Technical Report No. 24-12

Baseline Aquatic Biomonitoring for the Aktigiruq-Anarraaq Extension Project, 2023

by

Olivia N. Edwards

June 2024

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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By

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June 2024

Cover: East Fork Grayling Junior Creek with naturally red stained tributary, August 2023. Photo by Lauren Yancy.

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ACKNOWLEDGEMENTS

We thank Teck American Incorporated and Teck Alaska Incorporated[1] (collectively referred to as Teck) for their financial and logistical support for aquatic biomonitoring in streams associated with the Teck American Incorporated Aktigiruq-Anarraaq Extension Project. We specifically acknowledge the onsite assistance provided by current and former Teck employees: Wayne Hall, Robert Napier, Darren Jones, Joseph Diehl III, Uula Sheldon, Tristan Pattee, Trevor Phillips, and Carla Nelson.

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[1] The aquatic biomonitoring for this report was collected for the Aktigiruq-Anarraaq Extension Project, which is a Teck American Incorporated project. While onsite, Teck Alaska Incorporated staff provided logistical support.

EXECUTIVE SUMMARY

This report summarizes results of 2023 biomonitoring work conducted in streams in the vicinity of the Aktigiruq-Anarraaq Extension Project (AAEP) located northwest of the Red Dog Mine. Biomonitoring included surveys of periphyton, benthic macroinvertebrates, and fish; these data have been collected annually since 2014. Historic biomonitoring data from 2000–2002 are included for comparison (Weber-Scannell and Ott 2006). The purpose of this report is to document the existing aquatic environment and to provide a basis for monitoring as exploration continues.

Water quality in streams near the Aktigiruq and Anarraaq prospects varies considerably. Creeks draining from the orebody areas (West Fork Ikalukrok, Noa, Moil, Ikalukrok, and Competition creeks) exhibit naturally degraded water quality (i.e., high metals, low pH), low periphyton standing crop and benthic macroinvertebrate density, and very few fish. Conversely, creeks on the east side of the Ikalukrok Creek drainage (East Fork Ikalukrok, Grayling Junior, and Volcano creeks) generally have good water quality conducive to healthy stream biota.

Sampling locations and parameters for 2023 remained similar to 2022. However, no sampling occurred at Upper North Fork Red Dog Creek North, Upper North Fork Red Dog tributary, and North Fork Grayling Junior Creek in 2023. At Upper North Fork Red Dog Creek South, fish sampling continued but no periphyton or benthic macroinvertebrate samples were collected. In 2023, in situ water quality measurements were taken at sites where periphyton samples were collected. Water quality parameters recorded were temperature, dissolved oxygen, specific conductance, conductivity, pH, and turbidity.

Measurements of periphyton standing crop, benthic macroinvertebrates, and fish distribution varied among the sample sites in 2023. Periphyton as measured by chlorophyll-a was highest in Upper Volcano Creek (12.6 mg/m^2). Mean chlorophyll-a values in East Fork Ikalukrok and Sled creeks had overlapping error bars (SD) with Upper Volcano Creek. Periphyton as measured by chlorophyll-a at all other sites was very low (<1.00 mg/m^2). Benthic macroinvertebrate densities across all sites ranged from a low of 9 individuals per m^2 in Moil Creek to a high of 7,534 individuals per m^2 in East Fork Ikalukrok Creek. Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa were present at most sites excluding Sourdock, Lower Competition, Noa, Moil, and Warf creeks. Taxa richness ranged from a low of 2 in Moil Creek to a high of 20 in East Fork Ikalukrok Creek. Fish catch per unit effort (CPUE) was highest at Upper North Fork Red Dog

Creek South. In 2023, fish were captured at three other sites: Volcano Creek, North Fork Grayling Creek, and Grayling Junior Creek. Zero fish were captured at the remaining sites. Visual freshwater mussel surveys were performed at several sites in July 2023, but no evidence of mussels was found.

INTRODUCTION

Teck American has been conducting mineral exploration drilling around the Anarraaq Prospect since the mid-1990's and more recently at a second prospect (Aktigiruq) in the same general area. Both prospects are zinc and lead subsurface deposits collectively located in Sections 11, 14, and 23, T32N, R19W (De Long Mountains A-2). The deposits are located approximately 16 km northwest of the Red Dog Mine (Figure 1).

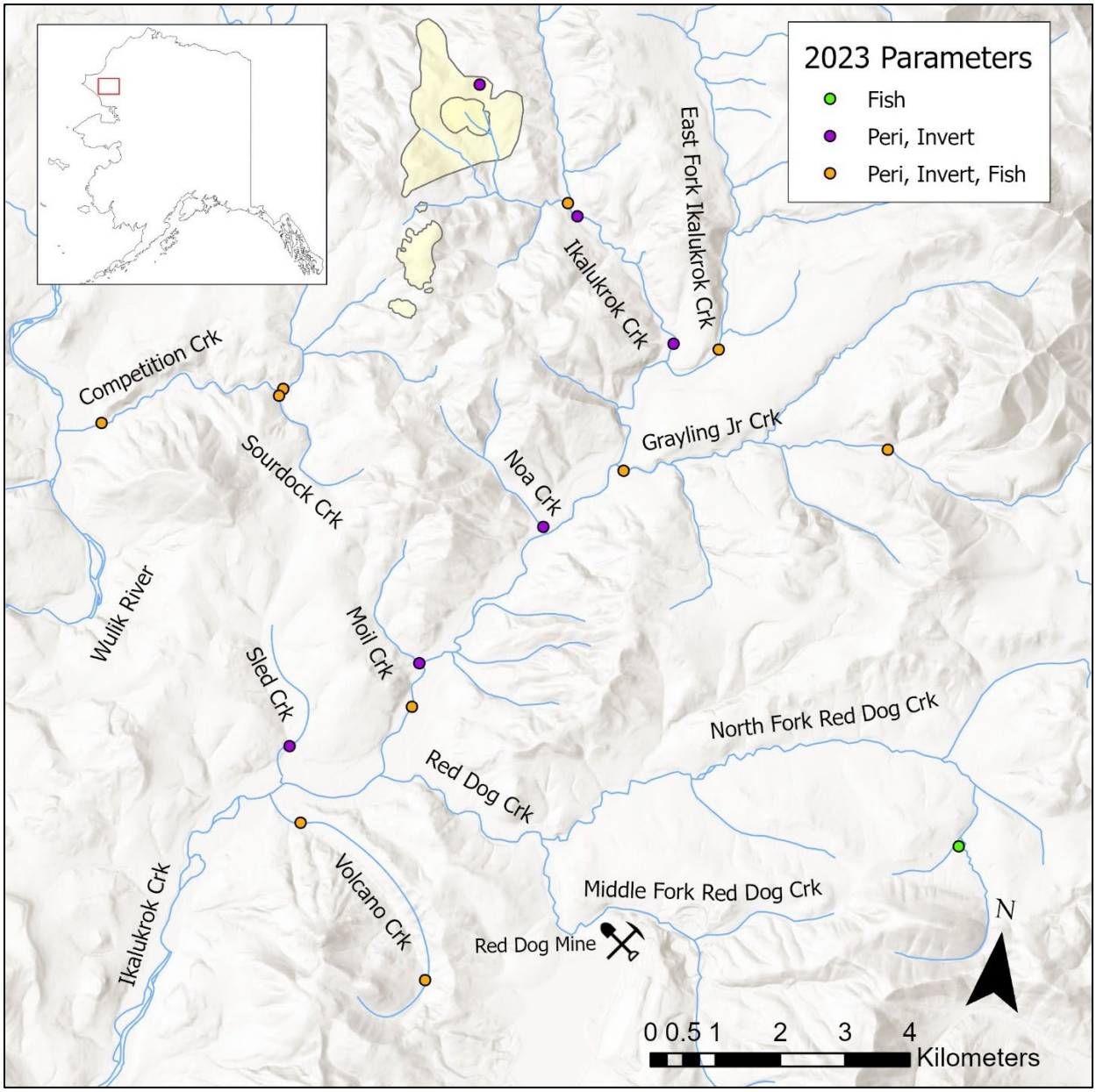

Figure 1.–Map showing 2023 sample sites and associated parameters. The general location of Aktigiruq and Anarraaq deposits are in yellow polygons.

Aquatic baseline data collection near the Anarraaq Prospect began in 2000 and continued through 2002. Alaska Department of Natural Resources (ADNR) technical reports summarize water quality, periphyton, benthic macroinvertebrate, and fish data collected in 2000, 2001, and 2002 (Weber-Scannell and Ott 2006).

From 2014–2023, sampling work focused on streams which flow to the west and east from the Aktigiruq and Anarraaq ore bodies. Most sites are spread throughout the Ikalukrok Creek drainage, and three sites are in the Wulik River drainage (Figure 1). Periphyton (chlorophyll-a concentrations), benthic macroinvertebrates (taxonomic richness and abundance), and fish (presence and size) data were collected. Mussel presence surveys were conducted in July at a subset of sites starting in 2020. Periphyton and benthic macroinvertebrates were collected in early July and fish sampling was conducted in early August.

In 2013, the United States Environmental Protection Agency (EPA) published the updated Clean Water Act, which included ambient water quality criteria recommendations for ammonia for the protection of the aquatic community, including fish, mussels, and other mollusks. Mussels in the order Unionoida (freshwater mussels) are some of the most sensitive aquatic species to ammonia but are not present in all waters. Therefore, the EPA allows for site-specific criteria with higher ammonia concentrations if applicants demonstrate that mussels are absent. These site-specific criteria are still protective of other aquatic life in the waterbody. The Alaska Department of Environmental Conservation has not yet implemented the more restrictive water quality criteria for ammonia but may do so in the future. To have the necessary documentation for future ammonia criteria recalculation, in 2020 the ADF&G Habitat Section added visual surveys for mussel presence/absence to the annual aquatic biomonitoring at a subset of sites.

Access for future exploration of the orebodies will be via an all-weather road following Mainstem Red Dog Creek, crossing North Fork Red Dog, Grayling Junior, and Ikalukrok creeks, and then following Ikalukrok Creek. These creeks are anadromous waterbodies that support Dolly Varden, as well as the resident fish species Arctic grayling and slimy sculpin.

The Aktigiruq and/or Anarraaq Prospects may ultimately be developed as underground mine(s) located about 600 m below the ground surface. Details on mine development, operations, and closure are not available at this time, but will be required prior to permit issuance and mining development.

METHODS

Details for most of the methods used for this aquatic biomonitoring study are described in ADF&G Technical Report 17-09 *Methods for Aquatic Life Monitoring at the Red Dog Mine Site* (Bradley 2017). Location of the sample sites described in this report and the years they were sampled are listed in Table 1. In 2023, periphyton and benthic macroinvertebrate sampling occurred from July 6–13 and fish sampling occurred from August 3–8.

A handheld multiparameter YSI was used to measure water temperature (°C), dissolved oxygen (mg/L), specific conductance (µS/cm), conductivity (µS/cm), and pH. The probe was placed in flowing water, and measurements were allowed to equilibrate for 15 minutes before being recorded. An Orion AQUAfast Turbidity meter was used to measure turbidity (NTU). At each site, the sample vial was rinsed with sample 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.

Periphyton attached microalgae biomass (periphyton) was sampled in July from cobbles in the streambed. The periphyton was collected from a riffle area of fully submerged cobble, following the rapid bioassessment techniques of Barbour et al. (1999) with ten replicates per site to increase sample precision. Periphyton samples were collected annually in early July. Chlorophyll-a concentrations were determined in the Fairbanks ADF&G lab to estimate periphyton standing crop and primary productivity in the stream. Results are presented as mean chlorophyll-a ($mg/m^2 \pm 1$ SD).

Prior to 2022, benthic macroinvertebrates were collected using drift nets but beginning in 2022, benthic macroinvertebrate sampling was conducted solely with Hess samplers[2]. Hess samplers are more effective for identifying the in situ benthic community than drift nets, which mostly capture macroinvertebrates drifting downstream suspended in the water column. Therefore, the Hess sampling method provides a more accurate baseline for evaluating changes and natural variability at each site, rather than conditions occurring upstream.

[2] Comparisons between drift net and Hess sampler results can be found in the ADF&G annual technical report *Baseline Aquatic Biomonitoring for the Anarraaq and Aktigiruq Prospects near the Red Dog Mine, 2021* (Clawson 2022).

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. The cod end contents were then removed and placed in individual pre-labeled Nalgene bottles with denatured ethyl alcohol to preserve the benthic macroinvertebrates (BMI). Samples were sorted and invertebrates identified to the lowest taxonomic level, typically family or genus, by NRF Taxonomic Services in Fairbanks, Alaska. 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. Macroinvertebrate density was calculated for each sample by dividing the number of BMI by 0.086 m^2, the Hess sampling area. Mean density was estimated for each site by calculating the mean density among the five samples. Taxa richness is reported as the number of taxonomic groups identified to the lowest practical level. Insects of the orders Ephemeroptera, Plecoptera, Trichoptera, and Diptera were identified to genus, except nonbiting midges in the Chironomidae family. All other invertebrates were identified to class or order. Terrestrial organisms were excluded from all calculations.

Fish were sampled by setting 10 minnow traps baited with cured salmon roe at each site for approximately 24 hours in early August. Fish captured in minnow traps were identified to species and measured (fork length or total length, depending on species), and released. Results are presented in catch per unit effort (CPUE) which is the total number of Dolly Varden caught at a site per 24-hour period.

Visual surveys for freshwater mussel presence or absence were conducted in areas of low water velocity such as back eddies or pools at a subset of sample sites in early July. Biologists looked for trails in the substrate, live animals, and shells from dead animals. In areas of poor water visibility an Aquascope was used to obtain a clearer view of the substrate.

Water quality sampling was performed by Teck Alaska throughout the 2023 open water season following their standard methodology. Sample analysis was performed by external laboratories and results provided to ADF&G for inclusion in this report. All metal concentration data in this report are presented as “total recoverable” unless otherwise specified. The number of water quality

samples taken each year varies, but samples are generally collected twice each month during the open water season.

Table 1.–Location of sample sites, parameters collected, and years sampled. Parameters include periphyton (P), benthic macroinvertebrates (B), fish (F), in situ water quality (W) and mussels (M).

Stream/Site Name	Station No.	2023 Parameters	Years Sampled
Upper Competition	203	P, B, F, W	2000-2002 and 2014-2023
Sourdock	204	P, B, F, W	2000-2002 and 2014-2023
Lower Competition	202	P, B, F, W	2000-2002 and 2014-2023
West Fork Ikalukrok[1]	205	P, B, F, W, M	2000-2002 and 2015-2023
Upper Ikalukrok (above West Fork)[1]	206	P, B, F, W, M	2000-2002 and 2015-2023
Lower Ikalukrok (below Cub Crk Seep)[1]	207	P, B, W, M	1997-1998, 2000-2002, and 2016-2023
East Fork Ikalukrok[1]	208	P, B, F, W, M	1997-1998, 2000-2002, and 2016-2023
Grayling Junior[1]	209	P, B, F, W, M	2000-2002 and 2016-2023
Noa	210	P, B, W	2000-2002 and 2016-2023
Moil	211	P, B, W	2000-2002 and 2016-2023
Sled	212	P, B, W	2000-2002 and 2015-2023
Volcano	n/a	P, B, F, W	2014-2023
Upper Volcano	n/a	P, B, F, W	2016 and 2022-2023
Warf	n/a	P, B, W	2021-2023
Ikalukrok (below West Fork)	230	P, B, W	2021-2023
NF Grayling Junior	n/a	P, B, F	2021-2023
Upper NFRD South	n/a	F	2021-2023
EF Grayling Junior[2]	n/a	F	2021-2022
Upper NFRD Trib[2]	n/a	F	2021-2022
Upper NFRD 2[2]	n/a	F	2021-2022

[1]Site was not sampled in 2020.
[2]Site was not sampled in 2023 but previous years' data are presented in the text.

RESULTS AND DISCUSSION

This section presents the biomonitoring results for each site listed in Table 1. Comparisons are made to prior work performed in 2000–2002 (Weber-Scannell and Ott 2006). Detailed data for fish catches can be found in Appendix 1. Additional detailed data (periphyton, benthic macroinvertebrates, and fish whole body element concentrations) are available upon request[3]. Seasonal water quality data collected by Teck can be found in Appendix 2. In situ water quality data collected during 2023 sampling can be found in Appendix 3.

UPPER COMPETITION CREEK (STATION 203)

Water Quality

Upper Competition Creek water samples had moderately low pH and elevated concentrations of aluminum, cadmium, nickel, and zinc in the early 2000's (Weber-Scannell and Ott 2006). In July 2023, the pH was acidic at 5.4 and specific conductance was high at 1,011 µs/cm (Appendix 3). The substrate had a grayish-yellow precipitate in the early 2000's, but the precipitate in 2014–2023 has varied from white to tan. The water clarity in Upper Competition Creek has varied among years from opaque white to orange in color (Figure 2).

Figure 2.–Upper Competition Creek in August 2022 (left) and July 2023 (right).

[3] Submit detailed data requests to ADF&G Habitat Section: 1300 College Rd, Fairbanks, Alaska 99701 or dfg.hab.infofai@alaska.gov.

