataset and better inform our understanding of what fish species utilize streams. ADF&G recommends annual biomonitoring as outlined in this report to build a baseline dataset that captures natural inter-annual variability. ADF&G also suggests expanding sampling near the Waterpump, Honker, Round Top, and TG North prospects to include periphyton and aquatic macroinvertebrate analyses. Additional recommendations include conducting aerial surveys in August and/or September to determine if there are coho, chum and/or Chinook salmon spawning in the vicinity of the Illinois Creek mine and associated prospects.

LITERATURE CITED

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Bradley, P. T. 2017. Methods for aquatic life monitoring at the Red Dog Mine site. Alaska Department of Fish and Game, Technical Report No. 17-09, Fairbanks, Alaska.

Brekken, J. M., K. J. Harper, J. M. Alas, and R. C. Benkert. 2022. Aquatic Biomonitoring at the Pebble Prospect, 2010-2013. Alaska Department of Fish and Game, Technical Report No. 22-09, Anchorage, Alaska.

Burrows, J. M. 2020. Baseline Aquatic Biomonitoring: Illinois Creek Mine and Associated Prospects, 2020. Alaska Department of Fish and Game, Technical Report No. 20-08, Fairbanks, Alaska.

Burrows, J. M., and O. N. Edwards. 2022. Baseline Aquatic Biomonitoring: Illinois Creek Mine and Associated Prospects, 2021. Alaska Department of Fish and Game, Technical Report No. 22-03, Fairbanks, Alaska.

Clawson, C. M. 2022. Aquatic Biomonitoring at the Arctic-Bornite Prospect, 2021. Alaska Department of Fish and Game Technical Report No. 22-06, Fairbanks, Alaska.

Donnellan, S. J., and A. R. Munro, editors. 2023. Run forecasts and harvest projections for 2023 Alaska salmon fisheries and review of the 2022 season. Alaska Department of Fish and Game, Special Publication No. 23-10, Anchorage, Alaska.

Legere, N. M., and J. Timothy. 2016. Tulsequah Chief acid mine drainage and Dolly Varden char whole body metal concentrations. Alaska Department of Fish and Game, Technical Report No. 16-06, Douglas, Alaska.

MacFarlane, B. 2004. Mercury concentrations in fish in Resurrection Creek, Alaska. 2004. USDA Forest Service, Chugach National Forest.

Winters, J. F. 1996. Illinois Creek Mine Fish Monitoring Study: Emphasis on Juvenile Chinook Salmon. Alaska Department of Fish and Game, Technical Report No. 96-7, Fairbanks, Alaska.

Winters, J. F. 1997. Illinois Creek Mine Fish Monitoring Study: Emphasis on Juvenile Chinook Salmon – Year 2 (1996). Alaska Department of Fish and Game, Internal Memo, Fairbanks, Alaska.

Winters, J. F. 1998a. Illinois Creek Mine Fish Monitoring Study: Emphasis on Juvenile Chinook Salmon – Year 3 (1997). Alaska Department of Fish and Game, Internal Memo, Fairbanks, Alaska.

Winters, J. F. 1998b. Illinois Creek Mine Fish Monitoring Study: Emphasis on Juvenile Chinook Salmon – Year 4 (1998). Alaska Department of Fish and Game, Internal Memo, Fairbanks, Alaska.

Yancy, L. E., and O. N. Edwards. 2023. Baseline Aquatic Biomonitoring at Illinois Creek Mine and Associated Prospects, 2022. Alaska Department of Fish and Game, Technical Report No 23-05, Fairbanks, Alaska.

APPENDIX 1: Fish catch by species at each sample site with coordinates (WGS 84), 2020–2023.

Sample Site 2023	Latitude	Longitude	Juvenile Coho Salmon	Juvenile Chinook Salmon	Slimy Sculpin	Dolly Varden	Alaska Blackfish
Lower Illinois Crk*	64.0288	-157.8666	22	5	11		
Upper Illinois Crk	64.0395	-157.8696	6	2	11		
Lower CA Crk 1	64.0230	-157.8117	5		15		
Lower CA Crk 2	64.0557	-157.7892	10		4	2	2
Waterpump Crk**	64.0649	-157.8057	4		5	8	
Upper Twin Crk**	64.0778	-157.7850				1	
Colorado Crk	64.1276	-157.7487			1	8	
CA Crk u/s CO Crk	64.1293	-157.7035	5		13	2	1
CA Crk Headwaters	64.1914	-157.6519				3	
CA Trib 1	64.1854	-157.6413			3	5	
CA Trib 2	64.1968	-157.7586				20	
Upper MN Crk	64.1306	-157.5760	3		3	7	1
MN Crk Trib 1	64.1549	-157.5944				1	
MN Crk Trib 2	64.1549	-157.5918				1	
MN Crk Trib 3	64.1358	-157.5934					
Eddy Crk	64.2206	-157.5747			1	9	
Honker Trail Crk**	64.0924	-157.9603				9	
Dome Crk Trib	64.1424	-157.9996					
Lower Dome Crk	64.1371	-158.0735			3	3	3
Upper Dome Crk	64.1331	-158.0719			2	1	

* Nine juvenile coho salmon were retained for whole-body element analysis.

