Technical Report No. 25-09

Baseline Aquatic Biomonitoring at the Arctic-Bornite Exploratory Mining Prospects, 2024

By
Olivia N. Edwards

April 2025

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. 25-09

BASELINE AQUATIC BIOMONITORING AT THE ARCTIC-BORNITE EXPLORATORY MINING PROSPECTS, 2024

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April 2025

Cover: Slimy sculpin captured in Sunshine Creek, a tributary to the Shungnak River, July 2024. Photograph by Olivia Edwards.

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EXECUTIVE SUMMARY

This report summarizes results of 2024 biomonitoring work conducted in streams in the vicinity of the Arctic-Bornite exploratory mining prospects located north of Kobuk, Alaska. Biomonitoring included surveys of water quality, periphyton, benthic macroinvertebrates (BMI), and fish; these data have been collected annually from 2016–2024. Sampling locations and parameters for 2024 remained similar to 2023, although fyke net and BMI sampling did not occur in Lower Ruby Creek due to high water conditions. Additionally, the Sunshine Creek sampling site was moved to a nearby channel with more consistent water flow than the location used in previous years.

Measurements of periphyton standing crop, BMI, and fish distribution varied among the sample sites in 2024. As in previous years, the mean chlorophyll-a concentration was highest in Upper Ruby Creek at 28.88 mg/m^2 (SD=22.15). The mean chlorophyll-a concentrations at the remaining sites ranged from 0.12–3.05 mg/m^2. BMI densities across all sites ranged from a low of 65/m^2 in Lower Red Rock Creek to a high of 5,588/m^2 in Riley Creek. Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa were present in some capacity at all sites in 2024. The percentage of Diptera exceeded the percentage of EPT taxa present in the samples at all sites except the Upper Shungnak River, Lower Subarctic Creek, and Jay Creek sites. BMI taxa richness ranged from a low of 7 at Lower Red Rock Creek to a high of 23 at Upper Ruby Creek. Both slimy sculpin and Dolly Varden were captured at all sites except for Jay, Center of the Universe, and Upper Subarctic creeks where only Dolly Varden were captured. Among all sites, the most Dolly Varden were captured in Upper Subarctic Creek and the most slimy sculpin were captured in Lower Ruby Creek, followed closely by Upper Ruby Creek.

INTRODUCTION

The Ambler Mining District is located in the Kobuk River drainage in the southwest region of the Brooks Range (Figure 1). Ambler Metals (formerly Trilogy Metals) has explored two primary deposits in the area, but a drilling program has not occurred since 2022. The Bornite deposit, located 17 km north of Kobuk in the Ruby Creek drainage, contains primarily copper and cobalt. The Arctic deposit, located 37 km northeast of Kobuk in the upper end of the Subarctic Creek drainage, contains copper, lead, zinc, silver, and gold. Both Ruby and Subarctic creeks are tributaries to the Shungnak River, which flows into the Kobuk River. A waterfall in the lower Shungnak River prevents upstream passage of fish, therefore no anadromous fish occur in the

drainage upstream of the falls and any resident species of fish upstream complete their life cycle within this isolated extent of the Shungnak River drainage (Figure 2).

All sample sites except Riley Creek are in the Shungnak River drainage. Riley Creek, a tributary to the Kogoluktuk River, is monitored since it may be impacted by future mine development.

Figure 1.–Location of the Arctic and Bornite deposits in northwest Alaska.

Figure 2.–Waterfall on the Shungnak River blocking fish passage upstream, July 21, 2016.

Aquatic baseline work conducted in the area in 2010 focused on macroinvertebrate and fish presence (Tetra Tech 2011). Fish species documented in the 2010 survey were Arctic grayling

(*Thymallus arcticus*), round whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*), and Dolly Varden (*Salvelinus malma*). Ambler Metals contracted the Alaska Department of Fish and Game (ADF&G) Habitat Section to continue aquatic sampling beginning in 2016. The ADF&G study plan is based on aquatic biomonitoring the Habitat Section conducts at various large hard rock mines throughout the state (Bradley 2017b). Three primary types of data are collected: periphyton, BMI, and fish, which includes samples for whole body element analyses. In-situ water quality data has also been collected in recent years. Biomonitoring has been performed annually except for 2020 when all camp operations were suspended due to the Covid-19 pandemic.

This report summarizes the 2024 in-situ water quality, periphyton, BMI, and fish data collected by ADF&G and element concentration data in water samples collected by Ambler Metals.

LOCATION AND DESCRIPTION OF MONITORING SITES

Biomonitoring was performed at ten sites in July 2024 (Table 1; Figure 3). Sampling effort continues to be concentrated in Ruby and Subarctic creeks as these aquatic systems may be altered by projected mining development. High water in 2024 precluded fyke net and periphyton sampling in Lower Ruby Creek. The Sunshine Creek sampling site was moved in 2024 to a nearby channel with more consistent water flow than the location used in previous years.

- **Upper Shungnak River** is characterized by outside bend cut banks and inside bend gravel bars, deep water, gravel substrate with some cobble, and forested riparian habitat (Figure 4). Sampling began at this site in 2016.
- **Sunshine Creek** is characterized by riffle/run habitats and gravel/cobble substrate. Riparian vegetation is primarily willows and grasses with mature spruce trees. The sample site is just upstream of a large beaver pond. The upper reaches of Sunshine Creek are very high gradient (Figure 4). Sampling began at this site in 2021.
- **Center of the Universe Creek** is a tributary of Red Rock Creek in the upper extent of the drainage. The creek is characterized by riffles and runs interspersed with pools. Substrate here is smaller gravel than at other downstream sites. Riparian habitat is mostly alpine tundra with some willows along the banks (Figure 5). Sampling began at this site in 2022.
- **Lower Red Rock Creek** is characterized by riffle/pool habitat with gravel/cobble substrate, with riparian vegetation of willows and mature spruce trees (Figure 5). This

drainage is directly north of Subarctic Creek drainage on the Shungnak River and may provide alternative fish habitat if Subarctic Creek is altered by future mining activity. Sampling began at this site in 2018.

- **Upper Subarctic Creek** is characterized by high gradient with step pools and large boulders with riparian habitat of alpine tundra with some shrubby willows along the banks. This sample site is located a few hundred meters below the origin of the creek, which abruptly forms when water transitions from subsurface to surface flow (Figure 6). Sampling began at this site in 2016.
- **Lower Subarctic Creek** is wider with a much lower gradient than the upper site, characterized by riffle/pool habitat with gravel/cobble substrate, with riparian vegetation of willows and mature spruce trees (Figure 6). Sampling began at this site in 2016.
- **Upper Ruby Creek** is characterized by beaver pond habitats, deep water, dense vegetative cover, short channels between beaver dams, and minimal gravel/cobble. The sample site is in a channel between beaver dams and was chosen for its gravel/cobble substrate (Figure 7). Sampling began at this site in 2016.
- **Jay Creek** is characterized by riffle/run habitats, gravel with some cobble substrate, and very dense mostly willow vegetation and overhanging canopy (Figure 7). Sampling began at this site in 2017.
- **Lower Ruby Creek** is characterized by pool/riffle habitat, relatively shallow water, and gravel substrate. Riparian vegetation is a mix of grasses and willows, with some mature spruce trees (Figure 8). Sampling began at this site in 2016.
- **Riley Creek** is characterized by riffle/pool habitat with gravel and cobble substrate. Riparian habitat is primarily willows and grasses with some mature trees (Figure 8). Sampling began at this site in 2016.

Table 1.–Arctic-Bornite sampling locations (WGS 84), 2024.

Sample Site	Latitude	Longitude	BMI	Periphyton	Fish
Upper Shungnak	67.2440	-156.6160	X	X	
Sunshine	67.2335	-156.6162	X	X	X
Center of the Universe	67.2010	-156.4041	X	X	X
Lower Red Rock	67.1932	-156.5991	X	X	X
Upper Subarctic	67.1926	-156.3911	X	X	X
Lower Subarctic	67.1720	-156.6208	X	X	X
Upper Ruby	67.0408	-156.9394	X	X	X
Jay	67.0804	-156.9445	X	X	X
Lower Ruby	67.1114	-156.9084	X		X
Riley	67.0426	-156.6923	X	X	X

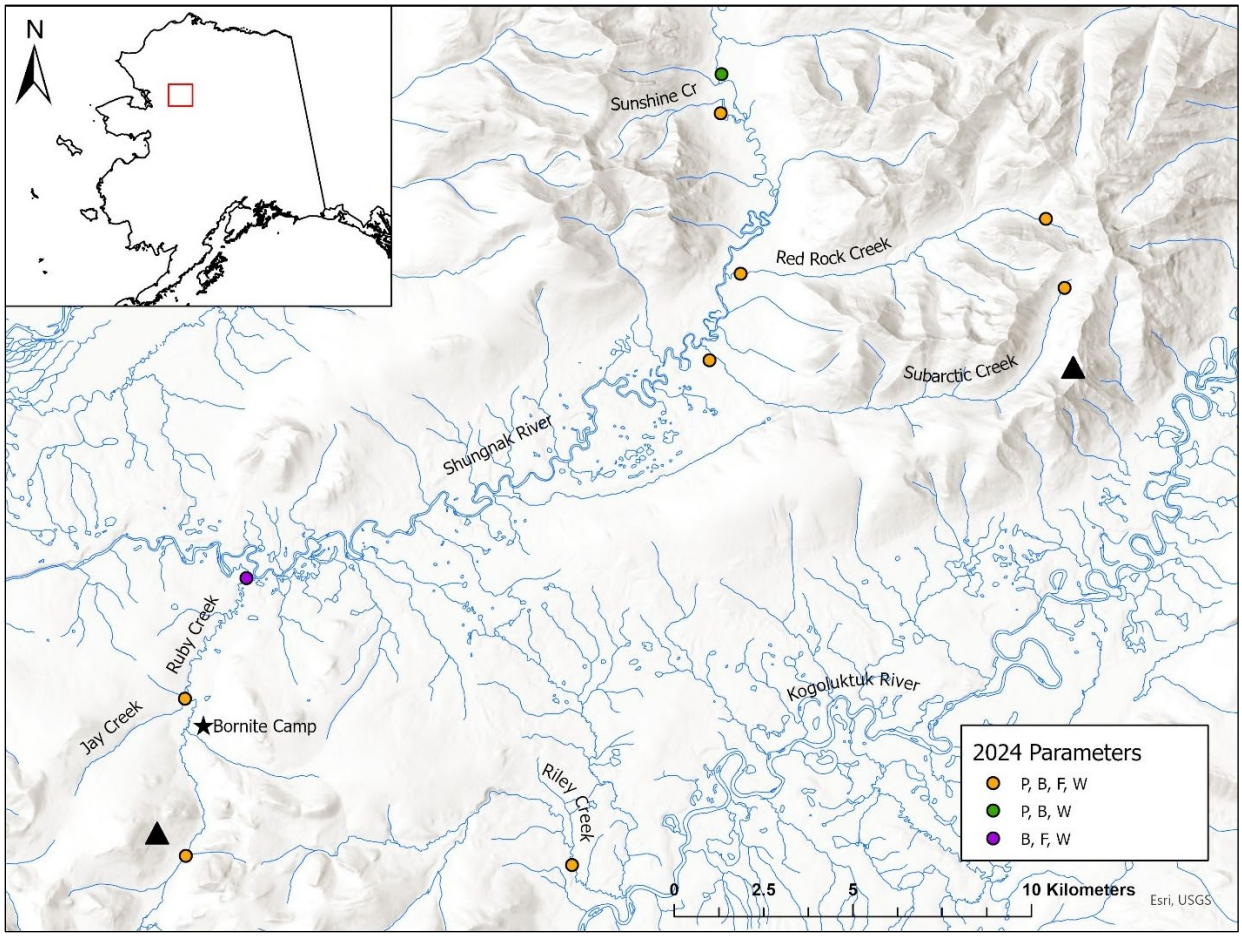

Figure 3.–All locations sampled during aquatic biomonitoring in July 2024. Sampling parameters are abbreviated as follows: P=periphyton, B=benthic macroinvertebrates, F=fish, and W=water quality. Black triangles depict general deposit locations.

Figure 4.–Sample sites on Upper Shungnak River (left) and Sunshine Creek (right), July 2024.

Figure 5.–Sample sites on Center of the Universe Creek (left) and Lower Red Rock Creek (right), July 2024.

Figure 6.–Sample sites on Upper Subarctic Creek (left) and Lower Subarctic Creek (right), July 2024.

Figure 7.–Sample sites on Upper Ruby Creek (left), July 2024 and Jay Creek (right), July 2023.

Figure 8.–Sample sites on Lower Ruby Creek (left), July 2019 and Riley Creek (right), July 2024.

METHODS

SAMPLING OVERVIEW

The objective of the Arctic Bornite biological monitoring program is to document in-situ productivity of aquatic communities at each sample site, and element concentration in the water in the vicinity and downstream of potential project facilities.

In 2024 there was one sampling event in the Arctic Bornite area which took place from July 10–15. Ambler Metals did not run an exploration program in 2024, so their camp was only operated for a short period to accomplish annual environmental monitoring. At each location replicate samples of the aquatic community were collected, including BMI, periphyton, and fish (Table 1). A subset of fish were retained for whole body element analysis.

Beginning in 2021, BMI were collected with Hess samplers rather than drift nets to identify and quantify the in-situ community. This change was made because the benthic community is a more accurate characterization of the conditions at each sample site, rather than the conditions upstream. This provides a more accurate baseline for evaluating changes at each sampling location.

Four Hobo TidbiT v2 water temperature data loggers were deployed in 2023 to record winter water temperatures. These were retrieved in July 2024 from two locations in Center of the Universe Creek and one location each in Subarctic Creek and Lower Red Rock Creek.

WATER QUALITY

Ambler Metals has collected water quality data for element concentration analysis from locations throughout the Arctic-Bornite Prospect project area. The 2016 ADF&G technical report summarized all water quality data collected from 2008–2016 (Bradley 2017a). This report summarizes water data collected in 2024 at Lower Ruby Creek, which was the only aquatic biomonitoring site also sampled for water quality by Ambler Metals in 2024. Alaska Department of Environmental Conservation (ADEC) water quality standards are noted in Appendix 1 for both acute (24 hr) and chronic (one month) aquatic life exposure limits. These vary because the element concentration limits are dependent on water hardness.

A handheld multiparameter YSI was used to measure in situ water temperature (°C), dissolved oxygen (mg/L), specific conductance (µS/cm), conductivity (µS/cm), and pH at each site concurrent with BMI and periphyton sampling. The probe was placed in flowing water, and measurements were allowed to equilibrate before being recorded. An Orion AQUAfast Turbidity meter was used to measure turbidity (NTU) in 2022. At each site, the sample vial was rinsed with stream water three times, then filled with flowing water. Three turbidity readings of the sample were taken, and the average value of those readings was recorded.

In 2023, Hobo TidbiT v2 water temperature data loggers were deployed at a total of four locations to record daily water temperatures through the winter and identify potential groundwater inputs. Locations were selected based on open water conditions observed in March 2021 and April 2023. One Hobo logger was deployed at each of the standard monitoring locations in Lower Red Rock Creek and Upper Subarctic Creek. Two Hobo loggers were placed in Center of the Universe Creek,

one near the standard monitoring location and one downstream of this location. These were retrieved during sampling in July 2024 and the data was downloaded.

PERIPHYTON

Field Methods

Periphyton is composed of chlorophyll producing organisms, such as algae, attached to submerged surfaces in a waterbody. Algal density and community structure are influenced by water and sediment quality through physical chemical and biological factors that change throughout the year (Barbour et al. 1999). The concentration of chlorophyll-a pigments in periphyton samples provides an estimate of active algal biomass and is often used in monitoring studies to detect changes in aquatic communities. Periphyton samples were collected at nine locations around the Arctic-Bornite area in 2024 (Table 1; Figure 3).

Ten flat rocks, each larger than 25 cm^2 were collected from submerged areas at each site. A 5 cm x 5 cm square of high-density flexible foam was placed on the rock. All the material around the foam was scrubbed off with a toothbrush and rinsed back into the stream. The foam square was then removed from the rock, and that section of the rock was brushed and rinsed onto a 0.45 µm glass fiber filter receptacle attached to a hand vacuum pump. Material from the toothbrush was also rinsed onto the filter. The water was extracted from the periphyton covered filter using a hand vacuum pump. Just before all the water was pumped through the filter, one to two drops of magnesium carbonate ($MgCO_3$) were added to the water to prevent acidification and additional conversion of chlorophyll-a to phaeophytin.

Filters from each rock were folded in half, with the sample material on the inside, and placed in individual dry paper coffee filters. All ten coffee filters were placed in a zip-lock bag containing desiccant to absorb remaining moisture. The bags were then wrapped in aluminum foil to prevent light from reaching the samples, placed in a cooler with ice packs, then transferred to a freezer at the Bornite camp. Samples were kept frozen until they were analyzed at the ADF&G laboratory in Fairbanks.

Laboratory Methods

In the lab, periphyton samples were removed from the freezer, the glass fiber filters were cut into small pieces and placed in individual 15 ml centrifuge tubes with 10 ml of 90% spectrophotometric

grade acetone. The centrifuge tubes were secured in a vial rack covered with aluminum foil to reduce light exposure and stored in a dark refrigerator overnight. On the following day (~18-24 hours after preparation), sample tubes were placed in a centrifuge and spun at 1,600 rpm for 20 minutes. Samples were then decanted individually into cuvettes and absorption values at 750 nm, 664 nm, 647 nm, and 630 nm were recorded on a split beam spectrophotometer. Each sample was treated with 80 µL of 0.1N hydrochloric acid for 90 seconds to convert the chlorophyll to phaeophytin and then absorbance was measured at 750 nm and 665 nm.

Trichromatic equations were used to estimate chlorophyll a, -b, and -c concentrations. Phaeophytin was calculated to determine if a chlorophyll-a conversion had occurred, and to correct chlorophyll-a concentrations for the presence of phaeophytin. Additional details regarding periphyton sampling and analysis methods can be found in ADF&G Technical Report No. 17-09 (Bradley 2017b).

BENTHIC MACROINVERTEBRATES

Field Methods

At each benthic macroinvertebrate (BMI) sample site, five replicates were collected using a Hess sampler (Table 1). 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. Rocks within the sample area were scoured by hand, and gravel, sand, and silt were disturbed to about 10 cm depth to dislodge macroinvertebrates occupying the benthos 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 macroinvertebrates.

Laboratory Methods

Samples were sorted and invertebrates identified by a private aquatic invertebrate lab in Fairbanks. Insects of the orders Ephemeroptera, Plecoptera, Trichoptera were identified to genus. Insects of the order Diptera were identified to genus, except the nonbiting midges of the family Chironomidae. Copepoda, Collembola, and Coleoptera were identified to genus. Cladocera and Hydroida were identified to order. Oligochaeta, Ostracoda, Platyhelminthes, Nematoda, and Nematomorpha were identified to class level. Because invertebrates belonging to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) are more sensitive to water quality, the total number of individual specimens of EPT was calculated and compared to groups of other invertebrates, which are less sensitive. The BMI density was

calculated for each sample by dividing the number of invertebrates 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. Density data is only reported for the years Hess samplers have been used since this method is not directly comparable to the previously used drift nets and the units differ. Taxa richness is reported as the number of taxonomic groups identified to the lowest practical level. Terrestrial organisms were excluded from all calculations.

FISH

Five baited minnow traps were placed upstream and five downstream of baseline sampling sites after collecting the periphyton and BMI samples (Table 1). Traps were placed in a variety of habitats, including cut banks, pools, and near submerged woody debris. Traps were soaked overnight and checked about 24 hours later. All captured fish were measured for fork or total length, depending on species. A subset of fish were retained for whole body element analyses. Those fish were handled wearing class 100 nitrile gloves and placed in individual pre-labeled plastic zip-top bags. The bagged fish were placed in a cooler with ice packs in the field and then transferred to a freezer in the camp. Due to a power outage at camp this freezer was cool, but not below freezing in 2024 for an unknown time, at least overnight. Following this incident samples remained frozen until they were analyzed by ACZ Laboratories, Inc.

RESULTS AND DISCUSSION

UPPER SHUNGNAK RIVER

Water Quality

In July 2024, pH was near neutral at 7.89, the water temperature was 5°C, and the dissolved oxygen was 11.83 mg/L in the Upper Shungnak River. In-situ water quality properties have remained consistent among years with values similar to 2024. All in-situ water quality data are presented in Appendix 2.

Periphyton

In 2024, mean chlorophyll-a concentration in Upper Shungnak River was 0.13 mg/m^2 (SD = 0.11). This value is similar to the 2023 mean but generally lower than previous years (Figure 10). Mean chlorophyll-a concentrations have remained below 1 mg/m^2 in the Upper Shungnak River since 2018. The notably higher mean concentration in 2016 is likely due to high values in the data (Figure 10). Periphyton data from 2024 are presented in Appendix 3.

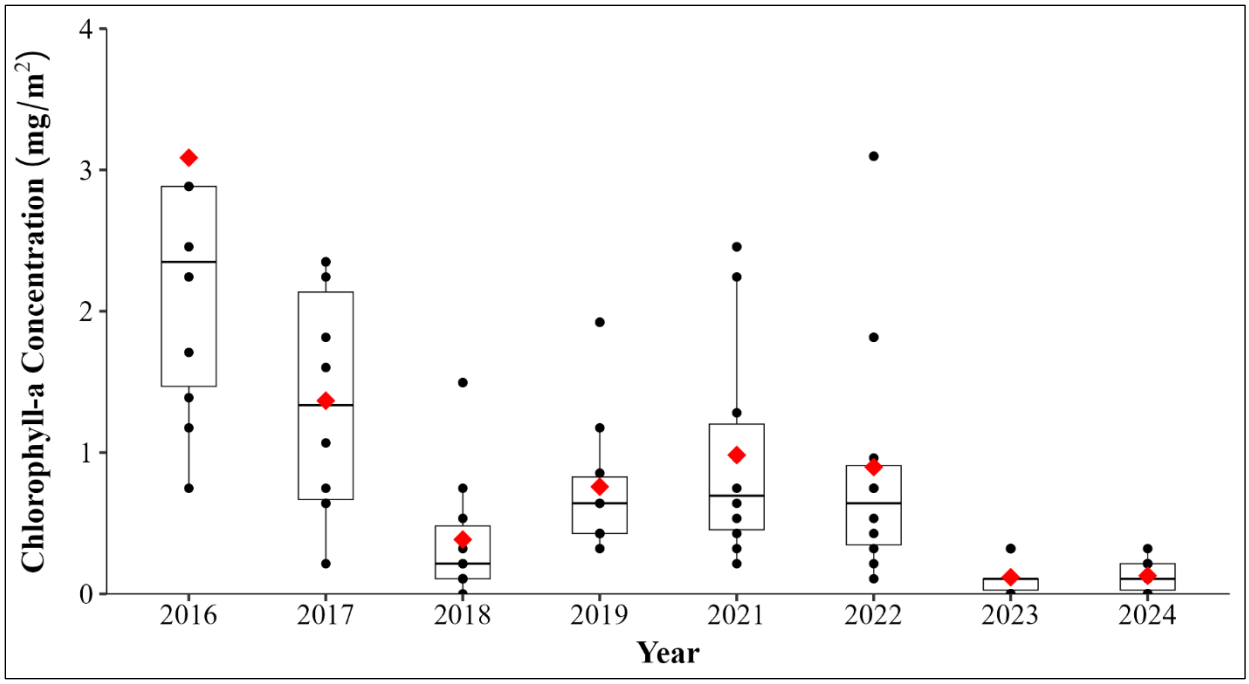

Figure 9.–Chlorophyll-a concentration boxplot by year at Upper Shungnak River, 2016–2024. Raw data are depicted by black dots and mean values are depicted in red. Note that two high values from 2016 (6.62 and 8.76 mg/m^2) are excluded from this plot but not from statistical analyses.

Benthic Macroinvertebrates

Mean BMI density in the Upper Shungnak River in 2024 was 381/m^2 (SD = 92). This is approximately three times the mean density in 2023 but still lower than the mean densities recorded in 2021 and 2022 (Figure 11). EPT taxa dominated sample composition in the Upper Shungnak River at 62% in 2024, but no Trichoptera were present for the second year in a row (Figure 12). Diptera were present in similar proportions as previous years at 32%. There were 13 taxa present in the samples from Upper Shungnak River in 2024 which is similar to the previous 3 years (Figure 13). Since sampling methods were switched from drift nets to a Hess sampler in 2021, taxa richness has been consistently lower than the first 4 years of sampling. BMI data from 2024 are presented in Appendix 4.

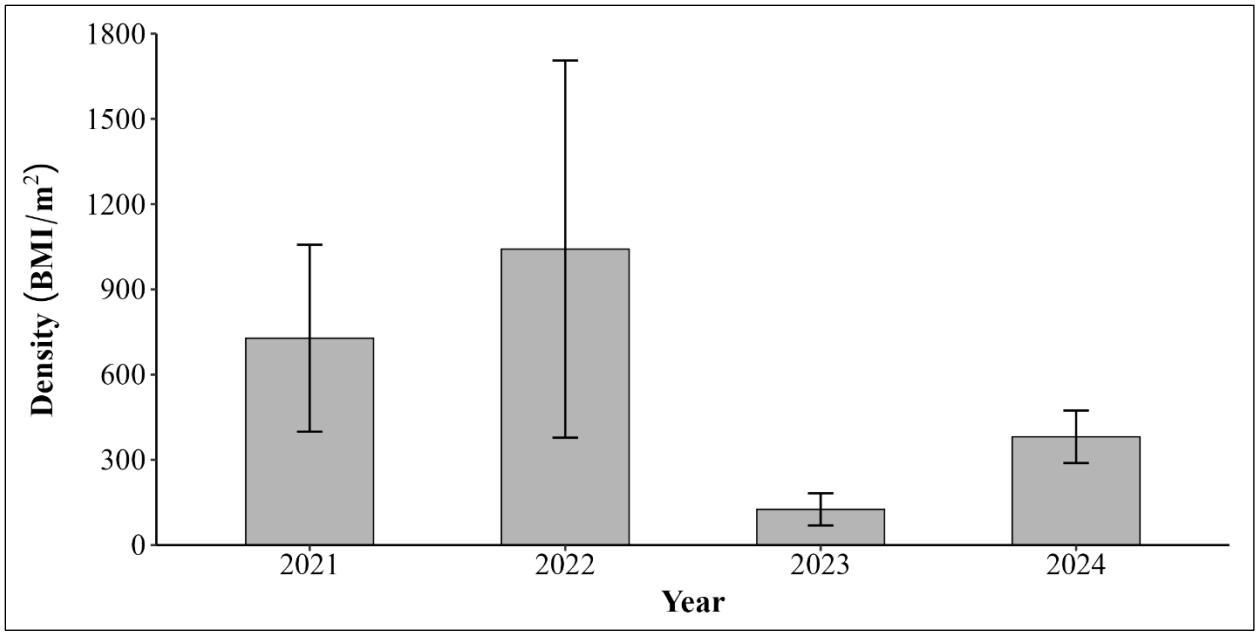

Figure 10.–Mean BMI density (± 1 SD) at Upper Shungnak River, 2021–2024.

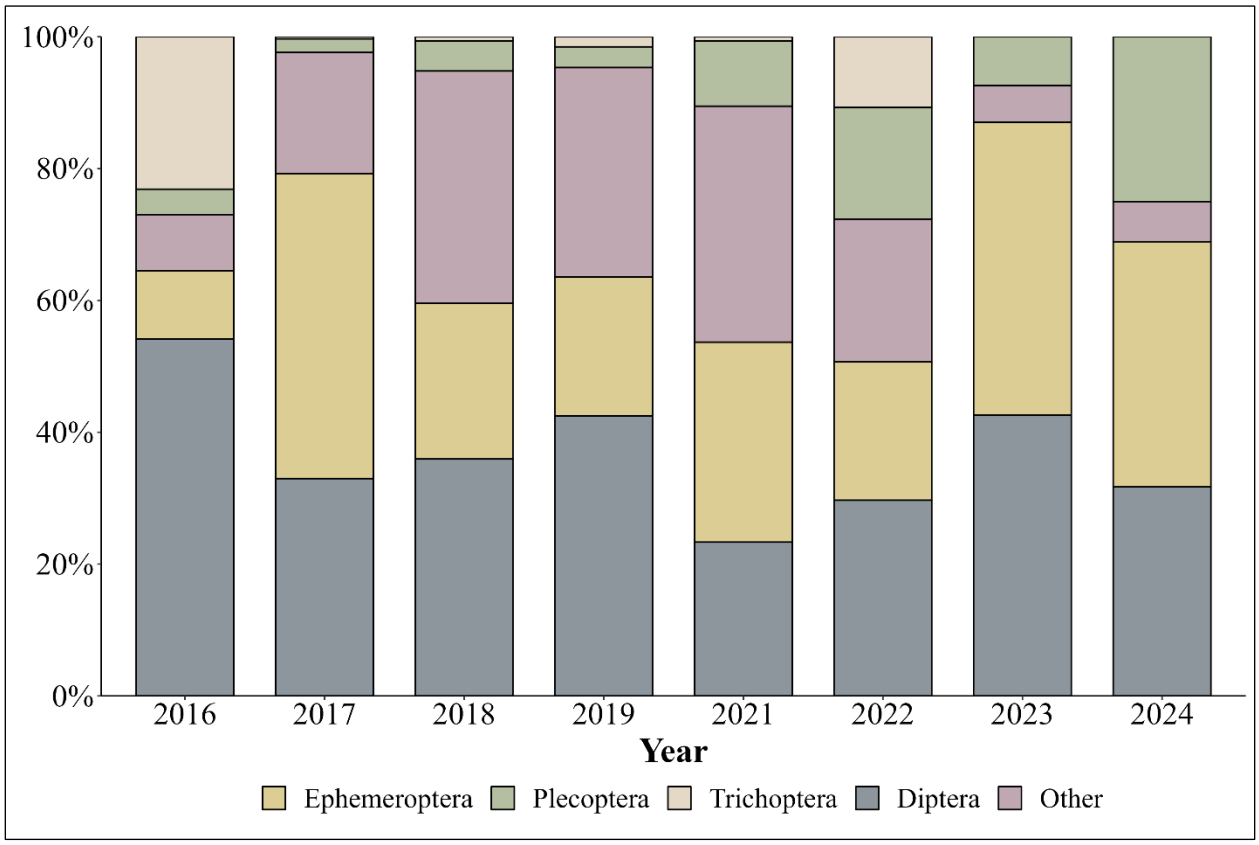

Figure 11.–Mean percent EPT, Diptera, and other taxa in Upper Shungnak River BMI samples, 2016–2024.

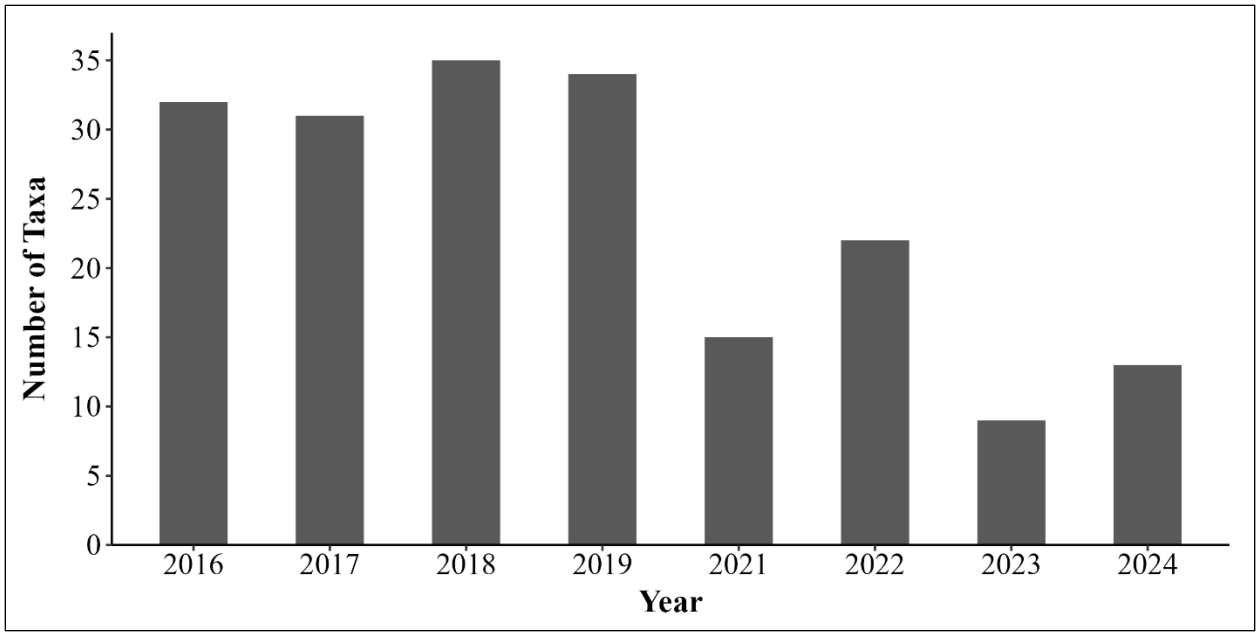

Figure 12.–Taxa richness in Upper Shungnak River BMI samples, 2016–2024.

SUNSHINE CREEK

Water Quality

In July 2024, the pH was 7.85, the water temperature was 5.5°C, and the dissolved oxygen was 12.14 mg/L in Sunshine Creek. In-situ water temperature has been variable among years ranging from 2.9°C in 2022 to 6.0°C in 2023. All in-situ water quality data are presented in Appendix 2.

Periphyton

In 2024, mean chlorophyll-a concentration in Sunshine Creek was 0.12 mg/m^2 (SD = 0.06). This value is lower than previous years' means which range from 0.83–1.54 mg/m^2 (Figure 14). This difference may be due to the change in site location to a different channel of the creek in 2024. Periphyton data from 2024 are presented in Appendix 3.

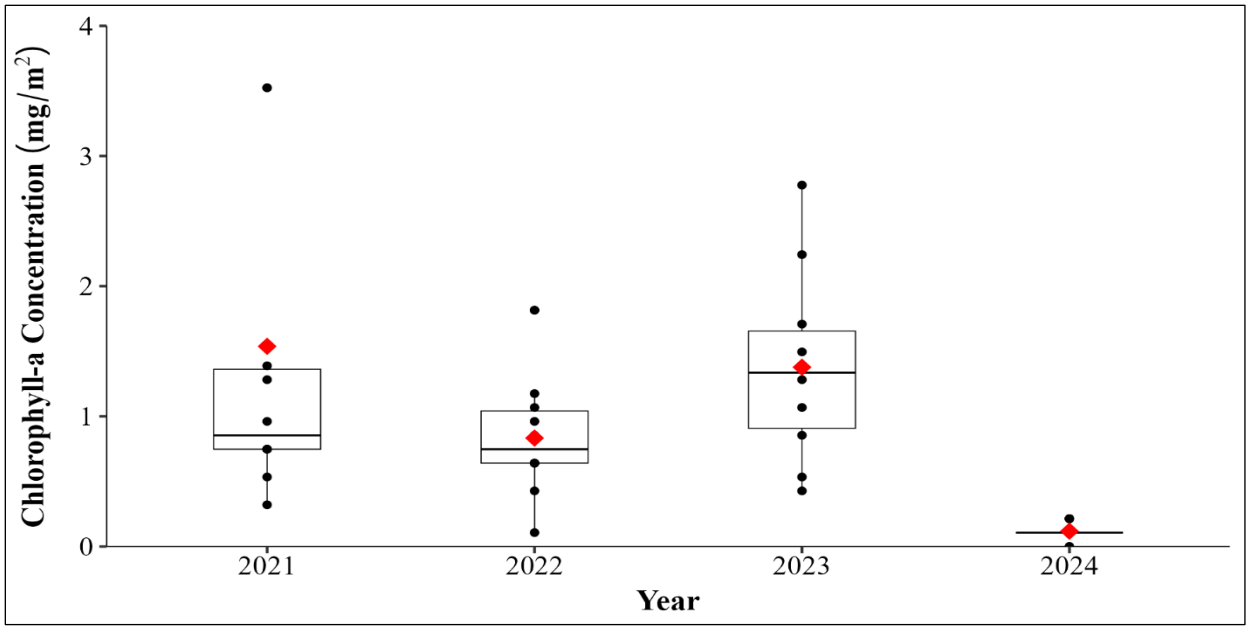

Figure 13.–Chlorophyll-a concentration boxplot by year at Sunshine Creek, 2021–2024. Raw data are depicted by black dots and mean values are depicted in red.