Periphyton

The mean chlorophyll-a concentration in Upper Competition Creek in 2023 was 0.06 mg/m^2 (SD = 0.09). This value is similar to the annual means during the recent sampling period (2014–2022) but well below the highest observed value of 0.42 mg/m^2 in 2002 (Figure 3). Mean chlorophyll-a concentrations have been consistently lower in Upper Competition Creek during the recent sampling period (2014–2022) compared to the early 2000's.

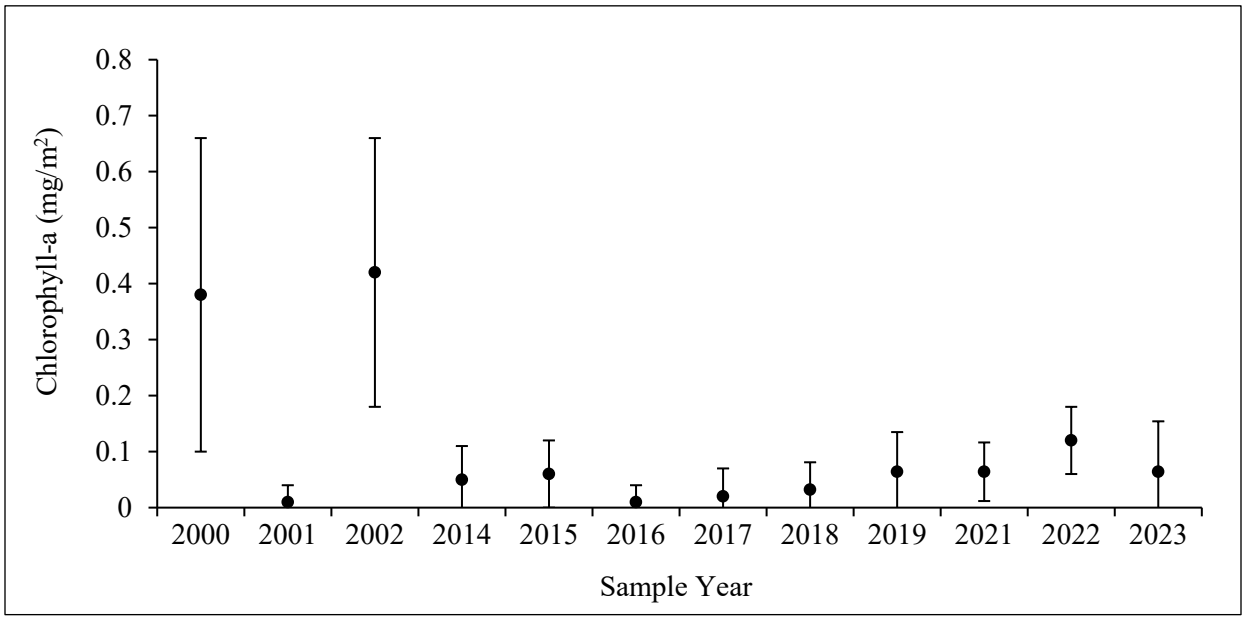

Figure 3.–Mean chlorophyll-a concentration (mg/m^2 ± 1 SD) in Upper Competition Creek.

Macroinvertebrates

Benthic macroinvertebrate density in Upper Competition Creek in 2023 was 67 BMI/m^2 (SD = 54). In 2023, EPT taxa were present for the first time since 2019 and comprised 17.24% of the sample (Figure 4). Similar to previous years' results, EPT taxa were comprised of Ephemeroptera (mayflies) and Plecoptera (stoneflies). Taxa richness in 2023 remained relatively low at 8 taxa. Prior to 2022, taxa richness ranged from 12–22 among the sample years (Figure 5). The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

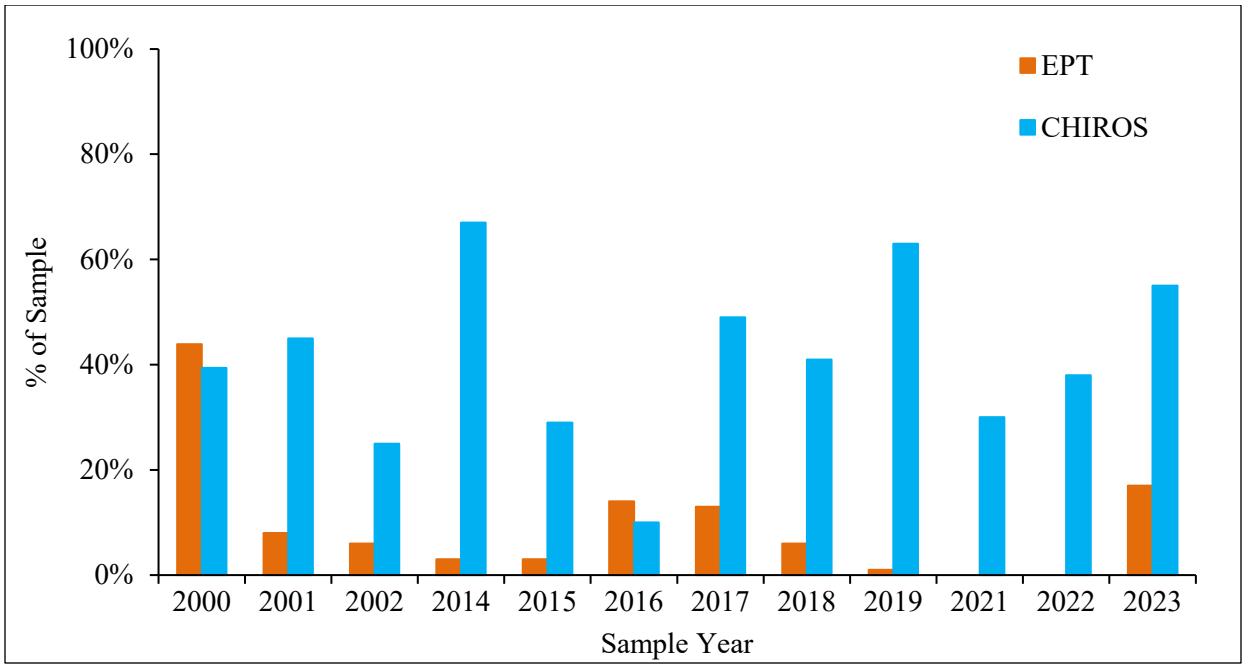

Figure 4.–Percent CHIROS and EPT in Upper Competition Creek.

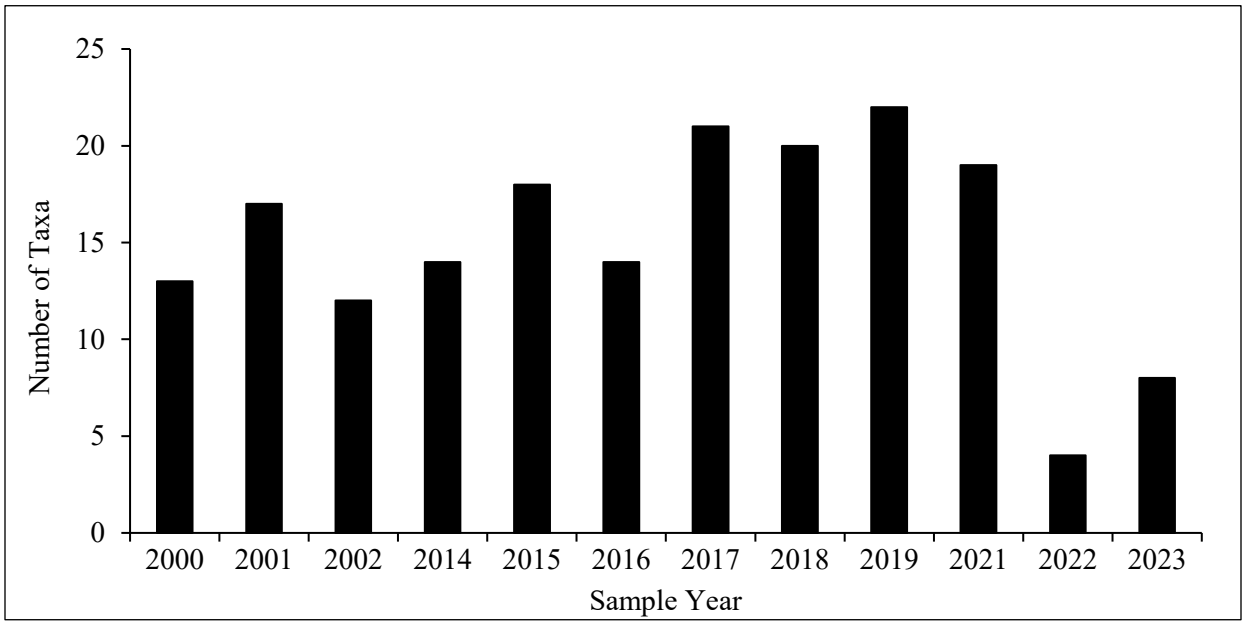

Figure 5.–Benthic macroinvertebrate taxa richness in Upper Competition Creek.

Fish

The CPUE for Dolly Varden in minnow traps at Upper Competition Creek was 5 fish in 2000 and 3 fish in 2002. These catches coincided with the 2 years that had the highest chlorophyll-a concentrations (Figure 3). No fish were caught at Upper Competition Creek from 2014–2023.

SOURDOCK CREEK (STATION 204)

Water Quality

In the early 2000's, Sourdock Creek water samples had moderate alkalinity (as $CaCO_3$) and the pH was neutral with slightly elevated concentrations of aluminum, cadmium, and zinc (Weber-Scannell and Ott 2006). In July 2023, the pH was neutral at 7.55 and turbidity was relatively high at 12.2 NTU (Appendix 3). The large boulders in the stream were covered with a thick layer of moss from 2000–2002, but moss has been mostly absent during the 2014–2023 sample period. In 2021 and 2022 there was orange staining on the rocks and the water was more opaque than in past years. In 2023 orange staining on the rocks persisted but the clarity of the water improved, likely due to higher flow rates in 2023 (Figure 6).

Figure 6.–Sourdock Creek in July 2022 (left) and July 2023 (right).

Periphyton

The mean chlorophyll-a concentration in Sourdock Creek in 2023 was 0.10 mg/m^2 (SD = 0.08). This is the lowest on record for this site but similar to the 2022 mean (Figure 7). The highest mean chlorophyll-a concentration observed in Sourdock Creek was 12.44 mg/m^2 in 2002 (Figure 7). Historically, chlorophyll-a concentrations were considerably higher in Sourdock Creek than in Upper Competition Creek, but since 2022 both have been very low. These two creeks merge just downstream of the sample sites into Competition Creek.

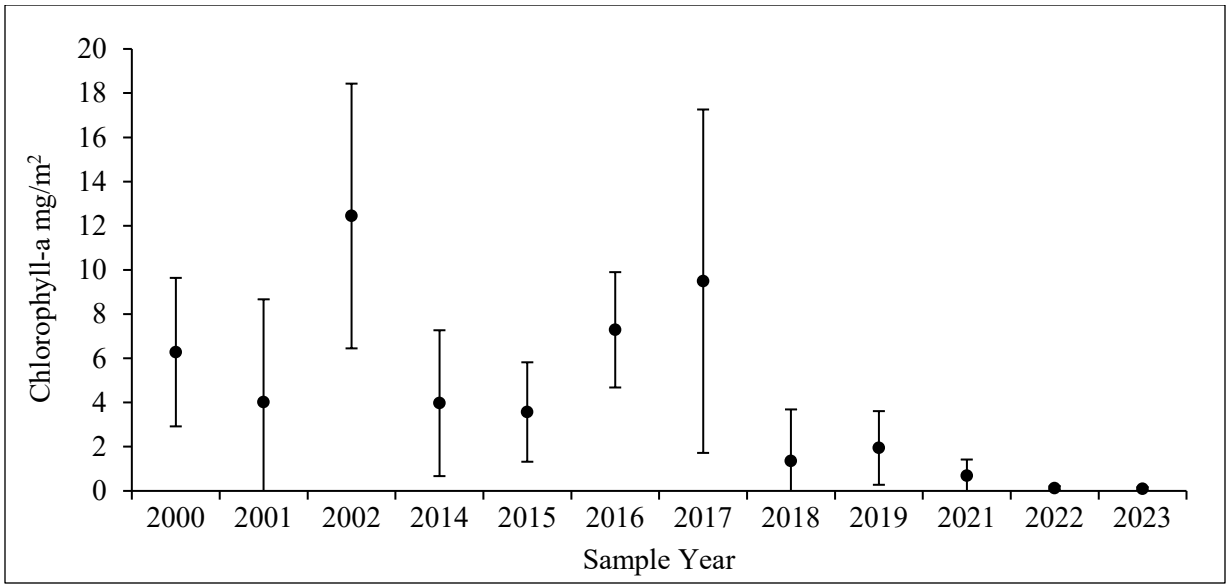

Figure 7.–Mean concentration of chlorophyll-a (± 1 SD) in Sourdock Creek.

Macroinvertebrates

Benthic macroinvertebrate density in Sourdock Creek in 2023 was 47 BMI/m^2 (SD = 31). The percent CHIROS in 2023 was the lowest on record at 10% and similar to 2022. No EPT were present in the 2023 samples (Figure 8). The remainder of the sample was composed of Dipterans, Collembolans, Oligochaetes, and Copepods. Taxa richness prior to 2022 ranged from 12–22 taxa but only 7 taxa were present in 2023 (Figure 9). The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

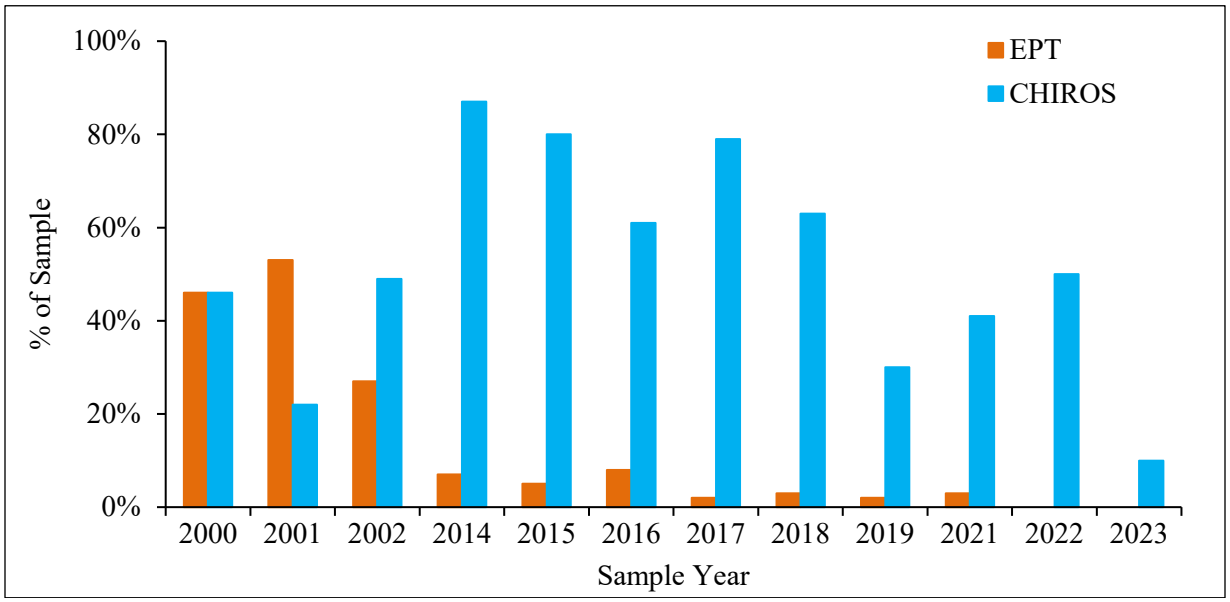

Figure 8.–Percent CHIROS and EPT in Sourdock Creek.

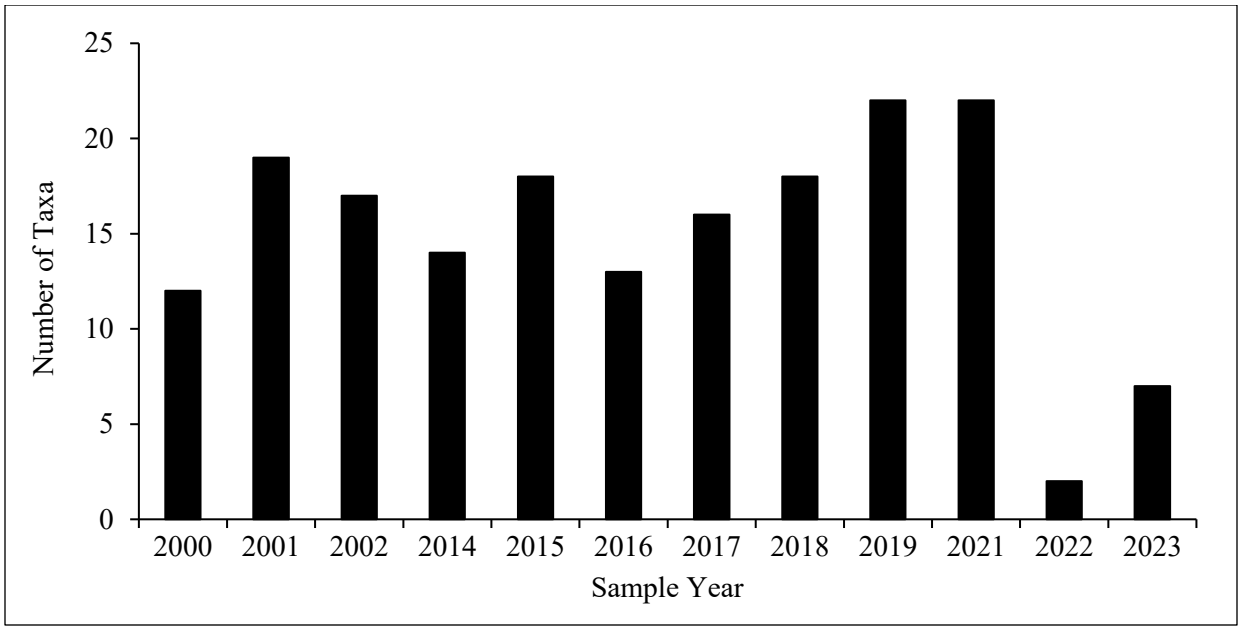

Figure 9.–Benthic macroinvertebrate taxa richness in Sourdock Creek.