** Unnamed stream with locally accepted names.

Sample Site 2022	Latitude	Longitude	Juvenile Coho Salmon	Slimy Sculpin	Dolly Varden	Alaska Blackfish
Lower Illinois Crk*	64.0288	-157.8666	31	3		2
Upper Illinois Crk	64.0395	-157.8696	8	8		
Lower California Crk 1	64.0230	-157.8117		7		
Lower California Crk 2	64.0557	-157.7892	11	6	1	3
Waterpump Crk**	64.0649	-157.8057	26		3	
Lower Twin Crk**	64.0750	-157.7813		1	3	
Upper Twin Crk**	64.0778	-157.7850			1	1
Colorado Crk	64.1276	-157.7487		3	2	
CA Crk u/s CO Crk	64.1293	-157.7035	23	2		
CA Crk Headwaters	64.1914	-157.6519			5	
California Crk Trib 1	64.1854	-157.6413		9		
California Crk Trib 2	64.1968	-157.7586			20	

Upper Minnesota Crk	64.1306	-157.5760	2	9	10	
Minnesota Crk Trib 1	64.1549	-157.5944			6	
Minnesota Crk Trib 2	64.1549	-157.5918				
Minnesota Crk Trib 3	64.1358	-157.5934		2	1	1
Eddy Crk	64.2206	-157.5747		1	3	
Honker Trail Crk**	64.0924	-157.9603			10	
Upper Dome Crk	64.1424	-157.9996		3	1	
Lower Dome Crk	64.1371	-158.0735		3	6	8
Dome Crk Trib	64.1331	-158.0719		1	1	

* Fifteen juvenile coho salmon were retained for whole-body element analysis.

** Unnamed stream with locally accepted names.

Sample Site 2021	Latitude	Longitude	Juvenile Coho Salmon	Slimy Sculpin	Dolly Varden	Alaska Blackfish
Lower Illinois Crk*	64.0280	-157.8667	116	8		1
Upper Illinois Crk	64.0395	-157.8696	229	7		
Lower California Crk 1	64.0228	-157.8127	2	10		1
Lower California Crk 2	64.0557	-157.7892	34			
CA Crk u/s CO Crk	64.1363	-157.7087	4	9	1	1
Eddy Crk	64.2231	-157.5799		1	7	
Honker Trail Crk**	64.0917	-157.9635			9	
Upper Dome Crk	64.1424	-157.9996		16		2
Lower Dome Crk	64.1368	-158.0659		2	7	12
Dome Crk Trib	64.1301	-158.0569			22	

* Fifteen juvenile coho salmon were retained for whole-body element analysis.

** Unnamed stream with locally accepted names.

Sample Site 2020	Latitude	Longitude	Juvenile Coho Salmon	Slimy Sculpin	Dolly Varden	Alaska Blackfish
Lower Illinois Crk*	64.0280	-157.8667	304	7		
Upper Illinois Crk*	64.0395	-157.8696	62	6		
Lower California Crk 1	64.0228	-157.8127	11	4		1
Lower California Crk 2***	64.0557	-157.7892	79			1
Upper Twin Crk**	64.0816	-157.7903			3	
Colorado Crk	64.1276	-157.7487		2	3	
CA Crk u/s CO Crk	64.1363	-157.7087	42	3	1	1
CA Crk Headwaters	64.1918	-157.6515		3	9	
California Crk Trib 1	64.1854	-157.6413	7	3	2	
California Crk Trib 2	64.1967	-157.7584			8	
Upper Minnesota Crk	64.1306	-157.5760	14		3	
Minnesota Crk Trib 1	64.1552	-157.5928			2	

Minnesota Crk Trib 2	64.1552	-157.5928				
Minnesota Crk Trib 3	64.1376	-157.5924	11	9	4	2
Eddy Crk	64.2231	-157.5799	6	1	6	
Honker Trail Crk**	64.0917	-157.9635			15	
Upper Dome Crk	64.1424	-157.9996		4		4
Lower Dome Crk	64.1368	-158.0659	6	6	1	
Dome Crk Trib	64.1301	-158.0569			4	

* Fifteen juvenile coho salmon were retained for elemental analysis: 7 from lower, 8 from upper.