Benthic Macroinvertebrates

Mean BMI density in Sunshine Creek in 2024 was 1,923/m^2 (SD = 913). This is similar to densities recorded in 2021 and 2023 but approximately one third of the density in 2022 (Figure 15). In 2024, Diptera made up 45% of the samples from Sunshine Creek while EPT taxa made up 34% (Figure 16). There were 17 taxa present in the samples from Sunshine Creek in 2024 which is similar to previous years (Figure 17). BMI data from 2024 are presented in Appendix 4.

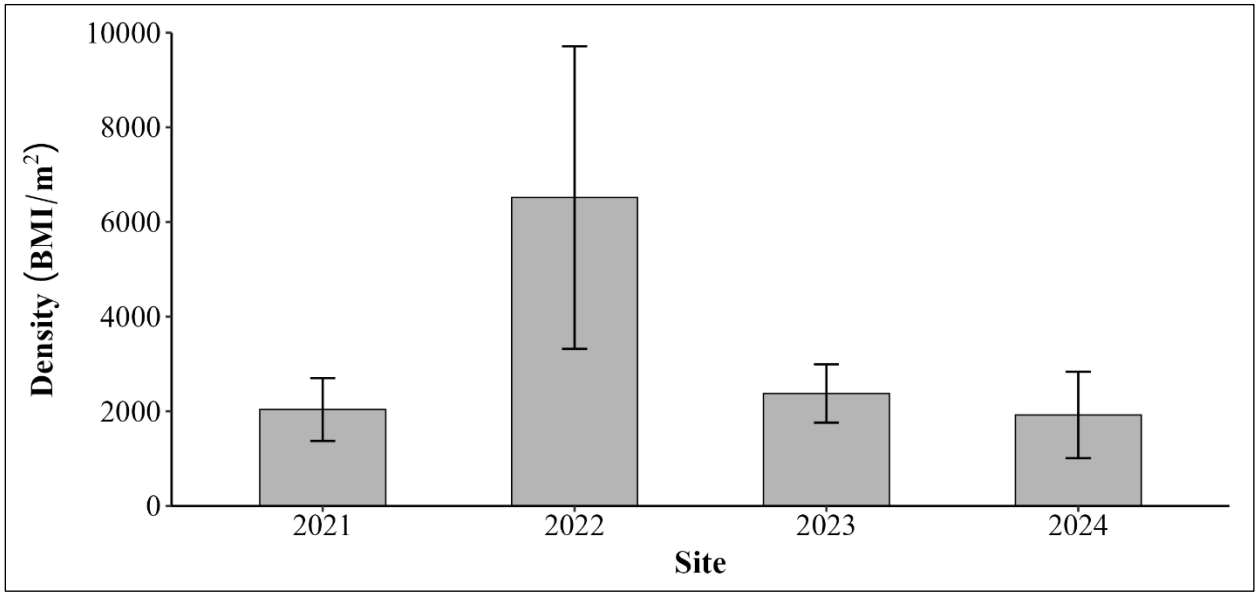

Figure 14.–Mean BMI density (± 1 SD) at Sunshine Creek, 2021–2024.

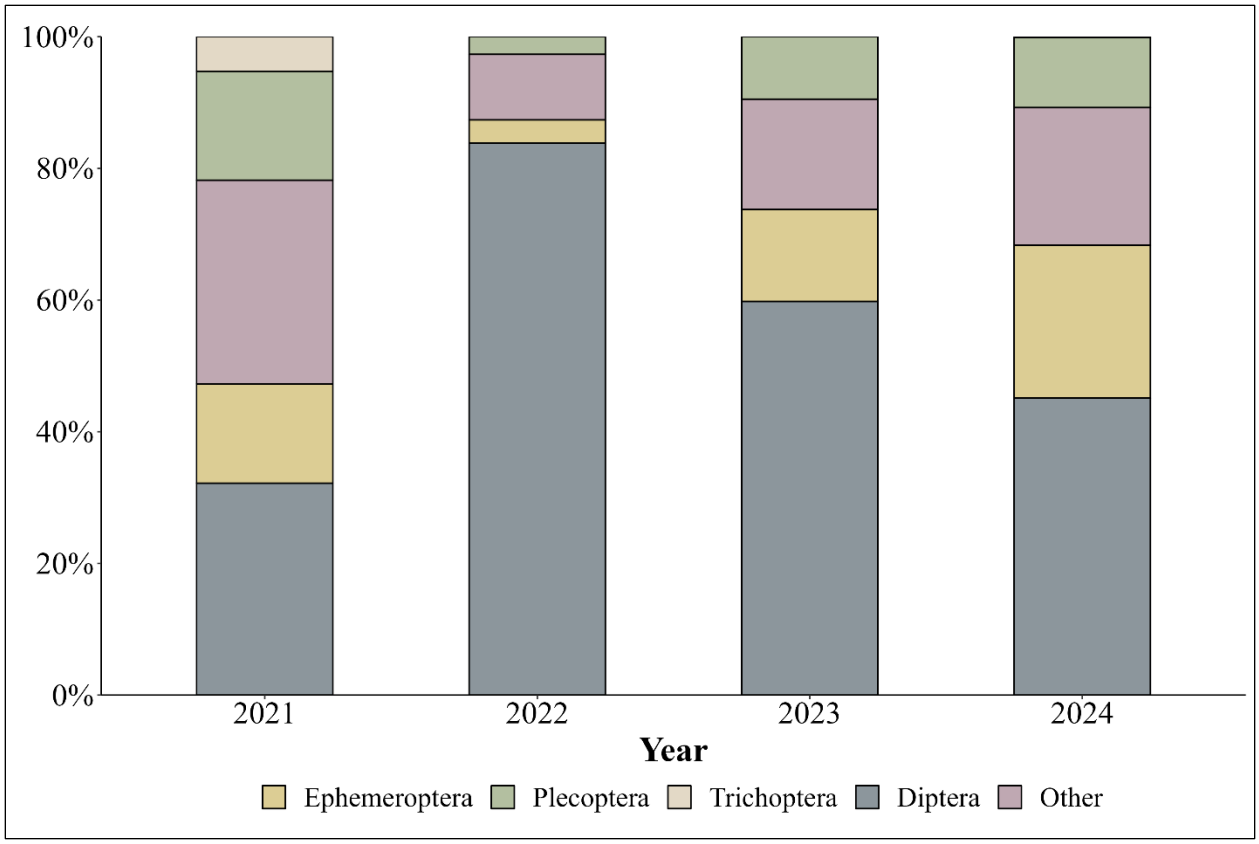

Figure 15.–Mean percent EPT, Diptera, and other taxa in Sunshine Creek BMI samples, 2021–2024.

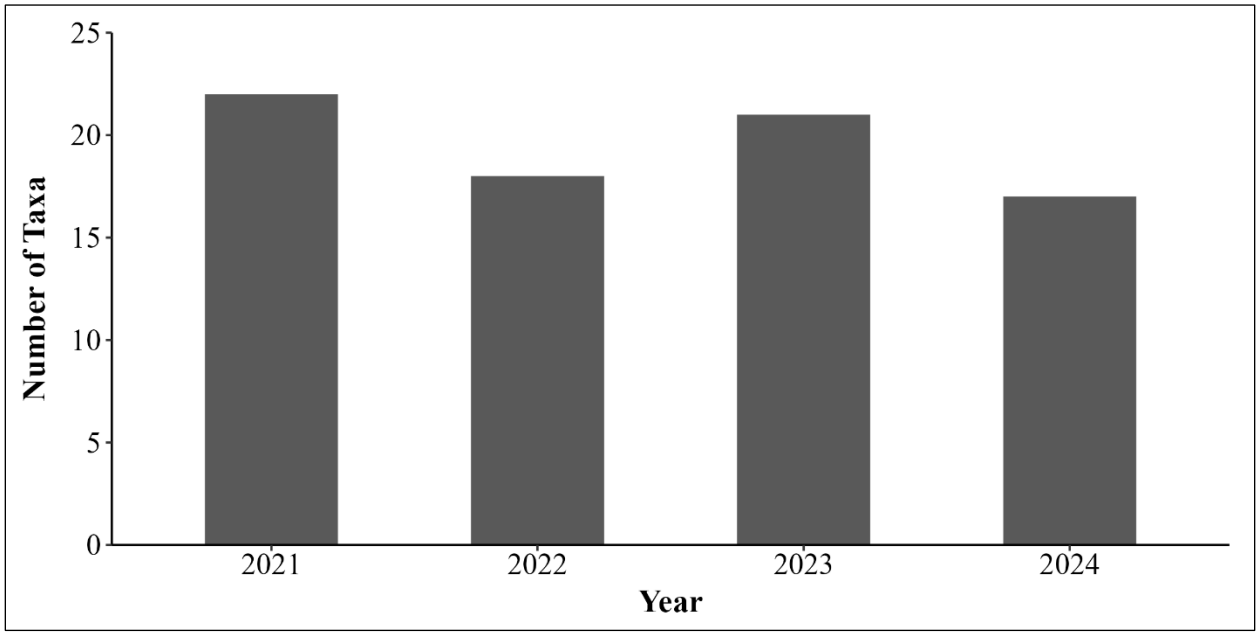

Figure 16.–Taxa richness in Sunshine Creek BMI samples, 2021–2024.

Fish Captures

A total of 2 Dolly Varden and 15 slimy sculpin were captured in Sunshine Creek in 2024. Dolly Varden captures were similar to previous years, but slimy sculpin captures were 5–7 times those of previous years (Figure 18). Similar numbers of Dolly Varden have been captured across all length categories resulting in a uniform distribution ranging from 59–138 mm fork length with a mean of 94.5 mm (SD = 27.1; Figure 19). The majority of slimy sculpin captured range between 60–90 mm total length with a mean of 75.6 mm (SD = 12.2; Figure 19). All fish capture data are presented in Appendix 5.

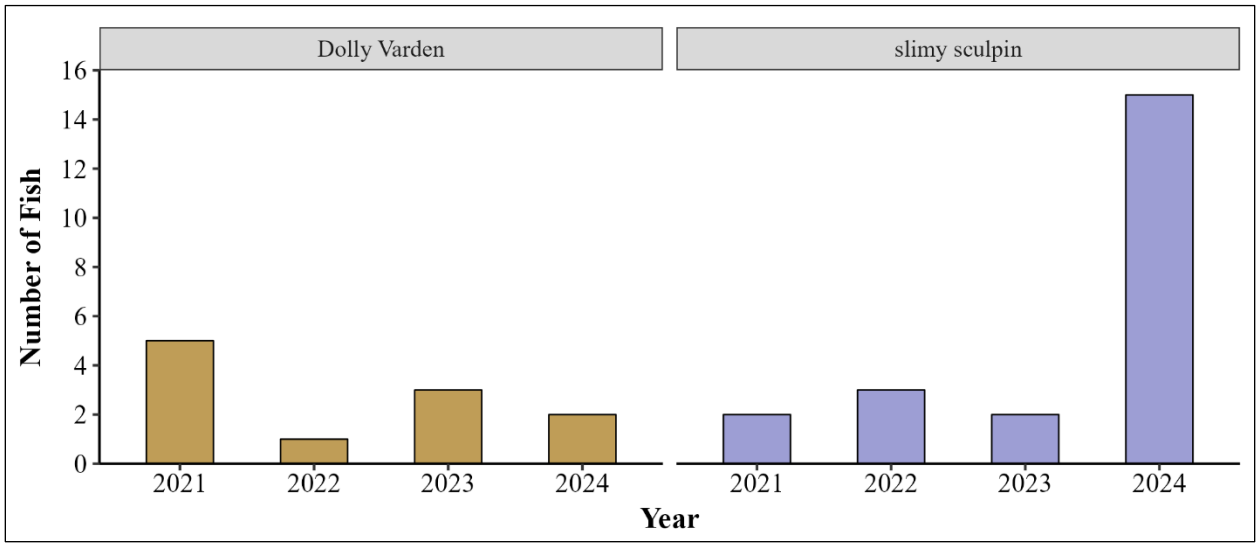

Figure 17.–Total number of fish captured in minnow traps from Sunshine Creek, 2021–2024.

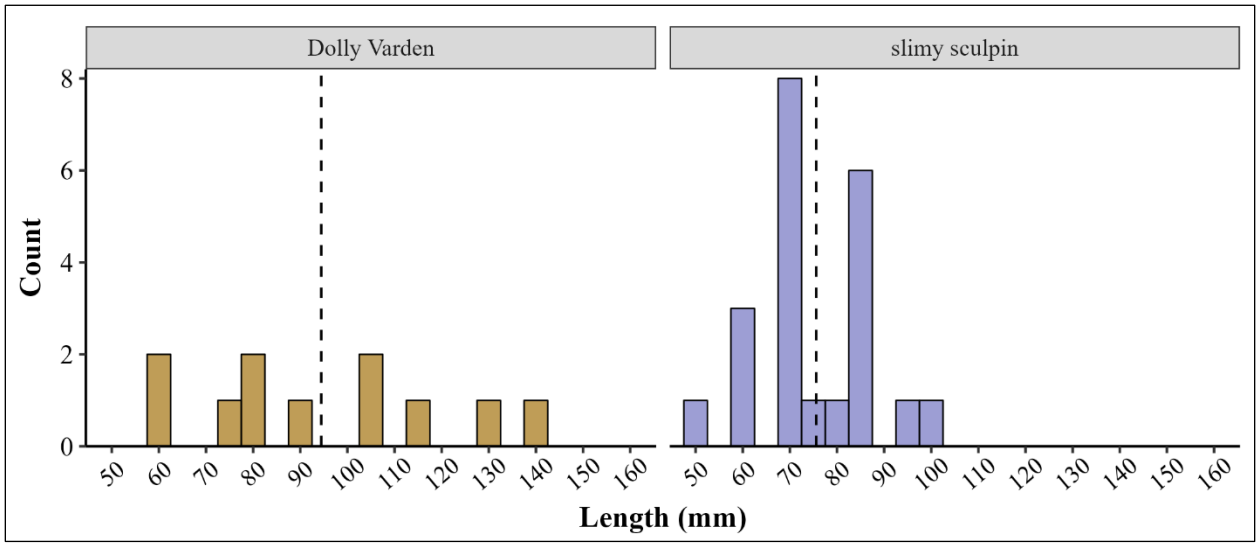

Figure 18.–Length frequency for all fish captured in minnow traps from Sunshine Creek, 2021–2024. Dolly Varden are measured to fork length and slimy sculpin are measured to total length. The vertical dashed line represents the sample mean length.

CENTER OF THE UNIVERSE CREEK

Water Quality

In July 2024, the pH was 7.99, the water temperature was 4.9°C, and the dissolved oxygen was 11.83 mg/L in Center of the Universe Creek. In-situ water quality properties have remained consistent among years with values similar to 2024. All in-situ water quality data are presented in Appendix 2.

The water temperature in Upper Center of the Universe Creek remained above 0°C for the entire Hobo logger monitoring period indicating consistent groundwater input (Figure 20). Conversely, the temperature downstream of the Upper Center of the Universe site dropped to -11.1°C on October 9, 2023. This is likely an air temperature due to a drop in water level and exposure of the logger. The temperature then increased to remain between -3°C and 0°C until April 28, 2024 when water temperature rose above 0°C for the remainder of the monitoring period (Figure 20).

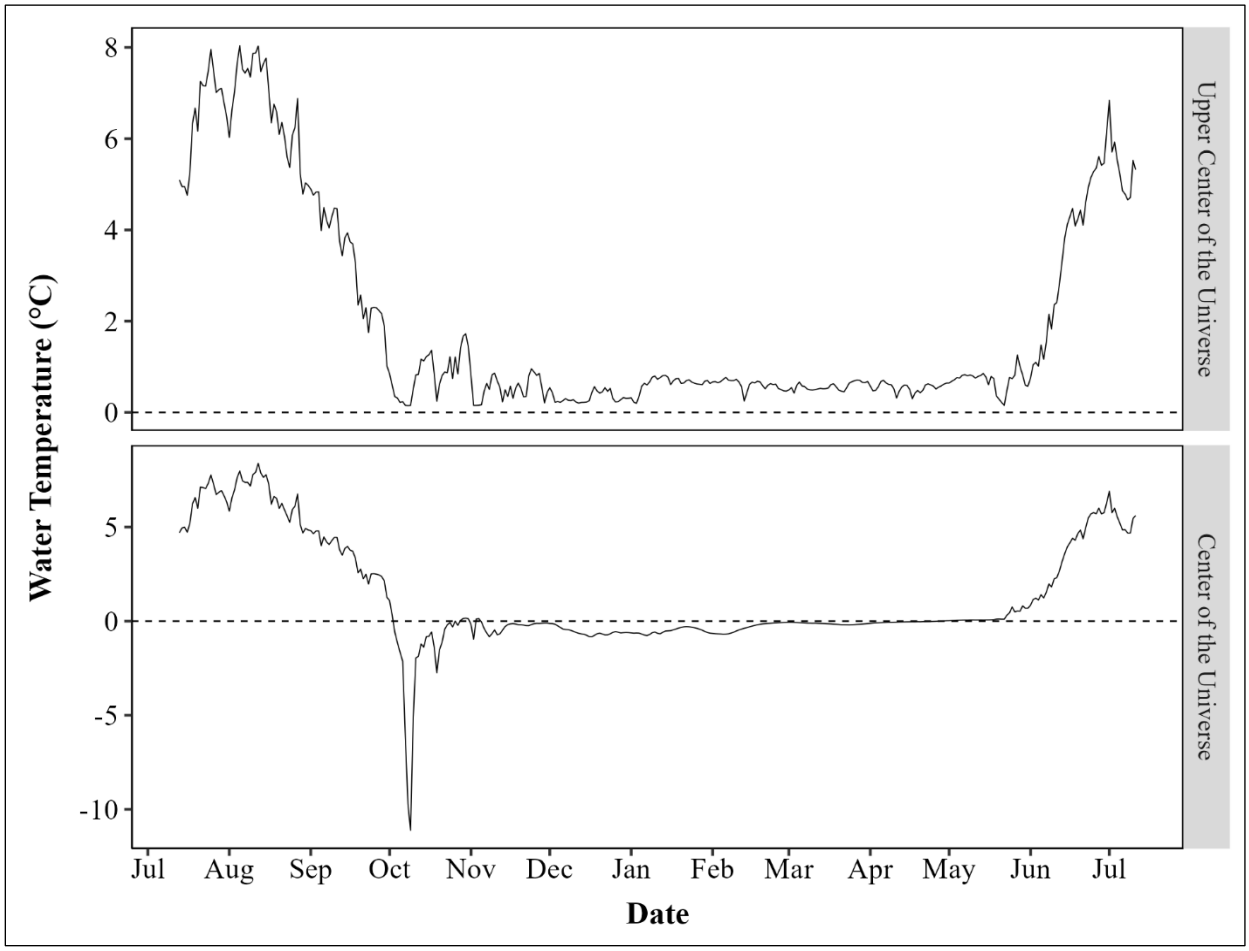

Figure 19.–Water temperature data from Hobo loggers placed at two sites in Center of the Universe Creek, July 2023–July 2024.

Periphyton

In 2024, the mean chlorophyll-a concentration in Center of the Universe Creek was 1.09 mg/m^2 (SD = 1.2). This value is similar to previous years' means (Figure 21). Periphyton data from 2024 are presented in Appendix 3.

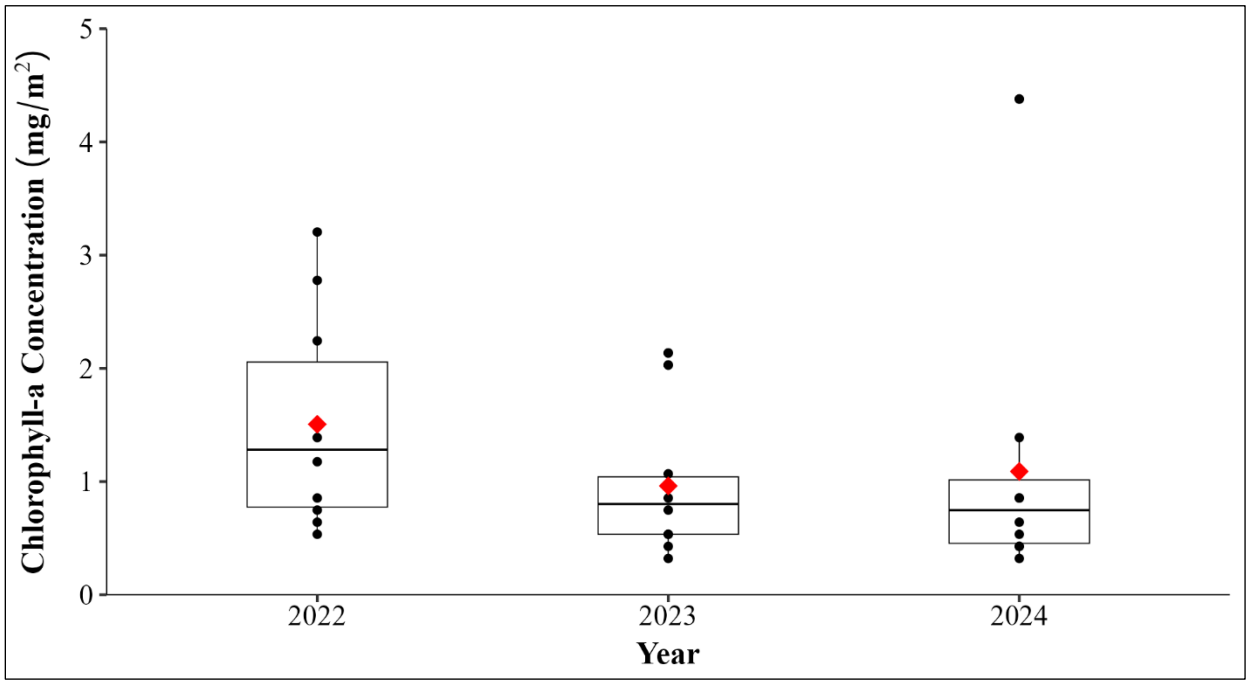

Figure 20.–Chlorophyll-a concentration boxplot by year at Center of the Universe Creek, 2022–2024. Raw data are depicted by black dots and mean values are depicted in red.

Benthic Macroinvertebrates

Mean BMI density in Center of the Universe Creek in 2024 was 2,441/m^2 (SD = 280). This is very similar to the density in 2023 of 2,244/m^2 (Figure 22). Diptera comprised 56% of the sample composition and EPT were 30% in 2024. This contrasts with 2023 when Diptera made up just 23% and EPT taxa made up 43% of the samples (Figure 23). Taxa richness was similar between the two years with 14 taxa present in 2023 and 18 taxa present in 2024 (Figure 24). BMI data from 2024 are presented in Appendix 4.

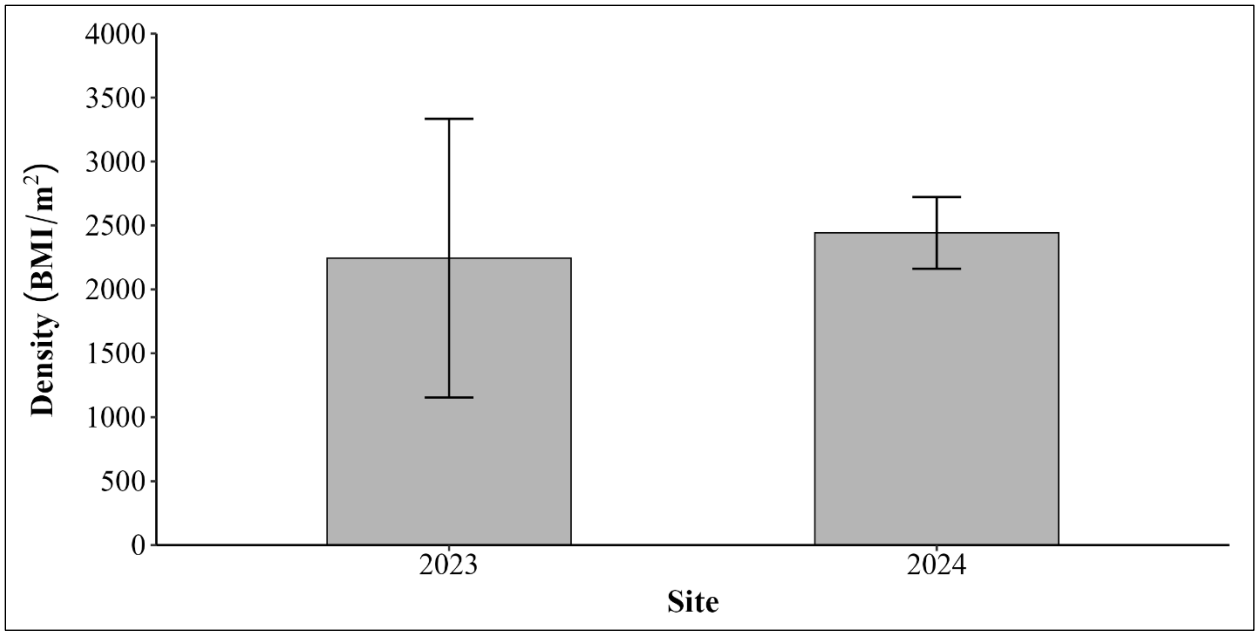

Figure 21.–Mean BMI density (± 1 SD) at Center of the Universe Creek, 2023–2024.

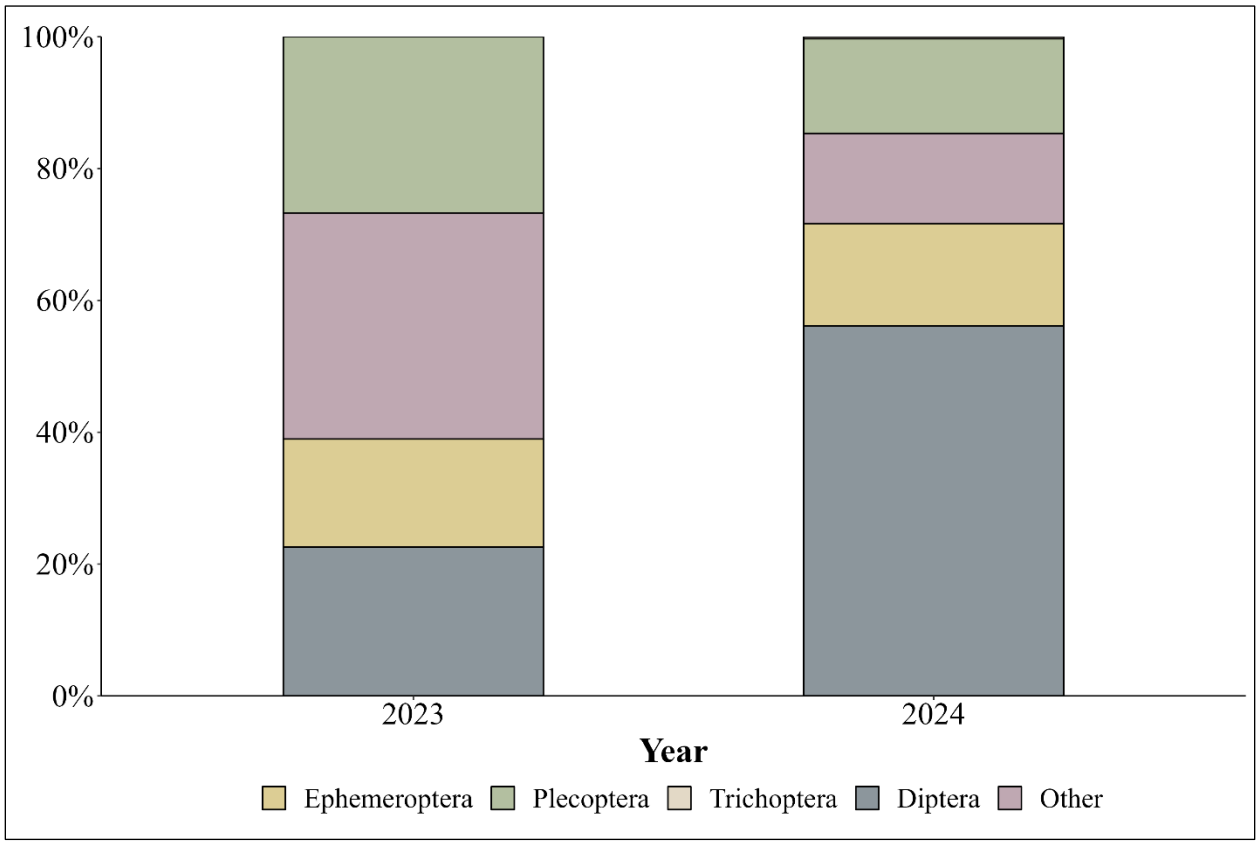

Figure 22.–Mean percent EPT, Diptera, and other taxa in Center of the Universe Creek BMI samples, 2023–2024.

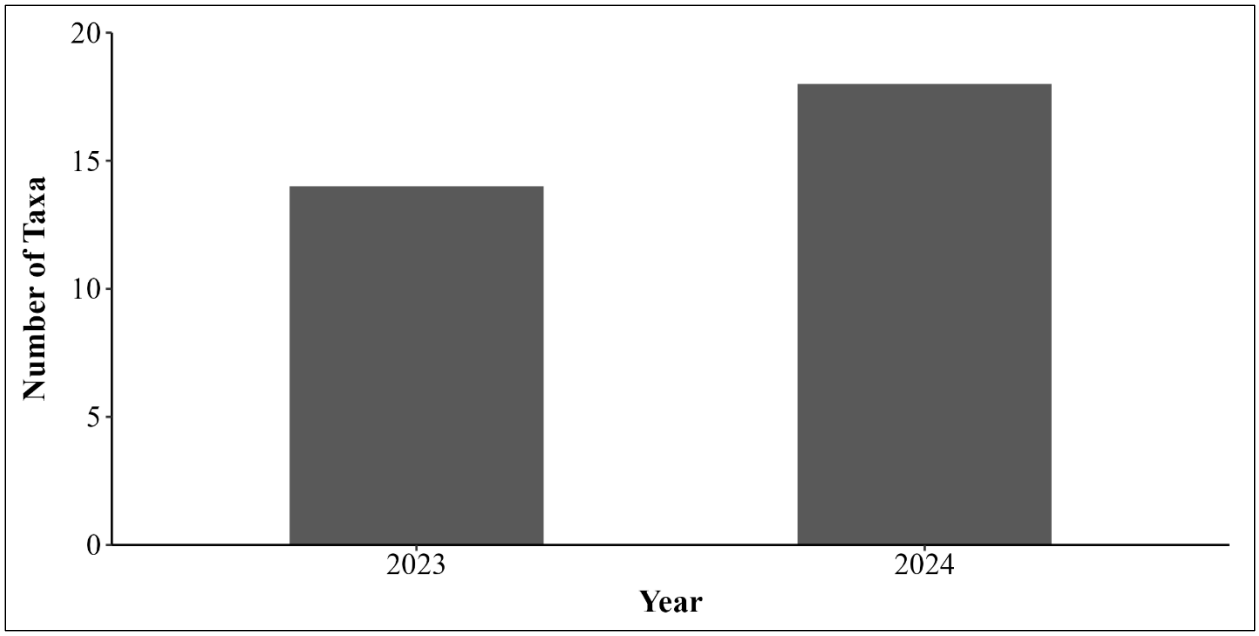

Figure 23.–Taxa richness in Center of the Universe Creek BMI samples, 2023–2024.

Fish Captures

Dolly Varden have been the only fish species captured in Center of the Universe Creek since sampling began here in 2021. A total of 7 Dolly Varden were captured in 2024 which is similar to previous years' catches (Figure 25). Multiple length classes are present in Center of the Universe Creek ranging from 63–158 mm fork length with a generally uniform distribution and mean of 116.9 mm (SD = 29.5; Figure 26). All fish capture data are presented in Appendix 5.

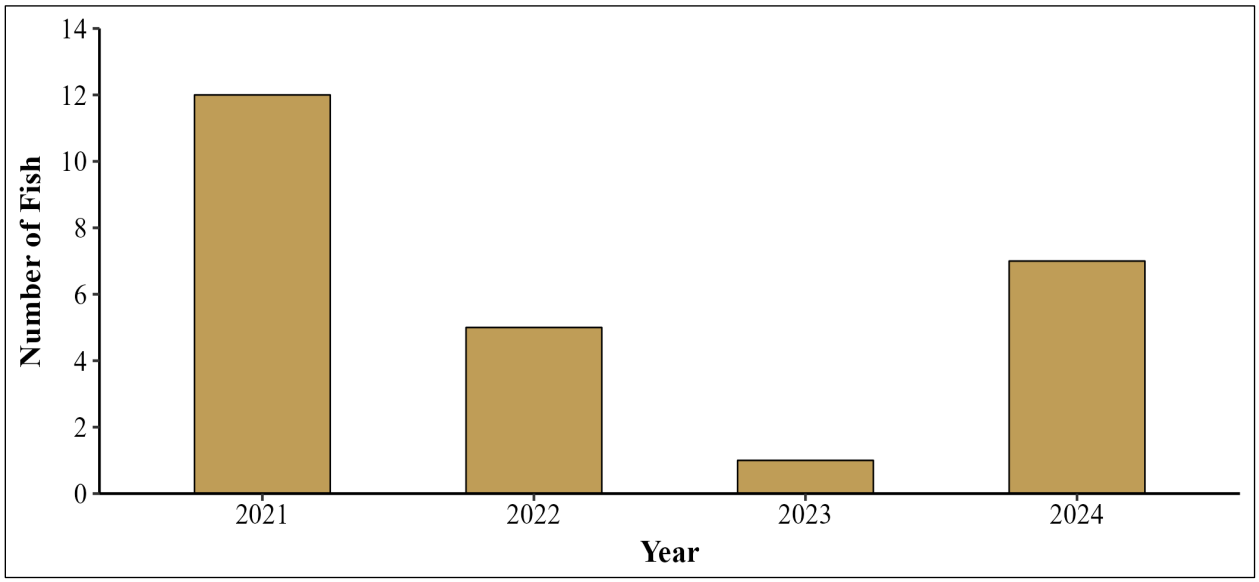

Figure 24.– Total number of fish captured in Center of the Universe Creek, 2021–2024.