Fish

The CPUE for juvenile Dolly Varden at Sourdock Creek in the early 2000's was highest in 2000 at 42 and decreased thereafter. Since sampling restarted in 2014 zero fish have been captured except in 2016, when one juvenile Dolly Varden was captured (Figure 10). Element concentrations (metals) in the water of Competition Creek may have increased, creating a chemical barrier that prevents upstream movement of Dolly Varden juveniles from the Wulik River. Water quality in Sourdock Creek also appears to be degrading in recent years, as evidenced by the decrease in chlorophyll-a concentrations and the overall change in appearance of the creek.

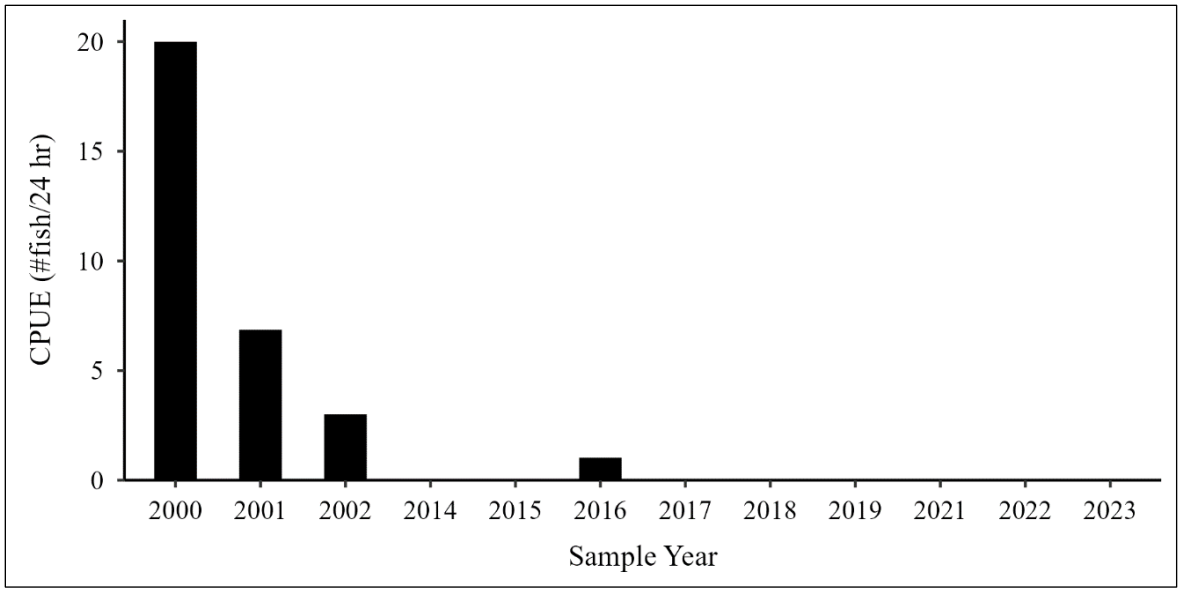

Figure 10.–Catch per unit of effort for juvenile Dolly Varden in Sourdock Creek.

The length frequency distribution for all juvenile Dolly Varden caught in Sourdock Creek since the early 2000's is presented in Figure 11. Only one fish has been captured since 2014, a 139 mm Dolly Varden in 2016. There appear to be at least two year-classes present which is consistent with data collected in nearby streams.

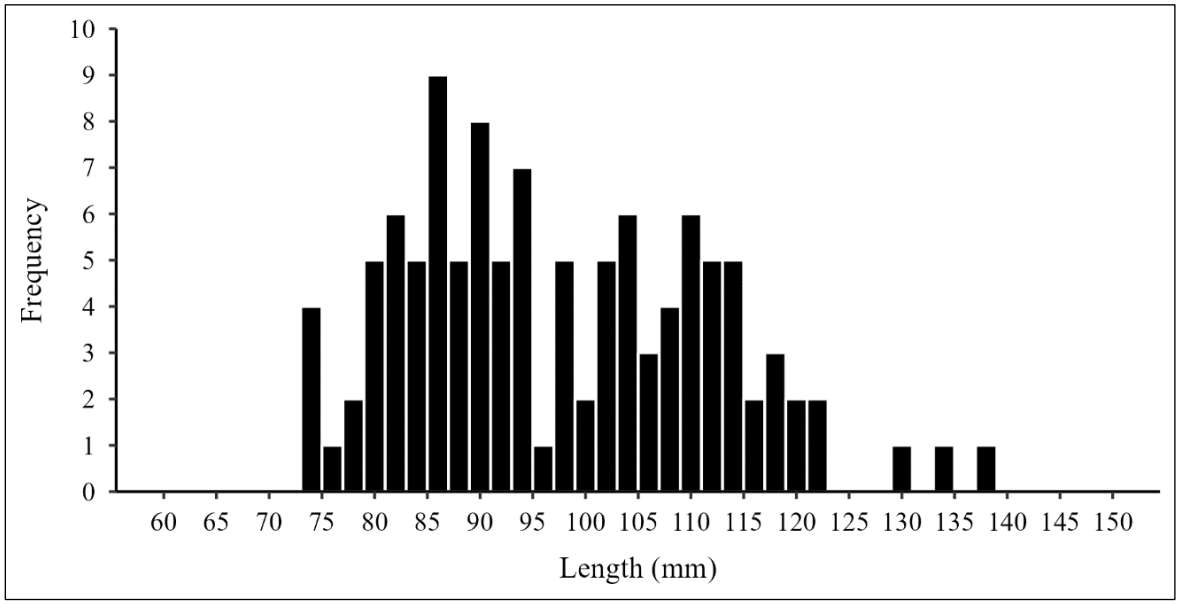

Figure 11.–Length frequency distribution (n = 111, bin width = 2) of Dolly Varden in Sourdock Creek.

LOWER COMPETITION CREEK (STATION 202)

Water Quality

Historically, Lower Competition Creek water quality appeared to be moderated by input from Sourdock Creek. Element concentrations (metals) in the water of Lower Competition Creek were substantially lower than at the Upper Competition Creek sample site in the early 2000's (Weber-Scannell and Ott 2006). Unlike the Upper Competition Site, no water samples from Lower Competition Creek contained concentrations of iron, nickel, or lead that exceeded the chronic criteria for aquatic life (Weber-Scannell and Ott 2006). Although no element concentration data has been collected in recent years, it was visually apparent beginning in 2018 that water quality had changed from that observed from 2000–2002 (clear water) to reddish orange staining on the substrate with opaque water. In July 2023, pH was near neutral at 6.85 and turbidity was relatively high at 13.46 NTU (Appendix 3). Water clarity has not returned to that of the early 2000's but appeared clearer in 2023 than in 2022, likely due to higher flow rates (Figure 12).

Figure 12.–Lower Competition Creek in July 2022 facing its confluence with the Wulik River (left) and in July 2023 facing upstream (right).

Periphyton

The mean chlorophyll-a concentration in Lower Competition Creek in 2023 was 0.09 mg/m^2 (SD = 0.27). Mean chlorophyll-a concentrations in Lower Competition Creek from 2014–2023 were substantially lower than those from 2000–2002, an indication of degraded water quality (Figure 13). The highest chlorophyll-a concentration on record was in 2002 at 4.42 mg/m^2.

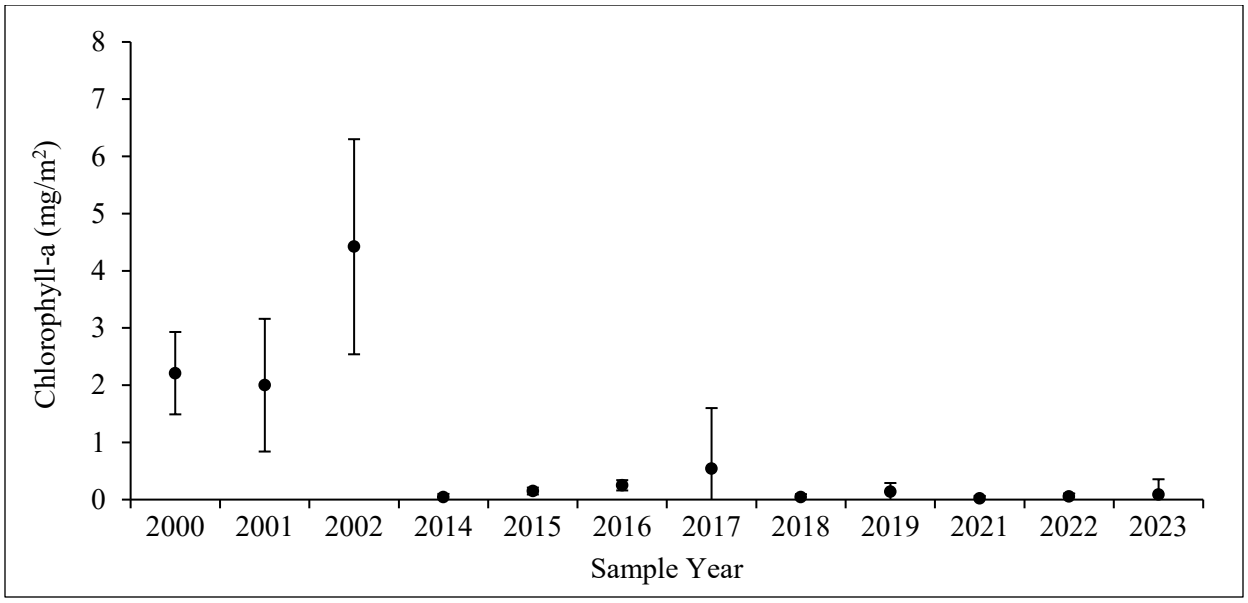

Figure 13.–Mean concentration of chlorophyll-a (± 1 SD) in Lower Competition Creek.

Macroinvertebrates

Benthic macroinvertebrate density in Lower Competition Creek in 2023 was 14 BMI/m^2 (SD = 13). In 2022, the percent EPT was higher than percent CHIROS for the first time since 2001 but no EPT were present in 2023 (Figure 14). Taxa richness declined in the last two years and the 2023 taxa was the lowest recorded at 3 taxa (Figure 15). Prior to 2022, taxa richness ranged from 13–24 taxa. The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

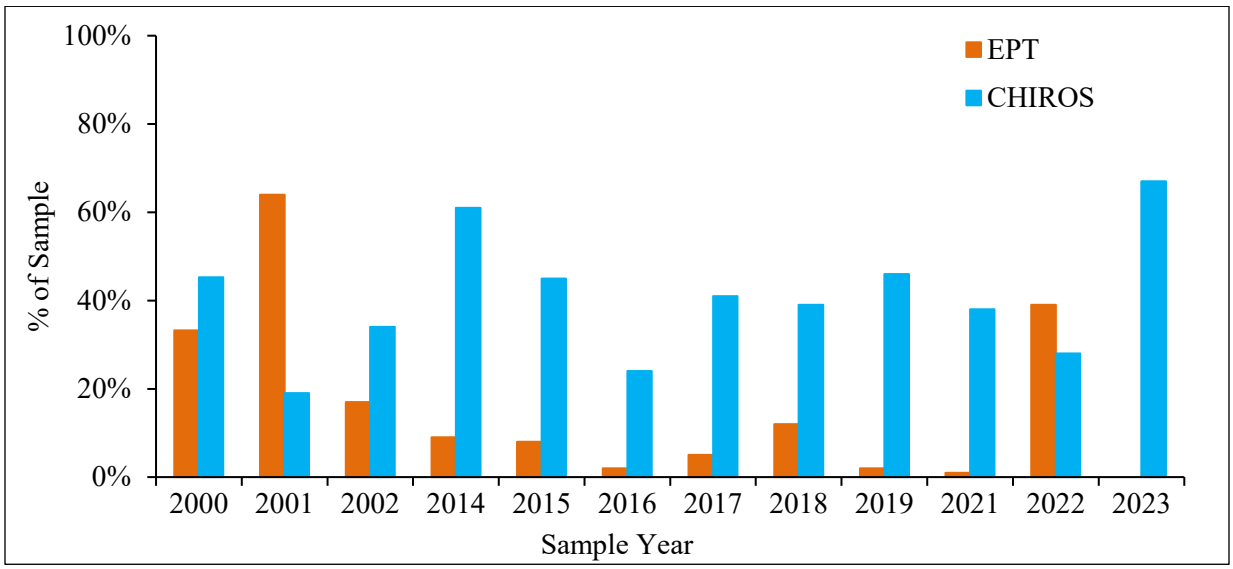

Figure 14.–Percent CHIROS and EPT in Lower Competition Creek.

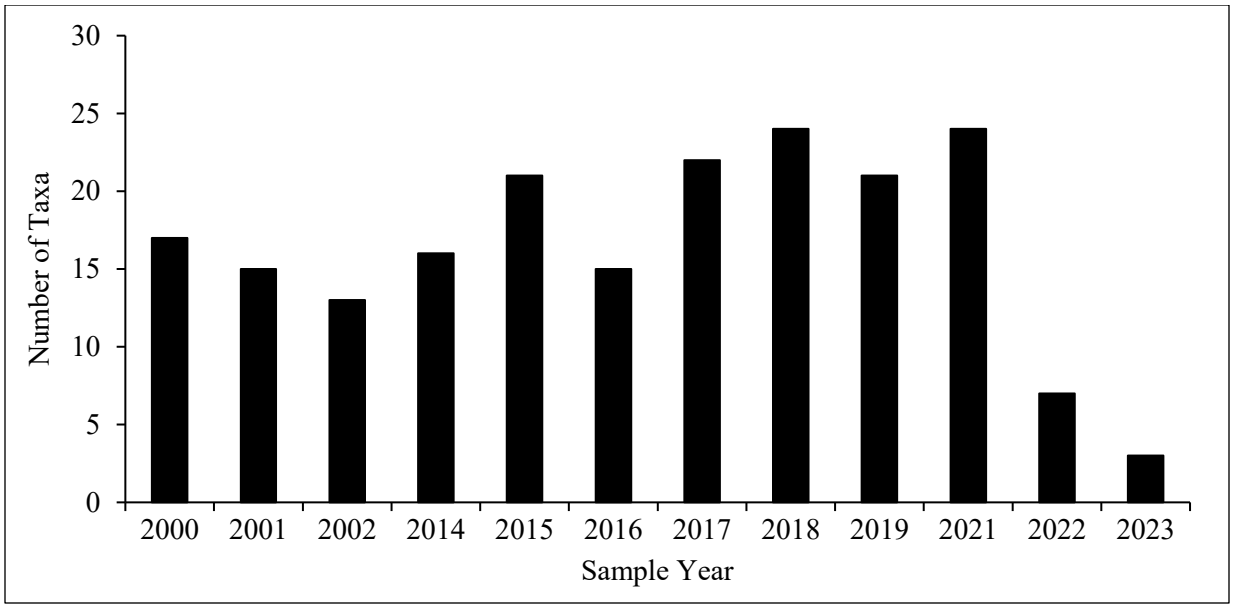

Figure 15.–Benthic macroinvertebrate taxa richness in Lower Competition Creek.

Fish

Juvenile Dolly Varden historically used Lower Competition Creek as rearing habitat during the ice-free season (Bradley and Ott 2018). In 2000, fyke nets were used to catch fish moving either upstream or downstream in early and late July. Catches yielded four juvenile Arctic grayling and 38 juvenile Dolly Varden (Weber-Scannell and Ott 2006).

Minnow trap data collected from 2000–2002 and from 2014–2023 are presented in Figure 16. The CPUE has been variable since 2014 with zero fish caught in 2021–2023, and a high CPUE of 47 in 2016 (Figure 16). Generally, the CPUE was higher from 2014–2019 than in 2000–2002. Water clarity was poor in 2021–2023 and chlorophyll-a was low compared to previous years, which may be why no fish were caught during the early August sampling events.