** Unnamed stream with locally accepted names.

*** One Arctic Grayling was caught here.

APPENDIX 2: Phaeophytin-corrected chlorophyll-a concentrations (mg/m^2) from Upper Illinois Creek, 2020–2023.

Sample #	**2020**	**2021**	**2022**	**2023**
1	5.34	2.67	3.95	20.51
2	2.35	3.63	3.74	19.76
3	1.28	6.51	5.45	17.94
4	1.17	9.93	9.08	17.52
5	11.21	3.74	18.05	31.83
6	3.31	2.03	2.46	52.01
7	24.45	1.17	13.35	17.19
8	4.05	1.82	44.96	27.87
9	1.06	7.90	63.87	22.53
10	8.44	3.31	25.74	20.19
Mean	4.27	6.27	19.06	24.73
SD	6.84	2.74	19.44	10.14

APPENDIX 3: Whole-body element concentrations (mg/kg dry weight) of silver (Ag), arsenic (As), cadmium (Cd), copper (Cu), mercury (Hg), lead (Pb), selenium (Se), antimony (Sb), chromium (Cr), and nickel (Ni) in juvenile coho salmon from Illinois Creek, 1996 and 2020–2023. Each sample represents results from one fish and gray filled cells indicate sample was below the MDL (method detection limit). In 1996 data, ND indicates concentrations below the MDL.

2023

Sample #	Ag	As	Cd	Cu	Hg	Pb	Se	Zn
1	0.09	4.08	0.05	3.29	0.15	0.09	1.30	128.28
2	0.07	4.41	0.28	3.33	0.17	0.07	1.60	146.95
3	0.10	3.67	0.06	2.80	0.17	0.10	0.94	110.19
4	0.10	5.10	0.06	4.12	0.21	0.10	1.06	190.91
5	0.09	5.69	0.35	5.29	0.19	0.10	1.52	163.56
6	0.07	6.45	0.21	3.32	0.20	0.07	1.09	126.54
7	0.08	3.98	0.25	3.88	0.27	0.10	1.41	145.00
8	0.06	4.28	0.10	2.87	0.44	0.16	0.91	124.65
9	0.10	5.68	0.16	4.73	0.21	0.10	1.44	159.47
Mean	0.08	4.82	0.17	3.74	0.22	0.10	1.25	143.95
SD	0.02	0.90	0.10	0.80	0.08	0.03	0.24	23.34

2022

Sample #	Ag	As	Cd	Cu	Hg	Pb	Se	Zn
1	0.07	6.47	0.13	3.64	0.19	0.07	1.08	150.62
2	0.07	1.19	0.04	2.85	0.55	0.15	0.88	110.23
3	0.09	5.13	0.24	3.43	0.16	0.11	0.91	117.52
4	0.09	2.00	0.06	2.55	0.40	0.11	0.92	102.82
5	0.07	3.79	0.10	2.71	0.13	0.09	0.86	118.22
6	0.08	7.31	0.08	3.00	0.16	0.08	0.83	128.93
7	0.09	2.89	0.14	2.80	0.11	0.09	1.02	115.11
8	0.08	1.79	0.14	2.48	0.36	0.10	0.63	91.44
9	0.06	10.75	0.14	3.56	0.18	0.22	1.05	159.84
10	0.09	1.94	0.08	2.84	0.31	0.09	1.01	100.80
11	0.10	1.92	0.06	2.98	0.35	0.10	0.82	107.66
12	0.10	2.56	0.05	2.93	0.41	0.10	0.79	129.78
13	0.07	3.83	0.09	2.92	0.18	0.07	1.15	123.60
14	0.08	4.88	0.12	3.27	0.27	0.21	1.26	159.15
15	0.07	4.05	0.16	2.83	0.23	0.21	1.65	135.11
Mean	0.08	4.03	0.11	2.99	0.26	0.12	0.99	123.39
SD	0.01	2.50	0.05	0.33	0.12	0.05	0.23	20.10