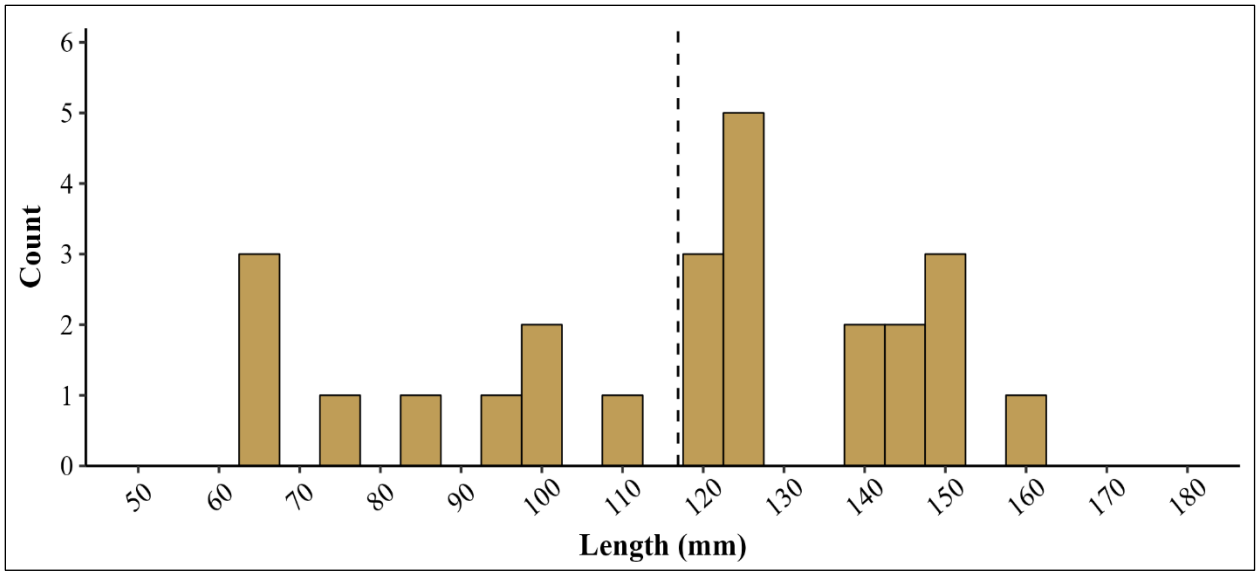

Figure 25.–Length frequency for Dolly Varden captured in minnow traps from Center of the Universe Creek, 2021–2024. The vertical dashed line represents the sample mean length.

LOWER RED ROCK CREEK

Water Quality

In July 2024, the pH was 8.05, the water temperature was 6.5°C, and the dissolved oxygen was 11.8 mg/L in Lower Red Rock Creek. In-situ water quality data was not gathered in 2022, but the water temperature in 2023 was 5°C. All in-situ water quality data are presented in Appendix 2.

Based on Hobo logger data, recorded temperature first fell below 0°C in Lower Red Rock Creek on October 7, 2023. This was followed by a period of fluctuations around 0°C until December 2, then temperature remained below 0°C until April 20, 2024 (Figure 27). Temperatures well below 0°C are likely air temperatures due to a drop in water level and exposure of the logger. This pattern indicates that groundwater does not play a role in winter water temperature mediation in this location in Lower Red Rock Creek and that the stream may freeze solid here.

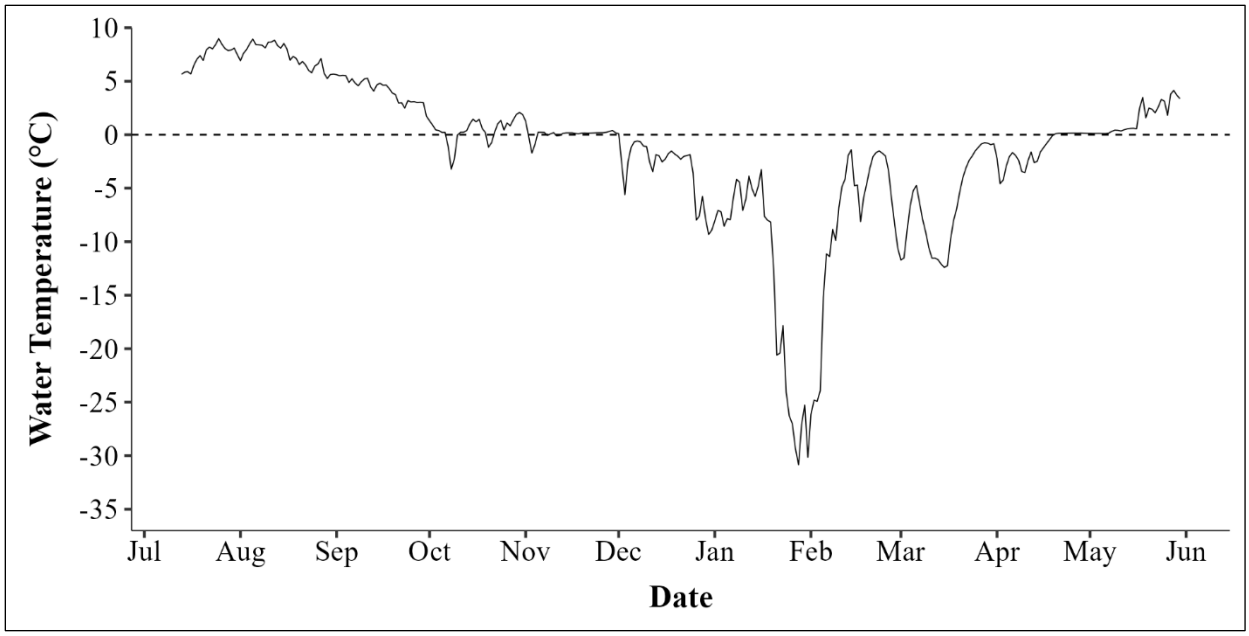

Figure 26.–Water temperature data from Hobo logger placed in Lower Red Rock Creek, July 2023–May 2024.

Periphyton

In 2024, mean chlorophyll-a concentration in Lower Red Rock Creek was 0.15 mg/m^2 (SD = 0.09). This value is similar to previous years' means which range from 0.1 mg/m^2 in 2023 to 0.32 mg/m^2 in 2021 (Figure 28). Periphyton data from 2024 are presented in Appendix 3.

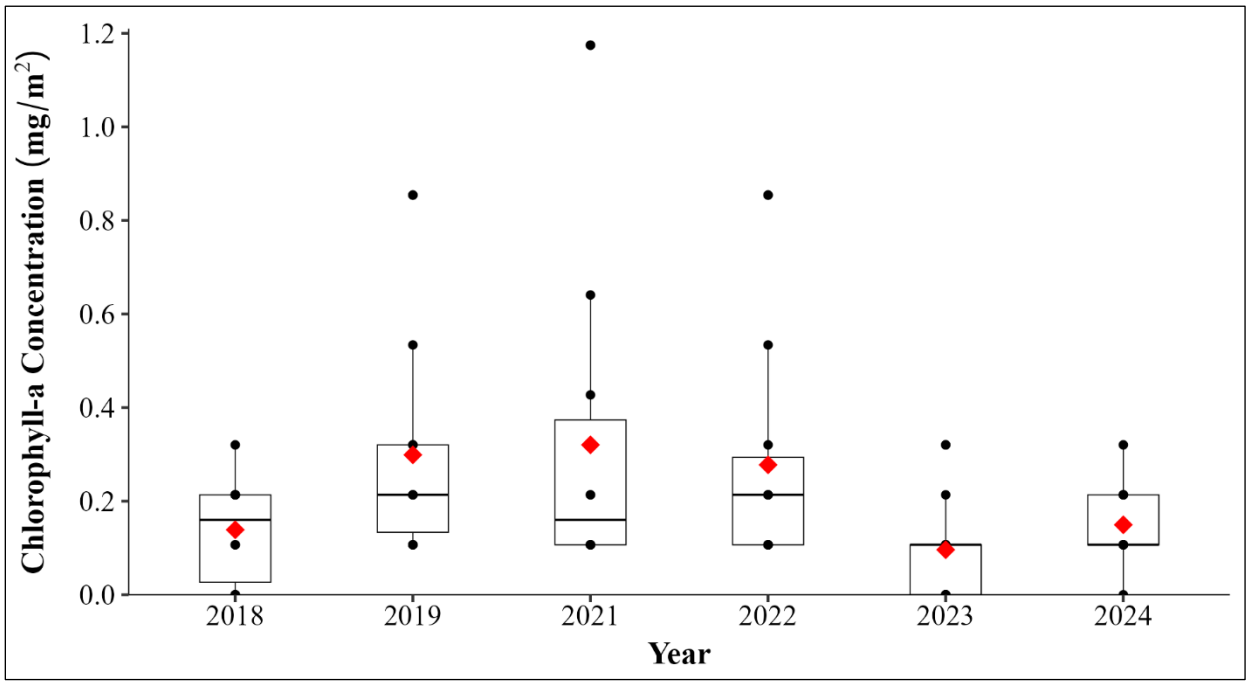

Figure 27.–Chlorophyll-a concentration boxplot by year at Lower Red Rock Creek, 2018–2024. Raw data are depicted by black dots and mean values are depicted in red.

Benthic Macroinvertebrates

Mean BMI density in Lower Red Rock Creek in 2024 was 65/m^2 (SD = 28). This is similar to densities recorded in 2022 and 2023 but approximately one quarter of the density in 2021 (Figure 29). Taxa composition has varied among years with EPT taxa dominating the samples in just one year (2021) and either Diptera or other taxa dominating in all other years (Figure 30). Overall, taxa composition in 2024 was very similar to 2023 except that Plecoptera proportion was twice that of 2023 at 32%. Taxa richness was the lowest on record in 2024 at 7 taxa present (Figure 31). Taxa richness has been generally lower since switching to Hess samplers in 2021. BMI data from 2024 are presented in Appendix 4.

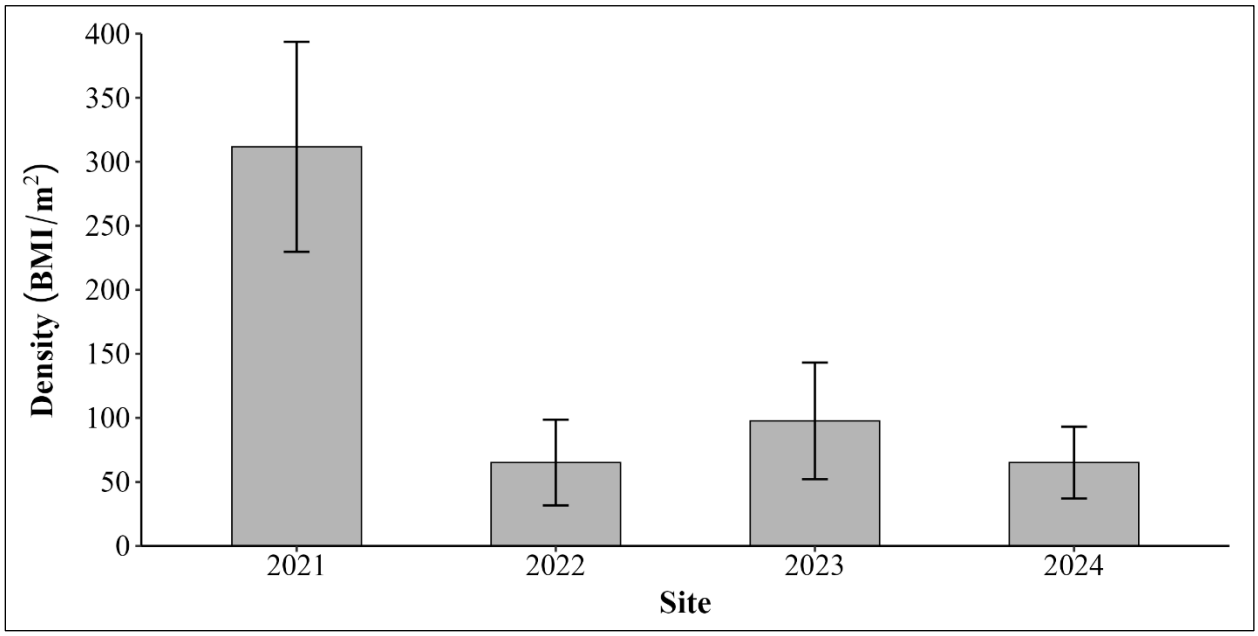

Figure 28.–Mean BMI density (± 1 SD) at Lower Red Rock Creek, 2021–2024.

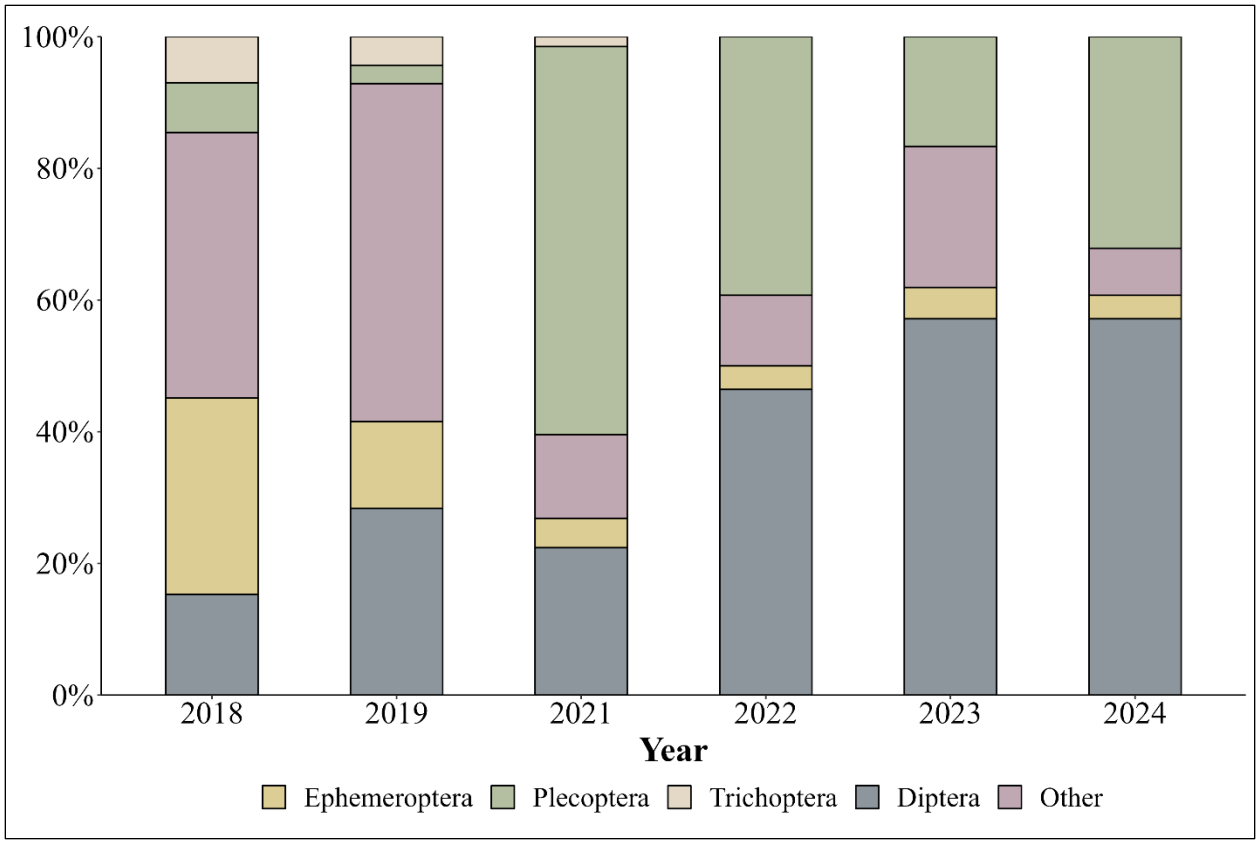

Figure 29.–Mean percent EPT, aquatic Diptera, and other taxa in Lower Red Rock Creek BMI samples, 2018–2024.

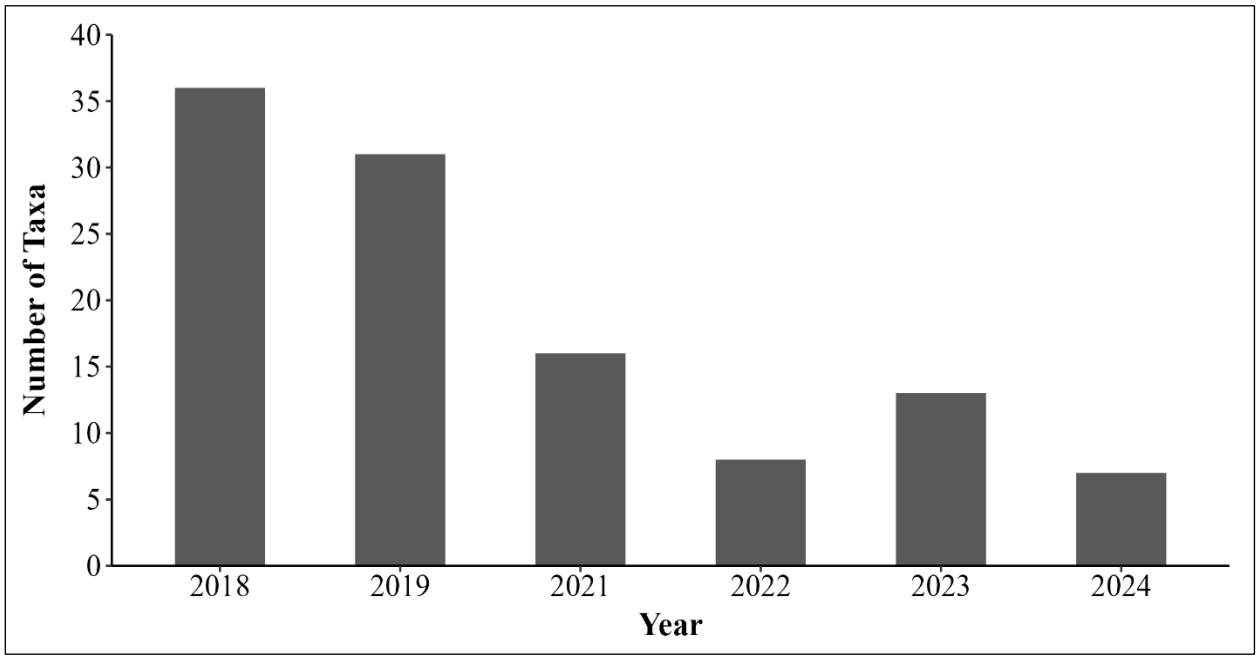

Figure 30.–Taxa richness in Lower Red Rock Creek BMI samples, 2018–2024.

Fish Captures

A total of 8 Dolly Varden and 7 slimy sculpin were captured in Lower Red Rock Creek in 2024. This is the second lowest Dolly Varden catch but the highest slimy sculpin catch on record since sampling began in 2018 (Figure 32). The Dolly Varden captured consist of multiple length classes ranging from 65–164 mm fork length with a mean of 118.2 mm (SD = 26.6; Figure 33). The majority of slimy sculpin captured fell within the 60–75 mm length classes with a mean of 66.9 mm (SD = 6.1; Figure 33). All fish capture data are presented in Appendix 5.

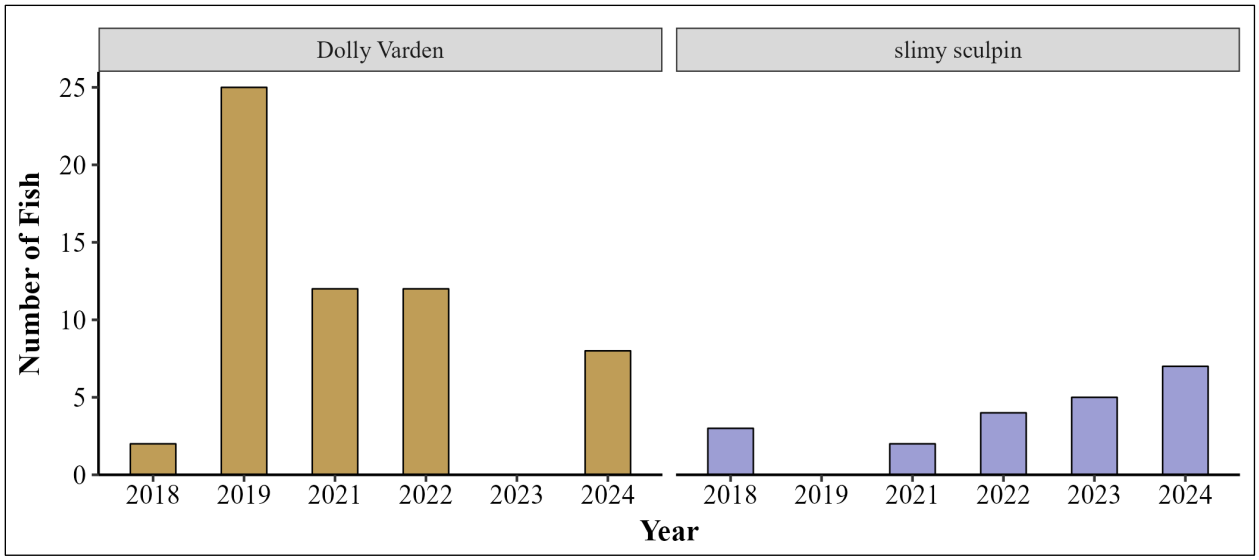

Figure 31.–Total number of fish captured in Lower Red Rock Creek, 2018–2024.

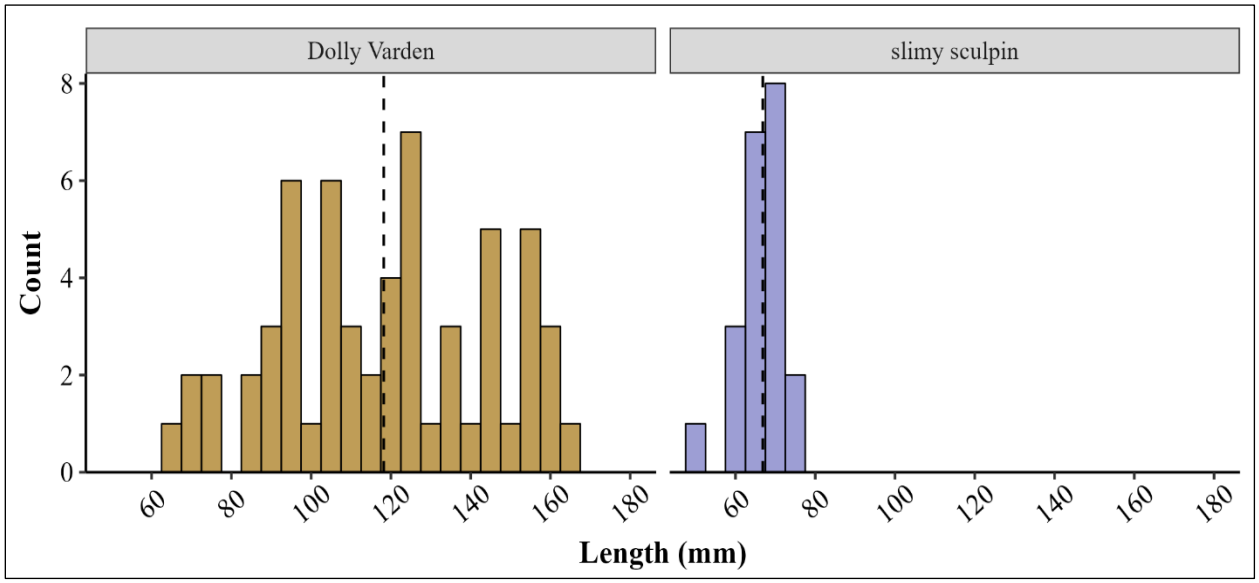

Figure 32.–Length frequency for all fish captured in minnow traps from Lower Red Rock Creek, 2018–2024. Dolly Varden are measured to fork length and slimy sculpin are measured to total length. The vertical dashed line represents the sample mean length.

UPPER SUBARCTIC CREEK

Water Quality

In July 2024, the pH was 7.97, the water temperature was 5.6°C, and the dissolved oxygen was 11.54 mg/L in Upper Subarctic Creek. Water temperature has been relatively variable among years ranging from 3.9–5.6°C. All in situ water quality data are presented in Appendix 2.

Based on Hobo logger data, water temperature in Upper Subarctic Creek remained above 0°C for the entire monitoring period (Figure 35). This indicates consistent groundwater input at this site, especially from December 13, 2023 to March 19, 2024 when water temperature remained within a small range of 0.7–1.03°C.

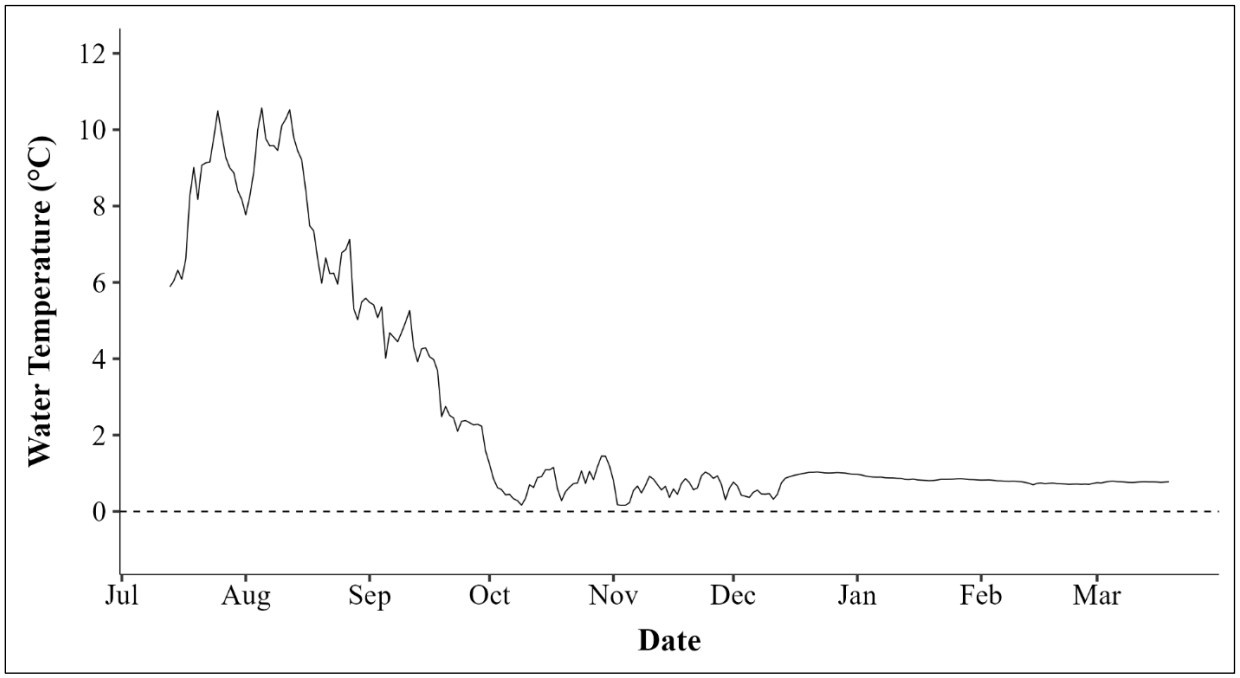

Figure 33.–Water temperature data from Hobo logger placed in Upper Subarctic Creek, July 2023–March 2024.

Periphyton

In 2024, mean chlorophyll-a concentration in Upper Subarctic Creek was 0.92 mg/m^2 (SD = 0.43). This value is similar to the mean in 2023 but mean values up to 4.5 mg/m^2 have been recorded in previous years (Figure 36). Periphyton data from 2024 are presented in Appendix 3.

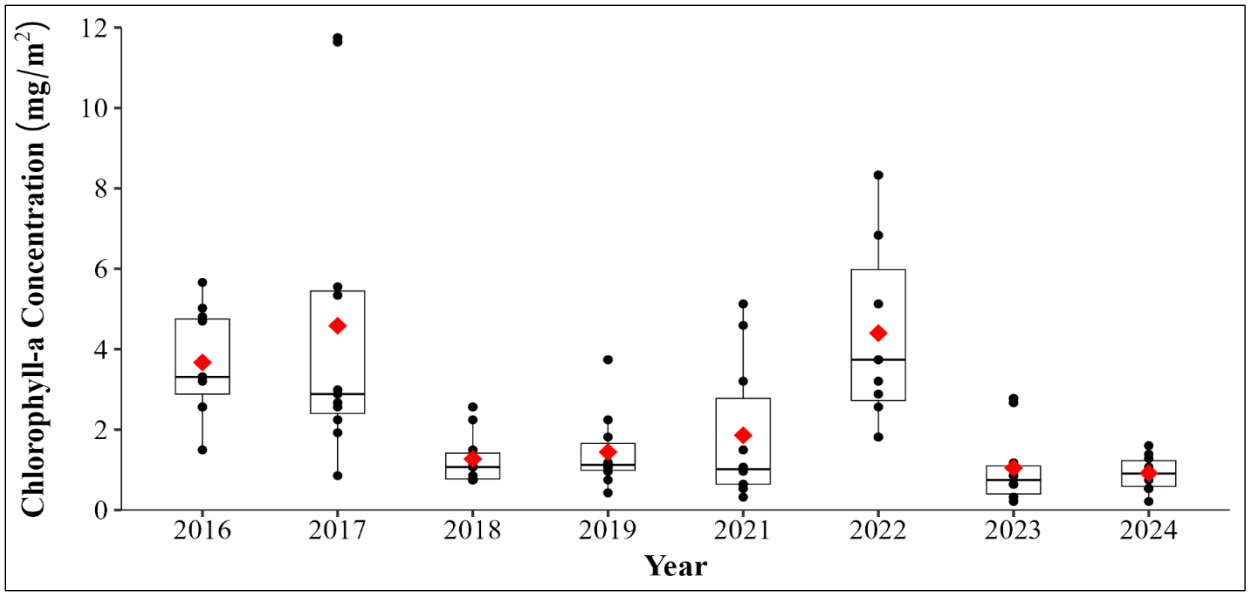

Figure 34.–Chlorophyll-a concentration boxplot by year at Upper Subarctic Creek, 2016–2024. Raw data are depicted by black dots and mean values are depicted in red.

Benthic Macroinvertebrates

Mean BMI density in Upper Subarctic Creek in 2024 was 5,290/m^2 (SD = 4,019). Density has been variable among years ranging from a low of 1,412/m^2 in 2023 to a high of 11,928/m^2 in 2021 (Figure 37). The proportion of EPT taxa present in samples from Upper Subarctic Creek has generally increased with time (Figure 38). In 2024, EPT taxa made up 33% and Diptera made up 35% of the samples. Taxa richness was the highest on record in 2024 at 21 taxa present. Taxa richness has been variable among years, previously ranging from 11 in 2016 to 19 in 2022 (Figure 39). BMI data from 2024 can be found in Appendix 4.

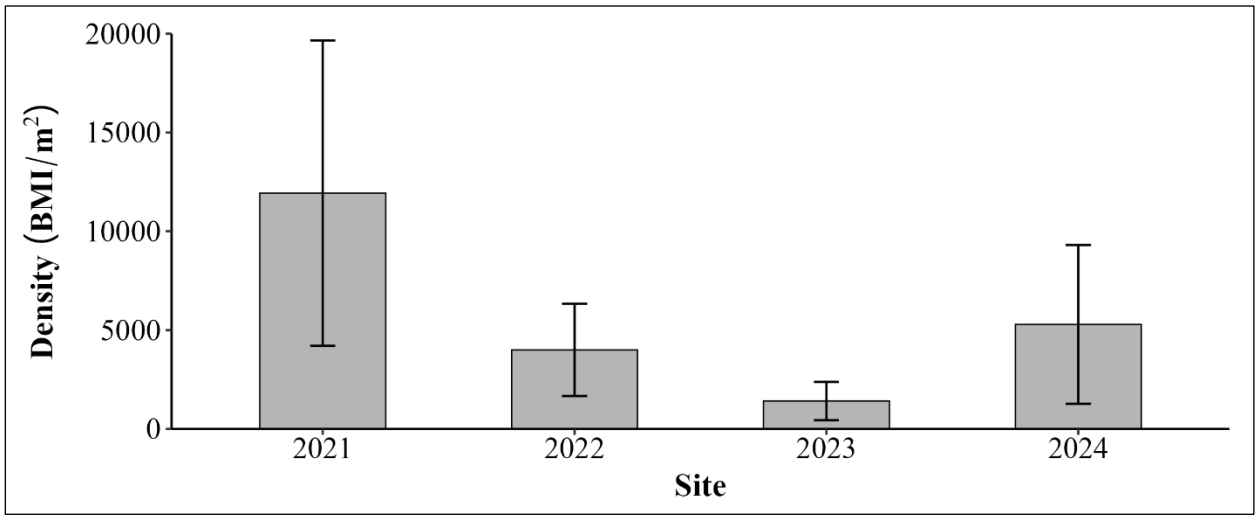

Figure 35.–Mean BMI density (± 1 SD) at Upper Subarctic Creek, 2021–2024.

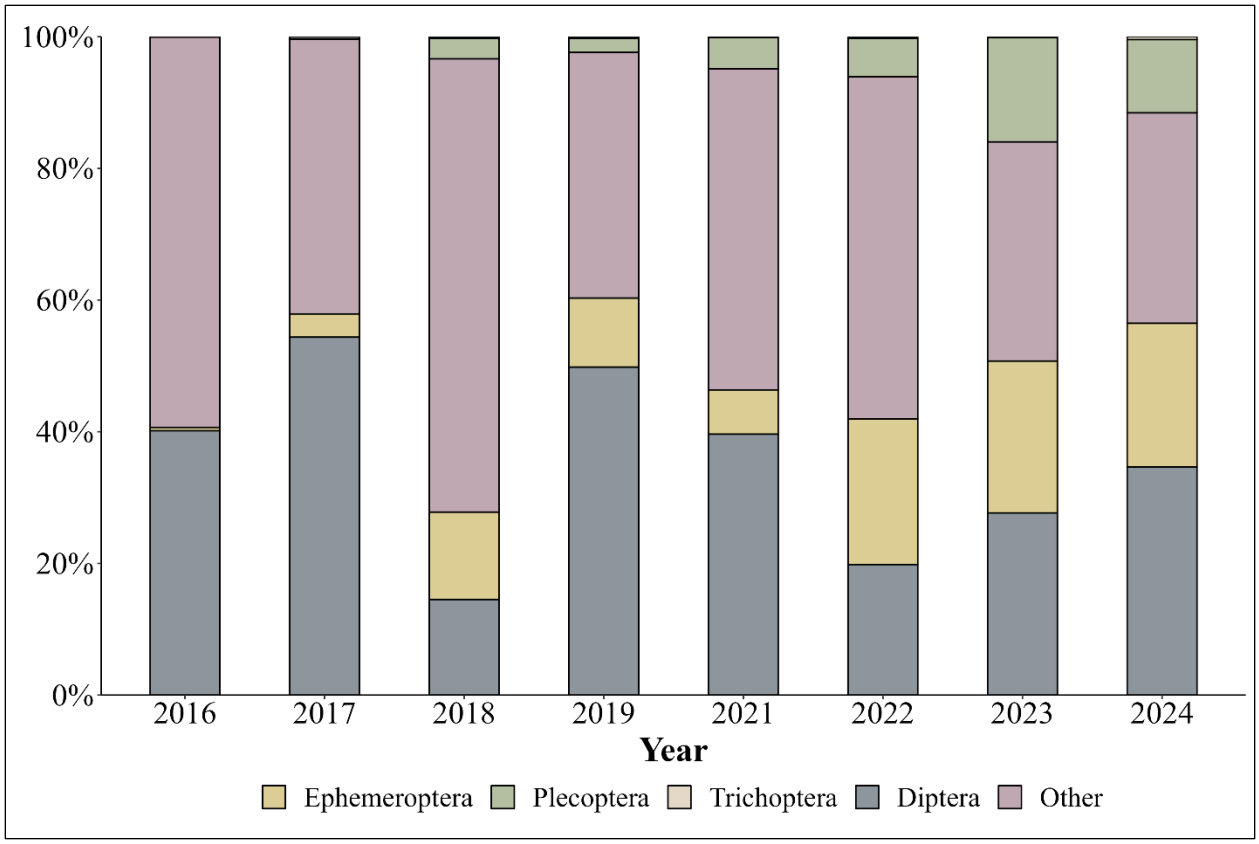

Figure 36.–Mean percent EPT, aquatic Diptera, and other taxa in Upper Subarctic Creek BMI samples, 2016–2024.