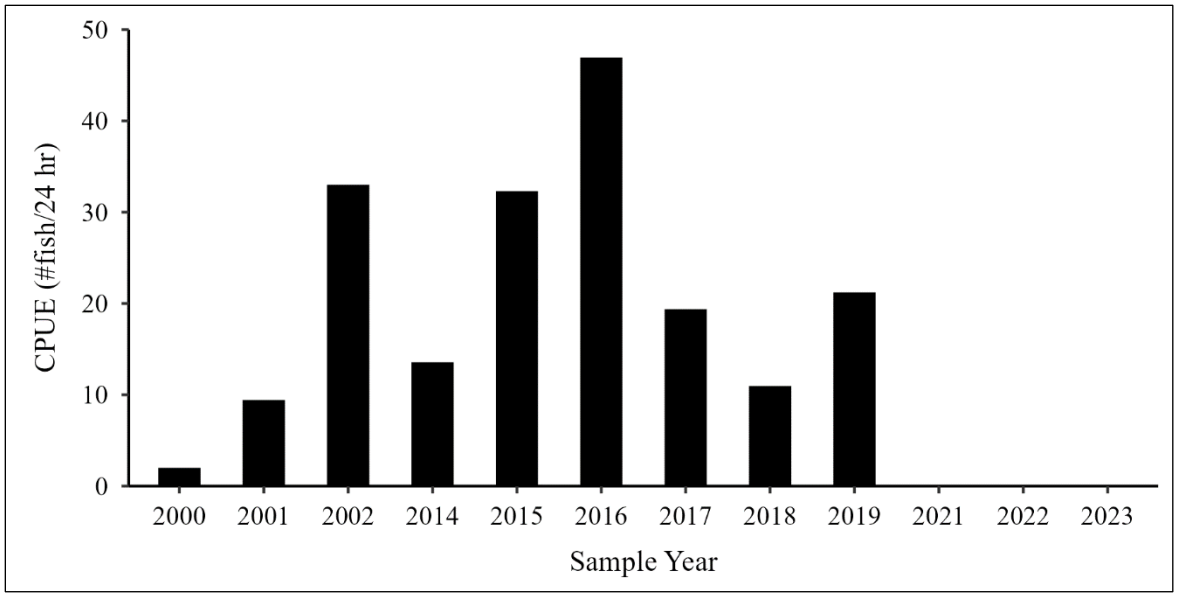

Figure 16.–Catch per unit of effort for juvenile Dolly Varden in Lower Competition Creek.

The length frequency distribution of juvenile Dolly Varden in Lower Competition Creek from all sampling years using both fyke nets and minnow traps is presented in Figure 17. There appear to be at least two year-classes (likely 1+ and 2+) which dominate the catch, and a small number of larger fish (multiple age classes). Note that fish have not been captured at this site since 2019 (Figure 16).

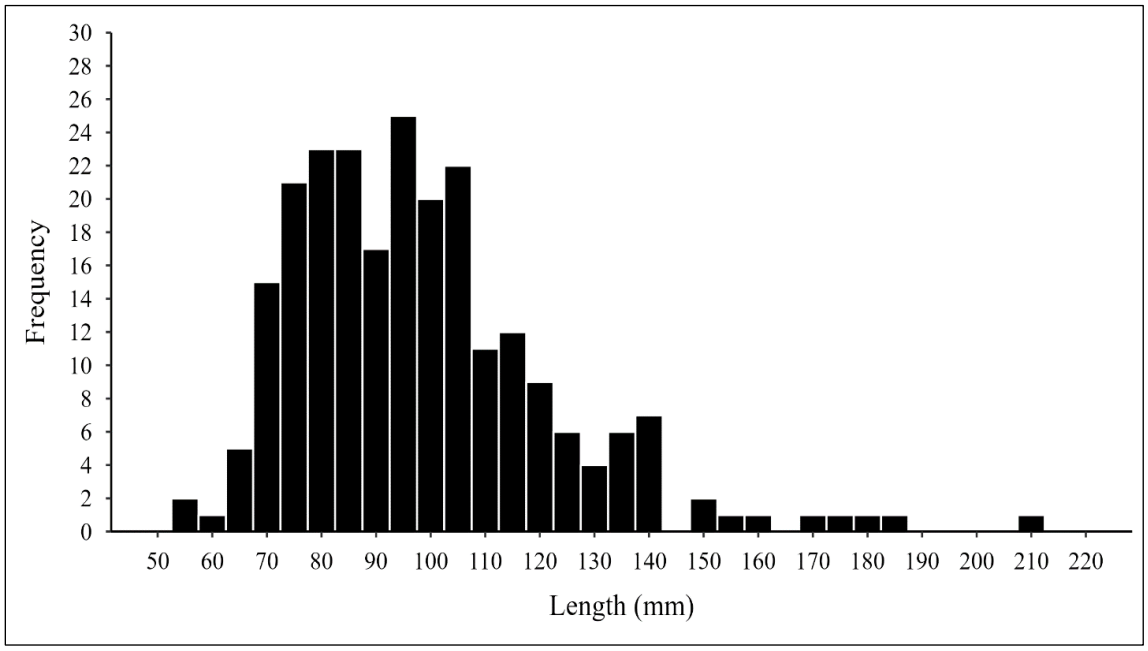

Figure 17.–Length frequency distribution (n = 200, bin width = 5) of Dolly Varden in Lower Competition Creek.

WEST FORK IKALUKROK CREEK (STATION 205)

Water Quality

In the early 2000's, water hardness and sulfate concentrations in West Fork Ikalukrok Creek were relatively high while alkalinity was low (Weber-Scannell and Ott 2006). The pH in this creek was low and ranged from 4.3–6.8. Water samples had high concentrations of most elements analyzed, especially aluminum, cadmium, copper, nickel, and zinc (Weber-Scannell and Ott 2006). In July 2023, pH was acidic at 5.02 and specific conductance was 725 µs/cm (Appendix 3). Since sampling began in the area, a white precipitate has been observed at the mouth of the creek where the waters mix with Ikalukrok Creek. In 2023, there was less red staining on the rocks than in recent years (Figure 18). Water quality data collected by Teck in 2023 is presented in Appendix 2.

Figure 18.–West Fork Ikalukrok Creek in July 2022 (left) and July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in West Fork Ikalukrok Creek in 2023 was 0.21 mg/m^2 (SD = 0.22). Mean chlorophyll-a concentrations ranged from a low of 0.04 mg/m^2 in 2018 to a high of 3.45 mg/m^2 in 2002. The mean chlorophyll-a concentrations in West Fork Ikalukrok Creek from 2015–2023 were generally lower than those from 2000–2002 (Figure 19).

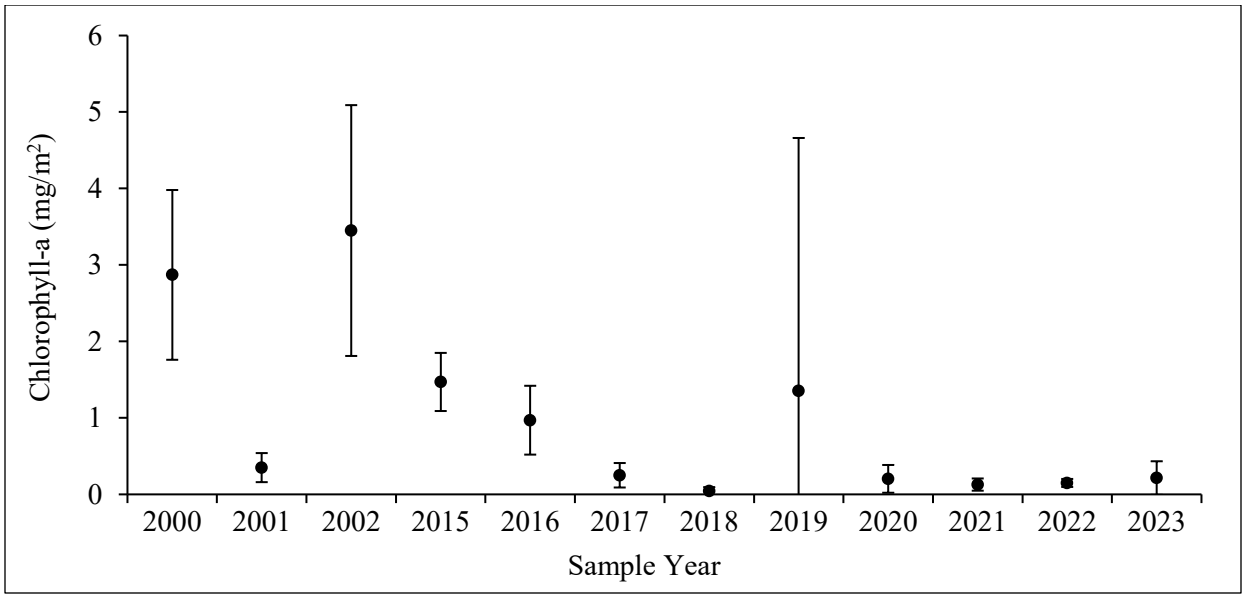

Figure 19.–Mean concentration of chlorophyll-a (± 1 SD) in West Fork Ikalukrok Creek.

Macroinvertebrates

Benthic macroinvertebrate density in West Fork Ikalukrok Creek in 2023 was 91 BMI/m^2 (SD = 52). The percent CHIROS exceeded the percent EPT in 9 of the 11 years of data (Figure 20). This was true in 2023 when EPT and CHIROS comprised 7.69% and 61.54% of the sample, respectively. Taxa richness previously ranged from 15–25 taxa, but only 7 taxa were identified in 2023 (Figure 21). The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

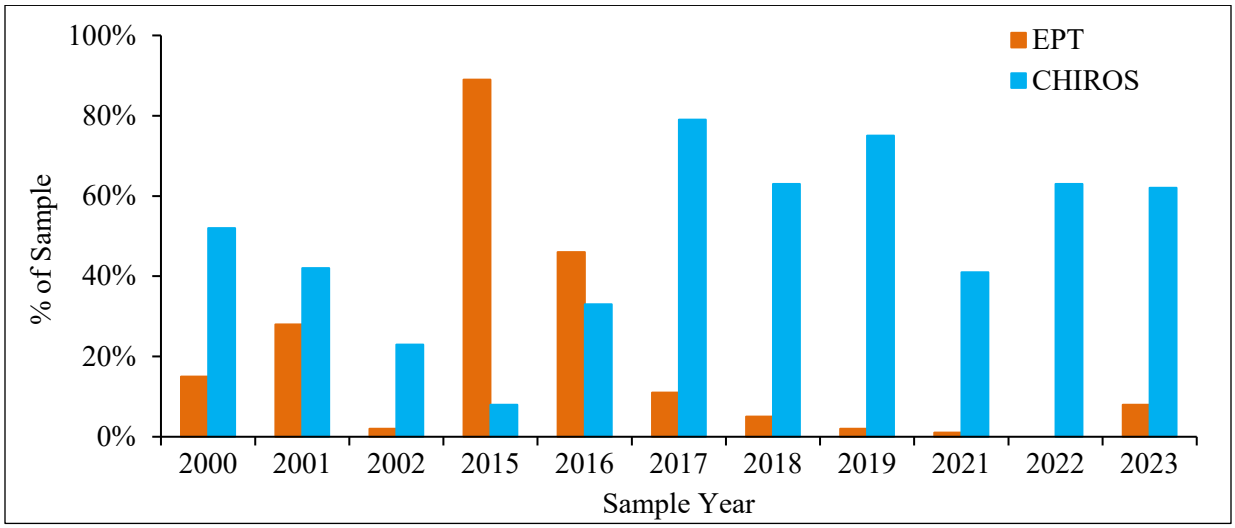

Figure 20.–Percent CHIROS and EPT in West Fork Ikalukrok Creek.

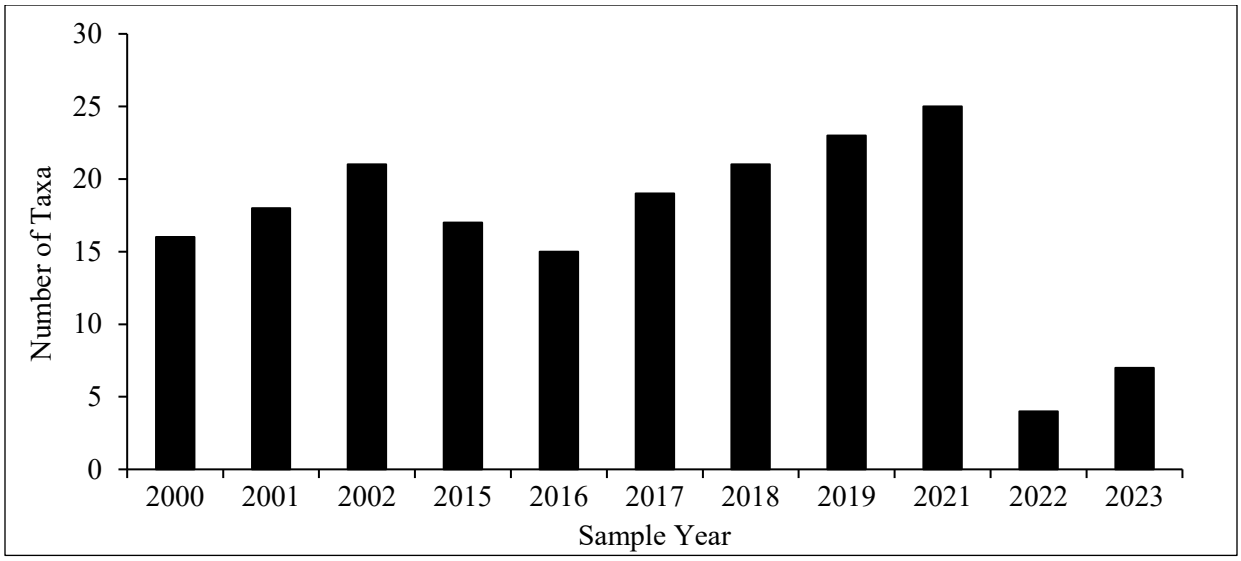

Figure 21.–Benthic macroinvertebrate taxa richness in West Fork Ikalukrok Creek.

Fish

Fish have not been captured or observed in West Fork Ikalukrok Creek. Absence of fish may be due to degraded water quality downstream in Ikalukrok Creek from various seeps, including the Cub Creek seep (located approximately 2 km downstream). These mineral seeps likely form a chemical barrier to fish passage, preventing fish from moving into the area from habitat downstream.

Mussels

No live mussels, mussel shells from dead animals, or mussel trails in the substrate have been observed to date.

UPPER IKALUKROK CREEK (STATION 206)

Water Quality

Upper Ikalukrok Creek (upstream of West Fork Ikalukrok Creek) is a clearwater system with generally good water quality. In the early 2000's, concentrations of all metals in Upper Ikalukrok Creek water samples were substantially lower than in Ikalukrok Creek downstream of the Cub Creek seep. From 2000–2002, the pH was near neutral and ranged from 6.5–8.1 (Weber-Scannell and Ott 2006). The pH was not recorded at this site in July 2023 but other in situ water quality data can be found in Appendix 3. Typically, Ikalukrok Creek above the West Fork confluence is clear, but in 2020 the water was milky with white and orange staining and precipitate on the rocks. The

water was clearer in 2021–2023 and the orange staining had lessened by 2023 (Figure 22). Water quality data collected by Teck in 2023 is presented in Appendix 2.

Figure 22.–Ikalukrok Creek immediately upstream of West Fork Ikalukrok Creek in July 2022 (left) and July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in Upper Ikalukrok Creek in 2023 was 0.25 mg/m^2 (SD = 0.15). This is a slight increase compared to 2019–2022 values but is low compared to most values measured before 2019 (Figure 23). Throughout the sample time frame, mean chlorophyll-a concentration has ranged from 0.03 mg/m^2 in 2020 to 3.48 mg/m^2 in 2002 (Figure 23).

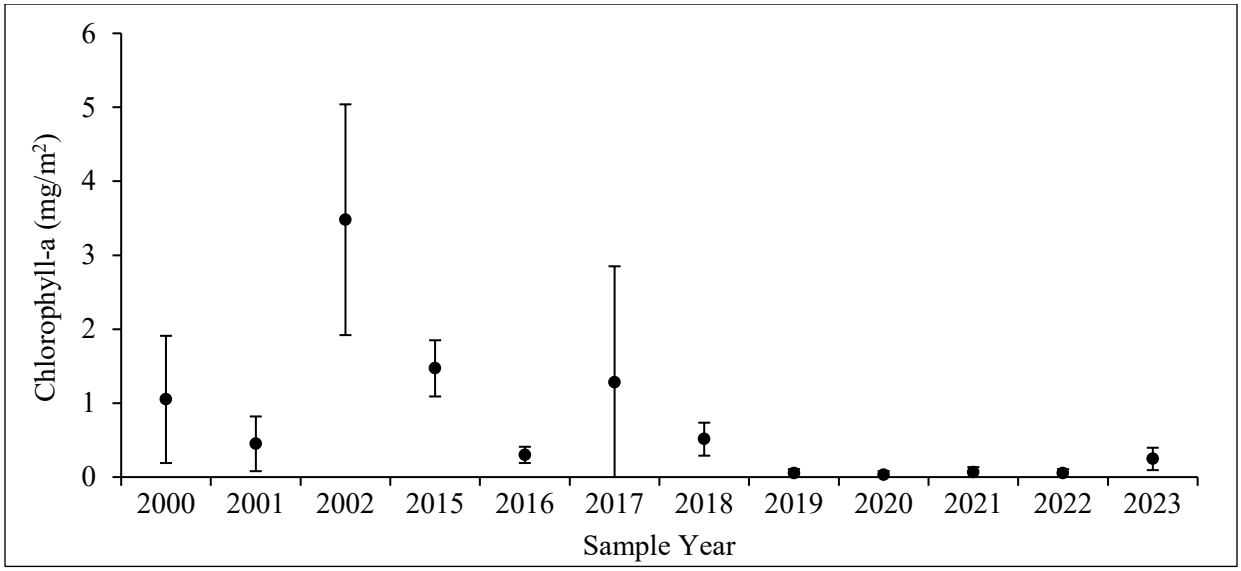

Figure 23.–Mean concentration of chlorophyll-a (± 1 SD) in Upper Ikalukrok Creek.