2021

Sample #	Ag	As	Cd	Cu	Hg	Pb	Se	Zn
1	0.09	2.10	0.05	3.30	0.20	0.09	0.95	135.60
2	0.10	2.10	0.05	2.88	0.15	0.10	1.10	136.40
3	0.07	6.70	0.06	3.57	0.20	0.14	1.40	128.60
4	0.06	7.20	0.08	2.86	0.20	0.09	1.10	135.60
5	0.12	2.50	0.09	4.55	0.21	0.12	2.20	200.60
6	0.07	3.20	0.06	3.10	0.16	0.07	1.20	142.20
7	0.09	1.80	0.05	2.58	0.21	0.09	0.94	129.60
8	0.07	1.90	0.13	2.43	0.15	0.07	1.00	115.50
9	0.09	2.30	0.04	2.27	0.17	0.09	1.60	138.20
10	0.08	2.40	0.06	3.17	0.16	0.08	0.97	145.50
11	0.08	5.50	0.06	3.36	0.16	0.22	0.91	101.50
12	0.08	4.90	0.05	3.05	0.18	0.13	1.10	172.00
13	0.06	2.70	0.04	2.23	0.16	0.06	1.00	129.90
14	0.07	2.60	0.22	2.85	0.19	0.19	1.10	126.30
15	0.06	2.60	0.03	2.32	0.12	0.06	0.79	115.40
Mean	0.08	3.37	0.07	2.97	0.17	0.11	1.16	136.86
SD	0.02	1.73	0.05	0.58	0.03	0.04	0.34	22.88

2020

Sample #	Ag	As	Cd	Cu	Hg	Pb	Se	Zn
1	0.09	3.60	0.06	3.40	0.27	0.18	1.50	163.30
2	0.08	2.30	0.07	2.70	0.17	0.24	1.20	106.00
3	0.06	3.60	0.10	3.40	0.19	0.09	1.80	138.10
4	0.07	3.80	0.06	5.00	0.21	0.27	1.70	135.10
5	0.07	3.30	0.06	3.10	0.20	0.12	0.96	119.00
6	0.08	2.90	0.10	4.90	0.17	0.34	1.56	223.10
7	0.11	3.60	0.40	5.30	0.24	0.24	2.39	225.20
8	0.08	0.62	0.06	3.20	0.13	0.08	0.98	140.20
9	0.08	0.44	0.04	2.90	0.15	0.08	0.82	131.10
10	0.08	0.70	0.04	2.40	0.20	0.08	0.94	142.90
11	0.08	0.84	0.11	3.50	0.25	0.08	1.20	150.70
12	0.09	1.30	0.04	4.70	0.22	16.30	0.86	87.40
13	0.09	0.49	0.04	3.70	0.34	0.12	0.88	100.50
14	0.08	1.30	0.06	2.70	0.19	0.08	1.00	79.10
15	0.08	0.57	0.04	3.00	0.26	0.15	0.72	93.90
Mean	0.08	1.96	0.09	3.59	0.21	1.23	1.23	135.71
SD	0.01	1.32	0.09	0.90	0.05	4.03	0.45	41.97

1996

Sample #	Ag	As	Cd	Cu	Hg	Pb	Cr	Ni	Sb
1	ND	0.5	0.04	3.96	0.12	0.15	8.7	1.2	0.06
2	ND	0.6	0.09	2.85	0.03	0.11	0.5	0.3	0.13
3	ND	ND	0.03	2.27	ND	0.07	0.6	0.3	0.09
4	ND	0.7	0.03	2.32	0.14	0.27	0.7	0.4	0.34
5	ND	0.6	0.03	2.65	0.07	0.15	0.6	0.3	0.14
6	ND	1.6		4.01	0.07				
7	ND	1.5		3.54	0.10				
8	ND	ND		3.40	0.08				
9	ND	1.0		3.17	0.08				
10	ND	1.1		2.65	0.07				
11	ND	1.6		3.26	0.07				
12	ND	1.0		2.69	0.13				
13	ND	1.3		2.75	0.08				
14	ND	1.1		2.69	0.08				
15	ND	3.0		2.84	0.10				
16	ND	1.9		2.64	0.12				
17	ND	3.5		3.32	0.08				
18	ND	2.3		3.38	0.07				
19	ND	3.0		2.77	0.07				
20	0.02	2.0		2.71	0.06				
21	0.08	1.6		2.44	0.06				
22	0.03	2.0		3.06	0.08				
23	0.11	1.9		2.23	0.11				
24	0.04	2.4		2.31	0.08				
25	0.02	1.9		3.52	0.08				
26	0.03	2.7		2.55	0.06				
27	0.03	2.1		2.23	0.07				
28	0.03	1.2		2.61	0.07				
29	0.08	3.1		2.46	0.10				
30	0.03	1.9		5.92	0.07				
Mean	0.05	1.75	0.04	2.97	0.08	0.15	2.22	0.50	0.15
SD	0.03	0.80	0.02	0.73	0.02	0.07	3.24	0.35	0.10