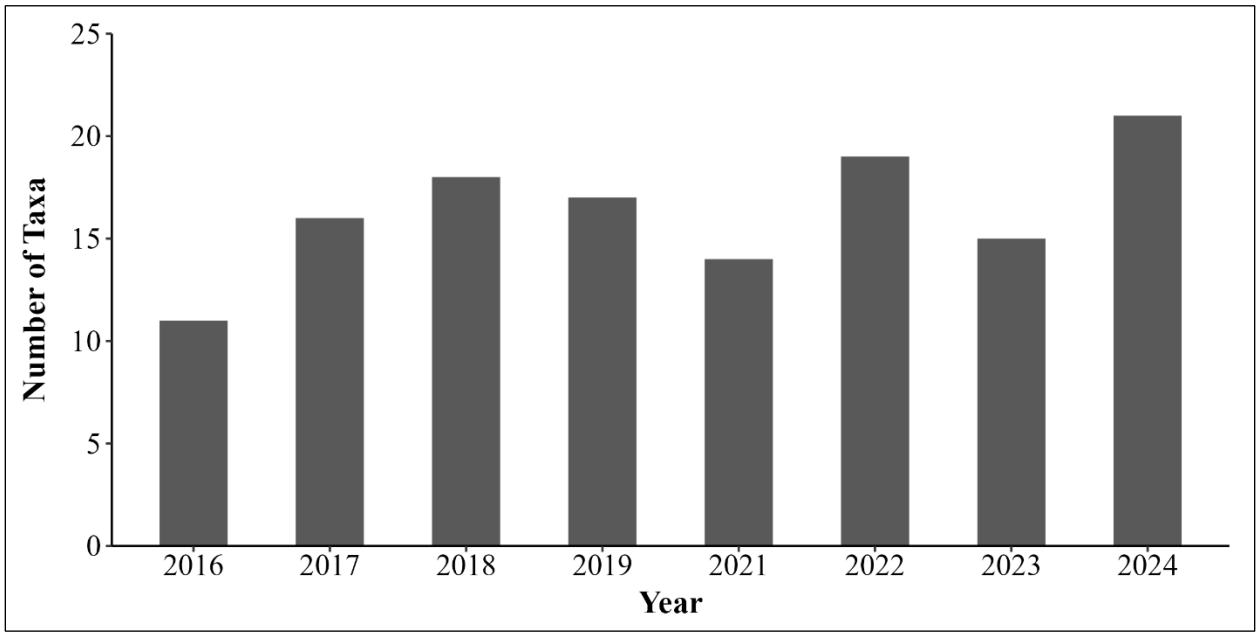

Figure 37.–Taxa richness in Upper Subarctic Creek BMI samples, 2016–2024.

Fish Captures

Dolly Varden have been the only fish species captured in Upper Subarctic Creek since sampling began in 2016. A total of 24 Dolly Varden were captured in 2024 which is similar to previous years' catches, except for 2019 when a bear crushed 9 out of 10 minnow traps and only 5 individuals were captured (Figure 40). Multiple length classes are present in Upper Subarctic Creek ranging from 64–165 mm fork length with a normal distribution and mean of 111.1 mm (SD = 19.2; Figure 41). All fish capture data are presented in Appendix 5.

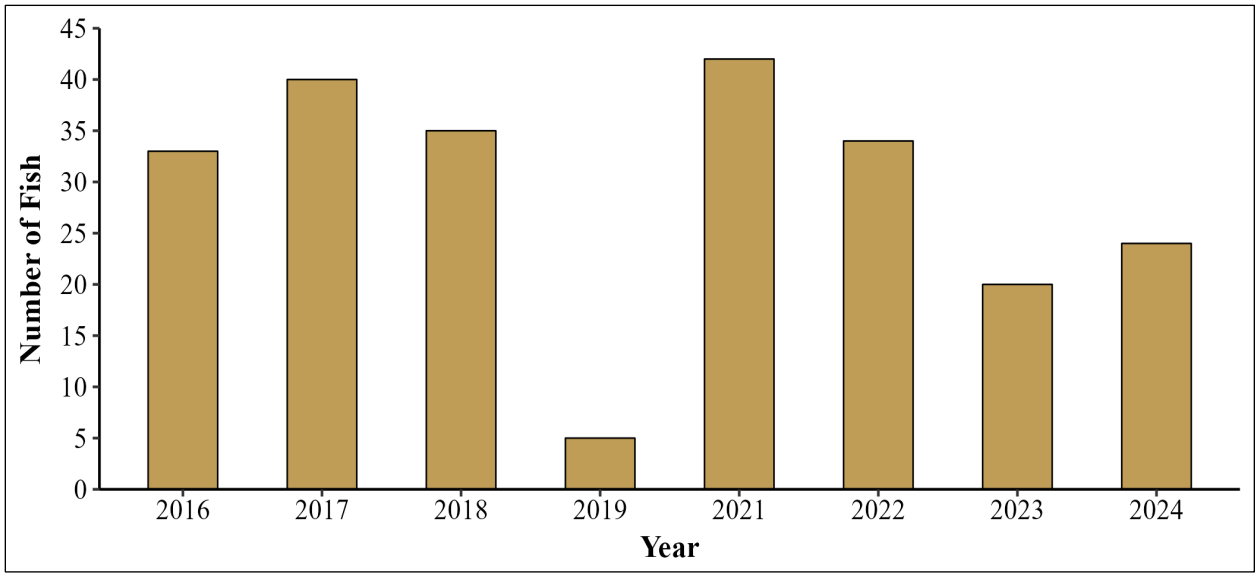

Figure 38.–Total number of fish captured in Upper Subarctic Creek, 2016–2024.

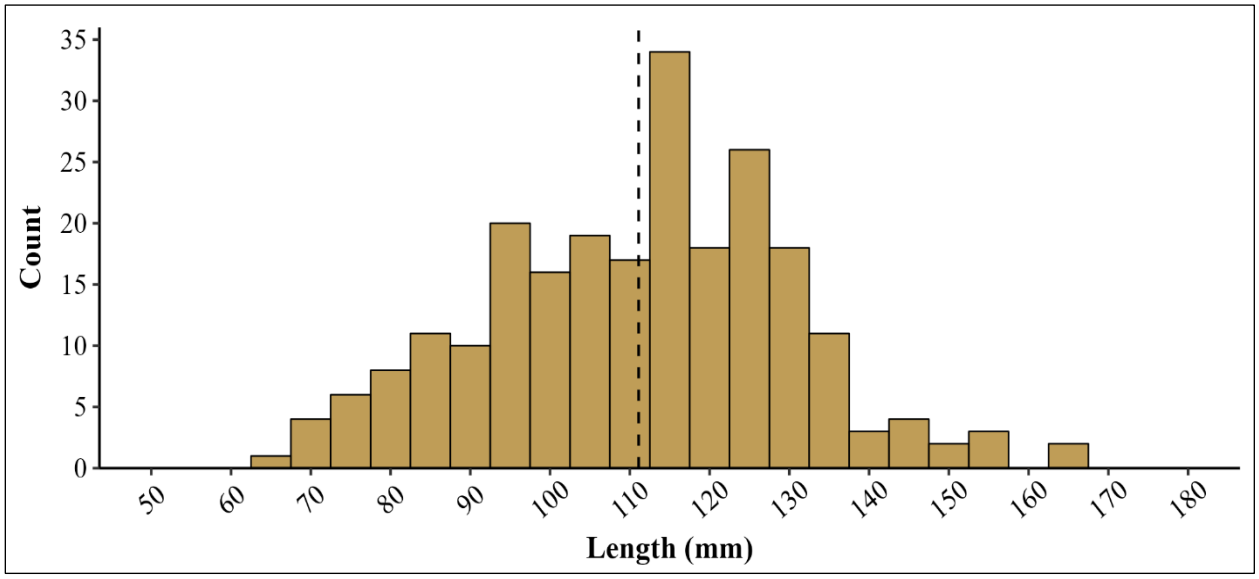

Figure 39.–Length frequency for Dolly Varden captured in minnow traps from Upper Subarctic Creek, 2016–2024. The vertical dashed line represents the sample mean length.

Fish Metals

Fifteen Dolly Varden were retained from Upper Subarctic Creek for element analysis in 2024. All results are for whole body dry weight. Mean cadmium concentration in 2024 was 0.67 mg/kg (SD = 0.23). This is within the previous years' means that range from 0.47–0.89 mg/kg (Figure 42). Mean copper concentration was the same in 2024 as in 2023 at 6.47 mg/kg (SD = 4). This value is the highest recorded in Upper Subarctic Creek with previous years' means all below 5.00 mg/kg (Figure 42). Mean mercury concentration in 2024 was 0.11 mg/kg (SD = 0.03) which is the highest mean recorded but still similar to previous years' means (Figure 42). Mean selenium concentration in 2024 was 4.63 mg/kg (SD = 0.77). This is within the previous years' means that range from 3.74–5.86 mg/kg (Figure 42). Mean zinc concentration in 2024 was the second highest on record after 2023 at 183.29 mg/kg (SD = 44.79). Mean zinc concentrations have shown a generally steady increase since 2018 when the mean was 115.97 mg/kg (Figure 42). Element analysis data from 2024 are presented in Appendix 6.

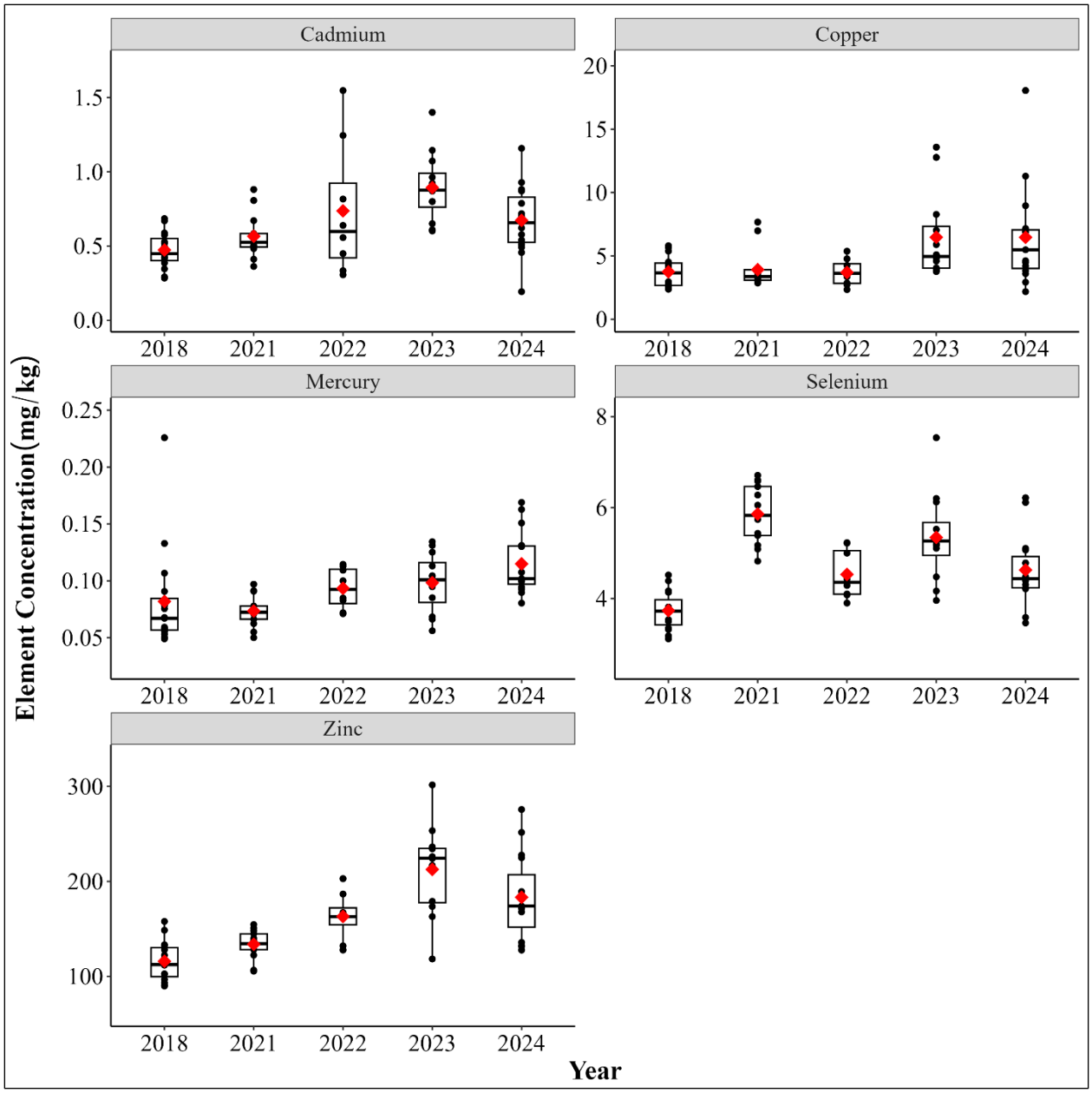

Figure 40.–Boxplots depicting element concentration data for Dolly Varden captured in Upper Subarctic Creek, 2018–2024. Raw data are in black dots and mean values are depicted in red. Note that y-axis scales vary among elements.

LOWER SUBARCTIC CREEK

Water Quality

In July 2024, the pH was 7.4, the water temperature was 6.9°C, and the dissolved oxygen was 11.82 mg/L in Lower Subarctic Creek. These values are similar to previous years. All in situ water quality data are presented in Appendix 2.

Periphyton

In 2024, mean chlorophyll-a concentration in Lower Subarctic Creek was 0.21 mg/m^2 (SD = 0.11). This value is the lowest mean on record with previous years' means ranging from 0.47 mg/m^2 in 2023 to 1.24 mg/m^2 in 2022 (Figure 44). Periphyton data from 2024 are presented in Appendix 3.

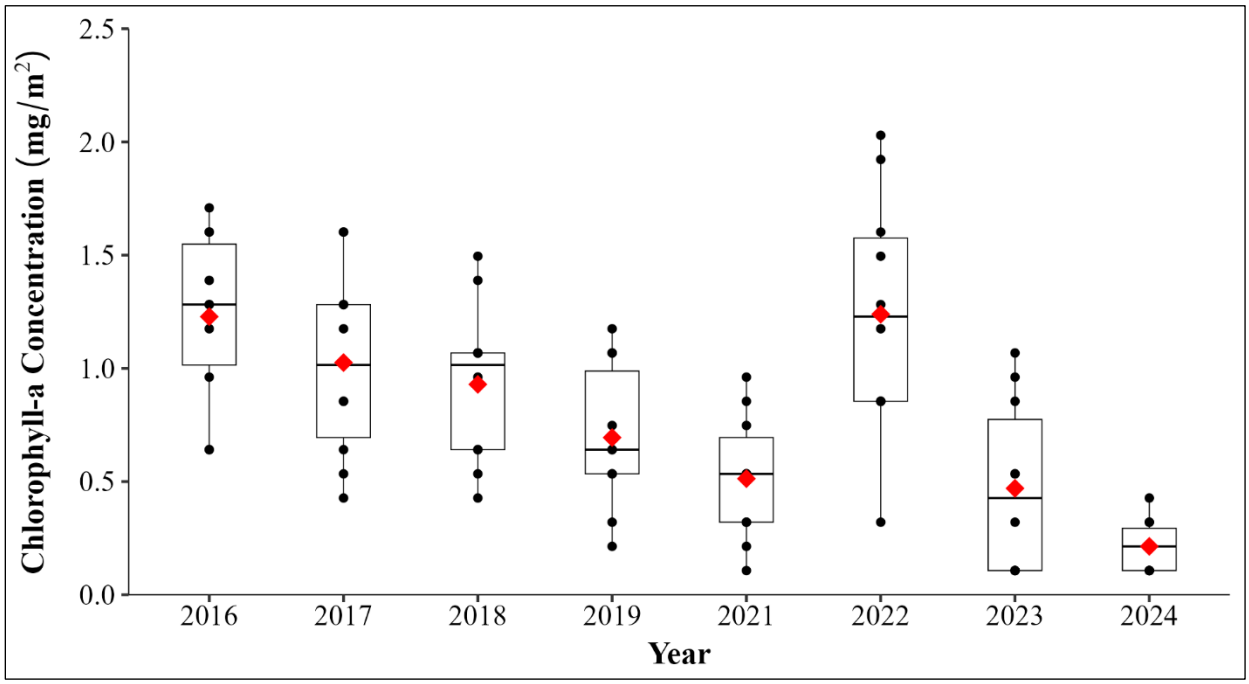

Figure 41.–Chlorophyll-a concentration boxplot by year at Lower Subarctic Creek, 2016–2024. Raw data are depicted by black dots and mean values are depicted in red.

Benthic Macroinvertebrates

Mean BMI density in Lower Subarctic Creek was the lowest on record in 2024 at 667/m^2 (SD = 252). Previously, mean BMI density ranged from 858/m^2 in 2023 to 1,484/m^2 in 2021 (Figure 45). Beginning in 2021, EPT taxa have made up a larger proportion of the samples from Lower Subarctic Creek than Diptera (Figure 46). EPT taxa composed 57% of the samples and Diptera composed 29% of the samples in 2024, which is very similar to the composition in 2023. Taxa richness was the lowest on record in 2024 at 11 taxa present in the samples. Taxa richness has been variable among years, but generally lower since the sampling method switched to Hess samplers in 2021. Prior to 2024, taxa richness ranged from 15 taxa in 2021 to 31 taxa in 2018 (Figure 47). BMI data from 2024 are presented in Appendix 4.

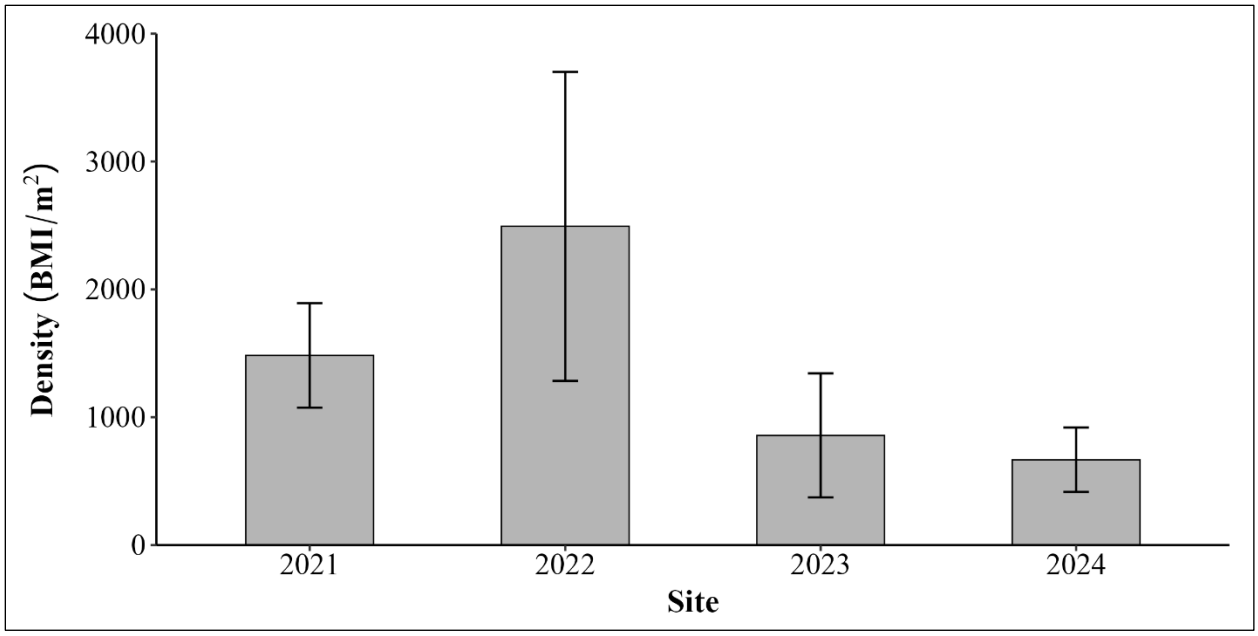

Figure 42.–Mean BMI density (± 1 SD) at Lower Subarctic Creek, 2021–2024.

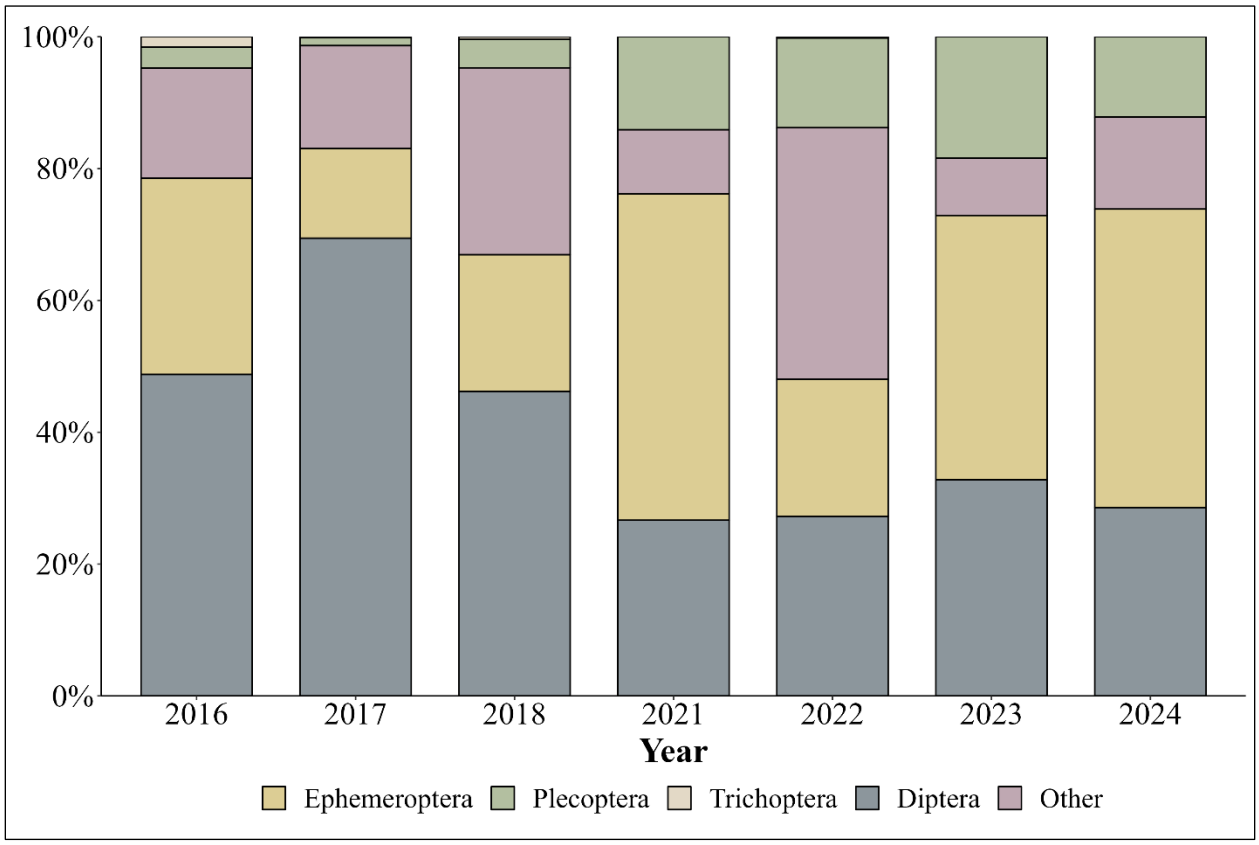

Figure 43.–Mean percent EPT, aquatic Diptera, and other taxa in Lower Subarctic Creek BMI samples, 2016–2024.

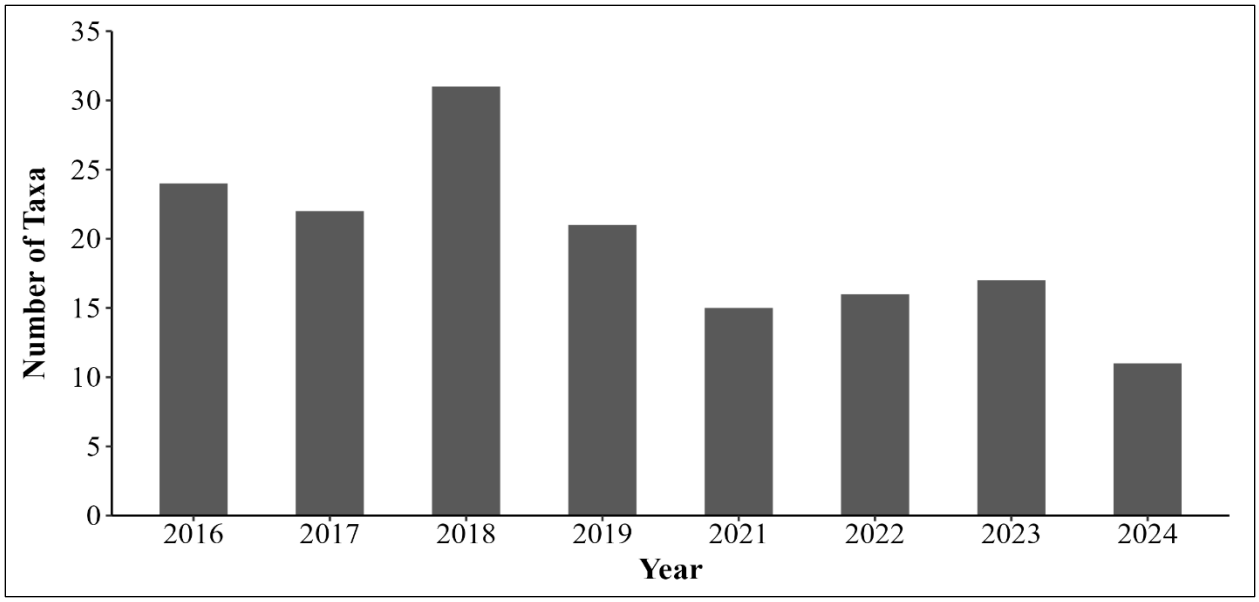

Figure 44.–Taxa richness in Lower Subarctic Creek BMI samples, 2016–2024.

Fish Captures

A total of 7 Dolly Varden and 5 slimy sculpin were captured in Lower Subarctic Creek in 2024. These catches are similar to previous years except for 2019 when 31 Dolly Varden were captured and 2023 when 20 slimy sculpin were captured (Figure 48). The Dolly Varden captured consist of multiple length classes ranging from 65–160 mm fork length with a mean of 102.1 mm (SD = 25; Figure 49). The majority of slimy sculpin captured fell within the 60–75 mm length classes resulting in a normal distribution with a mean of 63.8 mm (SD = 9.15; Figure 49). All fish capture data are presented in Appendix 5.

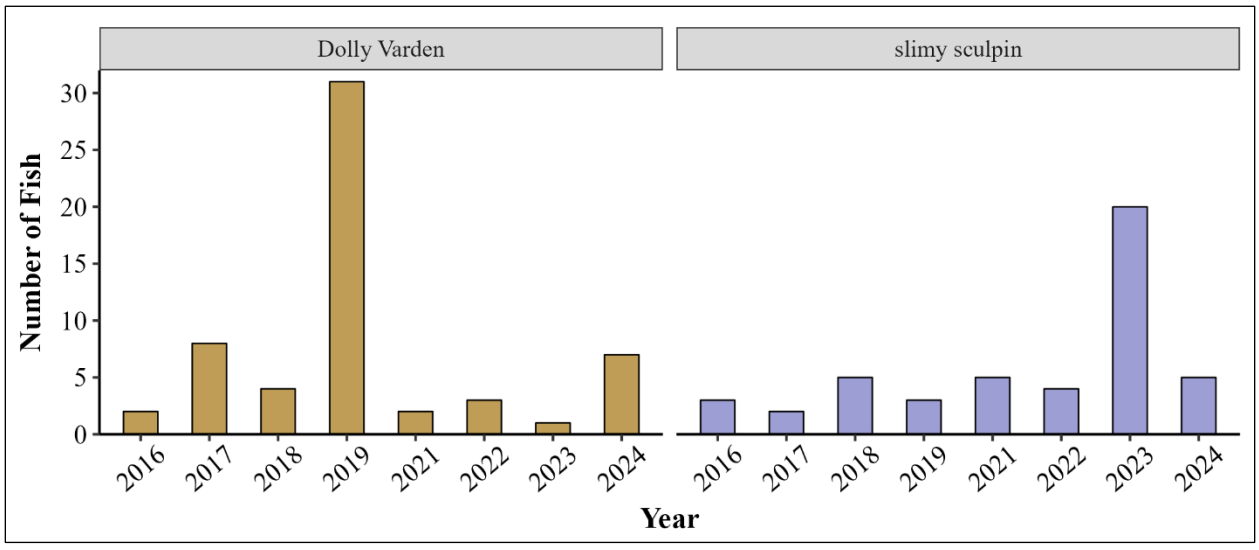

Figure 45.–Total number of fish captured in Lower Subarctic Creek, 2016–2024.

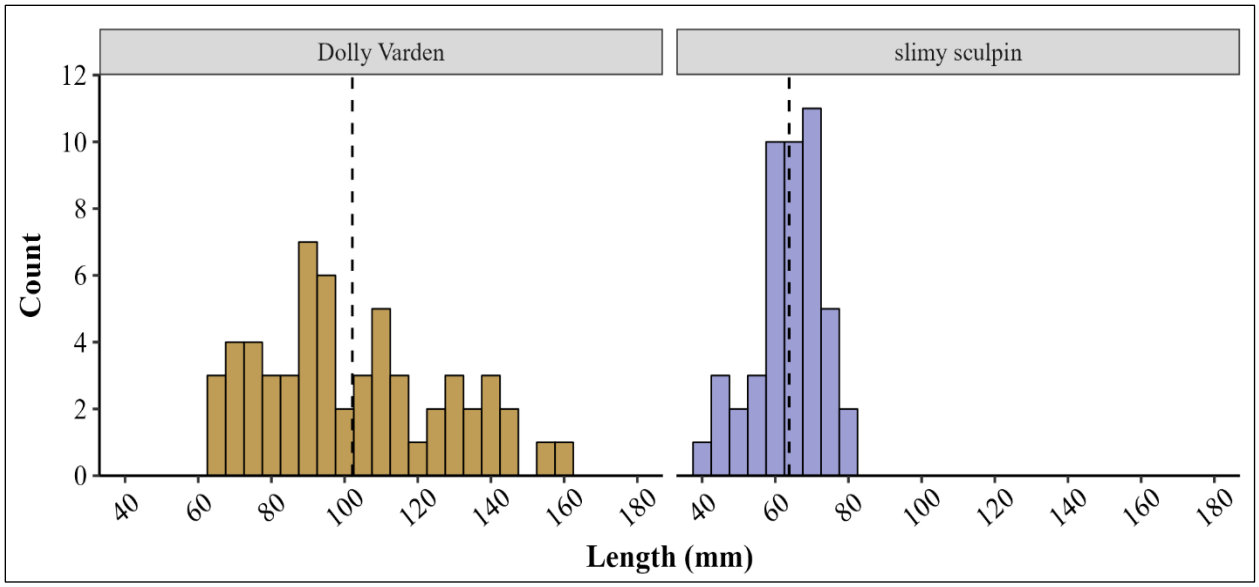

Figure 46.–Length frequency for all fish captured in minnow traps from Lower Subarctic Creek, 2016–2024. Dolly Varden are measured to fork length and slimy sculpin are measured to total length. The vertical dashed line represents the sample mean length.

UPPER RUBY CREEK

Water Quality

In July 2024, the pH was 8.14, the water temperature was 8.4°C, and the dissolved oxygen was 10.88 mg/L in Upper Ruby Creek. This is the first year in-situ data were collected at this site. All in-situ water quality data are presented in Appendix 2.

Periphyton

In 2024, mean chlorophyll-a concentration in Upper Ruby Creek was 28.88 mg/m^2 (SD = 23.35). This value is the lowest mean on record since 2017, but the range of sample values remained similar to the previous 3 years (Figure 51). Mean chlorophyll-a values starting in 2018 have been 3 to 6 times those recorded in 2016 and 2017, but the variability among individual samples is much more pronounced starting in 2018 (Figure 51). Periphyton data from 2024 are presented in Appendix 3.

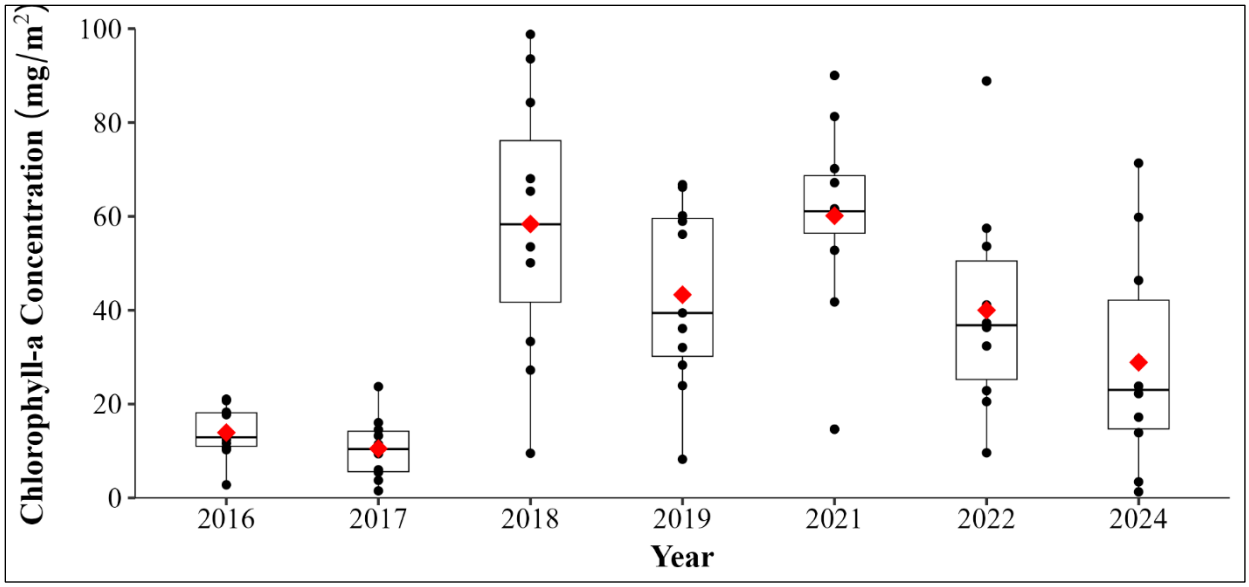

Figure 47.–Chlorophyll-a concentration boxplot by year at Upper Ruby Creek, 2016–2024. Raw data are depicted by black dots and mean values are depicted in red.