Macroinvertebrates

The benthic macroinvertebrate density in Upper Ikalukrok Creek in 2023 was 172 BMI/m^2 (SD = 73). The percent CHIROS exceeded percent EPT for the fourth year in a row in 2023 but the margin of difference was lowest among these years in 2023 (Figure 24). In 2023 the percent CHIROS was 57% and EPT was 35%. Taxa richness in 2023 was 13 taxa, which is double the 2022 taxa richness and within the historical range (Figure 25). The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

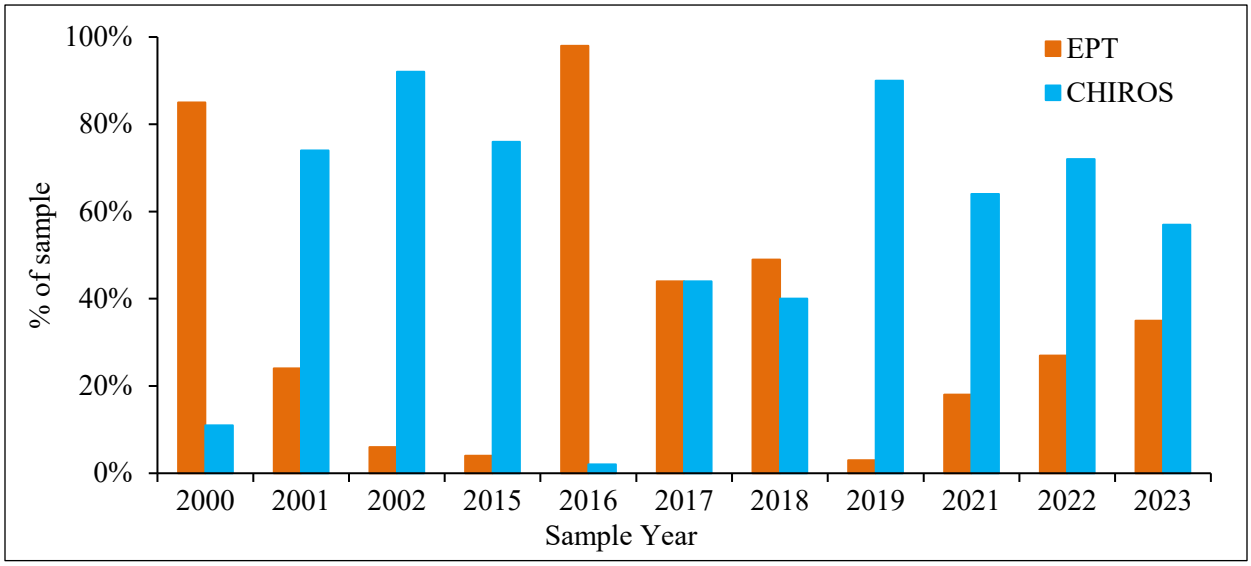

Figure 24.–Percent CHIROS and EPT in Upper Ikalukrok Creek.

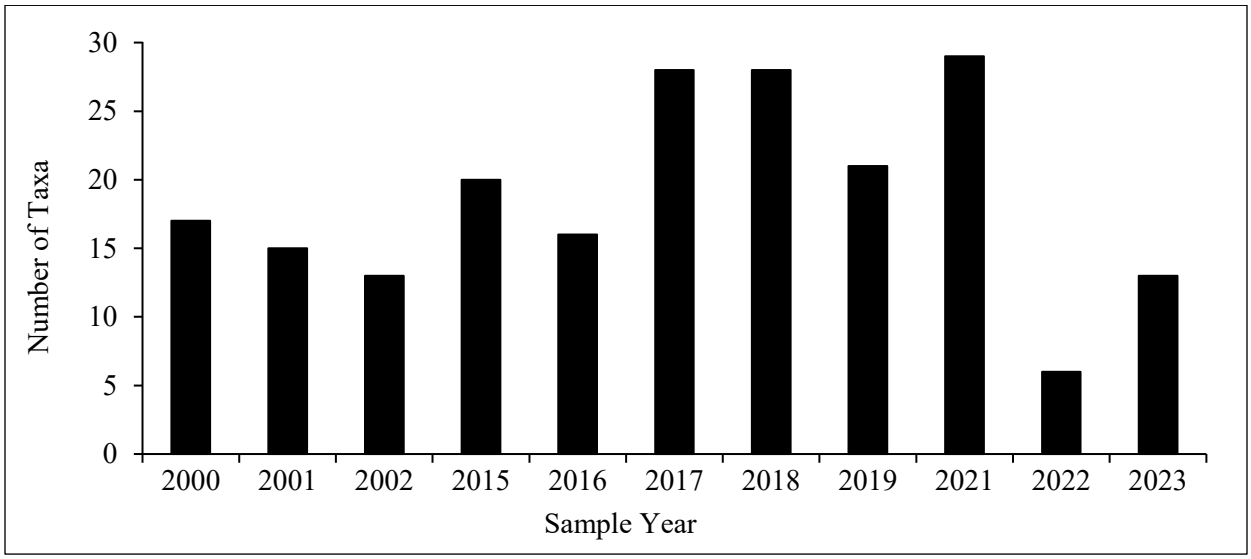

Figure 25.–Benthic macroinvertebrate taxa richness in Upper Ikalukrok Creek.

Fish

Similar to West Fork Ikalukrok Creek, fish have not been caught or observed in Upper Ikalukrok Creek, even though there appears to be high quality fish habitat in the creek. Mineral seeps downstream of this site likely form a chemical barrier to fish passage, preventing fish from moving into the area from downstream habitat.

Mussels

No live mussels, mussel shells from dead animals, or mussel trails in the substrate have been observed to date.

LOWER IKALUKROK CREEK (STATION 207)

Water Quality

Lower Ikalukrok Creek, upstream of East Fork Ikalukrok Creek, is directly impacted by natural mineral seeps including the Cub Creek seep. Specific element concentrations (aluminum, cadmium, copper, iron, nickel, lead, and zinc) in Ikalukrok Creek were high in the early 2000's and often exceeded the EPA chronic criteria for aquatic life (Weber-Scannell and Ott 2006). The pH of water samples collected by Teck from 2005–2019 in Cub Creek seep has ranged from 2.5–7.3, with a median value of 3.4 (R. Napier, Environmental Team Leader, Teck Alaska, personal communication). The pH was below the range for aquatic life in the majority of these water samples. The substrate in this section of Ikalukrok Creek is perpetually stained orange with iron flocculent and in some years the staining extends downstream for several kilometers (Figure 26). The pH in July 2023 was neutral at 6.93 and specific conductance was 446.9 µs/cm (Appendix 3). Water quality data collected by Teck in 2023 is presented in Appendix 2.

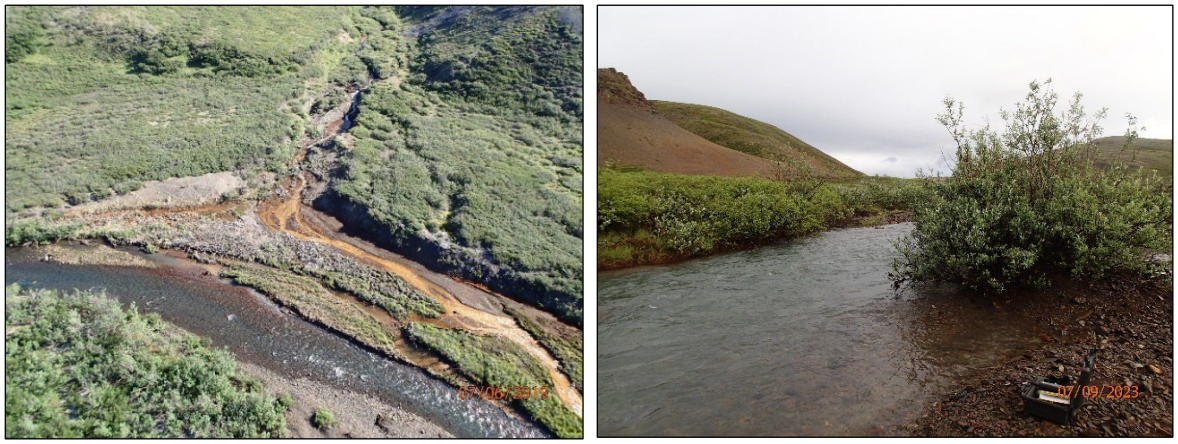

Figure 26.–The Cub Creek seep entering Ikalukrok Creek above the sample site in July 2019 (left) and Lower Ikalukrok Creek below Cub Creek seep in July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in Lower Ikalukrok Creek in 2023 was 0.07 mg/m^2 (SD = 0.05). Chlorophyll-a concentrations have been consistently low since sampling began. Mean chlorophyll-a concentration in 2021 was the highest on record at 0.11 mg/m^2, which is still relatively low (Figure 27). Most of the samples collected from 1997–2002 were below the minimum detection limit (Ott 1997).

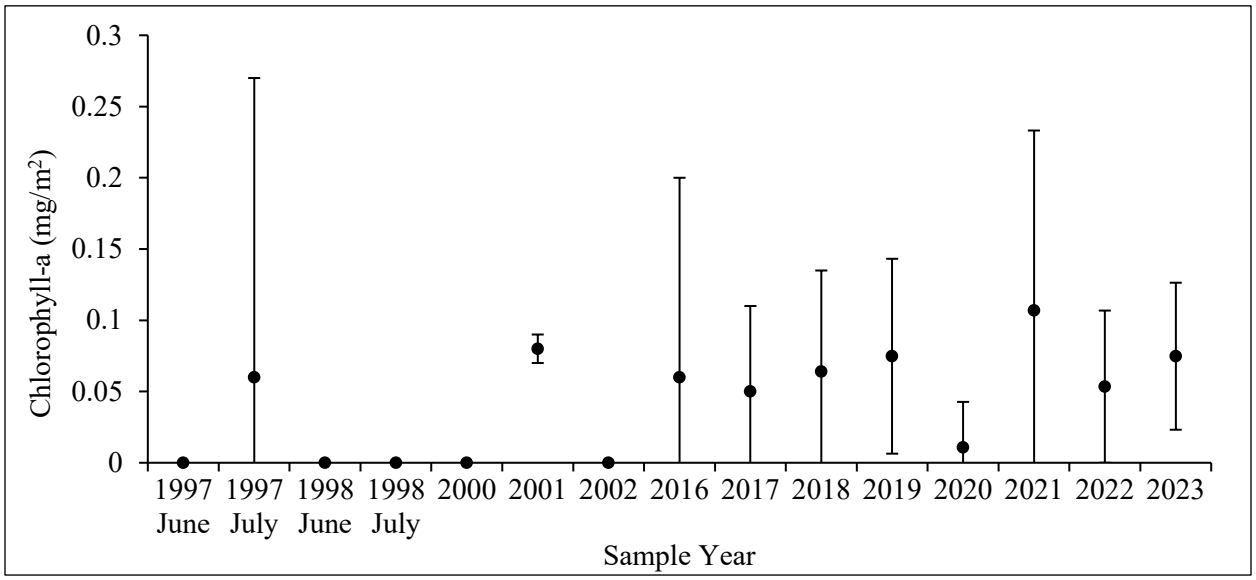

Figure 27.–Mean concentration of chlorophyll-a (± 1 SD) in Lower Ikalukrok Creek downstream of the Cub Creek seep.

Macroinvertebrates

The benthic macroinvertebrate density in Lower Ikalukrok Creek in 2023 was 209 BMI/m^2 (SD = 67). The percent CHIROS and percent EPT has varied across years, with CHIROS comprising over 50% of the samples since 2019 (Figure 28). Taxa richness was 8 in 2023 and has ranged from 8–29 taxa across all years of data (Figure 29). The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

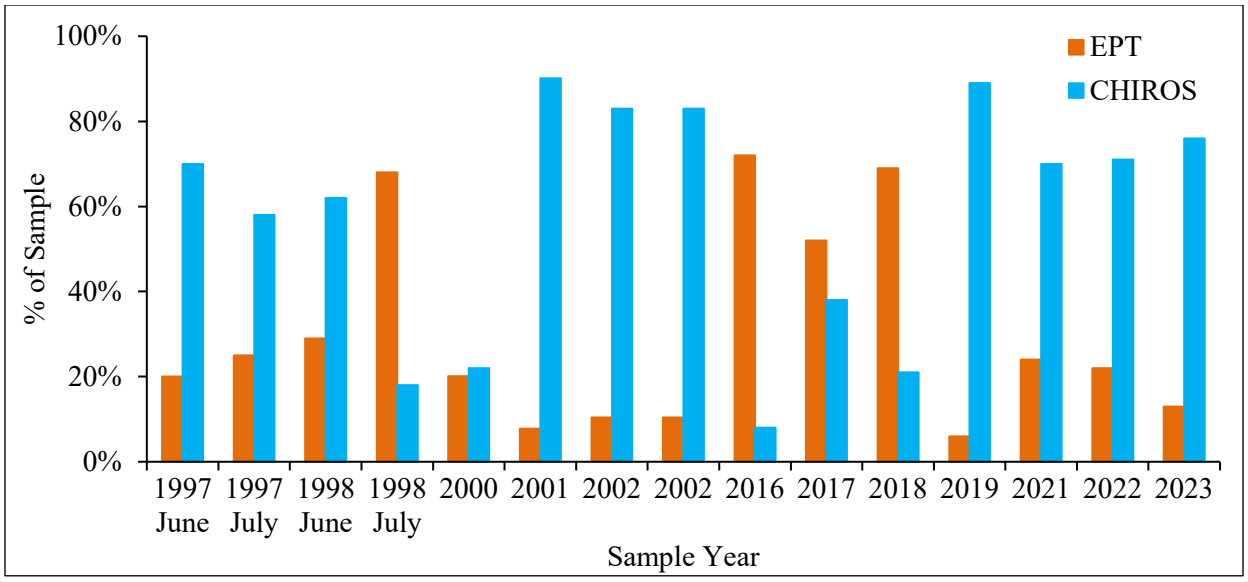

Figure 28.–Percent CHIROS and EPT in Ikalukrok Creek below Cub Creek.

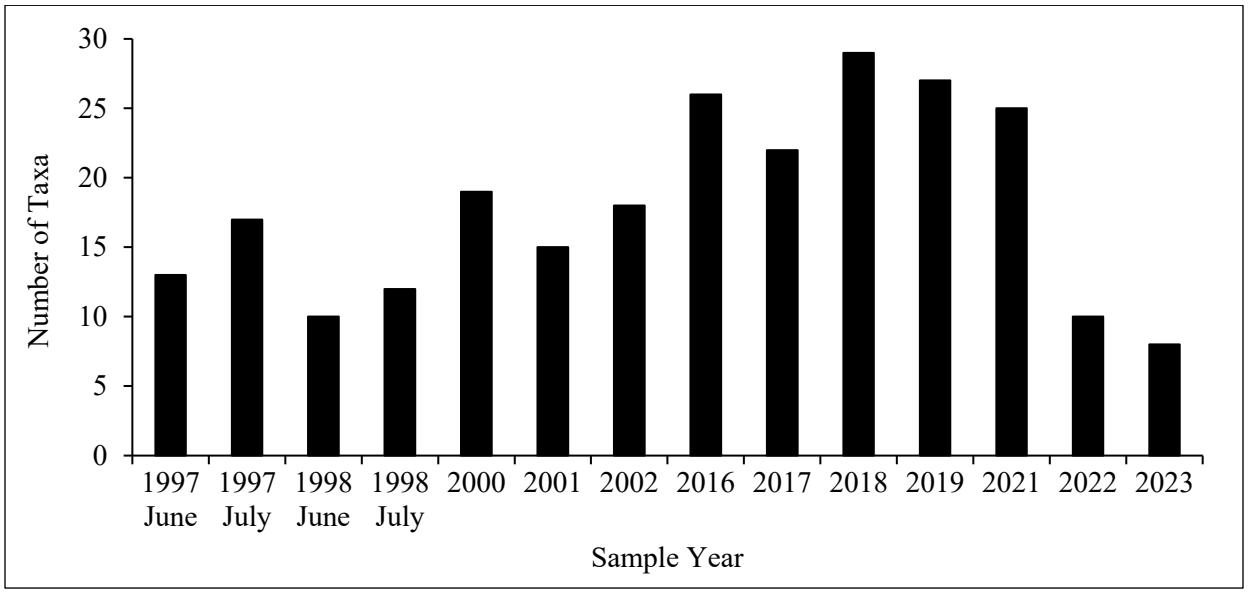

Figure 29.–Benthic macroinvertebrate taxa richness in Ikalukrok Creek below Cub Creek.

Fish

During the 2000 sampling event, one lethargic adult Arctic grayling was observed in Ikalukrok Creek near Station 207 (Weber-Scannell and Ott 2006). Since then, zero fish have been captured or observed in this section of Ikalukrok Creek, although minnow trapping has not been performed since 2002. Similar to West Fork Ikalukrok and Upper Ikalukrok creeks, mineral seeps downstream likely form a chemical barrier to fish passage, preventing fish from moving into the area from downstream habitat.

Mussels

No live mussels, mussel shells from dead animals, or mussel trails in the substrate have been observed to date.

EAST FORK IKALUKROK CREEK (STATION 208)

Water Quality

East Fork Ikalukrok Creek is a clearwater system that joins with Ikalukrok Creek just downstream of the sample site (Figure 30). In the early 2000's, only one spring water sample exceeded acute chronic criteria for cadmium, lead, and zinc. The pH was near neutral and ranged from 6.6–8.5 with lower values in early spring during snowmelt (Weber-Scannell and Ott 2006). In July 2023 the pH was 8.5 and specific conductance was 222.5 µs/cm (Appendix 3). Extensive aufeis occurs in the canyon-like area above the sample site. Water quality data collected by Teck in 2023 is presented in Appendix 2.

Figure 30.–Sample site on East Fork Ikalukrok Creek in July 2022 (left) and July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in East Fork Ikalukrok Creek in 2023 was 4.2 mg/m^2 (SD = 5.33). This value was the second highest on record since 2016. East Fork Ikalukrok Creek is generally one of the more biologically productive sites in the upper Ikalukrok drainage, although chlorophyll-a concentrations have remained relatively low in recent years compared to a high of 7.36 mg/m^2 in 2002 (Figure 31).

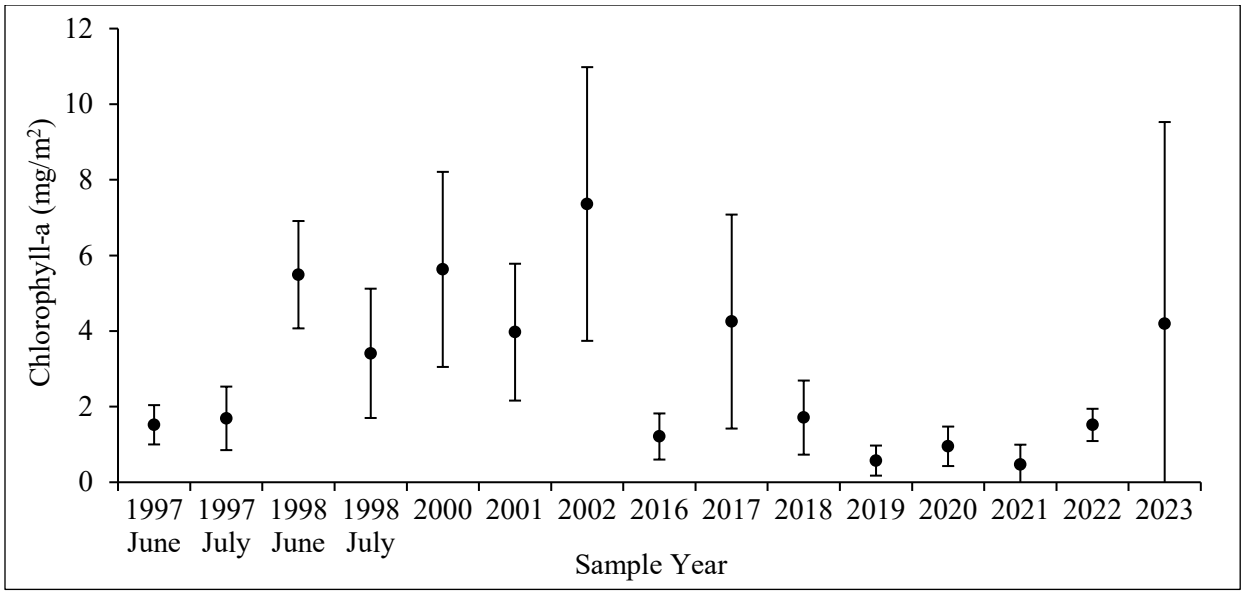

Figure 31.–Mean concentration of chlorophyll-a (± 1 SD) in East Fork Ikalukrok Creek.

Macroinvertebrates

The benthic macroinvertebrate density in East Fork Ikalukrok Creek in 2023 was 7,535 BMI/m^2 (SD = 6,377). The percent EPT was greater than the percent CHIROS in 2022 for the first time since 2002 but percent CHIROS was 13% greater than percent EPT in 2023 (Figure 32). Taxa richness ranged from a low of 13 taxa per site in 2000 to a high of 26 taxa in both 2019 and 2021 (Figure 33). Taxa richness was 20 in 2023. The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

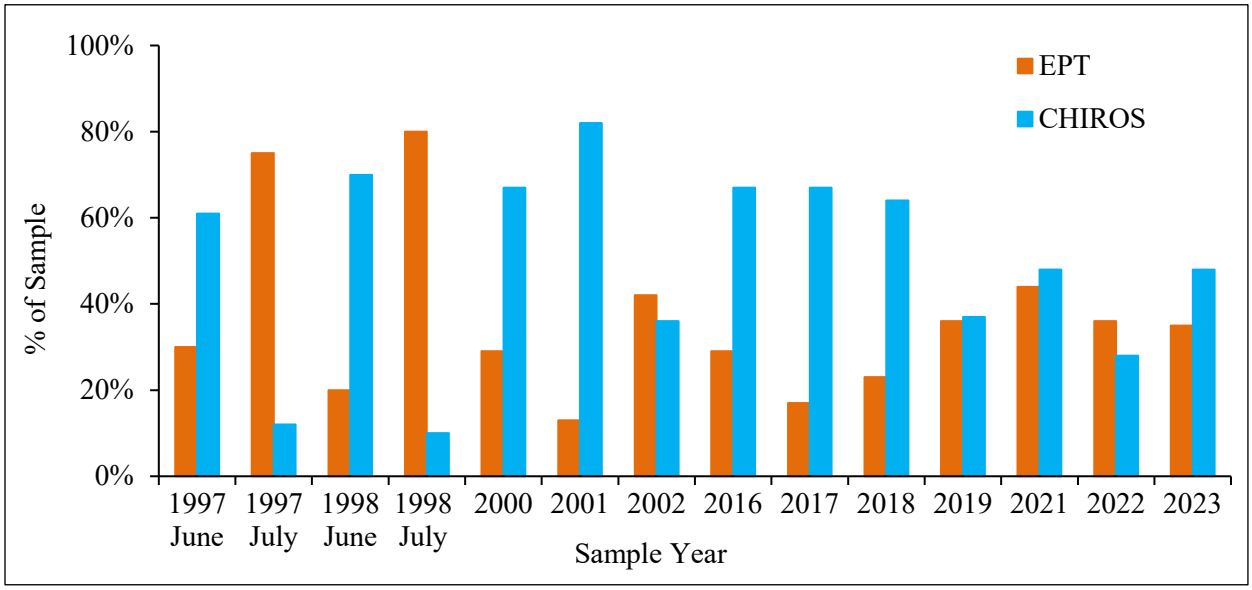

Figure 32.–Percent CHIROS and EPT in East Fork Ikalukrok Creek.

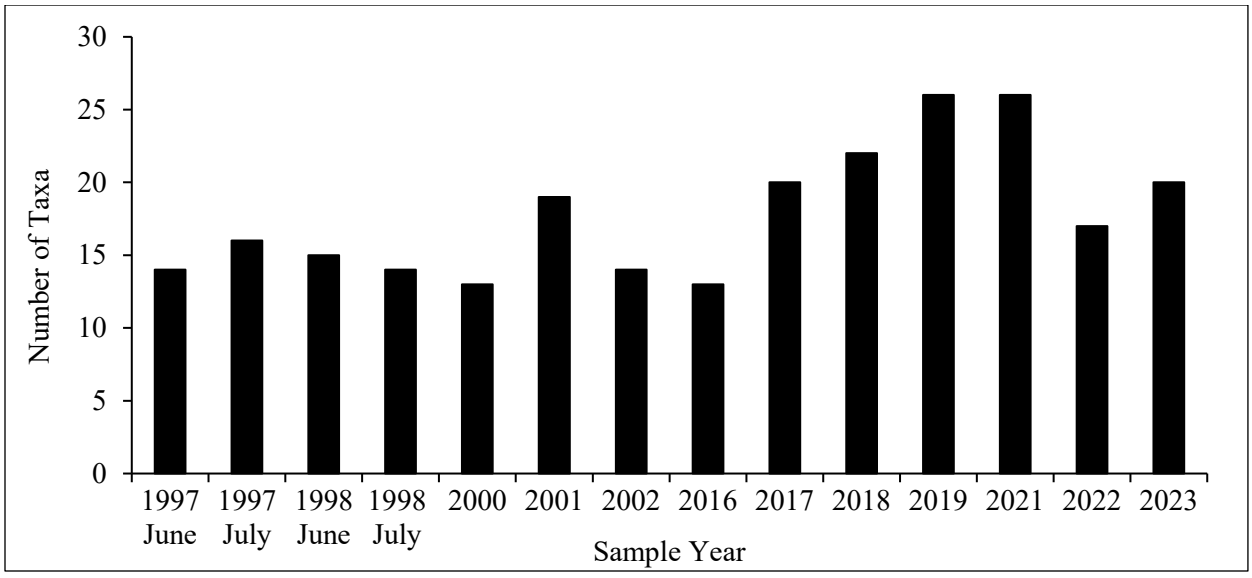

Figure 33.–Benthic macroinvertebrate taxa richness in East Fork Ikalukrok Creek.

Fish

A variety of fish sampling methods have been utilized in East Fork Ikalukrok Creek, including minnow trapping, rod and reel sampling, visual observations, and aerial surveys. Fish sampling with minnow traps was conducted in East Fork Ikalukrok Creek in 1999, 2000–2002, and 2016–2023 (Figure 34). The majority of juvenile Dolly Varden captured in East Fork Ikalukrok Creek are likely age-1 and age-2 with multiple age classes for the larger fish (≥ 120 mm; Figure 40). Juvenile Dolly Varden were captured most frequently, but two slimy sculpin (81 and 108 mm total length) were also caught in 2016. No fish were caught from 2020–2023.

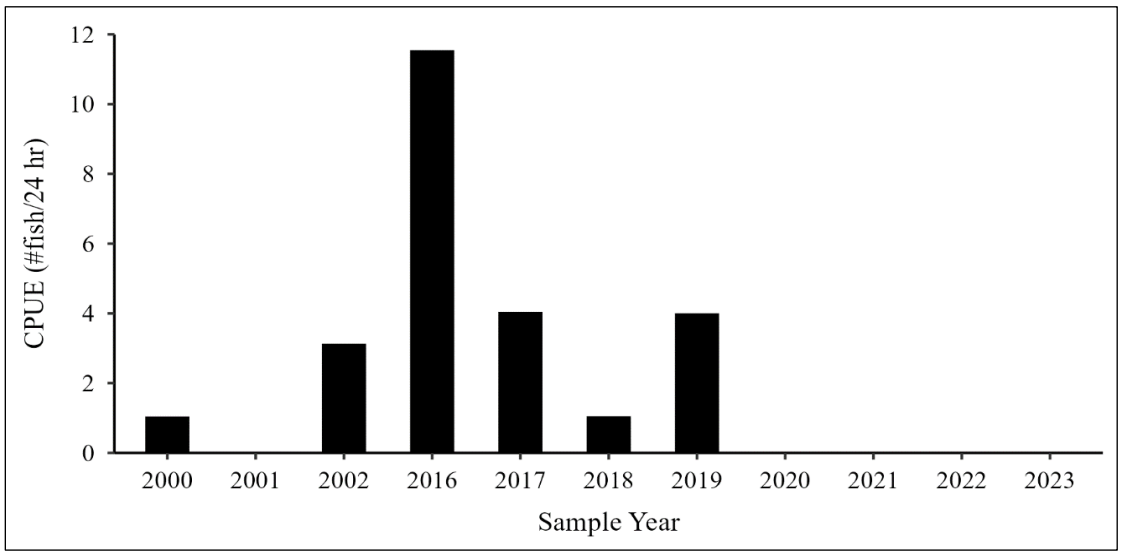

Figure 34.–Catch per unit of effort for juvenile Dolly Varden in East Fork Ikalukrok Creek.

The length frequency distribution of juvenile Dolly Varden in East Fork Ikalukrok Creek from all sampling years is presented in Figure 35. There appear to be at least two year-classes (likely 1+ and 2+) which dominate the catch, and a small number of larger fish (multiple age classes). Note that fish have not been captured at this site since 2019 (Figure 34).

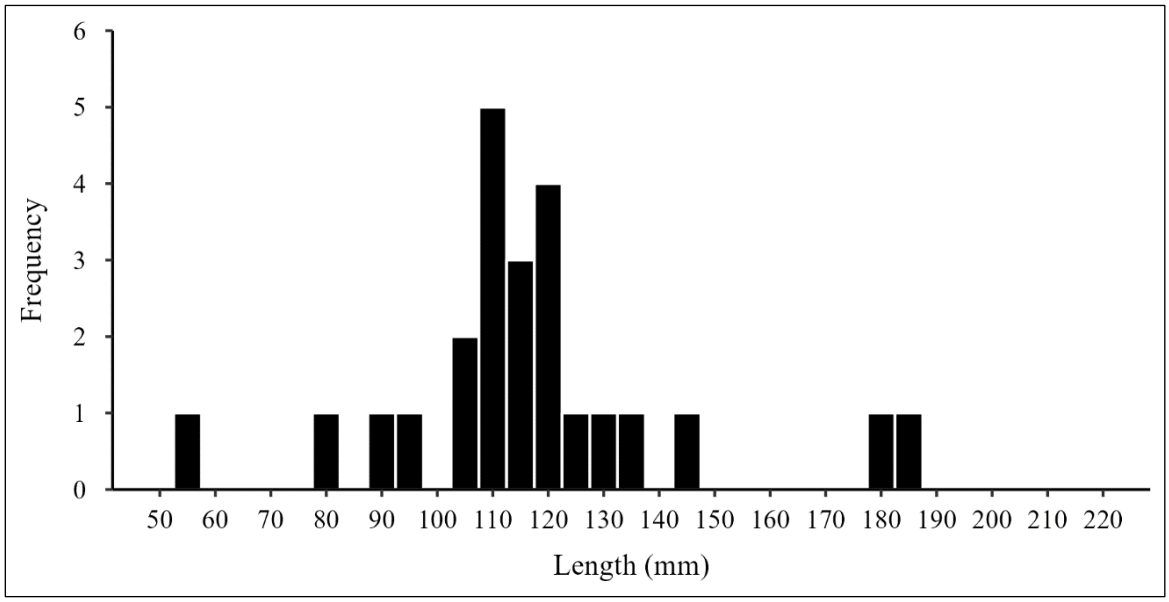

Figure 35.–Length frequency distribution (n = 24, bin width = 5) of Dolly Varden in East Fork Ikalukrok Creek.

Mussels

No live mussels, mussel shells from dead animals, or mussel trails in the substrate have been observed to date.

GRAYLING JUNIOR CREEK (STATION 209)

Water Quality

Grayling Junior Creek is a clearwater system that joins with Ikalukrok Creek just downstream of the sample site (Figure 1). Historically, the water quality was high with only a few water samples from the early 2000's exceeding the EPA aquatic life criteria for aluminum and iron. The pH was neutral to slightly basic and concentrations of zinc were slightly elevated and ranged from the detection limit to 106 µg/L (Weber-Scannell and Ott 2006). In 2020, Grayling Junior Creek was milky throughout the open water season, in marked contrast to the clear waters observed previously. The water was clearer in 2022 and 2023 than it has been since 2019 (Figure 36).

Turbidity in July 2023 was 3.48 NTU, pH was 8, and specific conductance was 463.2 µs/cm (Appendix 3). Water quality data collected by Teck Alaska in 2023 is presented in Appendix 2.

Figure 36.–Grayling Junior Creek in July 2022 (left) and July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in Grayling Junior Creek in 2023 was 0.14 mg/m^2 (SD = 0.09). Chlorophyll-a concentrations in Grayling Junior Creek ranged from a low of 0.02 mg/m^2 in 2020 to a high of 4.63 mg/m^2 in 2002 (Figure 37). Grayling Junior Creek is historically a more productive site, although chlorophyll-a has decreased significantly since 2018.