Benthic Macroinvertebrates

Mean BMI density in Upper Ruby Creek in 2024 was the lowest on record at 1,133/m^2 (SD = 336) which is a small fraction of the mean densities in 2021 and 2022 (Figure 52). Taxa composition has varied among years, but Diptera have exceeded EPT taxa in all years of data (Figure 53). EPT taxa composition was the highest on record in 2024 at 23% of the samples. Previously, EPT taxa composition ranged from 3% in 2018, 2019, and 2021 to 13% in 2016 (Figure 53). Conversely, taxa richness has remained within a small range of 22 in 2021 to 28 in 2017 (Figure 54). BMI data from 2024 are presented in Appendix 4.

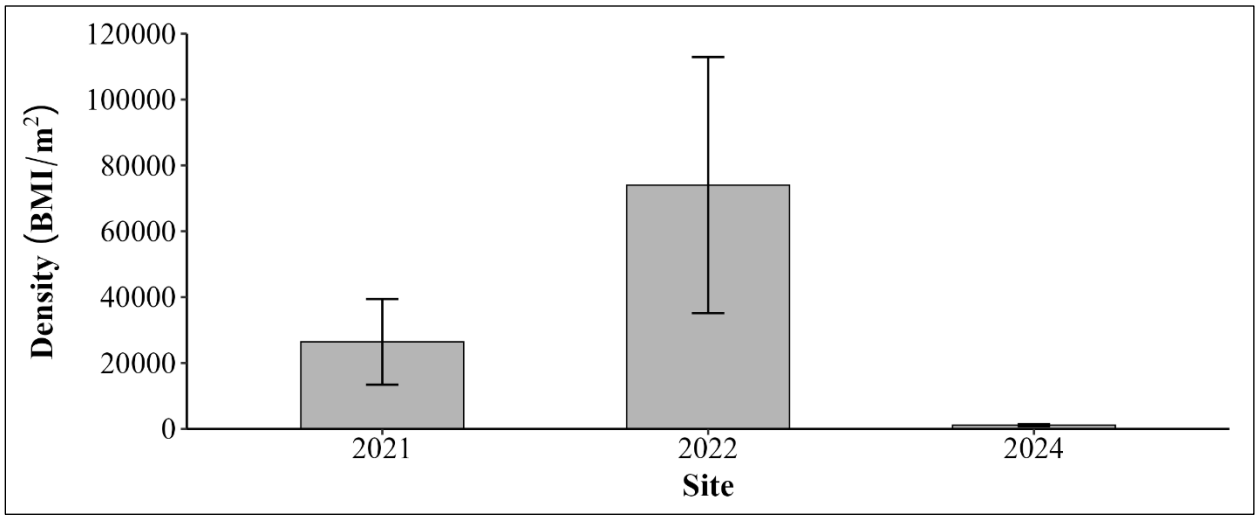

Figure 48.–Mean BMI density (± 1 SD) at Upper Ruby Creek, 2021–2024. Not sampled in 2023.

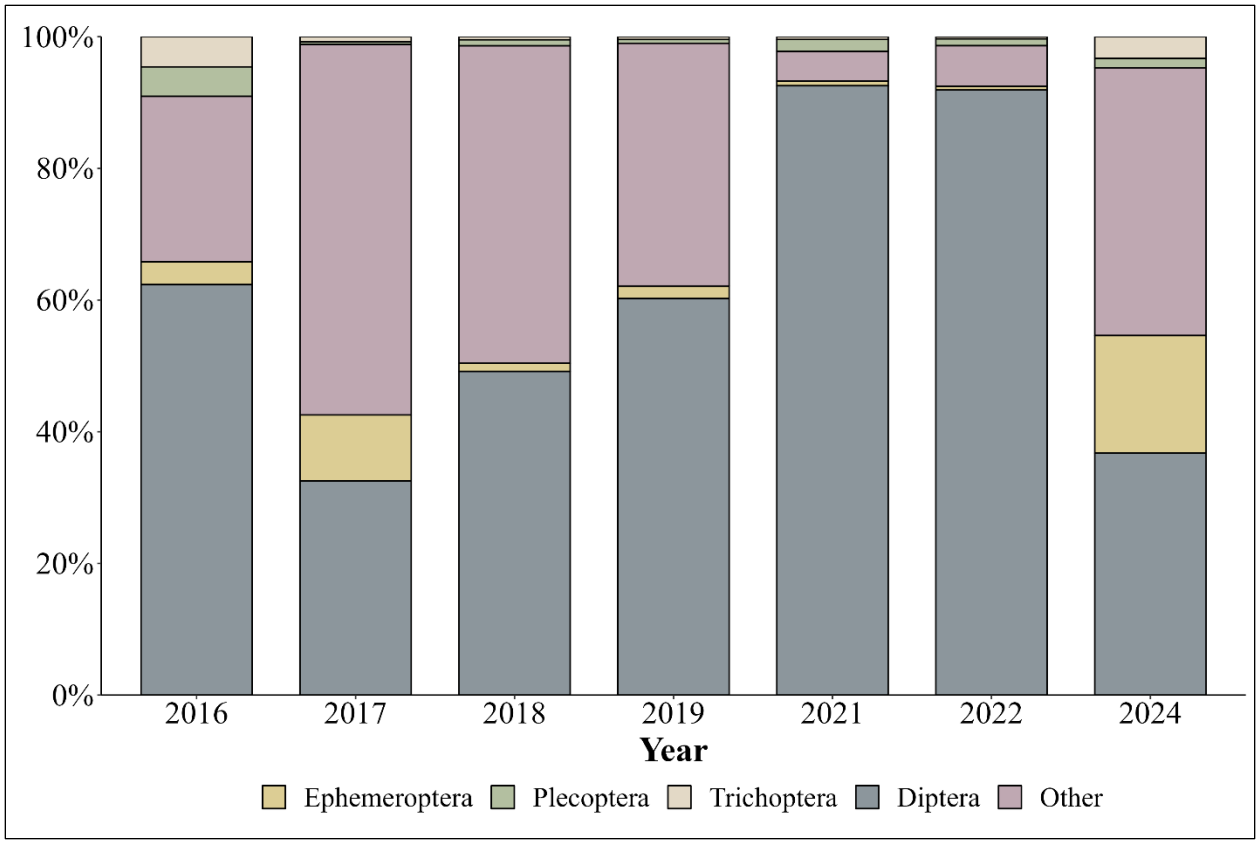

Figure 49.–Mean percent EPT, aquatic Diptera, and other taxa in Upper Ruby Creek BMI samples, 2016–2024.

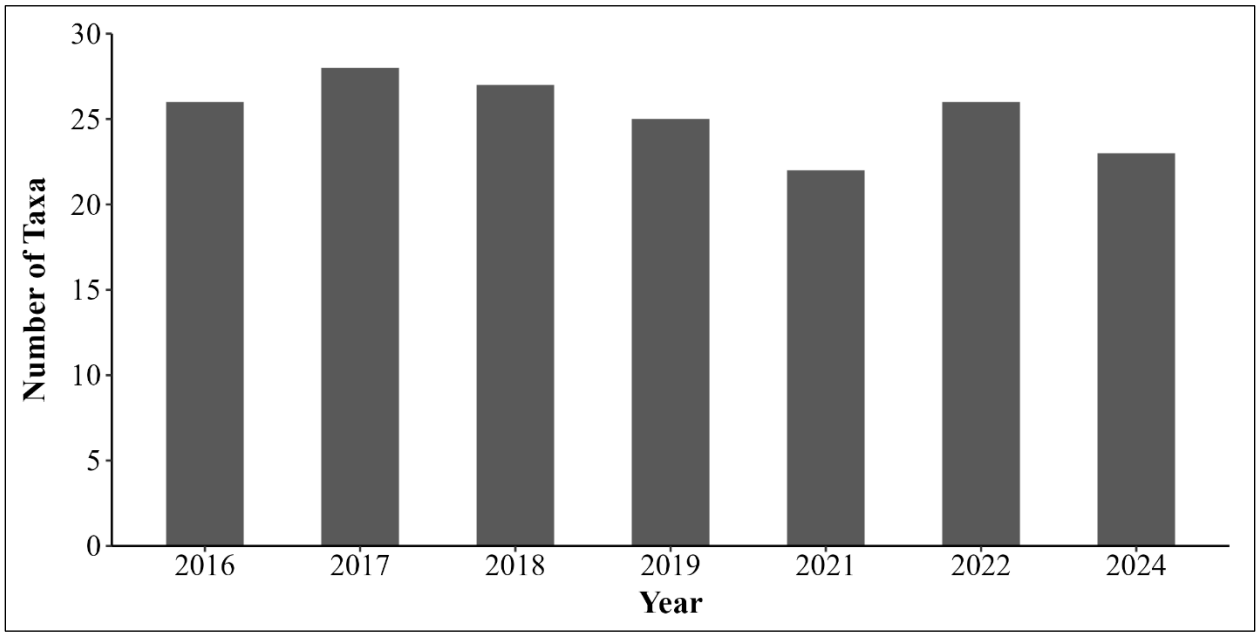

Figure 50.–Taxa richness in Upper Ruby Creek BMI samples, 2016–2024.

Fish Captures

Slimy sculpin continued to comprise the majority of fish captures in Upper Ruby Creek in 2024. A total of 38 slimy sculpin and 1 Dolly Varden were captured in 2024, which are similar to previous years' catches except for 2017 when 61 slimy sculpin were captured (Figure 55). The majority of Dolly Varden captured have been greater than 110 mm fork length with a mean of 141.3 mm (SD = 30.3; Figure 56). Slimy sculpin length frequency exhibits a normal distribution with a range of 28–100 mm total length and a mean of 75.1 mm (SD = 11.5; Figure 56). All fish capture data are presented in Appendix 5.

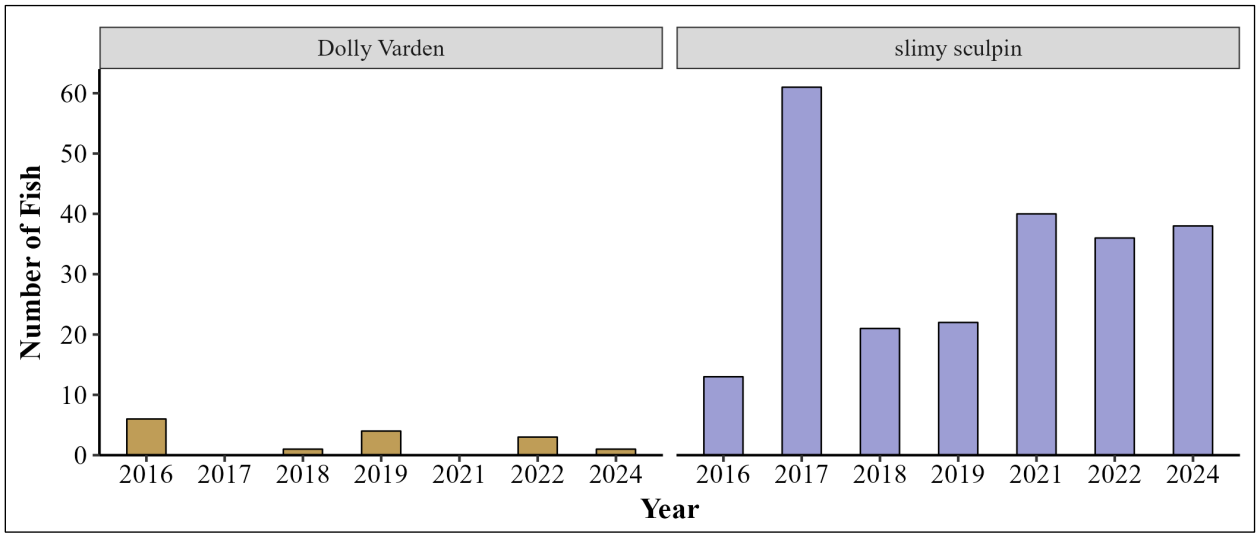

Figure 51.–Total number of fish captured in Upper Ruby Creek, 2016–2024.

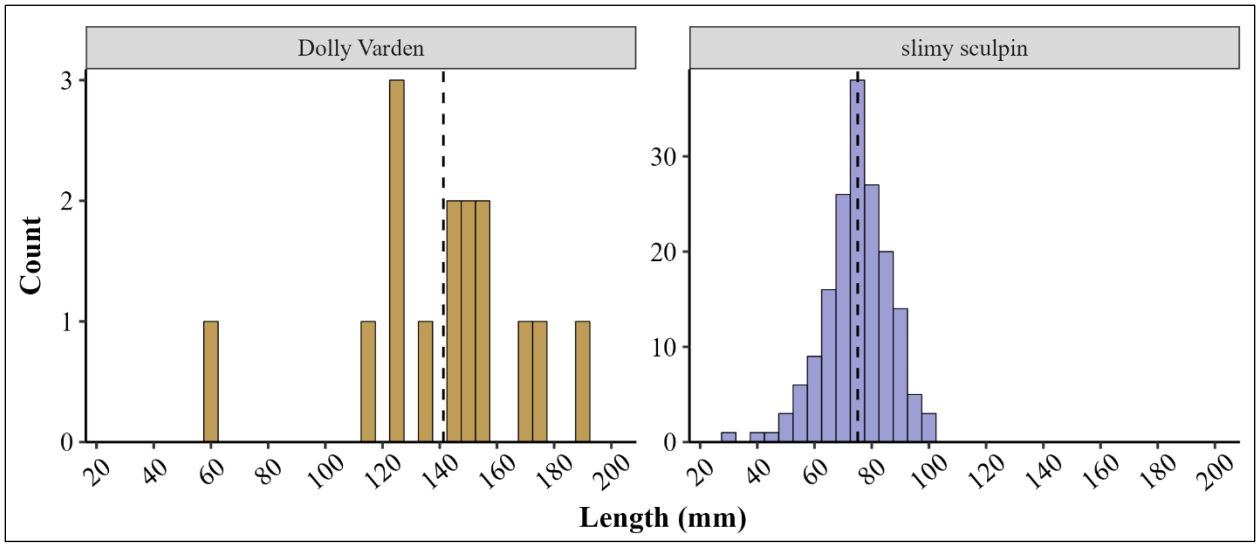

Figure 52.–Length frequency for all fish captured in minnow traps from Upper Ruby Creek, 2016–2024. Dolly Varden are measured to fork length and slimy sculpin are measured to total length. The vertical dashed line represents the sample mean length. Note difference in y-axis scale between species.

JAY CREEK

Water Quality

In July 2024, the pH was 7.81, the water temperature was 6.7°C, and the dissolved oxygen was 11.63 mg/L in Jay Creek. Water temperature has ranged from 5.6–7.0°C. Other water quality parameters have remained similar among years. All in situ water quality data are presented in Appendix 2.

Periphyton

In 2024, mean chlorophyll-a concentration in Jay Creek was 3.05 mg/m^2 (SD = 2.05). This value is similar to the majority of previous years' means (Figure 57). Notably higher means in 2017 and 2021 are likely due to two high value concentrations in the data (Figure 57). Periphyton data from 2024 are presented in Appendix 3.

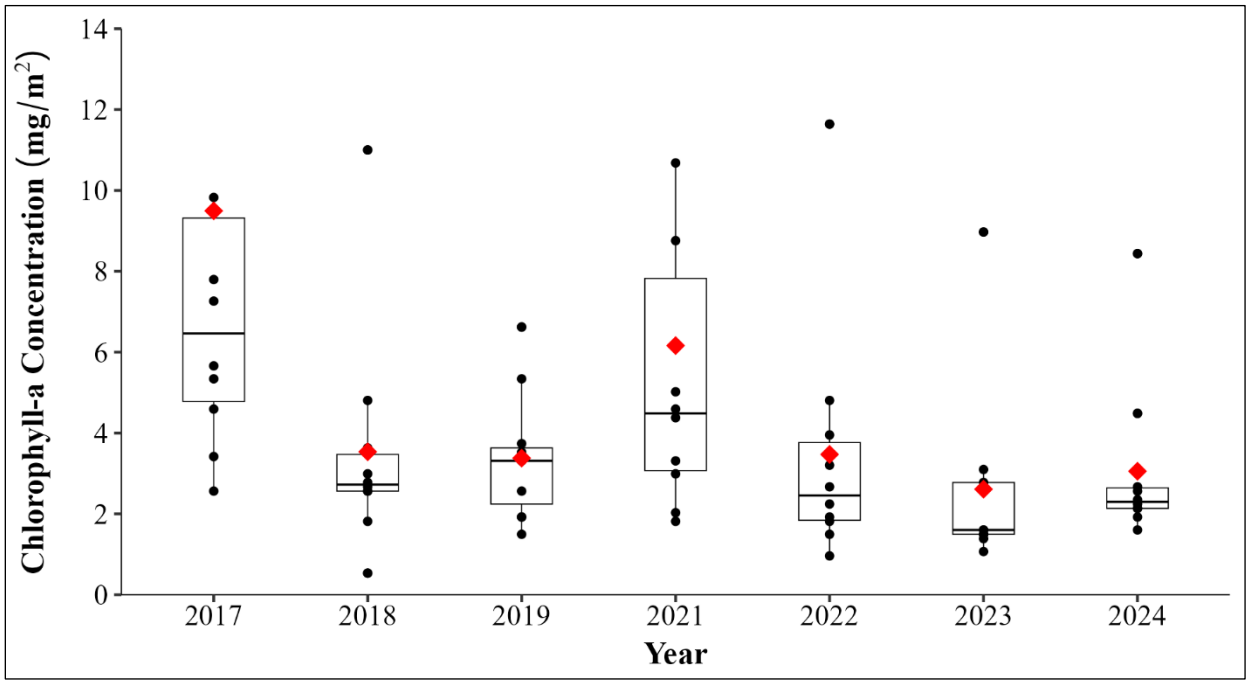

Figure 53.–Chlorophyll-a concentration boxplot by year at Jay Creek, 2017–2024. Raw data are depicted by black dots and mean values are depicted in red. Note that two high values from 2017 (21.78 and 26.7 mg/m^2) and one high value from 2021 (18.05 mg/m^2) are excluded from this plot but not from statistical analyses.

Benthic Macroinvertebrates

Mean BMI density in 2024 was 2,627/m^2 (SD = 632) which is similar to the mean in 2023 and falls within the range among all years of data (Figure 58). Taxa composition has varied among years. The proportion of EPT taxa was 48% of the sample in 2024 exceeding the proportion of

Diptera for the second time among all years of data (Figure 59). Although taxa richness was the lowest on record in 2024 at 19, taxa richness has remained within a small range of 19–26 among years (Figure 60). BMI data from 2024 are presented in Appendix 4.

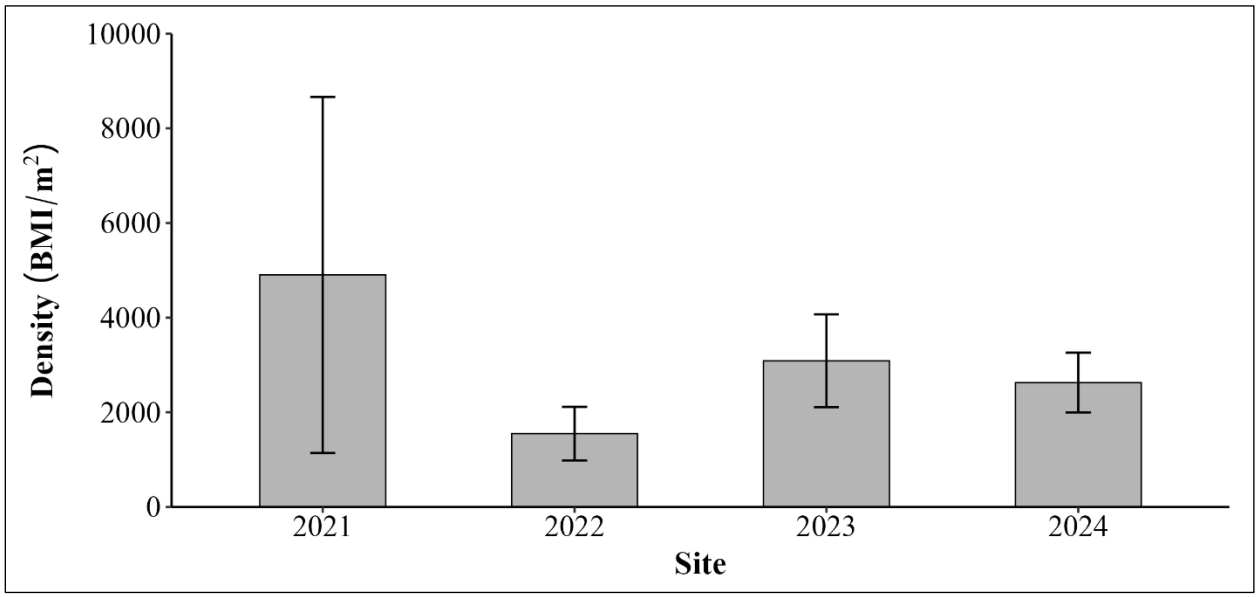

Figure 54.–Mean BMI density (± 1 SD) at Jay Creek, 2021–2024.

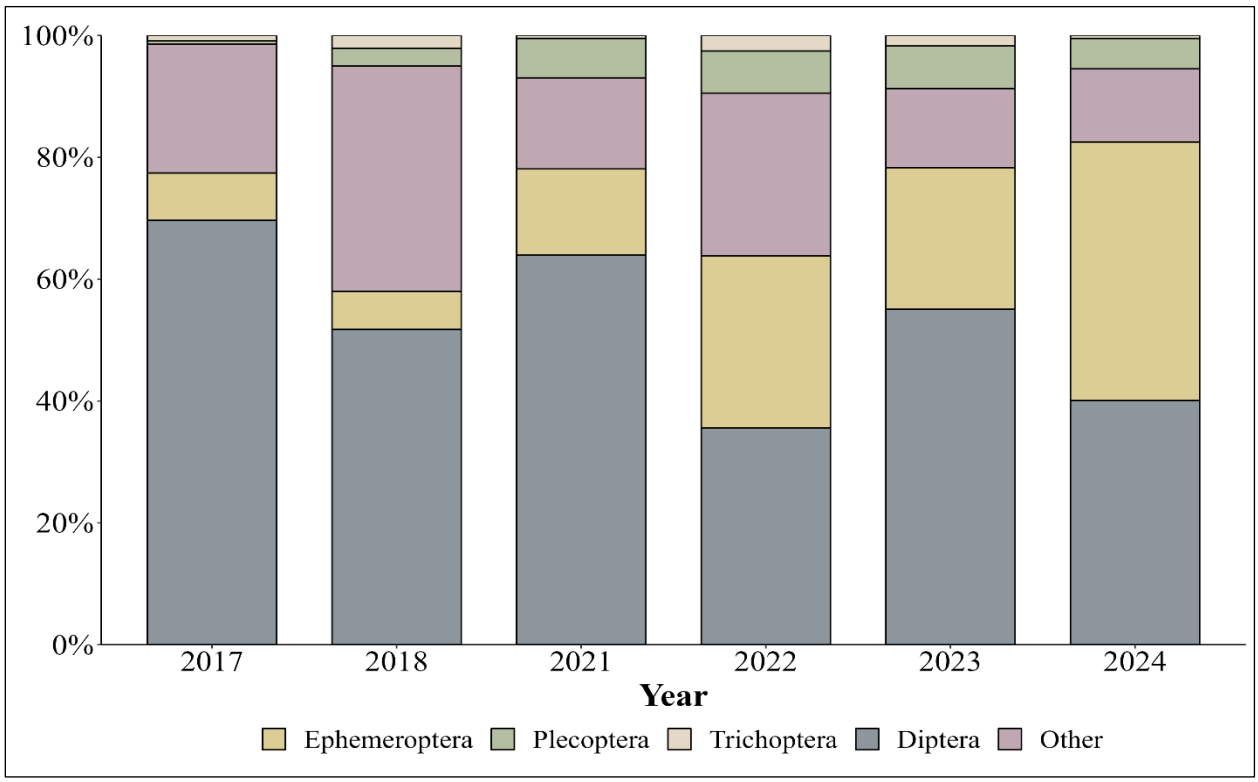

Figure 55.–Mean percent EPT, aquatic Diptera, and other taxa in Jay Creek BMI samples, 2017–2024.

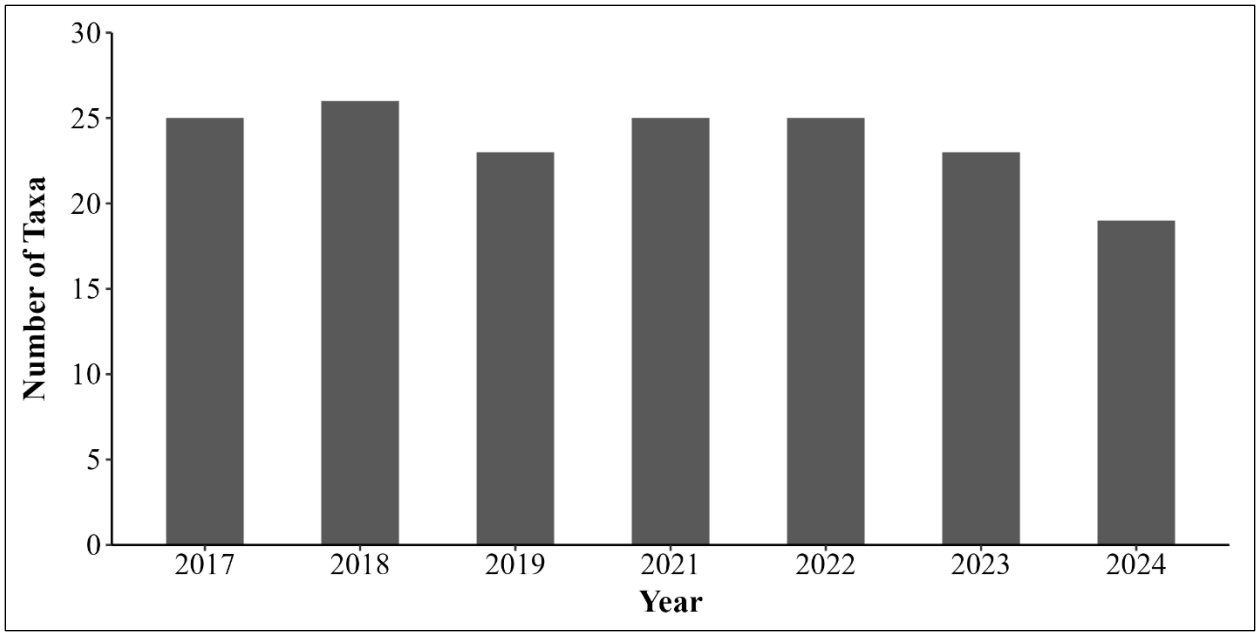

Figure 56.–Taxa richness in Jay Creek BMI samples, 2017–2024.

Fish Captures

Dolly Varden have been the only fish species captured in Jay Creek since sampling began here in 2018. Catches have been generally low with just 1 Dolly Varden captured in 2024 (Figure 61). Previous years' total catch ranges from 2–11 individuals. The length frequency exhibits a uniform distribution with a range of 79–168 mm and a mean of 124.5 mm fork length (SD = 25.6; Figure 62). All fish capture data are presented in Appendix 5.

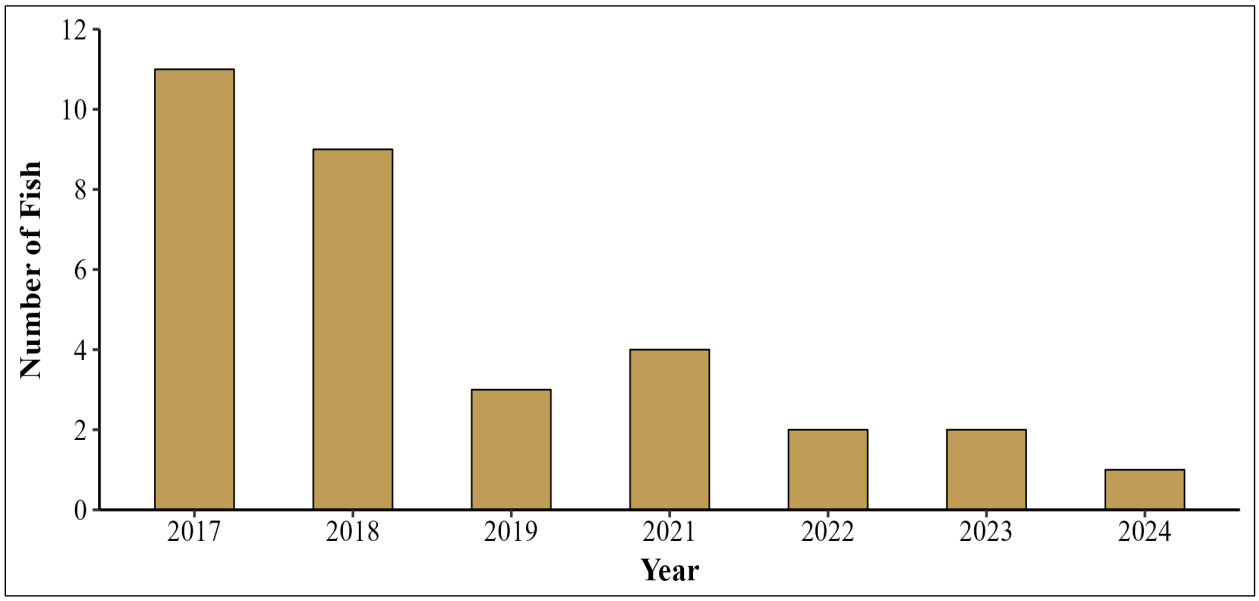

Figure 57.–Total number of fish captured in Jay Creek, 2018–2024.

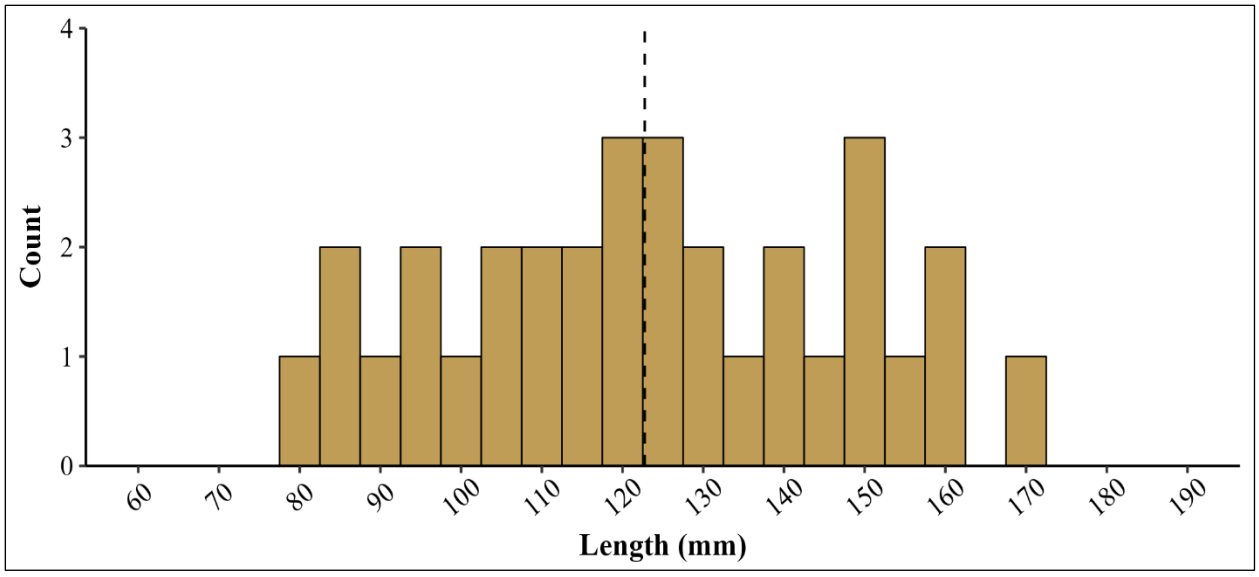

Figure 58.–Length frequency for Dolly Varden captured in minnow traps from Jay Creek, 2018–2024. The vertical dashed line represents the sample mean length.

LOWER RUBY CREEK

Water Quality

Element Concentration

Mean copper and total dissolved solids (TDS) values have remained similar among years, while mean cadmium, mercury, selenium, and zinc have shown more variability. However, in recent years some parameters only have one data point due to limited sampling (Figure 63). All water quality samples collected in Lower Ruby Creek have been below the acute aquatic life exposure limit for element concentrations (Appendix 1). Water quality element concentration data and associated sample dates are presented in Appendix 1.

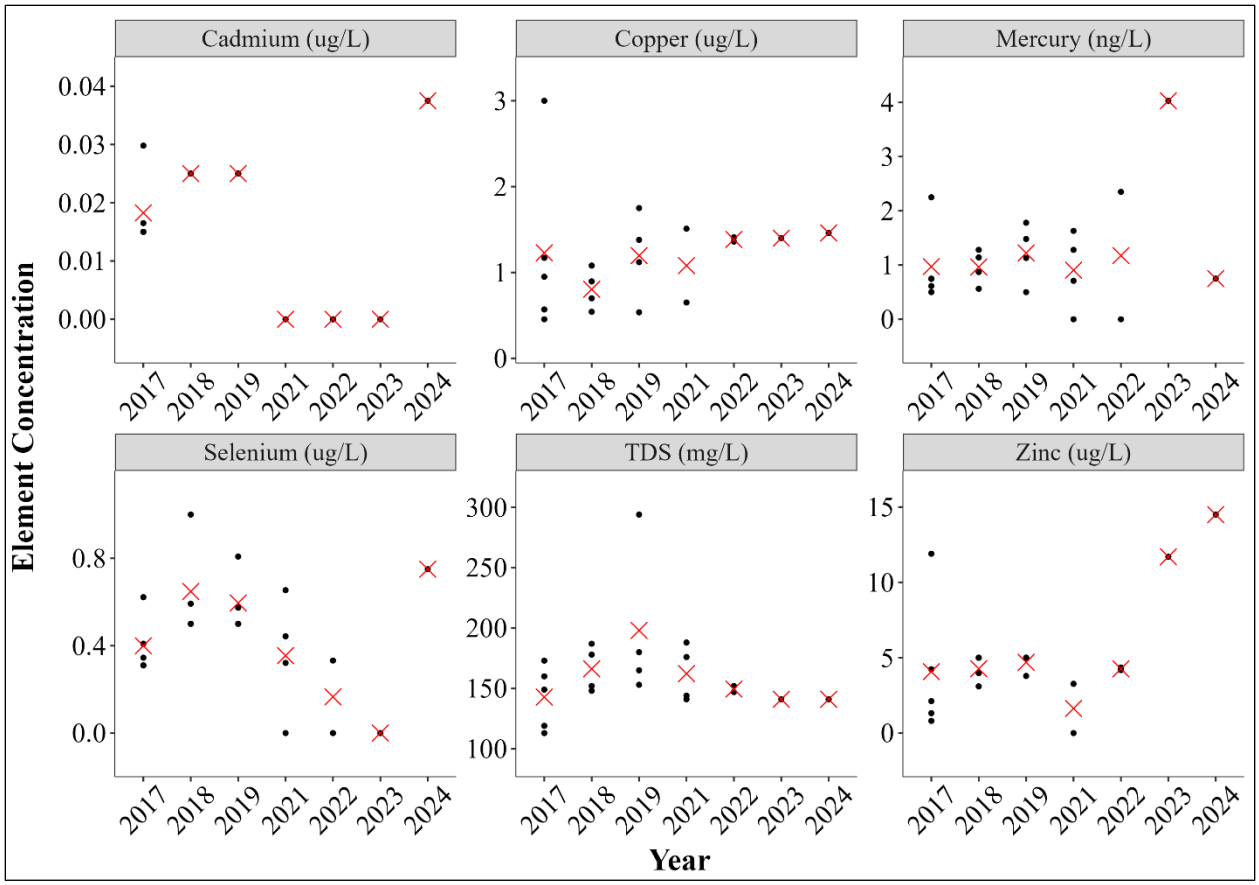

Figure 59.–Total recoverable element concentration data from water samples by year at Lower Ruby Creek, 2017–2024. Raw data are depicted by black dots and mean values are depicted in red.