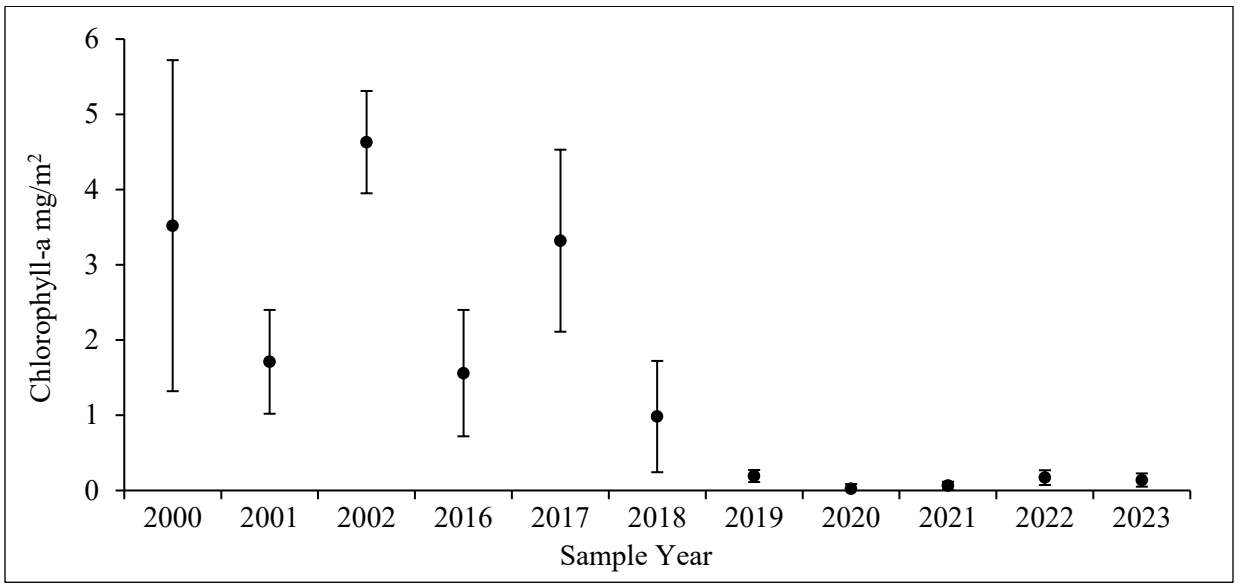

Figure 37.–Mean concentration of chlorophyll-a (± 1 SD) in Grayling Junior Creek.

Macroinvertebrates

The benthic macroinvertebrate density in Grayling Junior Creek in 2023 was 95 BMI/m^2 (SD = 62). In all sample years, the percent CHIROS exceeded the percent EPT, comprising roughly 40% to 75% of the samples (Figure 38). EPT taxa made up 19.51% of the sample in 2023. Taxa richness was 10 in 2023 which is within the historical range of 10–29 taxa and five times higher than the all-time low taxa richness of 2 in 2022 (Figure 39). The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

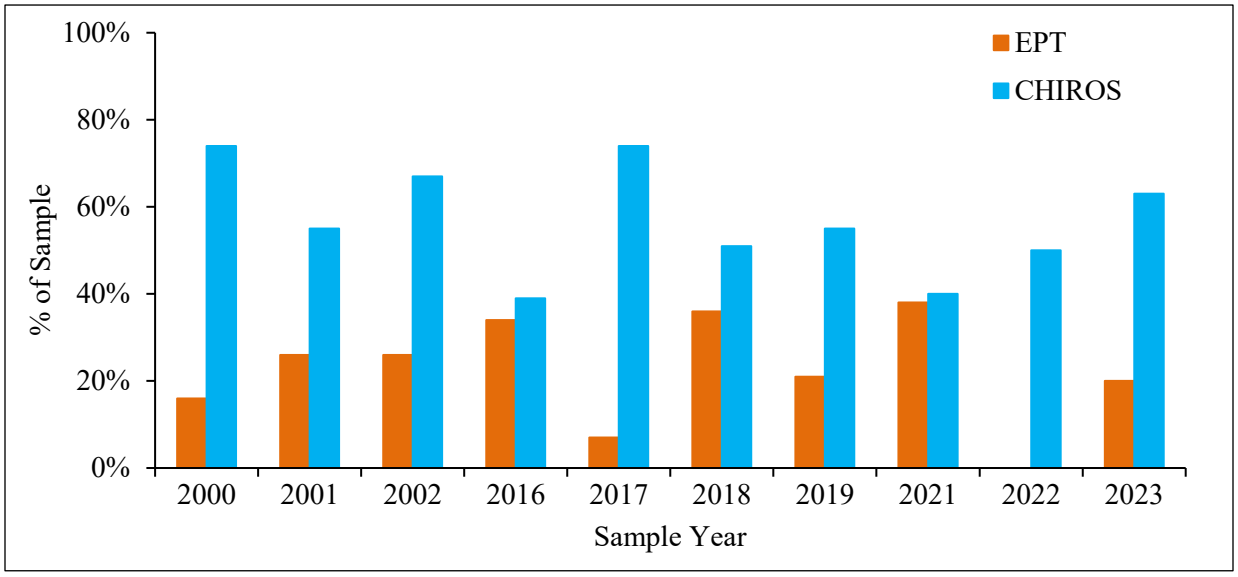

Figure 38.–Percent CHIROS and EPT in Grayling Junior Creek.

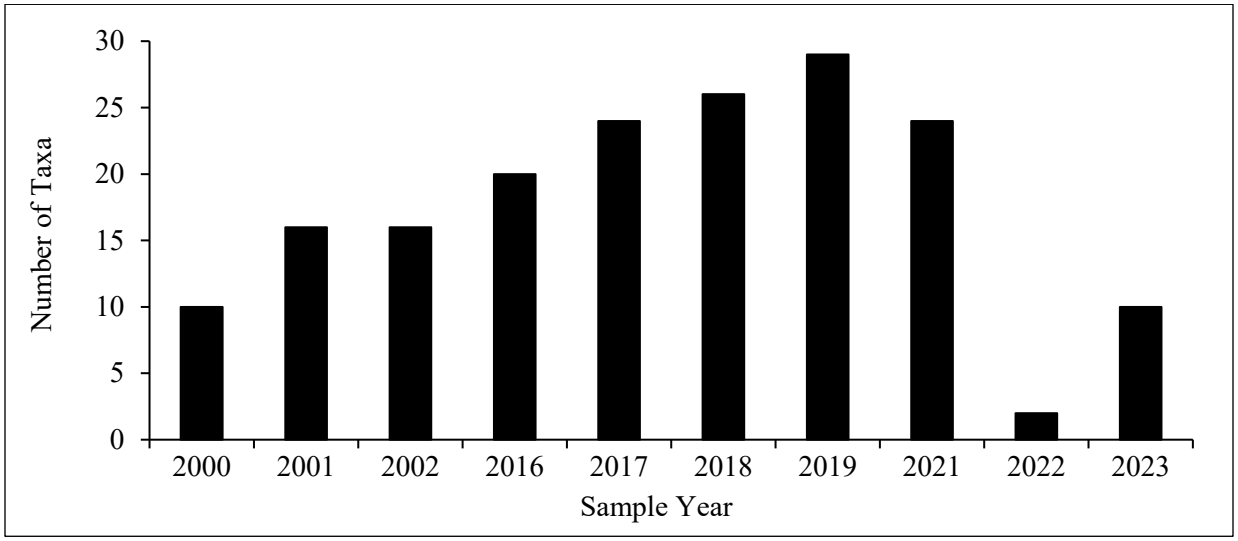

Figure 39.–Benthic macroinvertebrate taxa richness in Grayling Junior Creek.

Fish

Fish were sampled with minnow traps in Grayling Junior Creek from 2000–2002, 2004, and 2016–2023 (Appendix 1). Dolly Varden juveniles, slimy sculpin, and age-0 Arctic grayling were captured in minnow traps. Age-0 Arctic grayling were captured in late August 2004 indicating that spawning occurred there in spring 2004 (n = 5, mean fork length = 71.2 mm). The CPUE for Dolly Varden in minnow traps ranged from a low of zero in 2018 to a high of 44 in 2002 (Figure 40). Three juvenile Dolly Varden were captured in 2023. Length frequency distribution of Dolly Varden is shown in Figure 41. The majority of these fish are likely age-1 and age-2 with multiple age classes for the larger fish (≥ 120 mm).

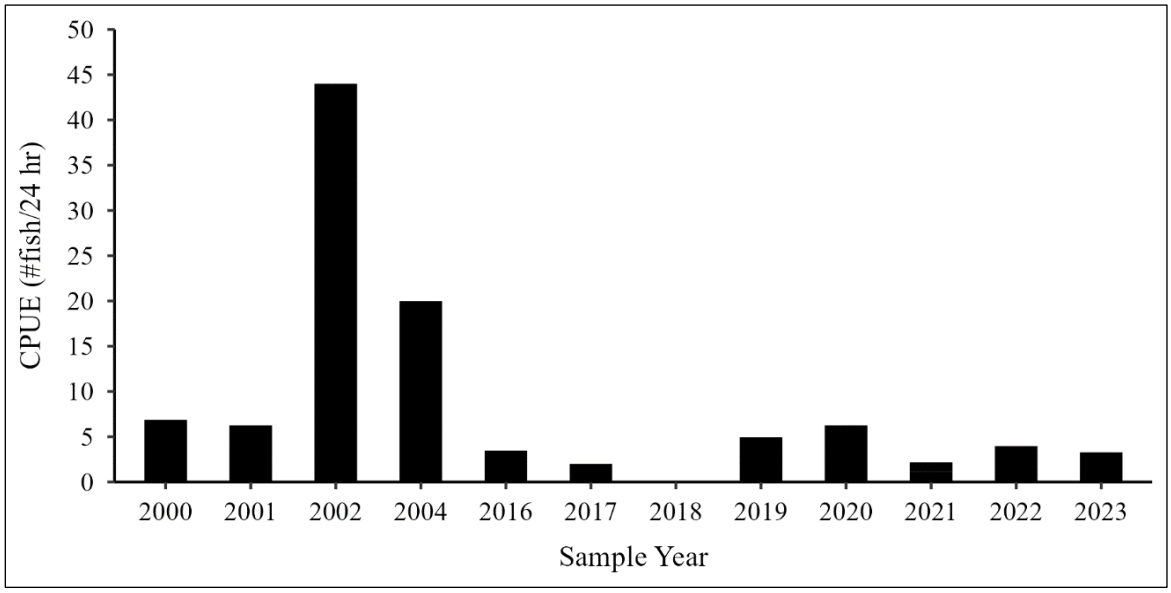

Figure 40.–Catch per unit of effort for juvenile Dolly Varden in Grayling Junior Creek.

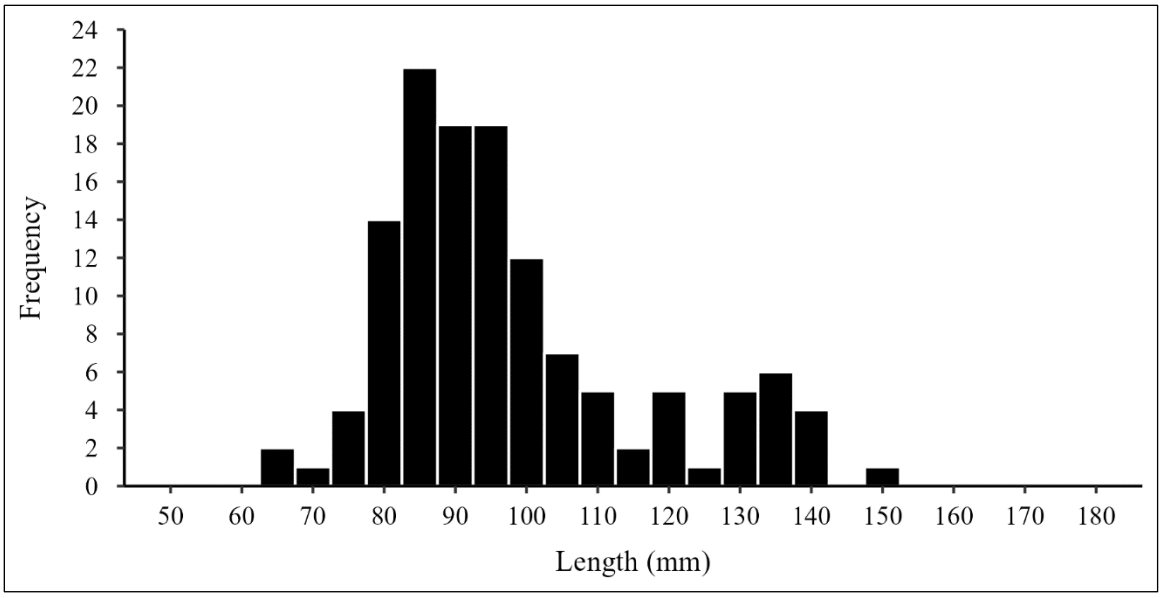

Figure 41.–Length frequency distribution (n = 129, bin width = 5) of juvenile Dolly Varden in Grayling Junior Creek, all years.

Mussels

No live mussels, mussel shells from dead animals, or mussel trails in the substrate have been observed in Grayling Junior Creek to date.

NOA CREEK (STATION 210)

Water Quality

Noa Creek, a tributary to Ikalukrok Creek, has naturally degraded water quality. In the early 2000's, 95% of water samples exceeded the chronic aquatic life criteria for aluminum and cadmium, 90% exceeded the nickel and zinc criteria, and 76% had a pH below the criteria (Weber-Scannell and Ott, 2006). In July 2023, the pH was acidic at 4.1 and specific conductance was relatively high at 1,334 µs/cm (Appendix 3). Noa Creek is a clearwater stream with orange-stained rocks and dense riparian vegetation (Figure 42). At the mouth of Noa Creek a white precipitate build up has been observed in Ikalukrok Creek (Figure 42). Water quality data collected by Teck in 2023 are presented in Appendix 2.

Figure 42.–The mouth of Noa Creek in July 2022 (left) and at the sample site in July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in Noa Creek in 2023 was 0.63 mg/m^2 (SD = 1.01). Prior to 2020, the mean chlorophyll-a concentrations in Noa Creek were consistently low, ranging from 0.07 mg/m^2 in 2019 to 0.32 mg/m^2 in 2000 (Figure 43). Mean chlorophyll-a concentrations since 2021 have remained the highest on record, but these values are still relatively low compared to highly productive streams in the area.

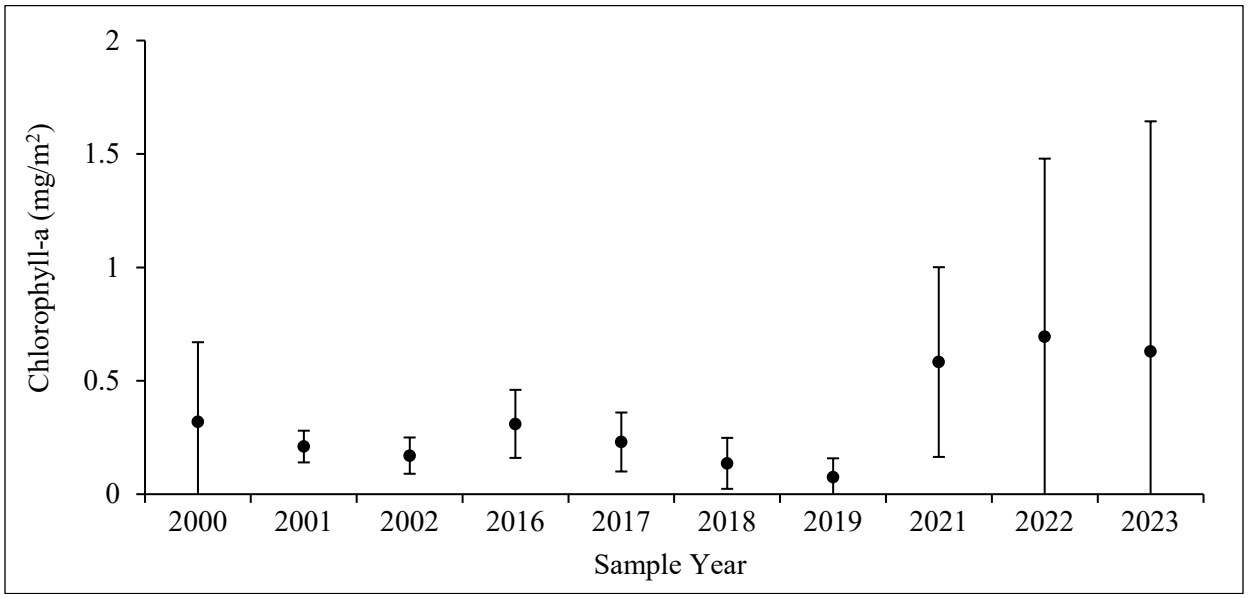

Figure 43.–Mean annual chlorophyll-a concentrations (± 1 SD) in Noa Creek.