In-Situ Data

In July 2024, the pH was 8.03, the water temperature was 8.6°C, and the dissolved oxygen was 10.52 mg/L in Lower Ruby Creek. Water temperature in 2024 was four degrees cooler than in 2022, likely due to recent rain and subsequent high water conditions. Other water quality parameters have remained similar among years. All in situ water quality data are presented in Appendix 2.

Benthic Macroinvertebrates

Mean BMI density in 2024 was the lowest on record at 330/m^2 (SD = 122) and is approximately one third of the density recorded in 2023 (Figure 65). Previously, BMI density ranged from 1,147/m^2 in 2021 to 4,793/m^2 in 2022. Diptera or other taxa have dominated sample composition in all years of data (Figure 66). EPT taxa proportion has ranged from 4% in 2017 to 17% in 2019, with 2024 falling within this range at 11%. Taxa richness has steadily decreased since 2022. Taxa

richness in 2024 was 10, which is less than one half of the total taxa present in 2022 samples (Figure 67). BMI data from 2024 are presented in Appendix 4.

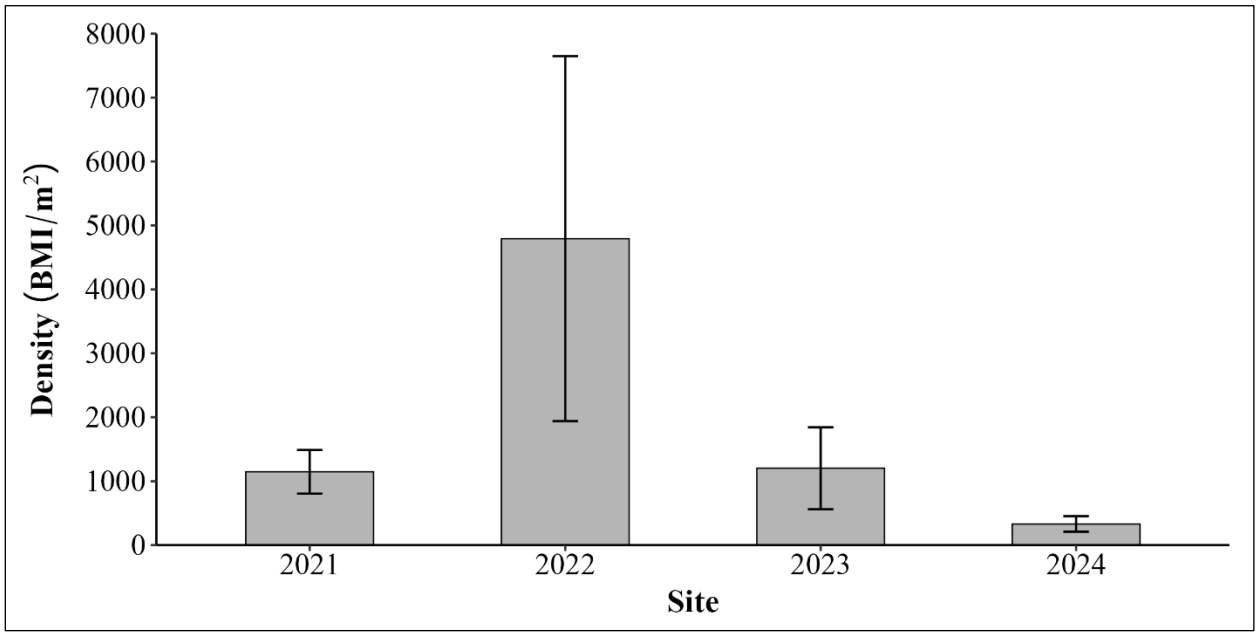

Figure 60.–Mean BMI density (± 1 SD) at Lower Ruby Creek, 2021–2024.

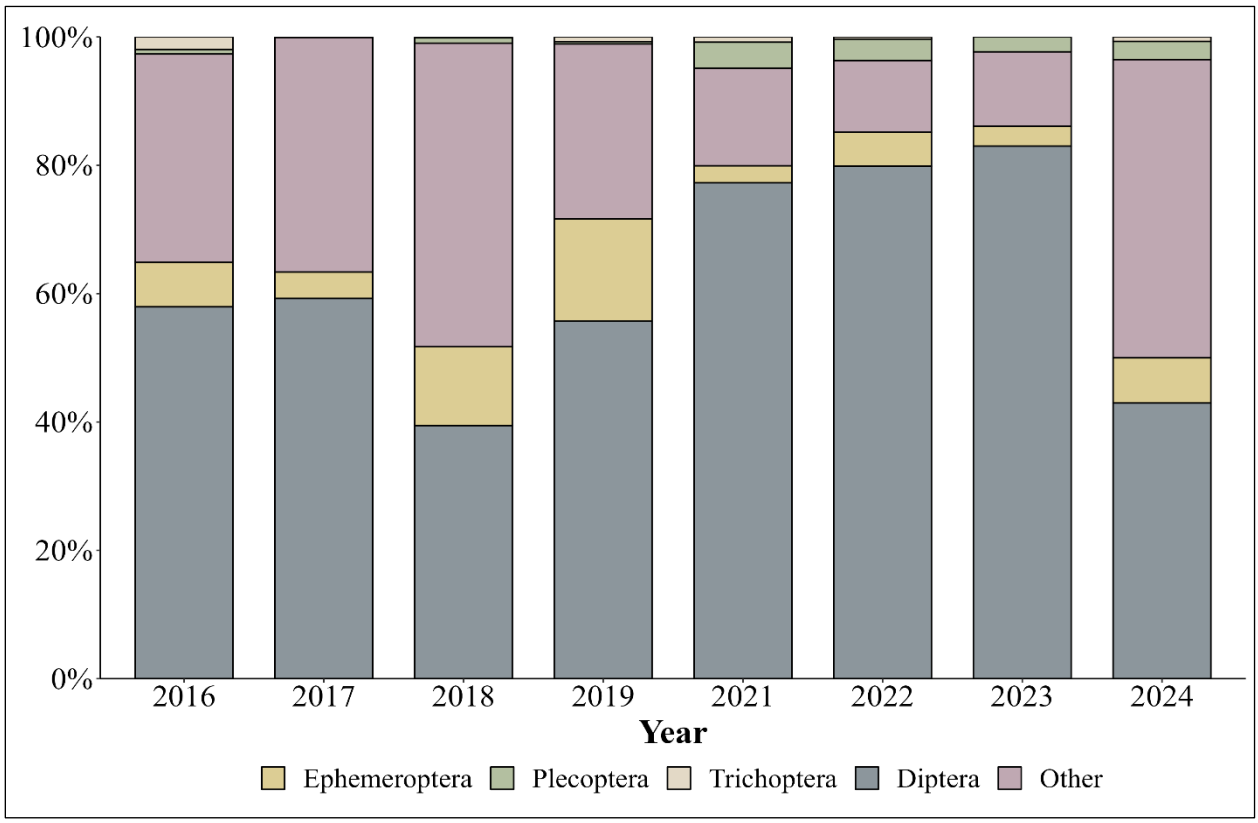

Figure 61.–Mean percent EPT, aquatic Diptera, and other taxa in Lower Ruby Creek BMI samples, 2016–2024.

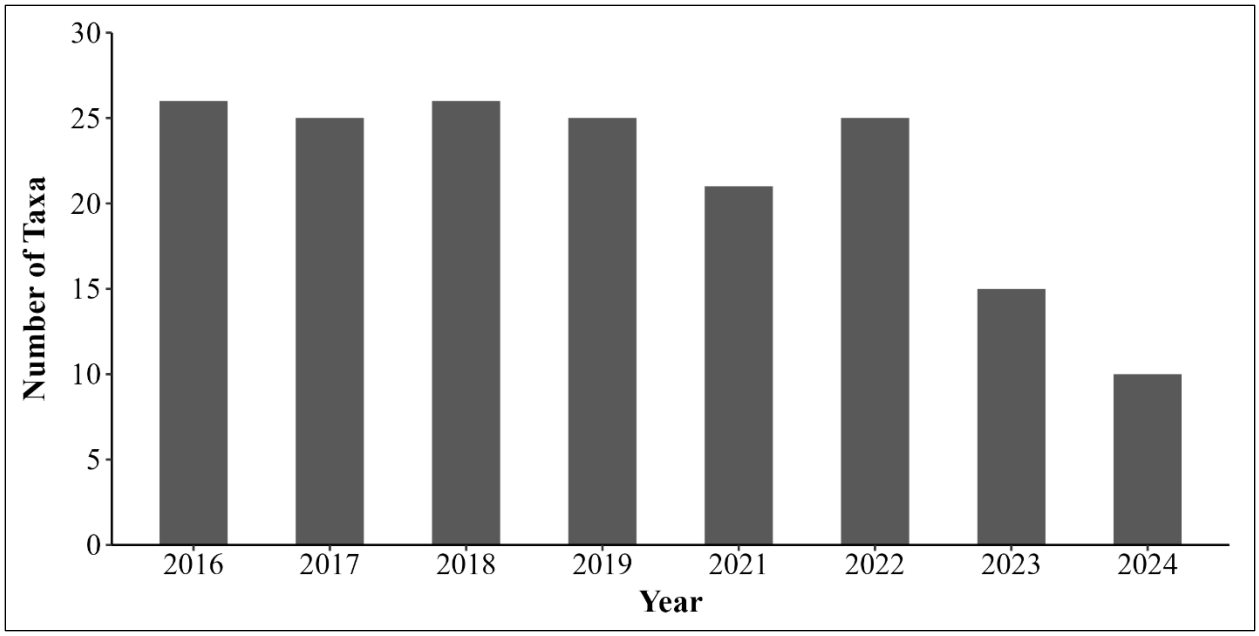

Figure 62.–Taxa richness in Lower Ruby Creek BMI samples, 2016–2024.

Fish Captures

Slimy sculpin continued to comprise the majority of fish captured in Lower Ruby Creek in 2024. A total of 39 slimy sculpin were captured, which is the highest slimy sculpin catch on record, while a total of just 2 Dolly Varden were captured (Figure 68). In most years, no Dolly Varden were captured in Lower Ruby Creek. A small number of other fish species have been previously captured in Lower Ruby Creek including Alaska blackfish in 2018 and 2023, longnose sucker in 2018, and round whitefish in 2019. The Dolly Varden length frequency exhibits a uniform distribution with range of 72–136 mm and a mean of 102.1 mm fork length (SD = 24.7; Figure 69). Slimy sculpin length frequency exhibits a normal distribution with a range of 45–95 mm and a mean of 65.6 mm total length (SD = 9.4; Figure 69). All fish capture data are presented in Appendix 5.

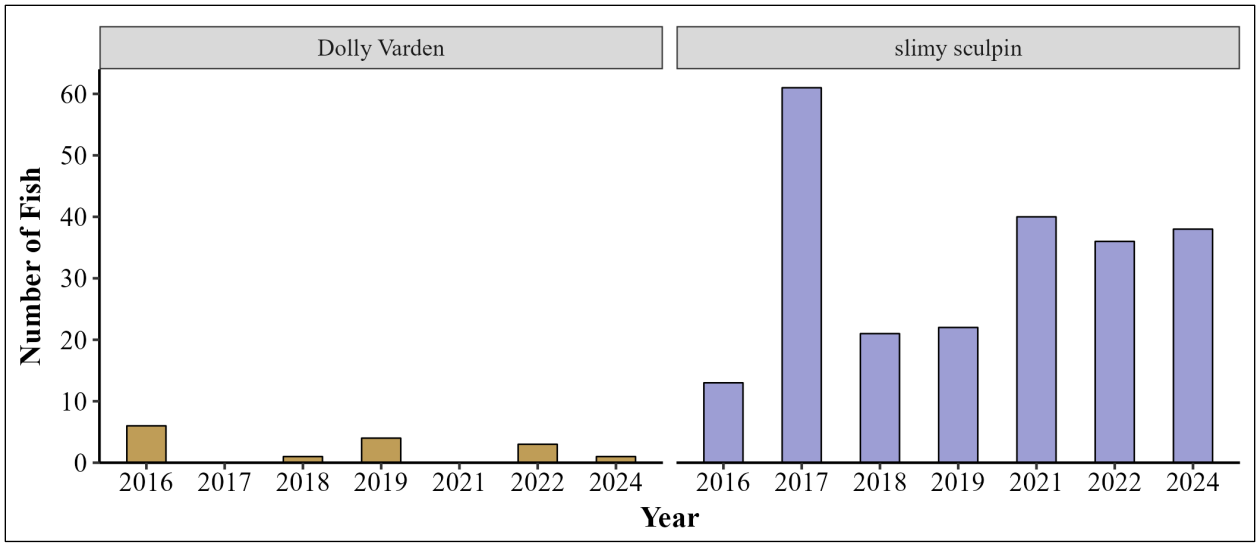

Figure 63.–Total number of fish captured in Lower Ruby Creek, 2016–2024.

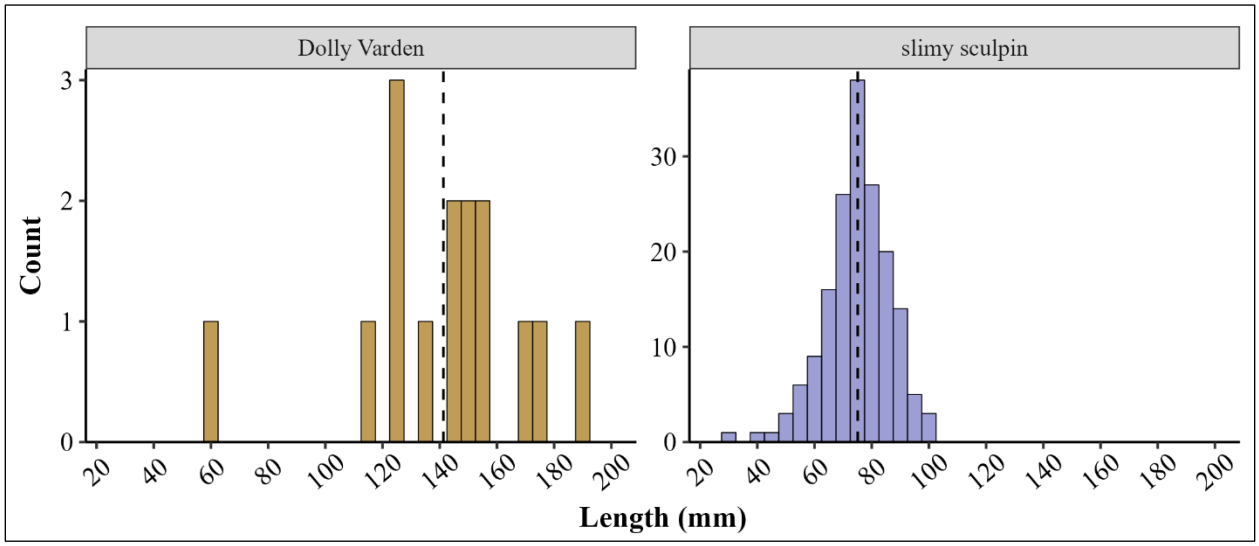

Figure 64.–Length frequency for all fish captured in minnow traps from Lower Ruby Creek, 2016–2024. Dolly Varden are measured to fork length and slimy sculpin are measured to total length. The vertical dashed line represents the sample mean length. Note difference in y-axis scale between species.

Fish Metals

Fifteen slimy sculpin were retained from Lower Ruby Creek for element analysis in 2024. Mean concentrations for all elements analyzed fell between previous years' means except for zinc which was the lowest mean on record (Figure 70). In general element concentrations have remained consistent among years.Mean element concentrations in slimy sculpin from Lower Ruby Creek in 2024 are as follows: cadmium was 0.20 mg/kg (SD = 0.17); copper was 3.09 mg/kg (SD = 0.80); mercury was 0.25 mg/kg (SD = 0.10); selenium was 4.78 mg/kg (SD = 1.09); and zinc was 110.81 mg/kg (SD = 28.19). Element analysis data from 2024 are presented in Appendix 6.

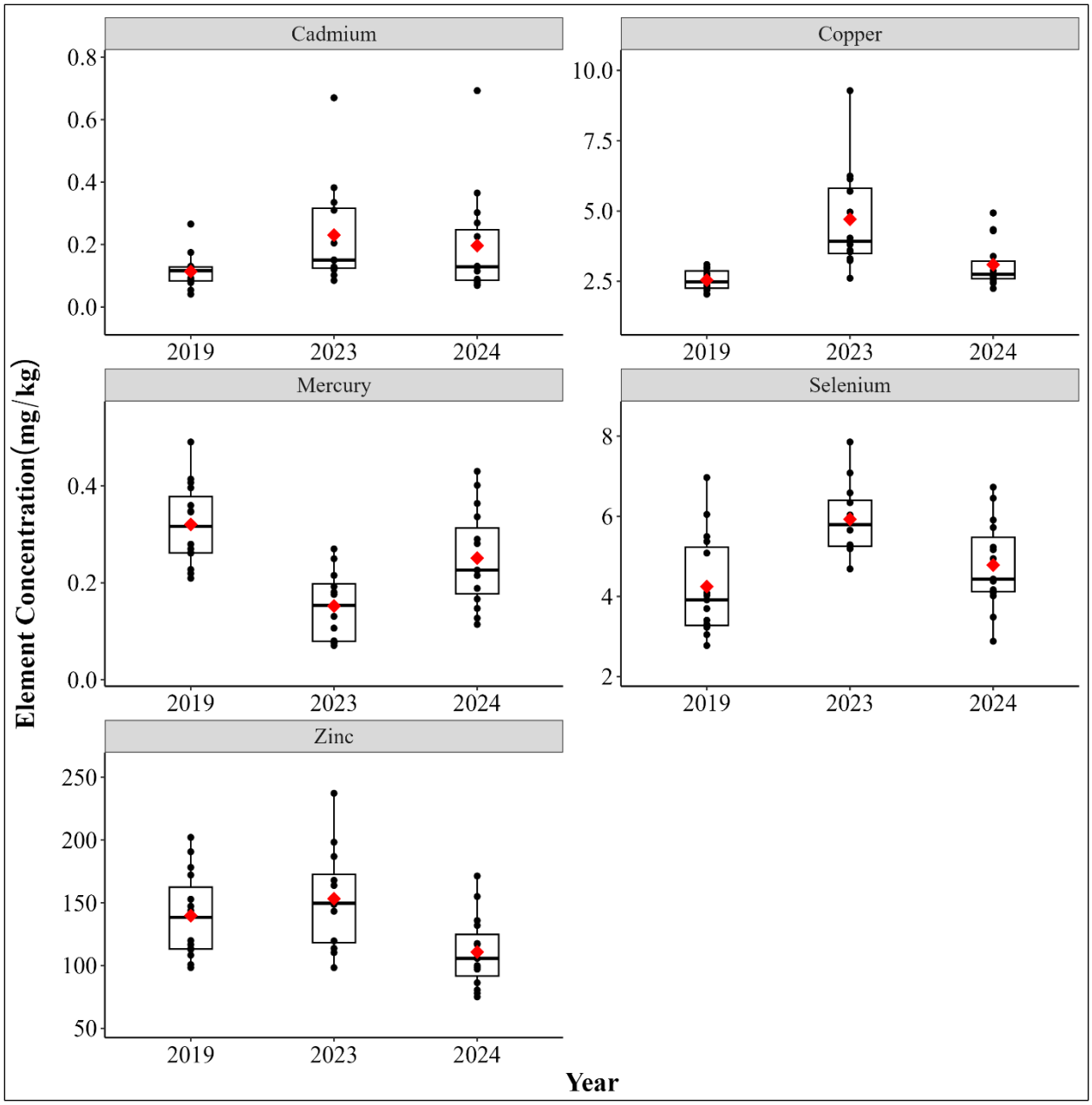

Figure 65.–Boxplots depicting element concentration data for slimy sculpin captured in Lower Ruby Creek, 2019–2024. Raw data are in black dots and mean values are depicted in red. Note that y-axis scales vary among elements.

RILEY CREEK

Water Quality

In July 2024, the pH was 8.37, the water temperature was 4.6°C, and the dissolved oxygen was 12.04 mg/L in Riley Creek. Water quality parameters have remained similar among years. All in situ water quality data are presented in Appendix 2.

Periphyton

In 2024, mean chlorophyll-a concentration in Riley Creek was 2.19 mg/m^2 (SD = 1.44). This value is similar to all years' means since 2018 (Figure 72). Notably higher means in 2016 and 2017 are due to high value concentrations in the data (Figure 72). Periphyton data from 2024 are presented in Appendix 3.

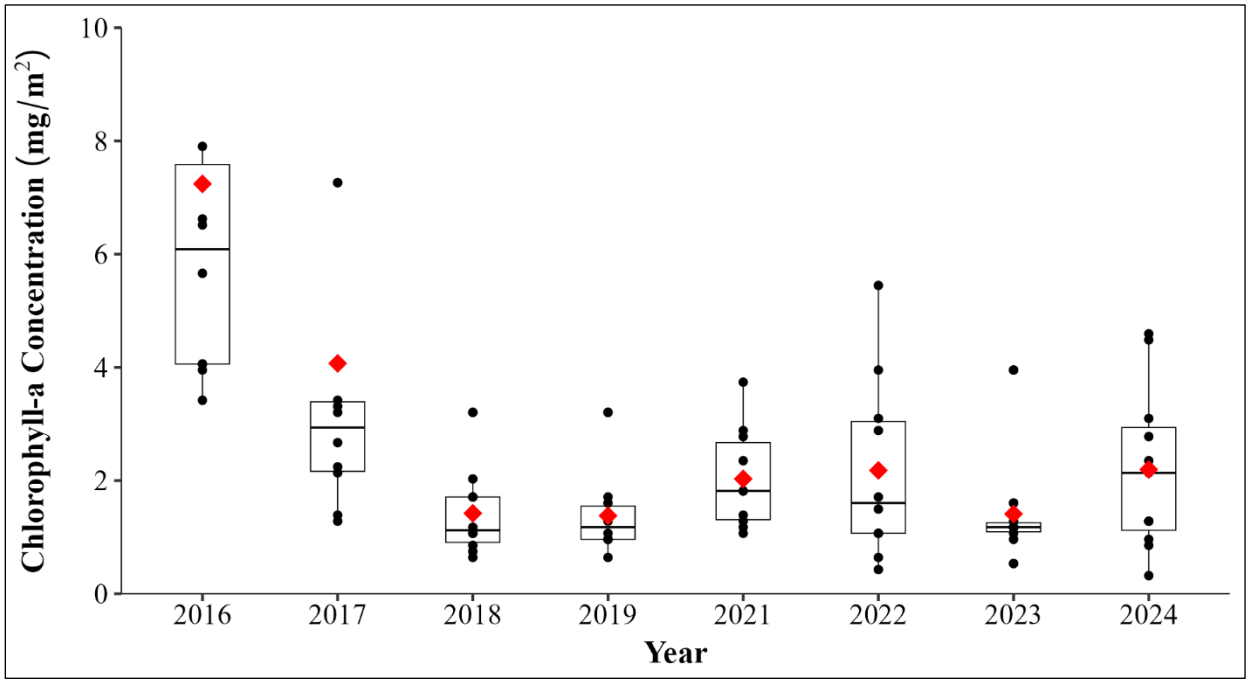

Figure 66.– Chlorophyll-a concentration boxplot by year at Riley Creek, 2016–2024. Raw data are depicted by black dots and mean values are depicted in red. Note that two high values from 2016 (14.2 and 16.02 mg/m^2) and one high value from 2017 (13.78 mg/m^2) are excluded on this plot but not from statistical analyses.

Benthic Macroinvertebrates

Mean BMI density in 2024 at Riley Creek was 5,588/m^2 (SD = 1,114) and has steadily increased since 2021 when the density was 3,105/m^2 (Figure 73). Taxa composition has varied among years, but Diptera have made up the highest proportion of the sample in all years except 2021 when EPT proportion was 49% (Figure 74). The proportions of Diptera and EPT taxa in 2024 were 40% and 23%, respectively. Taxa richness in 2024 was 19 which is within the range among all years of 18–29 (Figure 75). BMI data from 2024 are presented in Appendix 4.

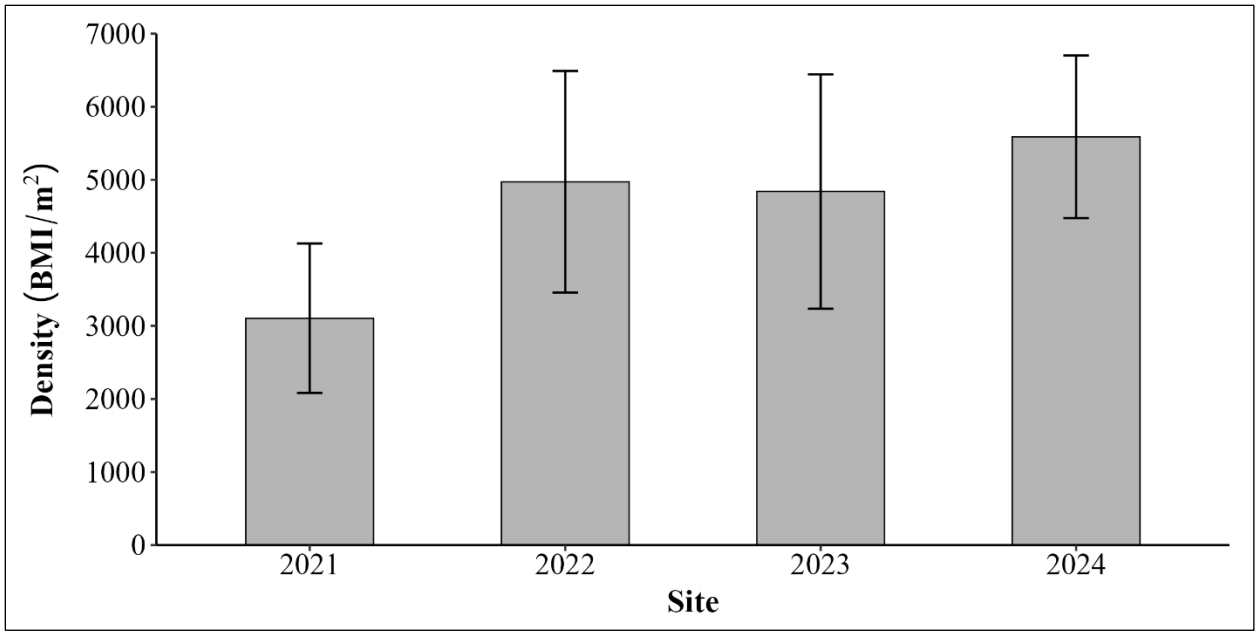

Figure 67.–Mean BMI density (± 1 SD) at Riley Creek, 2021–2024.

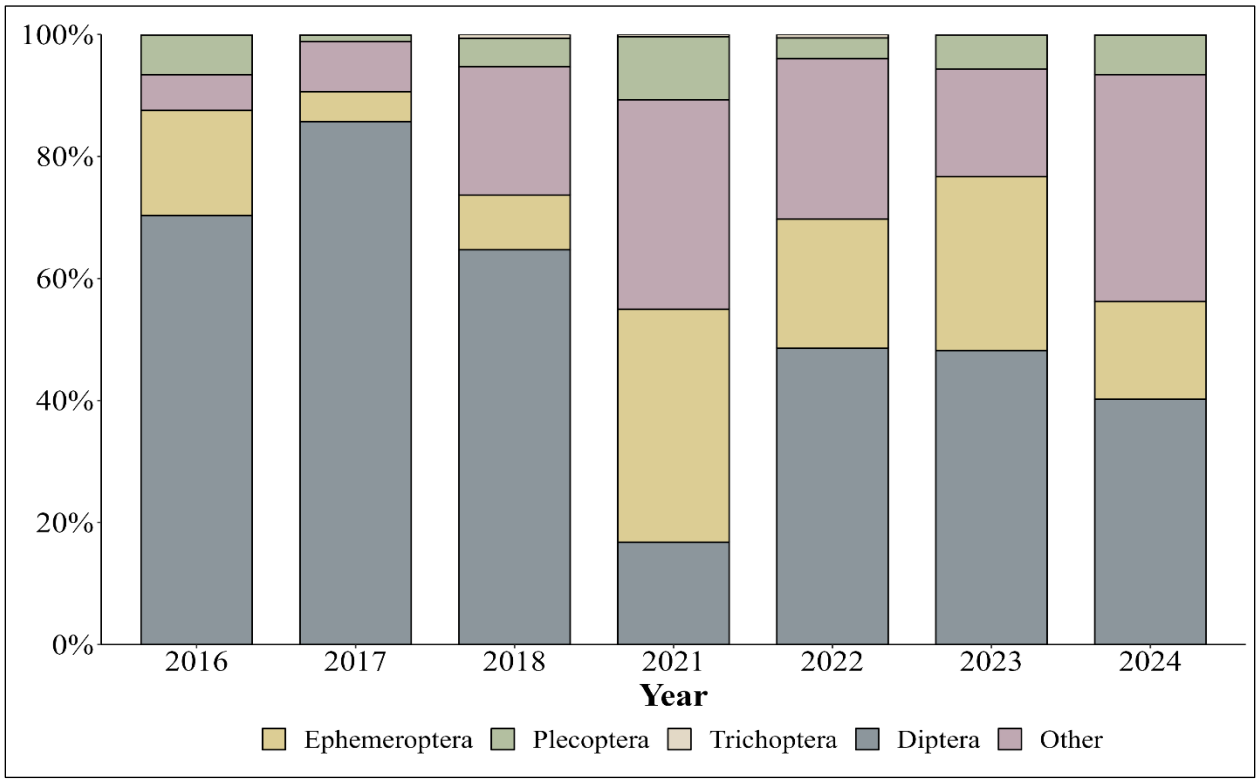

Figure 68.–Mean percent EPT, aquatic Diptera, and other taxa in Riley Creek BMI samples, 2016–2024.

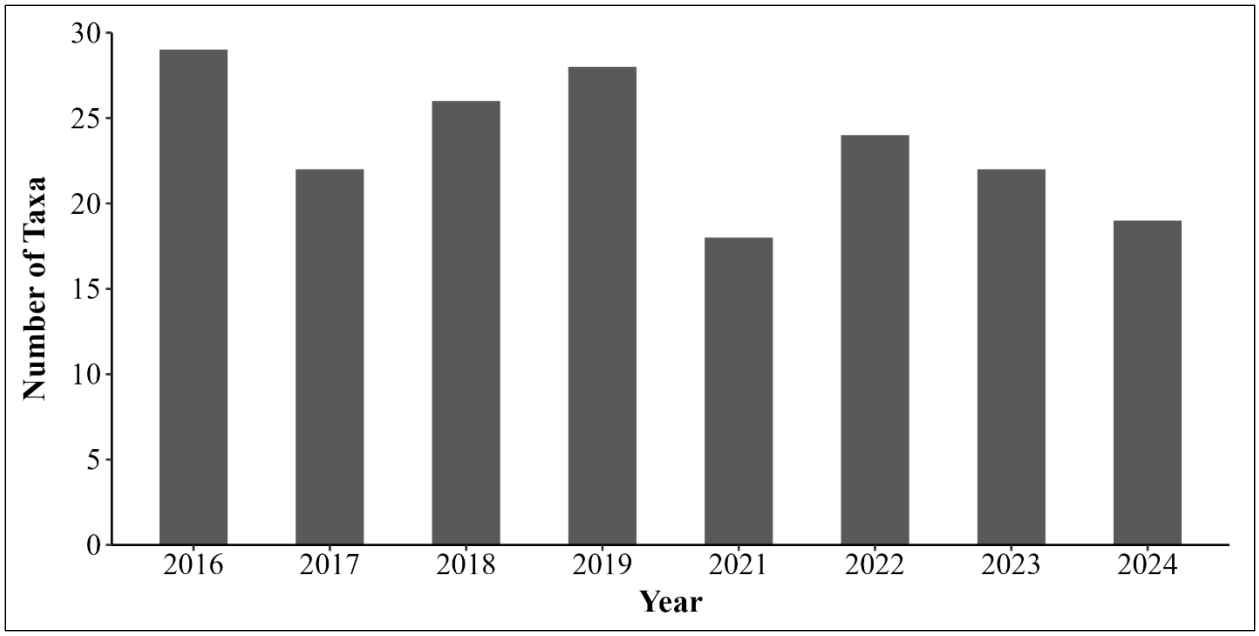

Figure 69.–Taxa richness in Riley Creek BMI samples, 2016–2024.

Fish Captures

A total of 6 Dolly Varden and 13 slimy sculpin were captured in Riley Creek in 2024 which are similar to previous years' catches (Figure 76). Similar numbers of Dolly Varden have been captured across all length categories resulting in a uniform distribution with a range of 60–133 mm and a mean of 89.7 mm fork length (SD = 23.2; Figure 77). Slimy sculpin length frequency exhibits a normal distribution with a range of 45–93 mm and a mean of 65.4 mm total length (SD = 10.4; Figure 77). All fish capture data are presented in Appendix 5.

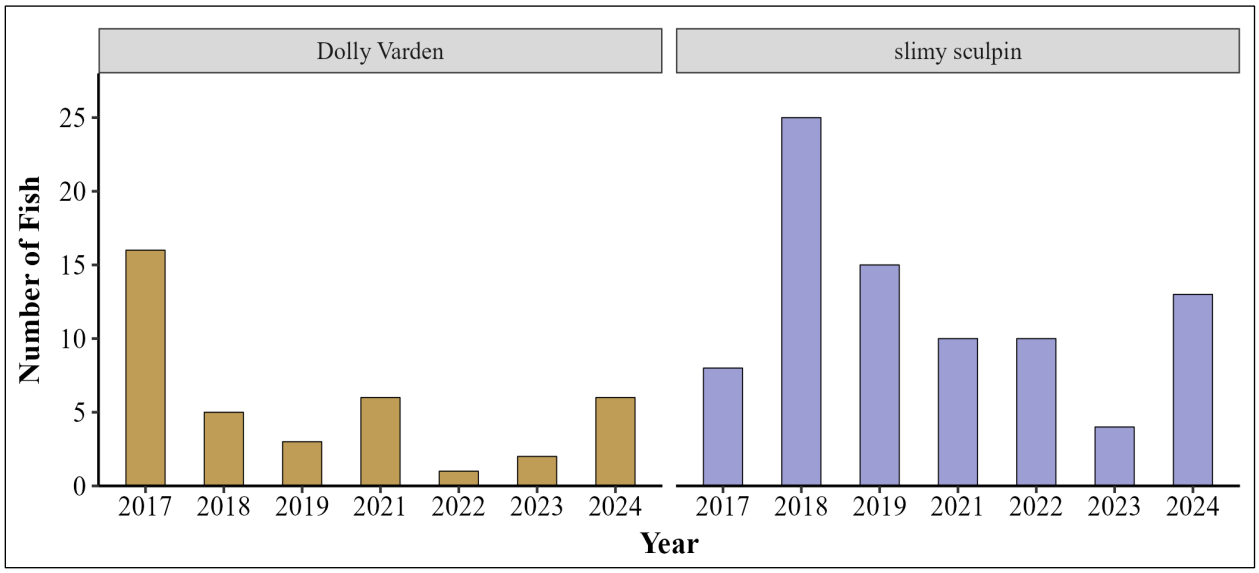

Figure 70.–Total number of fish captured in Riley Creek, 2018–2024.

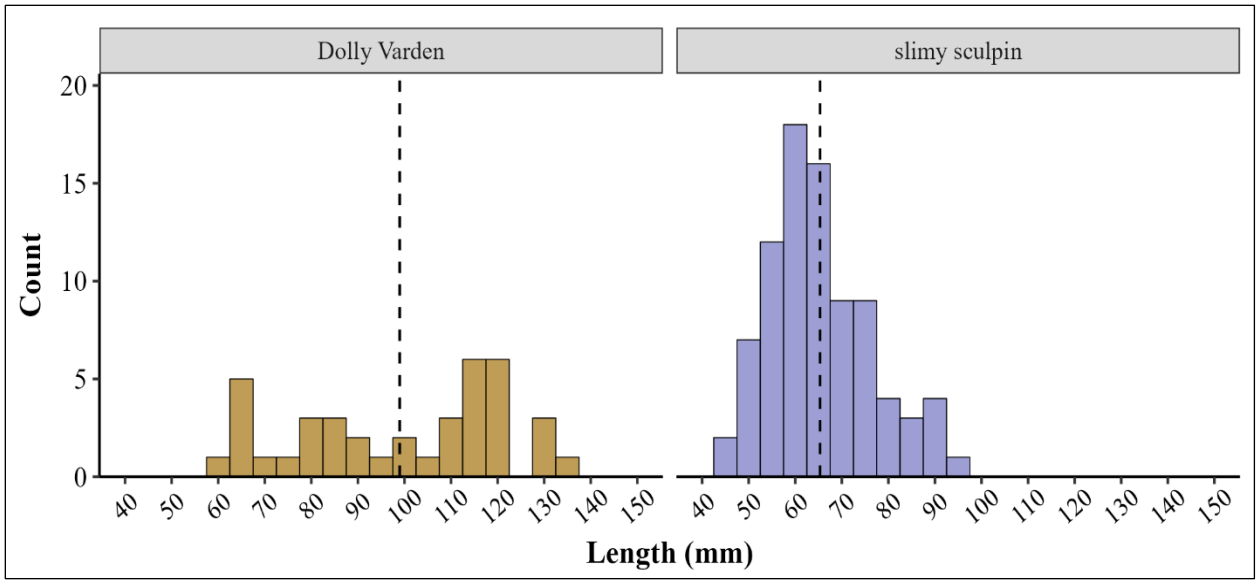

Figure 71.–Length frequency for all fish captured in minnow traps from Riley Creek, 2016–2024. Dolly Varden are measured to fork length and slimy sculpin are measured to total length. The vertical dashed line represents the sample mean length.

Fish Metals

Ten slimy sculpin were retained from Riley Creek for element analysis in 2024. Mean cadmium concentration in 2024 was 0.38 mg/kg (SD = 0.16). This is within the previous years' means that range from 0.12–0.45 mg/kg (Figure 78). Mean copper concentration was similar to previous years at 3.17 mg/kg (SD = 0.33; Figure 78). Mean mercury concentration in 2024 was the highest on record at 0.25 mg/kg (SD = 0.07) but still similar to previous years (Figure 78). Mean selenium concentration was also the highest on record in 2024 at 8.16 mg/kg (SD = 1.84). Previous means ranged from 4.55–7.65 mg/kg (Figure 78). Mean zinc concentration fell within all previous years' means at 122.01 mg/kg (SD = 25.28; Figure 78). Element concentration data from 2024 are presented in Appendix 6.

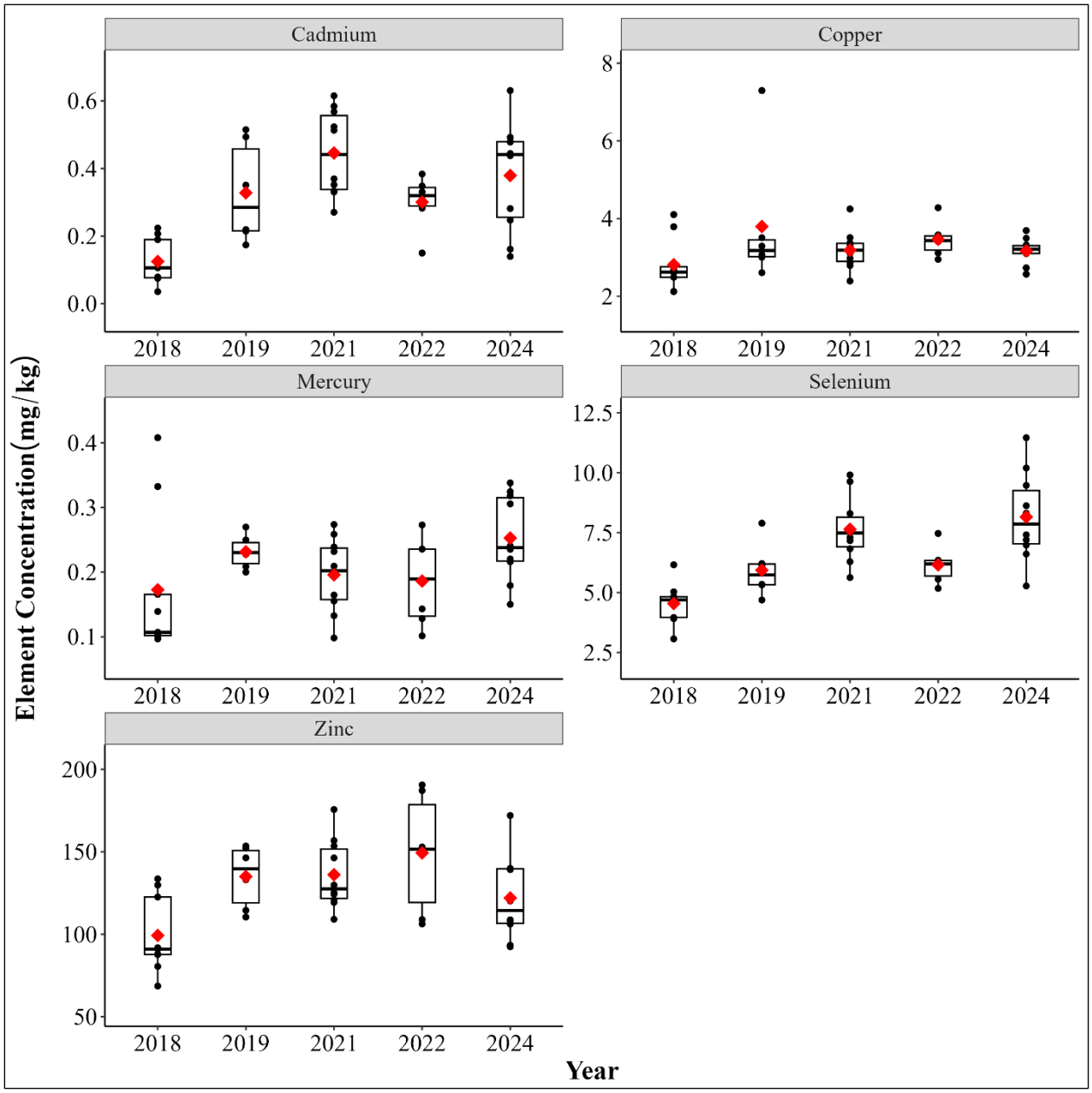

Figure 72.–Boxplots depicting element concentration data for slimy sculpin captured in Riley Creek, 2018–2024. Raw data are in black dots and mean values are depicted in red. Note that y-axis scales vary among elements.

CONCLUSION

All water quality samples analyzed for cadmium, copper, mercury, selenium, and zinc concentrations at Lower Ruby Creek were below the chronic aquatic life exposure limits. In-situ pH, dissolved oxygen, and water temperature at all sites were favorable for aquatic life in all years of available data. The chlorophyll-a values recorded in the vicinity of the Arctic-Bornite exploratory mining prospects across all years and sites fall in the middle of the range seen near

Red Dog Mine, where there are several highly productive sites with average chlorophyll-a concentrations above 5.0 mg/m^2 and several low production sites with concentrations below 0.10 mg/m^2 (Clawson 2023). Similar to mean chlorophyll-a concentrations, BMI results fall in the middle of the ranges seen near Red Dog Mine, where there are several highly productive sites with average densities above 5,000/m^2 and several lower production sites with densities below 1,000/m^2 (Clawson 2023). At the ten sites sampled near Red Dog Mine in 2023, BMI taxa richness varied from a minimum of 2 species to a maximum of 24 species (Clawson 2024).

Despite being isolated from the Kobuk River by a large waterfall, the upper Shungnak River drainage supports self-sustaining populations of Arctic grayling, Dolly Varden, round whitefish, slimy sculpin, longnose sucker, and Alaska blackfish. Fish are consistently captured at all biomonitoring sites from year to year. Resident Dolly Varden spawning is known to occur in Red Rock, Upper Subarctic, and Center of the Universe creeks as a very small young of the year fish was captured in Red Rock Creek in July 2018 and ripe males and females have been captured in the creeks during fall sampling (Clawson 2019). The Dolly Varden captured in Riley Creek in July have the potential to be anadromous as no permanent physical barrier exists downstream, but fall aerial surveys conducted in 2019 and 2022 did not document any anadromous fish upstream on the rapids (Clawson 2020 and Clawson 2023b). Overwintering Dolly Varden presence was confirmed in Upper Subarctic and Center of the Universe creeks in March 2021 and April 2022 (Clawson 2022 and Clawson 2023b). This is likely facilitated by the year-round groundwater input confirmed via Hobo logger data that revealed water temperatures above 0°C through the winter.

Mean element concentrations in fish tissues from streams in the vicinity of the Arctic-Bornite exploratory mining prospects have remained generally static among years and fall within concentrations documented in other regions of the state (Legere and Timothy 2016). Mean cadmium, copper, and selenium concentrations in fish tissues are comparable to those in the vicinity of Red Dog Mine (Ott et al. 2016; Clawson 2023). Mean mercury concentrations are generally higher than those in the vicinity of Red Dog Mine (Clawson 2023). Zinc concentrations in fish tissues are similar to those in Anxiety Creek, but lower than those in Mainstem Red Dog and Buddy creeks, all in the vicinity of Red Dog Mine (Clawson 2023).

Results of biomonitoring in the vicinity of the Arctic-Bornite exploratory mining prospects, indicate considerable variability in chlorophyll-a concentrations and BMI density and composition

among years. This illustrates the importance of continued in-situ water quality, periphyton, BMI, and fish sampling to capture the magnitude of natural variability at these sites prior to development, in order to better assess conditions post-development. Future fish work should be focused on expanding our understanding of how and when fish utilize target areas around the Arctic and Bornite deposits, including for overwintering and spawning habitat. Additional temperature logger deployments could be used to identify viable overwintering habitat. If full scale exploration begins again, we suggest re-implementing fall aerial surveys in the Kogoluktuk River drainage to monitor anadromous fish spawning distribution. Additionally, if the Riley Creek area becomes slated for mine facility development, we suggest genetic sampling to compare Riley Creek Dolly Varden to Subarctic resident Dolly Varden and Kobuk drainage anadromous Dolly Varden.

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APPENDICES

APPENDIX 1. WATER QUALITY DATA FROM LOCATIONS NEAR THE ARCTIC-BORNITE EXPLORATORY MINING PROSPECTS, 2017–2024.

These data were collected by Ambler Metals personnel. Only element data corresponding with those used in fish whole body element analyses are shown. Acute and chronic water quality standards for aquatic life are shown for cadmium, copper, and zinc, which are dependent on water hardness. Values highlighted in yellow were the only samples that exceeded the more stringent chronic aquatic life exposure limit. Values highlighted in green are below the method detection limit.

Year	Date	Site	Cadmium (µg/L)	Cadmium Acute Limit (µg/L)	Cadmium Chronic Limit (µg/L)	Copper (µg/L)	Copper Acute Limit (µg/L)	Copper Chronic Limit (µg/L)	Mercury (ng/L)	Selenium (µg/L)	Total Dissolved Solids (mg/L)	Zinc (µg/L)	Zinc Acute Limit (µg/L)	Zinc Chronic Limit (µg/L)	Hardness as CaCO3 (mg/L)
2024	7/12/2024	Lower Ruby	0.038	2.326	0.273	1.460	15.456	10.167	0.750	0.750	141.000	14.500	132.883	133.970	116.000
2023	7/11/2023	Lower Ruby	0.000	2.482	0.286	1.400	16.459	10.763	4.030	0.000	141.000	11.700	140.608	141.759	124.000
2022	10/18/2022	Lower Ruby	0.000	3.025	0.329	1.360	19.939	12.808	2.350	0.332	152.000	4.180	167.083	168.449	152.000
2022	8/19/2022	Lower Ruby	0.000	2.443	0.282	1.410	16.208	10.614	0.000	0.000	147.000	4.350	138.684	139.819	122.000
2021	9/30/2021	Lower Ruby	0.000	2.676	0.301	0.650	17.706	11.500	0.000	0.443	176.000	0.000	150.159	151.387	134.000
2021	8/31/2021	Lower Ruby	0.000	2.131	0.256	1.510	14.198	9.413	1.280	0.000	144.000	3.270	123.111	124.118	106.000
2021	6/9/2021	Lower Ruby							1.630	0.321	141.000				111.000
2021	1/28/2021	Lower Ruby							0.709	0.654	188.000				159.000
2019	12/9/2019	Lower Ruby	0.025	4.083	0.408	1.120	26.673	16.676	1.130	0.808	294.000	3.790	217.059	218.834	207.000
2019	9/2/2019	Lower Ruby	0.025	2.948	0.323	1.380	19.444	12.520	1.480	0.500	165.000	5.000	163.350	164.686	148.000
2019	6/22/2019	Lower Ruby	0.025	2.735	0.306	1.750	18.080	11.720	1.780	0.500	153.000	5.000	153.002	154.254	137.000
2019	3/30/2019	Lower Ruby	0.025	2.793	0.311	0.536	18.452	11.939	0.500	0.574	180.000	5.000	155.837	157.111	140.000
2018	12/10/2018	Lower Ruby	0.025	2.870	0.317	0.542	18.949	12.230	0.871	0.592	187.000	5.000	159.601	160.907	144.000
2018	8/24/2018	Lower Ruby	0.025	2.326	0.273	1.080	15.456	10.167	1.280	0.500	152.000	5.000	132.883	133.970	116.000
2018	6/28/2018	Lower Ruby	0.025	2.540	0.290	0.896	16.834	10.985	1.140	0.500	148.000	3.980	143.486	144.659	127.000
2018	3/22/2018	Lower Ruby	0.025	2.890	0.318	0.699	19.073	12.302	0.562	1.000	178.000	3.100	160.540	161.853	145.000
2017	11/30/2017	Lower Ruby	0.015	2.812	0.312	0.569	18.577	12.012	0.749	0.622	160	1.32	156.779	158.062	141
2017	9/22/2017	Lower Ruby	0.015	2.326	0.273	0.95	15.456	10.167	0.744	0.31	113	11.9	132.883	133.970	116
2017	8/26/2017	Lower Ruby	0.0165	2.365	0.276	1.17	15.707	10.316	0.612	0.409	149	2.12	134.822	135.925	118
2017	7/24/2017	Lower Ruby	0.0298	1.804	0.227	3	12.080	8.130	2.25	0.31	119	4.24	106.466	107.337	89.3
2017	4/27/2017	Lower Ruby	0.015	2.948	0.323	0.455	19.444	12.520	0.5	0.345	173	0.808	163.350	164.686	148
2022	8/12/2022	Lower Subarctic	0.104	0.978	0.147	0.699	6.677	4.749	0.000	0.380	66.000	21.000	62.473	62.984	47.600
2022	4/19/2022	Lower Subarctic	0.052	1.136	0.163	0.286	7.717	5.415	0.000	0.713	60.000	5.750	71.153	71.735	55.500
2021	9/29/2021	Lower Subarctic	0.107	0.904	0.139	0.702	6.187	4.432	0.000	0.725	71.000	13.700	58.333	58.810	43.900
2021	8/22/2021	Lower Subarctic	0.107	0.807	0.128	1.070	5.548	4.014	0.000	0.452	73.000	12.400	52.882	53.314	39.100
2021	6/20/2021	Lower Subarctic								0.446	36.000				41.000
2019	12/11/2019	Lower Subarctic	0.063	1.022	0.151	0.655	6.968	4.936	2.020	0.620	65.000	7.830	64.911	65.442	49.800
2019	6/7/2019	Lower Subarctic	0.085	0.557	0.098	2.230	3.873	2.898	1.210	0.420	34.000	11.300	38.277	38.590	26.700

Year	Date	Site	Cadmium (µg/L)	Cadmium Acute Limit (µg/L)	Cadmium Chronic Limit (µg/L)	Copper (µg/L)	Copper Acute Limit (µg/L)	Copper Chronic Limit (µg/L)	Mercury (ng/L)	Selenium (µg/L)	Total Dissolved Solids (mg/L)	Zinc (µg/L)	Zinc Acute Limit (µg/L)	Zinc Chronic Limit (µg/L)	Hardness as CaCO3 (mg/L)
2018	8/26/2018	Lower Subarctic	0.078	0.834	0.131	0.705	5.721	4.128	0.672	0.711	59.000	9.610	54.368	54.813	40.400
2018	6/27/2018	Lower Subarctic	0.102	0.628	0.107	1.610	4.349	3.219	0.859	0.337	47.000	16.400	42.488	42.835	30.200
2018	6/27/2018	Lower Subarctic	0.103	0.686	0.114	1.580	4.742	3.482	0.965	0.500	44.000	14.200	45.920	46.296	33.100
2018	3/24/2018	Lower Subarctic	0.042	1.030	0.152	0.303	7.021	4.970	0.500	1.000	73.000	4.490	65.352	65.887	50.200
2017	9/20/2017	Lower Subarctic	0.102	0.755	0.122	1.33	5.200	3.785	0.746	0.398	41	15.3	49.887	50.295	36.5
2017	8/24/2017	Lower Subarctic	0.0829	0.797	0.127	1.02	5.481	3.970	0.5	0.402	44	11.5	52.308	52.736	38.6
2017	7/19/2017	Lower Subarctic	0.161	0.958	0.145	3.22	6.545	4.664	0.95	0.315	62	16.1	61.359	61.861	46.6
2017	4/27/2017	Lower Subarctic	0.0415	1.046	0.154	0.306	7.126	5.038	0.5	0.704	68	4.32	66.234	66.776	51
2022	4/18/2022	Riley	0.000	3.237	0.345	0.345	21.296	13.596	0.000	0.000	190.000	0.000	177.273	178.723	163.000
2021	9/30/2021	Riley	0.000	2.560	0.292	0.404	16.958	11.059	0.000	0.819	167.000	0.000	144.442	145.624	128.000
2021	8/21/2021	Riley	0.000	2.151	0.258	0.581	14.324	9.489	0.000	0.740	132.000	0.000	124.094	125.109	107.000
2021	6/9/2021	Riley							0.793	0.635	125.000				99.900
2019	8/21/2019	Riley	0.025	2.307	0.271	0.602	15.331	10.092	1.440	0.593	143.000	5.000	131.912	132.991	115.000
2019	6/11/2019	Riley	0.025	1.892	0.235	0.618	12.653	8.479	0.500	0.700	151.000	5.000	110.995	111.903	93.800
2018	8/28/2018	Lower Riley	0.025	2.268	0.268	0.714	15.079	9.942	1.420	0.473	121.000	5.000	129.966	131.029	113.000
2018	7/1/2018	Lower Riley	0.025	1.992	0.244	0.513	13.300	8.872	0.890	0.825	106.000	3.100	116.087	117.037	98.900
2018	7/1/2018	Lower Riley	0.034	2.151	0.258	0.863	14.324	9.489	0.976	0.685	111.000	3.100	124.094	125.109	107.000
2017	9/20/2017	Riley	0.015	1.980	0.243	0.808	13.224	8.825	0.783	0.464	115	1.12	115.490	116.435	98.3
2017	8/22/2017	Riley	0.015	2.248	0.266	0.651	14.954	9.866	0.5	0.781	123	1.29	128.990	130.046	112
2017	7/19/2017	Riley	0.015	2.151	0.258	0.453	14.324	9.489	0.645	0.546	129	1.15	124.094	125.109	107
2022	8/14/2022	Upper Ruby	0.000	2.773	0.309	0.000	18.328	11.866	0.000	0.000	182.000	10.700	154.893	156.160	139.000
2022	4/18/2022	Upper Ruby	0.000	3.834	0.390	0.338	25.092	15.777	0.000	0.000	228.000	0.000	205.452	207.132	194.000
2021	8/29/2021	Upper Ruby	0.000	2.502	0.287	0.300	16.584	10.837	0.000	0.456	186.000	0.000	141.569	142.727	125.000
2021	6/8/2021	Upper Ruby							1.440	0.500	155.000				114.000
2019	12/5/2019	Upper Ruby	0.025	3.160	0.339	0.370	20.803	13.311	2.190	0.536	198.000	5.000	173.580	175.000	159.000
2019	8/29/2019	Upper Ruby	0.025	2.676	0.301	0.287	17.706	11.500	0.736	0.391	165.000	5.000	150.159	151.387	134.000
2019	6/6/2019	Upper Ruby	0.025	2.346	0.274	0.527	15.582	10.242	0.677	0.596	147.000	5.000	133.853	134.948	117.000
2019	3/30/2019	Upper Ruby	0.025	3.122	0.336	0.273	20.556	13.167	0.831	0.382	198.000	5.000	171.728	173.133	157.000
2018	12/10/2018	Upper Ruby	0.025	2.909	0.320	0.500	19.197	12.375	0.606	0.459	176.000	5.000	161.477	162.798	146.000
2018	12/10/2018	Upper Ruby	0.025	3.044	0.331	0.500	20.063	12.880	0.500	0.532	158.000	5.000	168.014	169.388	153.000
2017	12/2/2017	Upper Ruby	0.015	2.773	0.309	0.819	18.328	11.866	0.5	0.588	166	4.36	154.893	156.160	139
2017	9/18/2017	Upper Ruby	0.015	2.190	0.261	0.529	14.576	9.640	0.876	0.385	132	1.66	126.057	127.088	109
2017	8/23/2017	Upper Ruby	0.015	2.482	0.286	0.413	16.459	10.763	0.5	0.547	136	1.43	140.608	141.759	124
2017	7/18/2017	Upper Ruby	0.015	2.754	0.308	0.472	18.204	11.793	0.605	0.329	163	1.25	153.948	155.208	138
2017	4/27/2017	Upper Ruby	0.015	2.967	0.324	0.329	19.568	12.592	0.5	0.31	169	1.56	164.284	165.628	149

Year	Date	Site	Cadmium (µg/L)	Cadmium Acute Limit (µg/L)	Cadmium Chronic Limit (µg/L)	Copper (µg/L)	Copper Acute Limit (µg/L)	Copper Chronic Limit (µg/L)	Mercury (ng/L)	Selenium (µg/L)	Total Dissolved Solids (mg/L)	Zinc (µg/L)	Zinc Acute Limit (µg/L)	Zinc Chronic Limit (µg/L)	Hardness as CaCO3 (mg/L)
2022	8/13/2022	Upper Shungnak	0.413	1.943	0.240	2.170	12.983	8.680	0.000	0.447	128.000	32.700	113.596	114.525	96.400
2022	4/18/2022	Upper Shungnak	0.221	1.967	0.242	1.650	13.135	8.772	0.000	0.544	129.000	35.300	114.793	115.732	97.600
2021	9/29/2021	Upper Shungnak	0.370	1.928	0.238	2.140	12.881	8.618	0.000	0.695	121.000	30.100	112.797	113.720	95.600
2021	8/20/2021	Upper Shungnak	0.391	1.647	0.213	2.130	11.058	7.504	0.000	0.624	112.000	28.800	98.327	99.132	81.300
2021	6/20/2021	Upper Shungnak								0.465	115.000				75.500
2019	8/24/2019	Upper Shungnak	0.369	1.774	0.225	2.160	11.889	8.013	0.544	0.393	75.000	29.000	104.949	105.807	87.800
2019	6/27/2019	Upper Shungnak	0.239	1.570	0.206	1.440	10.557	7.195	0.671	0.341	124.000	19.300	94.316	95.088	77.400
2018	8/26/2018	Upper Shungnak	0.227	1.727	0.220	1.420	11.582	7.826	0.513	0.595	104.000	17.200	102.513	103.352	85.400
2018	6/27/2018	Upper Shungnak	0.219	1.467	0.196	1.820	9.887	6.780	1.040	0.521	86.000	18.000	88.919	89.646	72.200
2017	9/20/2017	Upper Shungnak	0.217	1.503	0.200	1.53	10.120	6.924	0.701	0.31	92	16.7	90.794	91.536	74
2017	8/24/2017	Upper Shungnak	0.219	1.599	0.209	1.45	10.750	7.314	0.5	0.563	97	17.1	95.862	96.647	78.9
2017	7/22/2017	Upper Shungnak	0.13	1.690	0.217	0.88	11.339	7.677	0.5	0.369	116	7.45	100.577	101.400	83.5
2017	4/27/2017	Upper Shungnak	0.097	1.688	0.217	0.665	11.326	7.669	0.5	0.334	108	8.39	100.475	101.297	83.4
2023	7/11/2023	Upper Subarctic	0.017	0.920	0.140	0.000	6.293	4.501	0.000	0.000	46.000	11.400	59.233	59.717	44.700
2022	8/12/2022	Upper Subarctic	0.015	1.016	0.151	0.000	6.928	4.911	0.000	0.000	56.000	10.500	64.579	65.108	49.500
2022	4/22/2022	Upper Subarctic	0.063	1.074	0.157	0.766	7.310	5.155	0.000	0.000	93.000	4.750	67.771	68.325	52.400
2021	9/29/2021	Upper Subarctic	0.018	0.952	0.144	0.000	6.506	4.638	0.000	0.000	62.000	0.000	61.024	61.523	46.300
2021	8/22/2021	Upper Subarctic	0.020	0.922	0.141	0.000	6.307	4.509	0.000	0.000	72.000	4.050	59.345	59.830	44.800
2021	6/20/2021	Upper Subarctic								0.000	32.000				38.200
2021	3/11/2021	Upper Subarctic							0.610	0.000	77.000				47.300
2021	1/26/2021	Upper Subarctic							0.518	0.395	64.000				61.400
2019	12/8/2019	Upper Subarctic	0.025	1.076	0.157	0.203	7.323	5.164	0.733	0.500	67.000	5.000	67.881	68.436	52.500
2019	8/23/2019	Upper Subarctic	0.018	0.954	0.144	0.247	6.519	4.647	0.500	0.500	51.000	5.000	61.136	61.636	46.400
2019	6/7/2019	Upper Subarctic	0.018	0.541	0.096	0.250	3.763	2.823	1.940	0.500	23.000	5.000	37.303	37.608	25.900
2019	4/1/2019	Upper Subarctic	0.047	1.000	0.149	0.305	6.823	4.843	0.707	0.409	63.000	5.000	63.694	64.215	48.700
2018	12/7/2018	Upper Subarctic	0.017	1.034	0.153	0.250	7.047	4.987	0.601	0.500	56.000	5.000	65.573	66.109	50.400
2018	8/26/2018	Upper Subarctic	0.025	0.928	0.141	0.249	6.347	4.535	0.773	0.450	56.000	5.000	59.681	60.170	45.100
2018	6/24/2018	Upper Subarctic	0.025	0.703	0.116	0.323	4.850	3.554	0.889	0.500	38.000	3.100	46.859	47.242	33.900
2018	3/25/2018	Upper Subarctic	0.015	1.080	0.158	0.250	7.350	5.181	0.500	1.000	72.000	3.100	68.100	68.657	52.700
2017	9/20/2017	Upper Subarctic	0.0166	0.848	0.133	0.263	5.815	4.189	0.695	0.31	48	1.35	55.165	55.616	41.1
2017	8/21/2017	Upper Subarctic	0.0963	1.026	0.152	0.691	6.994	4.953	0.5	0.426	58	3.29	65.132	65.664	50
2017	7/21/2017	Upper Subarctic	0.0165	0.870	0.135	0.219	5.961	4.285	0.5	0.31	55	0.958	56.413	56.875	42.2

APPENDIX 2. IN SITU WATER QUALITY DATA FROM LOCATIONS NEAR THE ARCTIC-BORNITE EXPLORATORY MINING PROSPECTS, 2022–2024.

In 2023, only water temperature was recorded with a handheld thermometer. A multiparameter handheld YSI was used for all other years.

Year	Date	Site	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µs/cm)	Specific Conductance (µs/cm)	pH	Turbidity (NTU)	Atmospheric Pressure (mmHg)
2024	7/11/2024	Center of the Universe	4.9	11.83	83.3	135.5	7.99		704.9
2023	7/12/2023	Center of the Universe	4.8						
2022	7/20/2022	Center of the Universe	4.3	12.04	95.3	157.7	7.93	0.19	
2024	7/14/2024	Jay	6.7	11.63	61.5	94.5	7.81		733.9
2023	7/12/2023	Jay	7						
2022	7/21/2022	Jay	5.6	12.26	59.7	94.9	7.82	1.49	
2024	7/11/2024	Lower Red Rock	6.5	11.8	113.6	175.5	8.05		741.6
2023	7/11/2023	Lower Red Rock	5						
2024	7/13/2024	Lower Ruby	8.6	10.52	150.8	219.3	8.03		739.2
2022	7/19/2022	Lower Ruby	10.7	11.55	203.6	280	8.01	3.46	
2024	7/11/2024	Lower Subarctic	6.9	11.82	61.1	93.4	7.4		742.9
2023	7/11/2023	Lower Subarctic	5						
2022	7/19/2022	Lower Subarctic	6.6	13.02	77.8	120.1	7.63	0.3	
2024	7/13/2024	Riley	4.6	12.04	138.9	227.7	8.37		741.4
2023	7/13/2023	Riley	4.6						
2022	7/22/2022	Riley	4.4	12.35	159.5	263.2	8.07	0.49	
2024	7/12/2024	Sunshine	5.5	12.14	77.8	123.9	7.85		741.2
2023	7/11/2023	Sunshine	6						
2022	7/22/2022	Sunshine	2.9	9.59	81.2	140.4	6.92	1.15	
2024	7/13/2024	Upper Ruby	8.4	10.88	166.2	243.6	8.14		732.9
2024	7/12/2024	Upper Shungnak	5	11.83	113.1	182.9	7.89		741.8
2023	7/11/2023	Upper Shungnak	5						
2022	7/22/2022	Upper Shungnak	5.4	11.8	127.4	203.7	7.82	0.17	
2024	7/11/2024	Upper Subarctic	5.6	11.54	59	93.7	7.97		696.2
2023	7/11/2023	Upper Subarctic	4.5						
2022	7/20/2022	Upper Subarctic	3.9	12.02	56	93.9	7.73	0.02	

APPENDIX 3. CHLOROPHYLL DATA FROM LOCATIONS NEAR THE ARCTIC-BORNITE EXPLORATORY MINING PROSPECTS, 2024.

The values reported and analyzed in this report are in the phaeo-corrected chlorophyll-a value column. Values highlighted in green are below the detection limit (IDL) of 0.14.

IDL = 0.14 mg/m^2				Linear Check Maximum = 69.02 mg/m^2				
EDL = 0.51 mg/m^2					**Phaeo Corrected**			
		Date	Vial	Chl a	**Chl a**	**664/665**	Chl b	Chl c
Daily Vial #	Site	Analyzed	Chl a	mg/m2	**mg/m2**	**Ratio**	mg/m2	mg/m2
2	Lower Subarctic	11/18/24	0.03393	0.14	0.32		0.01	0.05
3	Lower Subarctic	11/18/24	0.04416	0.18	0.11	1.33	0.06	0.11
4	Lower Subarctic	11/18/24	0.05601	0.22	0.21	1.67	0.04	0.10
5	Lower Subarctic	11/18/24	0.04416	0.18	0.11	1.33	0.06	0.11
6	Lower Subarctic	11/18/24	0.06632	0.27	0.21	1.50	0.10	0.06
7	Lower Subarctic	11/18/24	0.06624	0.26	0.21	1.50	0.09	0.16
8	Lower Subarctic	11/18/24	0.03231	0.13	0.11	1.50	0.08	0.12
9	Lower Subarctic	11/18/24	0.06786	0.27	0.32	2.00	0.02	0.10
10	Lower Subarctic	11/18/24	0.04092	0.16	0.11	1.33	0.21	0.24
11	Lower Subarctic	11/18/24	0.12387	0.50	0.43	1.57	0.06	0.20
12	Upper Shungnak	11/18/24	0.02046	0.08	0.00	1.00	0.10	0.12
13	Upper Shungnak	11/18/24	0.02046	0.08	0.11	2.00	0.10	0.12
14	Upper Shungnak	11/18/24	0.02046	0.08	0.11	2.00	0.10	0.12
15	Upper Shungnak	11/18/24	0.03069	0.12	0.00	1.00	0.16	0.18
16	Upper Shungnak	11/18/24	0.02046	0.08	0.11	2.00	0.10	0.12
17	Upper Shungnak	11/18/24	0.07817	0.31	0.21	1.40	0.08	0.06
18	Upper Shungnak	11/18/24	0.05609	0.22	0.21	1.67	0.05	0.00
19	Upper Shungnak	11/18/24	0.02208	0.09	0.21		0.03	0.05
20	Upper Shungnak	11/18/24	0	0.00	0.00		0.00	0.00
21	Upper Shungnak	11/18/24	0.07817	0.31	0.32	1.75	0.08	0.06
22	Upper Subarctic	11/18/24	0.43987	1.76	1.60	1.63	0.23	0.20
23	Upper Subarctic	11/18/24	0.341	1.36	1.28	1.67	0.02	0.31
24	Upper Subarctic	11/18/24	0.14765	0.59	0.53	1.63	0.02	0.09
25	Upper Subarctic	11/18/24	0.06786	0.27	0.21	1.50	0.02	0.10
26	Upper Subarctic	11/18/24	0.14603	0.58	0.53	1.63	0.10	0.15
27	Upper Subarctic	11/18/24	0.40748	1.63	1.39	1.57	0.14	0.18
28	Upper Subarctic	11/18/24	0.18158	0.73	0.75	1.78	0.03	0.13
29	Upper Subarctic	11/18/24	0.30553	1.22	1.07	1.59	0.10	0.23
30	Upper Subarctic	11/18/24	0.21551	0.86	0.85	1.73	0.04	0.18
31	Upper Subarctic	11/18/24	0.27314	1.09	0.96	1.60	0.00	0.22
32	Riley	11/18/24	0.55829	2.23	2.14	1.69	0.01	0.23
33	Riley	11/18/24	0.67055	2.68	2.35	1.59	0.12	0.14
34	Riley	11/18/24	0.27314	1.09	0.96	1.60	0.00	0.22
35	Riley	11/18/24	0.21551	0.86	0.85	1.73	0.04	0.18
36	Riley	11/18/24	0.3427	1.37	1.28	1.67	0.00	0.14
37	Riley	11/18/24	0.80943	3.24	3.10	1.69	0.00	0.29
38	Riley	11/18/24	0.35293	1.41	1.28	1.63	0.01	0.21
39	Riley	11/18/24	0.71633	2.87	2.78	1.70	0.10	0.18
40	Riley	11/18/24	0.07809	0.31	0.32	1.75	0.07	0.16
41	Riley	11/18/24	1.21138	4.85	4.59	1.68	0.00	0.40
41	Riley duplicate	11/18/24	1.22161	4.89	4.49	1.65	0.00	0.46
42	Lower Red Rock	11/18/24	0.04416	0.18	0.21	2.00	0.06	0.11
43	Lower Red Rock	11/18/24	0.05447	0.22	0.21	1.67	0.12	0.07
44	Lower Red Rock	11/18/24	0.03231	0.13	0.11	1.50	0.08	0.12
45	Lower Red Rock	11/18/24	0.01015	0.04	0.11		0.04	0.16
46	Lower Red Rock	11/18/24	0.15132	0.61	0.32	1.27	0.36	0.52
47	Lower Red Rock	11/18/24	0.03223	0.13	0.11	1.50	0.07	0.21
48	Lower Red Rock	11/18/24	0.01023	0.04	0.00	1.00	0.05	0.06
49	Lower Red Rock	11/18/24	0.01023	0.04	0.11		0.05	0.06
50	Lower Red Rock	11/18/24	0.05609	0.22	0.21	1.67	0.05	0.00
51	Lower Red Rock	11/18/24	0.01023	0.04	0.11		0.05	0.06

Daily Vial #	Site	Date Analyzed	Vial Chl a	Chl a mg/m2	**Chl a mg/m2**	**664/665 Ratio**	Chl b mg/m2	Chl c mg/m2
52	Sunshine	11/18/24	0.03231	0.13	0.11	1.50	0.08	0.12
53	Sunshine	11/18/24	0.03231	0.13	0.11	1.50	0.08	0.12
54	Sunshine	11/18/24	0.03393	0.14	0.11	1.50	0.01	0.05
55	Sunshine	11/18/24	0.01185	0.05	0.11		0.00	0.00
56	Sunshine	11/18/24	0.03231	0.13	0.11	1.50	0.08	0.12
57	Sunshine	11/18/24	0.02046	0.08	0.11	2.00	0.10	0.12
58	Sunshine	11/18/24	0.03231	0.13	0.00	1.00	0.08	0.12
59	Sunshine	11/18/24	0.03393	0.14	0.11	1.50	0.01	0.05
60	Sunshine	11/18/24	0.04424	0.18	0.21	2.00	0.07	0.01
61	Sunshine	11/18/24	0.04416	0.18	0.21	2.00	0.06	0.11
2	Upper Ruby	11/19/24	3.74225	14.97	13.88	1.66	0.00	1.28
3	Upper Ruby	11/19/24	12.4209	49.68	46.35	1.67	0.00	5.12
4	Upper Ruby	11/19/24	19.7793	79.12	71.34	1.63	0.00	6.34
5	Upper Ruby	11/19/24	4.8236	19.29	17.19	1.62	0.00	1.36
6	Upper Ruby	11/19/24	0.34108	1.36	1.28	1.67	0.03	0.21
7	Upper Ruby	11/19/24	16.8412	67.36	59.81	1.61	0.00	4.15
8	Upper Ruby	11/19/24	0.93646	3.75	3.42	1.64	0.00	0.45
9	Upper Ruby	11/19/24	6.05489	24.22	22.21	1.64	0.00	1.73
10	Upper Ruby	11/19/24	7.99582	31.98	29.48	1.65	0.00	3.37
11	Upper Ruby	11/19/24	6.43401	25.74	23.82	1.66	0.00	1.62
12	Center of the Universe	11/19/24	1.18081	4.72	4.38	1.64	0.84	0.34
13	Center of the Universe	11/19/24	0.30707	1.23	1.07	1.59	0.01	0.26
14	Center of the Universe	11/19/24	0.23443	0.94	0.85	1.62	0.23	0.27
15	Center of the Universe	11/19/24	0.12395	0.50	0.43	1.57	0.07	0.10
16	Center of the Universe	11/19/24	0.21551	0.86	0.85	1.73	0.04	0.18
17	Center of the Universe	11/19/24	0.11372	0.45	0.43	1.67	0.01	0.04
18	Center of the Universe	11/19/24	0.1595	0.64	0.64	1.75	0.00	0.08
19	Center of the Universe	11/19/24	0.38532	1.54	1.39	1.62	0.10	0.22
20	Center of the Universe	11/19/24	0.16973	0.68	0.53	1.50	0.05	0.14
21	Center of the Universe	11/19/24	0.12071	0.48	0.32	1.38	0.21	0.23
22	Jay	11/19/24	0.61438	2.46	2.14	1.59	0.06	0.23
23	Jay	11/19/24	0.58207	2.33	2.14	1.65	0.00	0.12
24	Jay	11/19/24	0.63954	2.56	2.35	1.65	0.00	0.35
25	Jay	11/19/24	0.70772	2.83	2.56	1.63	0.00	0.05
26	Jay	11/19/24	0.41064	1.64	1.60	1.71	0.00	0.14
27	Jay	11/19/24	0.60569	2.42	2.24	1.66	0.00	0.20
28	Jay	11/19/24	2.46597	9.86	8.44	1.57	0.33	1.25
29	Jay	11/19/24	0.70918	2.84	2.67	1.68	0.00	0.18
30	Jay	11/19/24	0.52428	2.10	1.92	1.64	0.00	0.28
31	Jay	11/19/24	1.22414	4.90	4.49	1.64	0.36	0.37

APPENDIX 4. BENTHIC MACROINVERTEBRATE DATA FROM LOCATIONS NEAR THE ARCTIC-BORNITE EXPLORATORY MINING PROSPECTS, 2024.

Year	Order	Family	Genus	Lower Ruby	Lower Subarctic	Riley	Upper Ruby	Upper Shungnak	Upper Subarctic	Jay	Lower Red Rock	Sunshine	Center of the Universe
2024	Acari	Acarina	spp	0	0	4	7	6	3	7	1	4	6
2024	Bivalvia	Sphaeriidae	Sphaerium	0	0	0	1	0	0	0	0	0	0
2024	Bivalvia	Sphaeriidae	spp	0	0	0	1	0	0	0	0	0	0
2024	Collembola	spp	spp	0	0	1	0	0	0	2	0	0	0
2024	Collembola	Isotomidae	spp	0	0	0	1	0	0	0	0	0	0
2024	Collembola	Neanuridae	spp	0	0	0	1	0	0	0	0	0	0
2024	Copepoda	Cyclopoida	spp	0	0	0	0	0	0	0	0	0	3
2024	Copepoda	Harpacticoida	spp	0	0	5	5	1	0	0	0	0	0
2024	Diptera	Chironomidae	spp	42	75	843	111	47	779	433	12	364	514
2024	Diptera	Empididae	Chelifera	0	2	17	3	0	0	2	0	1	1
2024	Diptera	Simuliidae	spp	0	0	59	11	1	2	4	0	1	22
2024	Diptera	Tipulidae	Tipula	0	0	2	0	0	2	0	0	0	50
2024	Diptera	spp	spp	0	0	2	1	1	1	7	1	0	2
2024	Diptera	Tipulidae	Dicranota	0	0	3	0	0	2	7	0	4	0
2024	Diptera	Tipulidae	Rhabdomastix	0	0	0	0	1	0	0	3	0	0
2024	Diptera	Ceratopogonidae	spp	7	0	28	48	2	1	0	0	0	0
2024	Diptera	Tipulidae	spp	12	0	1	1	0	0	0	0	0	0
2024	Diptera	Empididae	Clinocera	0	2	0	0	0	1	0	0	2	0
2024	Diptera	Empididae	spp	0	1	0	0	0	0	0	0	0	0
2024	Diptera	Simuliidae	Simulium	0	2	11	0	0	0	0	0	1	0
2024	Diptera	Simuliidae	Nemoura	0	0	0	1	0	0	0	0	0	0
2024	Diptera	Tipulidae	Hexatoma	0	0	0	3	0	0	0	0	0	0
2024	Ephemeroptera	Ameletidae	Ameletus	0	0	0	0	0	353	1	0	1	8
2024	Ephemeroptera	Baetidae	Baetis	0	31	77	14	4	75	320	1	7	126
2024	Ephemeroptera	Baetidae	spp	1	0	0	28	0	21	3	0	0	9
2024	Ephemeroptera	Ephemerellidae	spp	0	0	6	1	0	0	0	0	0	1
2024	Ephemeroptera	Heptageniidae	Cinygmula	7	81	225	4	45	37	148	0	171	16
2024	Ephemeroptera	Heptageniidae	Epeorus	0	18	75	0	9	5	7	0	13	1
2024	Ephemeroptera	Heptageniidae	spp	0	0	0	0	0	0	0	0	0	1
2024	Ephemeroptera	spp	spp	0	0	2	14	2	6	0	0	0	1
2024	Ephemeroptera	Baetidae	Acentrella	2	0	0	24	0	0	0	0	0	0
2024	Ephemeroptera	Ephemerellidae	Ephemerella	0	0	0	2	1	0	0	0	0	0

Year	Order	Family	Genus	Lower Ruby	Lower Subarctic	Riley	Upper Ruby	Upper Shungnak	Upper Subarctic	Jay	Lower Red Rock	Sunshine	Center of the Universe
2024	Gastropoda	Valvatidae	Valvata	0	0	0	0	0	0	1	0	0	0
2024	Gastropoda	spp	spp	0	0	0	1	0	0	0	0	0	0
2024	Mollusca	Gastropoda	spp	0	0	0	2	0	0	0	0	0	0
2024	Nematoda	spp	spp	3	0	20	18	0	2	31	0	0	0
2024	Nematomorpha	spp	spp	0	0	0	0	0	1	0	1	0	0
2024	Oligochaeta	spp	spp	63	38	840	145	3	35	84	0	163	89
2024	Ostracoda	spp	spp	0	2	24	15	0	686	7	0	2	38
2024	Platyhelminthes	spp	spp	0	0	0	1	0	0	4	0	4	8
2024	Plecoptera	Chloroperlidae	Suwallia	0	28	0	3	1	151	2	1	49	34
2024	Plecoptera	Chloroperlidae	spp	0	1	11	0	6	22	0	3	7	49
2024	Plecoptera	Leutridae	Paraleutra	0	0	0	0	0	0	0	0	0	1
2024	Plecoptera	Leutridae	spp	0	0	4	0	0	0	0	5	0	10
2024	Plecoptera	Nemouridae	Zapada	0	2	33	1	0	73	38	0	22	54
2024	Plecoptera	Nemouridae	spp	0	0	2	0	1	2	1	0	0	1
2024	Plecoptera	spp	spp	4	4	100	3	33	1	8	0	7	2
2024	Plecoptera	Capniidae	spp	0	0	0	0	0	1	2	0	1	0
2024	Plecoptera	Perlodidae	Isoperla	0	0	0	0	0	0	3	0	0	0
2024	Plecoptera	Perlodidae	spp	0	0	0	0	0	0	2	0	2	0
2024	Plecoptera	Chloroperlidae	Sweltsa	0	0	4	0	0	0	0	0	0	0
2024	Plecoptera	Leutridae	Perlomyia	0	0	1	0	0	1	0	0	0	0
2024	Plecoptera	Capniidae	Capnia	0	0	0	0	0	1	0	0	0	0
2024	Plecoptera	Nemouridae	Podmosta	0	0	0	0	0	1	0	0	0	0
2024	Trichoptera	Ryachophiliide	Ryachophilia	0	0	3	0	0	8	0	0	1	2
2024	Trichoptera	spp	spp	1	0	0	3	0	2	2	0	0	1
2024	Trichoptera	Limnephilidae	spp	0	0	0	0	0	0	4	0	0	0
2024	Trichoptera	Brachycentridae	Brachycentrus	0	0	0	8	0	0	0	0	0	0
2024	Trichoptera	Brachycentridae	spp	0	0	0	1	0	0	0	0	0	0
2024	Trichoptera	Glossosomatidae	spp	0	0	0	4	0	0	0	0	0	0

APPENDIX 5. FISH CAPTURE DATA FROM LOCATIONS NEAR THE ARCTIC-BORNITE EXPLORATORY MINING PROSPECTS, 2016–2024.

Year	Site	Dolly Varden	Arctic grayling	slimy sculpin	Alaska blackfish	longnose sucker	round whitefish
2024	Center of the Universe	7	0	0	0	0	0
2023	Center of the Universe	1	0	0	0	0	0
2022	Center of the Universe	5	0	0	0	0	0
2021	Center of the Universe	12	0	0	0	0	0
2024	Jay	1	0	0	0	0	0
2023	Jay	2	0	0	0	0	0
2022	Jay	2	0	0	0	0	0
2021	Jay	4	0	0	0	0	0
2019	Jay	3	0	0	0	0	0
2018	Jay	9	0	0	0	0	0
2017	Jay	11	0	0	0	0	0
2024	Lower Red Rock	8	0	7	0	0	0
2023	Lower Red Rock	0	0	5	0	0	0
2022	Lower Red Rock	12	0	4	0	0	0
2021	Lower Red Rock	12	0	2	0	0	0
2019	Lower Red Rock	25	0	0	0	0	0
2018	Lower Red Rock	2	0	3	0	0	0
2024	Lower Ruby	2	0	39	0	0	0
2023	Lower Ruby	1	0	21	3	0	0
2022	Lower Ruby	0	0	36	0	0	0
2021	Lower Ruby	0	0	24	0	0	0
2019	Lower Ruby	0	0	30	0	0	1
2018	Lower Ruby	0	0	15	3	1	0
2017	Lower Ruby	4	0	17	0	0	0
2016	Lower Ruby	0	0	20	0	0	0
2024	Lower Subarctic	7	0	5	0	0	0
2023	Lower Subarctic	1	0	20	0	0	0
2022	Lower Subarctic	3	0	4	0	0	0
2021	Lower Subarctic	2	0	5	0	0	0
2019	Lower Subarctic	31	0	3	0	0	0
2018	Lower Subarctic	4	0	5	0	0	0
2017	Lower Subarctic	8	0	2	0	0	0
2016	Lower Subarctic	2	0	3	0	0	0
2024	Riley	6	0	13	0	0	0
2023	Riley	2	0	4	0	0	0
2022	Riley	1	0	10	0	0	0
2021	Riley	6	0	10	0	0	0
2019	Riley	3	1	15	0	0	0
2018	Riley	5	0	25	0	0	0
2017	Riley	16	1	8	0	0	0
2024	Sunshine	2	0	15	0	0	0
2023	Sunshine	3	0	2	0	0	0
2022	Sunshine	1	0	3	0	0	0
2021	Sunshine	5	0	2	0	0	0
2024	Upper Ruby	1	0	38	0	0	0
2022	Upper Ruby	3	0	36	0	0	0
2021	Upper Ruby	0	0	40	0	0	0
2019	Upper Ruby	4	0	22	0	0	0
2018	Upper Ruby	1	0	21	0	0	0
2017	Upper Ruby	0	0	61	0	0	0
2016	Upper Ruby	6	0	13	0	0	0
2024	Upper Subarctic	24	0	0	0	0	0
2023	Upper Subarctic	20	0	0	0	0	0
2022	Upper Subarctic	34	0	0	0	0	0
2021	Upper Subarctic	42	0	0	0	0	0
2019	Upper Subarctic	5	0	0	0	0	0
2018	Upper Subarctic	35	0	0	0	0	0
2017	Upper Subarctic	40	0	0	0	0	0
2016	Upper Subarctic	33	0	0	0	0	0

APPENDIX 6. RESULTS FOR WHOLE BODY ELEMENT ANALYSIS FOR FISH FROM RUBY, UPPER SUBARCTIC, AND RILEY CREEKS, 2024.

Sample ID	Species	Creek	Collection Date	Analyte	Dry Wt Result (mg/kg)	Dry Wt MDL (mg/kg)	% Solid	Fish Length (mm)	Fish Weight (g)
071224LRUBSS01	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.08	0.04	27.2	77	5.3
071224LRUBSS02	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.23	0.03	26.9	79	7.1
071224LRUBSS03	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.30	0.04	22.3	70	4.1
071224LRUBSS04	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.27	0.03	27.9	70	3.7
071224LRUBSS05	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.08	0.04	22.7	75	5
071224LRUBSS06	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.69	0.05	21.8	60	3.4
071224LRUBSS07	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.07	0.04	25.4	66	3.2
071224LRUBSS08	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.20	0.04	22.2	64	3.3
071224LRUBSS09	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.12	0.04	29.1	63	3
071224LRUBSS10	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.13	0.03	25.2	60	2.7
071224LRUBSS11	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.36	0.04	28.5	72	4.1
071224LRUBSS12	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.13	0.04	23.4	80	5.5
071224LRUBSS13	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.13	0.03	20.9	70	4.1
071224LRUBSS14	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.09	0.03	23.7	80	6.4
071224LRUBSS15	slimy sculpin	Lwr Ruby	7/12/2024	Cadmium	0.07	0.04	21.8	67	4.1
071224LRUBSS01	slimy sculpin	Lwr Ruby	7/12/2024	Copper	2.46	0.68	27.2	77	5.3
071224LRUBSS02	slimy sculpin	Lwr Ruby	7/12/2024	Copper	2.75	0.48	26.9	79	7.1
071224LRUBSS03	slimy sculpin	Lwr Ruby	7/12/2024	Copper	4.93	0.65	22.3	70	4.1
071224LRUBSS04	slimy sculpin	Lwr Ruby	7/12/2024	Copper	4.34	0.53	27.9	70	3.7
071224LRUBSS05	slimy sculpin	Lwr Ruby	7/12/2024	Copper	3.05	0.58	22.7	75	5
071224LRUBSS06	slimy sculpin	Lwr Ruby	7/12/2024	Copper	4.30	0.77	21.8	60	3.4
071224LRUBSS07	slimy sculpin	Lwr Ruby	7/12/2024	Copper	2.67	0.68	25.4	66	3.2
071224LRUBSS08	slimy sculpin	Lwr Ruby	7/12/2024	Copper	2.73	0.61	22.2	64	3.3
071224LRUBSS09	slimy sculpin	Lwr Ruby	7/12/2024	Copper	2.53	0.60	29.1	63	3
071224LRUBSS10	slimy sculpin	Lwr Ruby	7/12/2024	Copper	2.87	0.52	25.2	60	2.7
071224LRUBSS11	slimy sculpin	Lwr Ruby	7/12/2024	Copper	2.66	0.58	28.5	72	4.1
071224LRUBSS12	slimy sculpin	Lwr Ruby	7/12/2024	Copper	3.03	0.65	23.4	80	5.5
071224LRUBSS13	slimy sculpin	Lwr Ruby	7/12/2024	Copper	3.39	0.54	20.9	70	4.1
071224LRUBSS14	slimy sculpin	Lwr Ruby	7/12/2024	Copper	2.44	0.52	23.7	80	6.4
071224LRUBSS15	slimy sculpin	Lwr Ruby	7/12/2024	Copper	2.24	0.59	21.8	67	4.1
071224LRUBSS01	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.43	0.01	27.2	77	5.3
071224LRUBSS02	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.25	0.01	26.9	79	7.1
071224LRUBSS03	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.40	0.02	22.3	70	4.1
071224LRUBSS04	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.28	0.01	27.9	70	3.7
071224LRUBSS05	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.36	0.01	22.7	75	5
071224LRUBSS06	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.11	0.01	21.8	60	3.4
071224LRUBSS07	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.15	0.01	25.4	66	3.2
071224LRUBSS08	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.29	0.02	22.2	64	3.3
071224LRUBSS09	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.13	0.01	29.1	63	3
071224LRUBSS10	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.17	0.01	25.2	60	2.7
071224LRUBSS11	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.23	0.01	28.5	72	4.1
071224LRUBSS12	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.34	0.01	23.4	80	5.5
071224LRUBSS13	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.23	0.02	20.9	70	4.1
071224LRUBSS14	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.22	0.01	23.7	80	6.4
071224LRUBSS15	slimy sculpin	Lwr Ruby	7/12/2024	Mercury	0.19	0.01	21.8	67	4.1

Sample ID	Species	Creek	Collection Date	Analyte	Dry Wt Result (mg/kg)	Dry Wt MDL (mg/kg)	% Solid	Fish Length (mm)	Fish Weight (g)
071224LRUBSS01	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	2.88	0.08	27.2	77	5.3
071224LRUBSS02	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	4.94	0.06	26.9	79	7.1
071224LRUBSS03	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	6.73	0.08	22.3	70	4.1
071224LRUBSS04	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	6.45	0.07	27.9	70	3.7
071224LRUBSS05	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	4.38	0.07	22.7	75	5
071224LRUBSS06	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	4.14	0.10	21.8	60	3.4
071224LRUBSS07	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	4.02	0.08	25.4	66	3.2
071224LRUBSS08	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	5.72	0.08	22.2	64	3.3
071224LRUBSS09	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	4.43	0.08	29.1	63	3
071224LRUBSS10	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	4.17	0.07	25.2	60	2.7
071224LRUBSS11	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	3.48	0.07	28.5	72	4.1
071224LRUBSS12	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	4.09	0.08	23.4	80	5.5
071224LRUBSS13	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	5.17	0.07	20.9	70	4.1
071224LRUBSS14	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	5.91	0.07	23.7	80	6.4
071224LRUBSS15	slimy sculpin	Lwr Ruby	7/12/2024	Selenium	5.23	0.07	21.8	67	4.1
071224LRUBSS01	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	116.91	5.07	27.2	77	5.3
071224LRUBSS02	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	131.97	3.57	26.9	79	7.1
071224LRUBSS03	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	135.87	4.84	22.3	70	4.1
071224LRUBSS04	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	97.13	3.98	27.9	70	3.7
071224LRUBSS05	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	105.73	4.36	22.7	75	5
071224LRUBSS06	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	155.05	5.78	21.8	60	3.4
071224LRUBSS07	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	100.00	5.08	25.4	66	3.2
071224LRUBSS08	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	117.57	4.59	22.2	64	3.3
071224LRUBSS09	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	78.01	4.54	29.1	63	3
071224LRUBSS10	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	80.56	3.93	25.2	60	2.7
071224LRUBSS11	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	86.32	4.32	28.5	72	4.1
071224LRUBSS12	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	171.37	4.87	23.4	80	5.5
071224LRUBSS13	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	111.96	4.02	20.9	70	4.1
071224LRUBSS14	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	75.11	3.92	23.7	80	6.4
071224LRUBSS15	slimy sculpin	Lwr Ruby	7/12/2024	Zinc	98.62	4.40	21.8	67	4.1
071124USADV01	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.58	0.03	18.7	125	26.5
071124USADV02	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.87	0.03	19.3	104	9.4
071124USADV03	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.51	0.04	20	97	8.1
071124USADV04	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.66	0.03	20.4	99	10.2
071124USADV05	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.49	0.03	23.4	91	6.7
071124USADV06	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.72	0.04	22	96	7.5
071124USADV07	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.70	0.03	19	119	14.8
071124USADV08	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.88	0.06	17.7	101	8.9
071124USADV09	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.19	0.04	20.5	109	10.9
071124USADV10	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.46	0.04	18.3	118	13.7
071124USADV11	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.79	0.04	19.3	107	10
071124USADV12	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	1.16	0.04	22.2	93	6.6
071124USADV13	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.93	0.04	19.5	93	7.1
071124USADV14	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.54	0.04	19.8	129	16.3
071124USADV15	Dolly Varden	Upr Subarctic	7/11/2024	Cadmium	0.62	0.05	19.3	123	18.9

Sample ID	Species	Creek	Collection Date	Analyte	Dry Wt Result (mg/kg)	Dry Wt MDL (mg/kg)	% Solid	Fish Length (mm)	Fish Weight (g)
071124USADV01	Dolly Varden	Upr Subarctic	7/11/2024	Copper	7.17	0.56	18.7	125	26.5
071124USADV02	Dolly Varden	Upr Subarctic	7/11/2024	Copper	6.37	0.56	19.3	104	9.4
071124USADV03	Dolly Varden	Upr Subarctic	7/11/2024	Copper	4.20	0.64	20	97	8.1
071124USADV04	Dolly Varden	Upr Subarctic	7/11/2024	Copper	6.86	0.55	20.4	99	10.2
071124USADV05	Dolly Varden	Upr Subarctic	7/11/2024	Copper	4.49	0.53	23.4	91	6.7
071124USADV06	Dolly Varden	Upr Subarctic	7/11/2024	Copper	2.93	0.62	22	96	7.5
071124USADV07	Dolly Varden	Upr Subarctic	7/11/2024	Copper	18.05	0.55	19	119	14.8
071124USADV08	Dolly Varden	Upr Subarctic	7/11/2024	Copper	6.95	0.93	17.7	101	8.9
071124USADV09	Dolly Varden	Upr Subarctic	7/11/2024	Copper	2.18	0.60	20.5	109	10.9
071124USADV10	Dolly Varden	Upr Subarctic	7/11/2024	Copper	3.83	0.61	18.3	118	13.7
071124USADV11	Dolly Varden	Upr Subarctic	7/11/2024	Copper	4.62	0.64	19.3	107	10
071124USADV12	Dolly Varden	Upr Subarctic	7/11/2024	Copper	8.96	0.63	22.2	93	6.6
071124USADV13	Dolly Varden	Upr Subarctic	7/11/2024	Copper	5.49	0.59	19.5	93	7.1
071124USADV14	Dolly Varden	Upr Subarctic	7/11/2024	Copper	3.60	0.57	19.8	129	16.3
071124USADV15	Dolly Varden	Upr Subarctic	7/11/2024	Copper	11.30	0.73	19.3	123	18.9
071124USADV01	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.15	0.02	18.7	125	26.5
071124USADV02	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.11	0.02	19.3	104	9.4
071124USADV03	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.11	0.02	20	97	8.1
071124USADV04	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.08	0.01	20.4	99	10.2
071124USADV05	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.10	0.01	23.4	91	6.7
071124USADV06	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.10	0.01	22	96	7.5
071124USADV07	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.09	0.02	19	119	14.8
071124USADV08	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.16	0.02	17.7	101	8.9
071124USADV09	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.10	0.01	20.5	109	10.9
071124USADV10	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.13	0.02	18.3	118	13.7
071124USADV11	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.17	0.02	19.3	107	10
071124USADV12	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.09	0.02	22.2	93	6.6
071124USADV13	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.10	0.02	19.5	93	7.1
071124USADV14	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.09	0.02	19.8	129	16.3
071124USADV15	Dolly Varden	Upr Subarctic	7/11/2024	Mercury	0.13	0.02	19.3	123	18.9
071124USADV01	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	4.21	0.07	18.7	125	26.5
071124USADV02	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	4.39	0.07	19.3	104	9.4
071124USADV03	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	4.78	0.08	20	97	8.1
071124USADV04	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	4.24	0.07	20.4	99	10.2
071124USADV05	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	3.59	0.07	23.4	91	6.7
071124USADV06	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	4.44	0.08	22	96	7.5
071124USADV07	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	5.11	0.07	19	119	14.8
071124USADV08	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	5.07	0.12	17.7	101	8.9
071124USADV09	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	3.46	0.08	20.5	109	10.9
071124USADV10	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	4.48	0.08	18.3	118	13.7
071124USADV11	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	6.11	0.08	19.3	107	10
071124USADV12	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	6.22	0.08	22.2	93	6.6
071124USADV13	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	4.78	0.07	19.5	93	7.1
071124USADV14	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	4.24	0.07	19.8	129	16.3
071124USADV15	Dolly Varden	Upr Subarctic	7/11/2024	Selenium	4.31	0.09	19.3	123	18.9

Sample ID	Species	Creek	Collection Date	Analyte	Dry Wt Result (mg/kg)	Dry Wt MDL (mg/kg)	% Solid	Fish Length (mm)	Fish Weight (g)
071124USADV01	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	189.30	4.17	18.7	125	26.5
071124USADV02	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	224.87	4.20	19.3	104	9.4
071124USADV03	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	183.50	4.80	20	97	8.1
071124USADV04	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	174.02	4.12	20.4	99	10.2
071124USADV05	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	135.90	3.97	23.4	91	6.7
071124USADV06	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	127.73	4.64	22	96	7.5
071124USADV07	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	251.58	4.11	19	119	14.8
071124USADV08	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	227.68	6.95	17.7	101	8.9
071124USADV09	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	131.71	4.54	20.5	109	10.9
071124USADV10	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	132.24	4.59	18.3	118	13.7
071124USADV11	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	275.65	4.82	19.3	107	10
071124USADV12	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	171.62	4.73	22.2	93	6.6
071124USADV13	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	173.85	4.46	19.5	93	7.1
071124USADV14	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	181.82	4.24	19.8	129	16.3
071124USADV15	Dolly Varden	Upr Subarctic	7/11/2024	Zinc	167.88	5.44	19.3	123	18.9
071324RILSS01	slimy sculpin	Riley	7/12/2024	Cadmium	0.14	0.05	20	74	5.4
071324RILSS02	slimy sculpin	Riley	7/13/2024	Cadmium	0.48	0.04	19.8	61	2.5
071324RILSS03	slimy sculpin	Riley	7/13/2024	Cadmium	0.44	0.04	24.3	63	2.5
071324RILSS04	slimy sculpin	Riley	7/13/2024	Cadmium	0.48	0.03	29.2	70	3.3
071324RILSS05	slimy sculpin	Riley	7/13/2024	Cadmium	0.25	0.04	17.8	77	5.2
071324RILSS06	slimy sculpin	Riley	7/13/2024	Cadmium	0.16	0.04	20.9	87	9
071324RILSS07	slimy sculpin	Riley	7/13/2024	Cadmium	0.63	0.03	23.3	73	4
071324RILSS08	slimy sculpin	Riley	7/13/2024	Cadmium	0.49	0.04	26.2	60	2.9
071324RILSS09	slimy sculpin	Riley	7/13/2024	Cadmium	0.28	0.03	25.5	64	3.4
071324RILSS10	slimy sculpin	Riley	7/13/2024	Cadmium	0.44	0.04	24.2	60	2.7
071324RILSS01	slimy sculpin	Riley	7/12/2024	Copper	3.13	0.76	20	74	5.4
071324RILSS02	slimy sculpin	Riley	7/13/2024	Copper	3.69	0.65	19.8	61	2.5
071324RILSS03	slimy sculpin	Riley	7/13/2024	Copper	3.10	0.59	24.3	63	2.5
071324RILSS04	slimy sculpin	Riley	7/13/2024	Copper	3.24	0.42	29.2	70	3.3
071324RILSS05	slimy sculpin	Riley	7/13/2024	Copper	3.22	0.72	17.8	77	5.2
071324RILSS06	slimy sculpin	Riley	7/13/2024	Copper	3.20	0.59	20.9	87	9
071324RILSS07	slimy sculpin	Riley	7/13/2024	Copper	2.57	0.55	23.3	73	4
071324RILSS08	slimy sculpin	Riley	7/13/2024	Copper	3.50	0.58	26.2	60	2.9
071324RILSS09	slimy sculpin	Riley	7/13/2024	Copper	2.73	0.53	25.5	64	3.4
071324RILSS10	slimy sculpin	Riley	7/13/2024	Copper	3.32	0.60	24.2	60	2.7

Sample ID	Species	Creek	Collection Date	Analyte	Dry Wt Result (mg/kg)	Dry Wt MDL (mg/kg)	% Solid	Fish Length (mm)	Fish Weight (g)
071324RILSS01	slimy sculpin	Riley	7/12/2024	Mercury	0.34	0.02	20	74	5.4
071324RILSS02	slimy sculpin	Riley	7/13/2024	Mercury	0.24	0.01	19.8	61	2.5
071324RILSS03	slimy sculpin	Riley	7/13/2024	Mercury	0.15	0.01	24.3	63	2.5
071324RILSS04	slimy sculpin	Riley	7/13/2024	Mercury	0.24	0.01	29.2	70	3.3
071324RILSS05	slimy sculpin	Riley	7/13/2024	Mercury	0.31	0.01	17.8	77	5.2
071324RILSS06	slimy sculpin	Riley	7/13/2024	Mercury	0.32	0.01	20.9	87	9
071324RILSS07	slimy sculpin	Riley	7/13/2024	Mercury	0.32	0.01	23.3	73	4
071324RILSS08	slimy sculpin	Riley	7/13/2024	Mercury	0.18	0.01	26.2	60	2.9
071324RILSS09	slimy sculpin	Riley	7/13/2024	Mercury	0.22	0.01	25.5	64	3.4
071324RILSS10	slimy sculpin	Riley	7/13/2024	Mercury	0.22	0.01	24.2	60	2.7
071324RILSS01	slimy sculpin	Riley	7/12/2024	Selenium	10.20	0.10	20	74	5.4
071324RILSS02	slimy sculpin	Riley	7/13/2024	Selenium	11.46	0.08	19.8	61	2.5
071324RILSS03	slimy sculpin	Riley	7/13/2024	Selenium	7.20	0.07	24.3	63	2.5
071324RILSS04	slimy sculpin	Riley	7/13/2024	Selenium	6.99	0.05	29.2	70	3.3
071324RILSS05	slimy sculpin	Riley	7/13/2024	Selenium	8.31	0.09	17.8	77	5.2
071324RILSS06	slimy sculpin	Riley	7/13/2024	Selenium	9.47	0.07	20.9	87	9
071324RILSS07	slimy sculpin	Riley	7/13/2024	Selenium	5.28	0.07	23.3	73	4
071324RILSS08	slimy sculpin	Riley	7/13/2024	Selenium	8.63	0.07	26.2	60	2.9
071324RILSS09	slimy sculpin	Riley	7/13/2024	Selenium	7.41	0.07	25.5	64	3.4
071324RILSS10	slimy sculpin	Riley	7/13/2024	Selenium	6.61	0.07	24.2	60	2.7
071324RILSS01	slimy sculpin	Riley	7/12/2024	Zinc	172.00	5.70	20	74	5.4
071324RILSS02	slimy sculpin	Riley	7/13/2024	Zinc	139.90	4.85	19.8	61	2.5
071324RILSS03	slimy sculpin	Riley	7/13/2024	Zinc	120.16	4.44	24.3	63	2.5
071324RILSS04	slimy sculpin	Riley	7/13/2024	Zinc	92.47	3.18	29.2	70	3.3
071324RILSS05	slimy sculpin	Riley	7/13/2024	Zinc	139.89	5.39	17.8	77	5.2
071324RILSS06	slimy sculpin	Riley	7/13/2024	Zinc	139.23	4.45	20.9	87	9
071324RILSS07	slimy sculpin	Riley	7/13/2024	Zinc	108.15	4.12	23.3	73	4
071324RILSS08	slimy sculpin	Riley	7/13/2024	Zinc	108.78	4.35	26.2	60	2.9
071324RILSS09	slimy sculpin	Riley	7/13/2024	Zinc	93.33	4.00	25.5	64	3.4
071324RILSS10	slimy sculpin	Riley	7/13/2024	Zinc	106.20	4.46	24.2	60	2.7