Macroinvertebrates

The benthic macroinvertebrate density in Noa Creek in 2023 was 37 BMI/m^2 (SD = 53). EPT were virtually absent from the samples until 2022 when CHIROS and EPT each made up 17% of the sample (Figure 44). Percent EPT returned to a historical normal of zero in 2023 (Figure 50). Taxa

richness ranged from 15–23 prior to 2022 but were lower in 2022 and 2023 at 4 and 6 taxa, respectively (Figure 45). The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

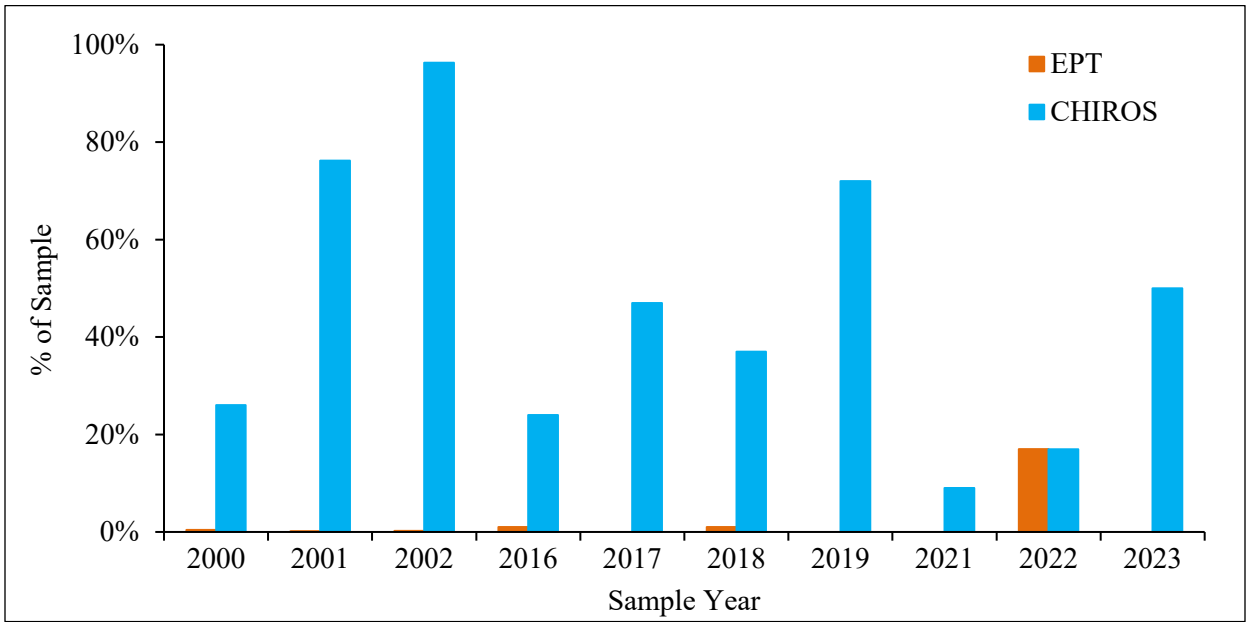

Figure 44.–Percent CHIROS and EPT in Noa Creek.

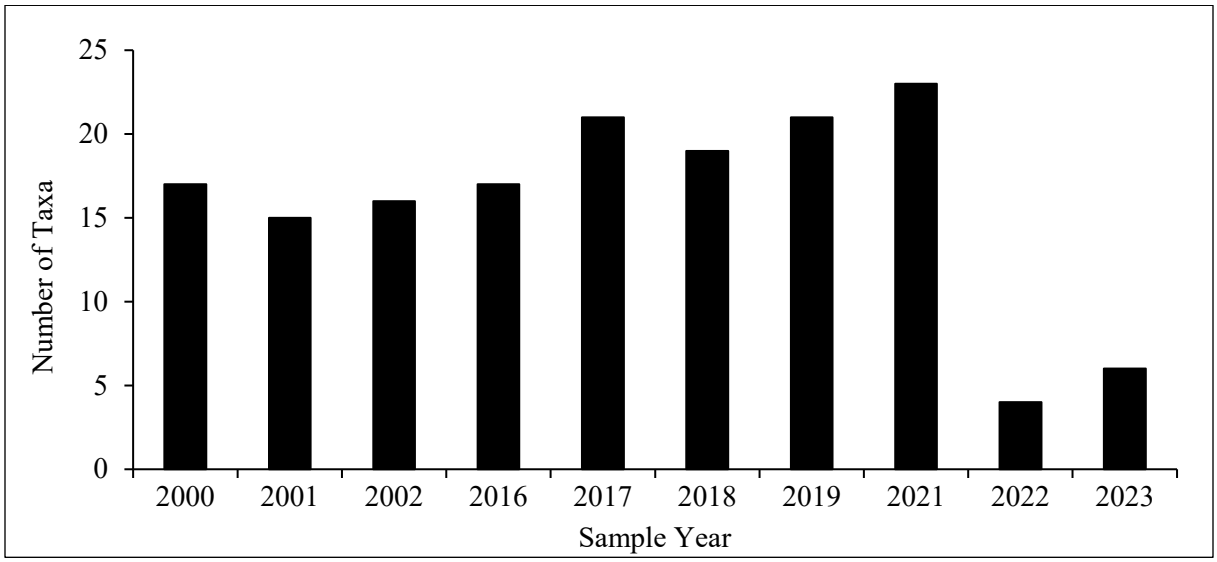

Figure 45.–Benthic macroinvertebrate taxa richness in Noa Creek.

Fish

Fish sampling with minnow traps and visual observations was conducted in Noa Creek from 2000–2002. No fish were captured or visually observed (Weber-Scannell and Ott, 2006). Fish sampling has not occurred since the early 2000's. Noa Creek is connected by surface flow to Ikalukrok

Creek, so fish do have access to the stream during the ice-free months, but impaired water quality likely prevents fish from entering the stream.

MOIL CREEK (STATION 211)

Water Quality

Moil Creek, a small tributary to Ikalukrok Creek, has naturally degraded water quality and summer discharges typically ranging from 3–5 cubic feet per second. In the early 2000's, the overall water quality was poor with 95% of water samples exceeding the chronic aquatic life criteria for cadmium, copper, nickel, and zinc and 65% with a pH below the chronic aquatic life criteria (Weber-Scannell and Ott, 2006). In July 2023, the pH was acidic at 3.92 and specific conductance was high at 1,210 µs/cm (Appendix 3). The water was opaque with a turbidity of 16.83 NTU and the rocks were stained orange (Figure 46). Water quality data collected by Teck in 2023 are presented in Appendix 2.

Figure 46.–Moil Creek at the sample site in July 2022 (left) and July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in Moil Creek in 2023 was 0.07 mg/m^2 (SD = 0.07). Mean chlorophyll-a concentrations in Moil Creek have remained low compared to highly productive streams in the area across all years, ranging from 0 mg/m^2 in 2002 to 0.14 mg/m^2 in 2017 (Figure 47).

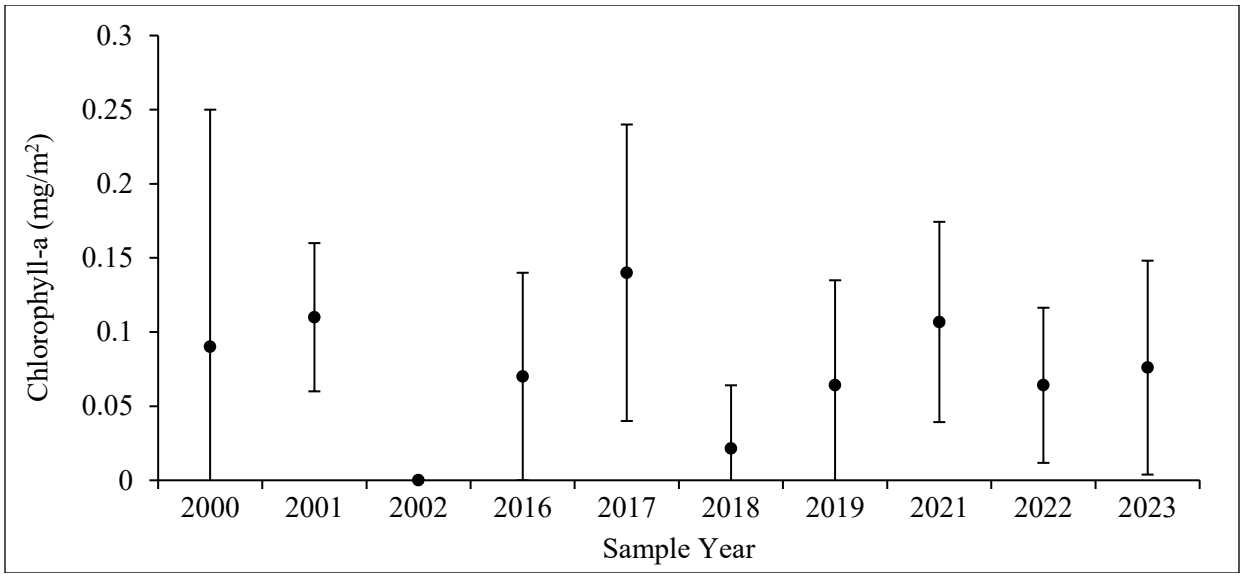

Figure 47.–Mean concentration of chlorophyll-a (± 1 SD) in Moil Creek.

Macroinvertebrates

The benthic macroinvertebrate density in Moil Creek in 2023 was 9 BMI/m^2 (SD = 5). EPT were absent or made up a small percentage of the samples in all years, including 2023 when zero EPT were identified (Figure 48). Taxa richness previously ranged from 13–24 taxa but only 2 were identified in 2023 (Figure 49). The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

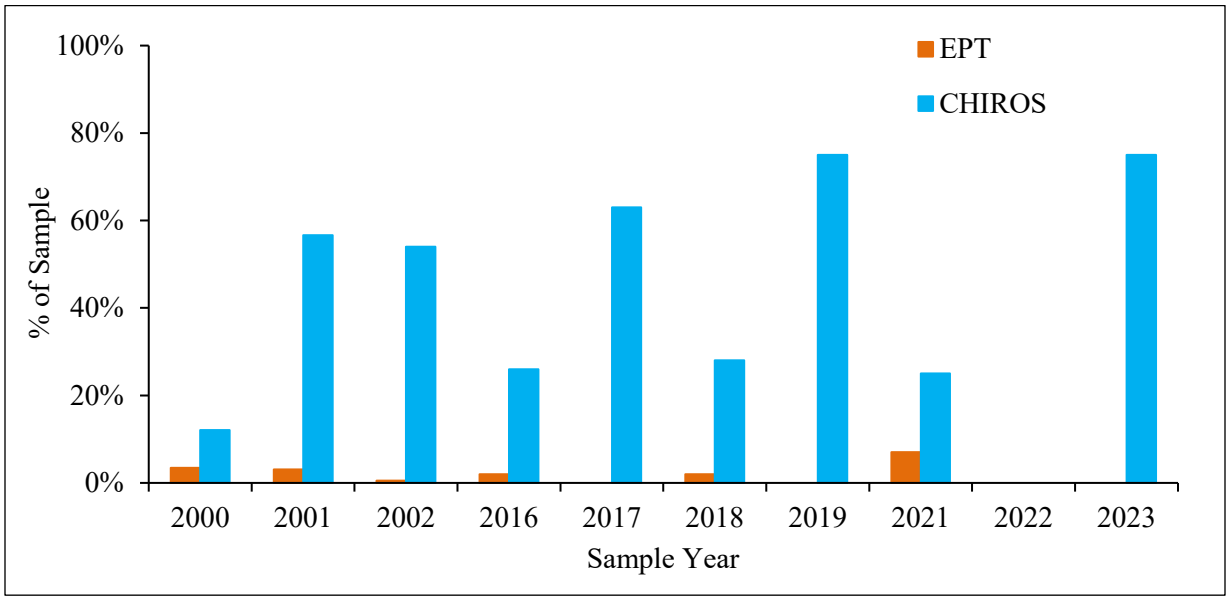

Figure 48.–Percent CHIROS and EPT in Moil Creek.

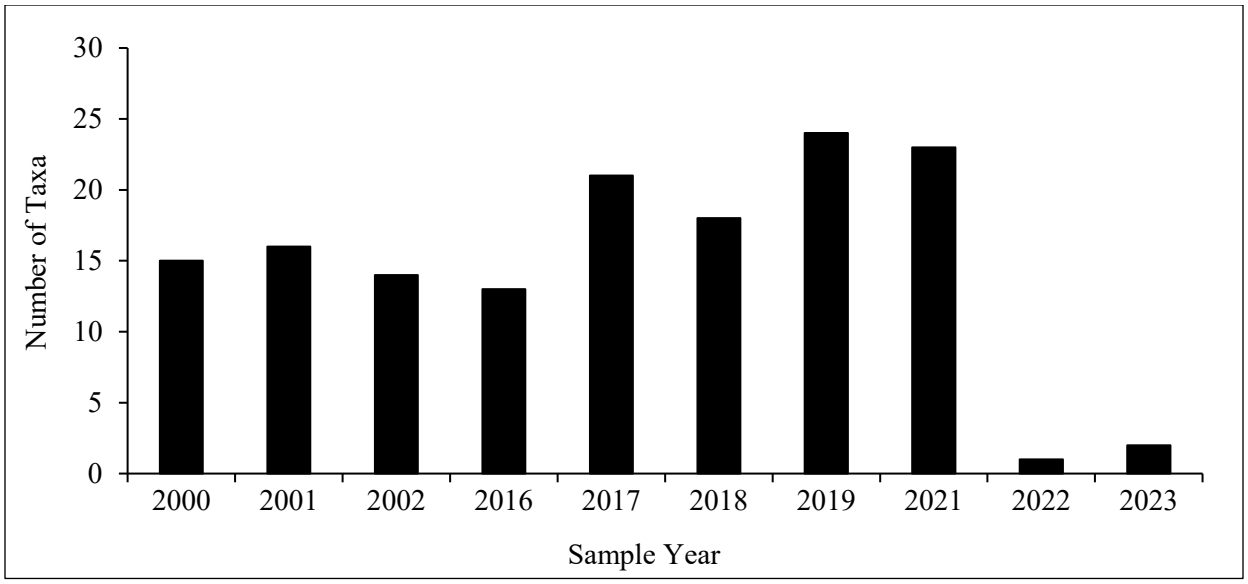

Figure 49.–Benthic macroinvertebrate taxa richness in Moil Creek.

Fish

Fish sampling with minnow traps was conducted in Moil Creek from 2000–2002. No fish were captured or visually observed (Weber-Scannell and Ott, 2006). Fish sampling has not occurred since 2002. Moil Creek is connected by surface flow to Ikalukrok Creek, so fish have access to the creek during the ice-free months but impaired water quality likely prevents fish from utilizing the stream. In some years, large adult Arctic grayling have been seen in Ikalukrok Creek near the mouth of Moil Creek but have not been observed entering Moil Creek.

SLED CREEK (STATION 212)

Water Quality

Sled Creek, a tributary to Ikalukrok Creek, has good water quality with dense riparian vegetation throughout the sample reach (Figure 50). In the early 2000's, only two samples exceeded the aquatic life criterion for aluminum and one sample exceeded the criteria for cadmium, copper, and zinc (Weber-Scannell and Ott, 2006). In July 2023, pH was neutral at 7.9 and specific conductance and turbidity were low at 267.1 µs/cm and 3.66 NTU, respectively (Appendix 3).

Figure 50.–Sled Creek in July 2022 (left) and July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in Sled Creek in 2023 was 4.61 mg/m^2 (SD = 2.78). Mean chlorophyll-a concentrations in Sled Creek have remained relatively high among years ranging from 1.85 mg/m^2 in 2002 to 6.96 mg/m^2 in 2019 (Figure 51).

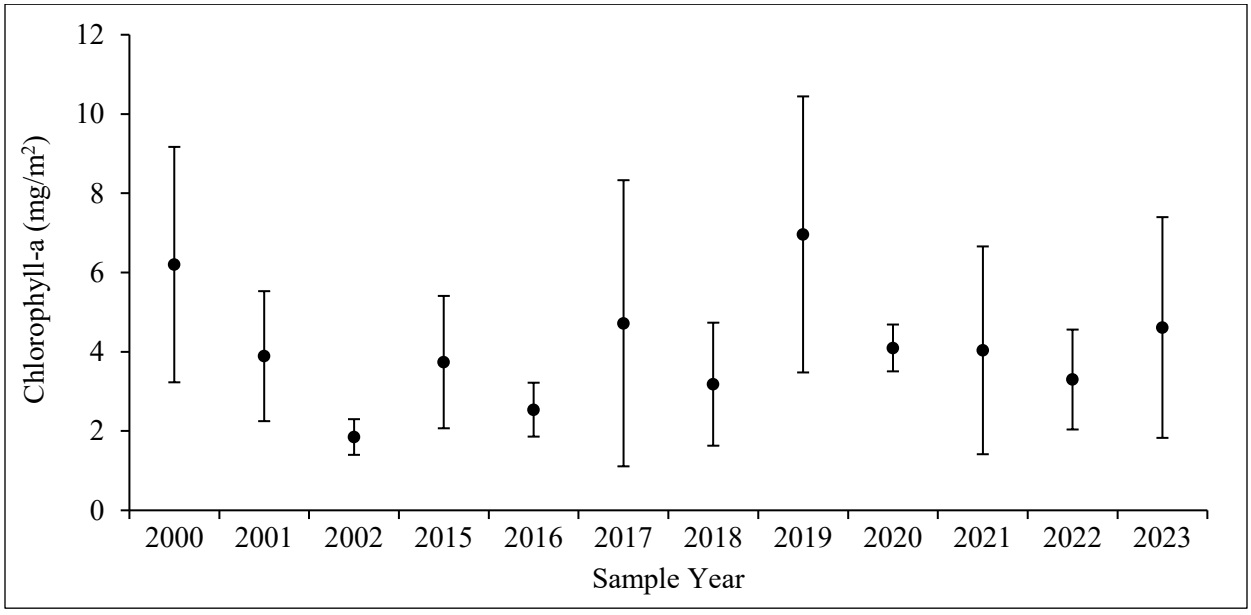

Figure 51.–Mean concentration of chlorophyll-a (± 1 SD) in Sled Creek.

Macroinvertebrates

The benthic macroinvertebrate density in Sled Creek in 2023 was 2,744 BMI/m^2 (SD = 700). EPT were present in all sample years and thrice exceeded the percent CHIROS (Figure 52). Percent EPT did not exceed that of CHIROS in 2023 (Figure 52). Taxa richness ranged from 10–29 over

the sample years and was 19 in 2023 (Figure 53). Any contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

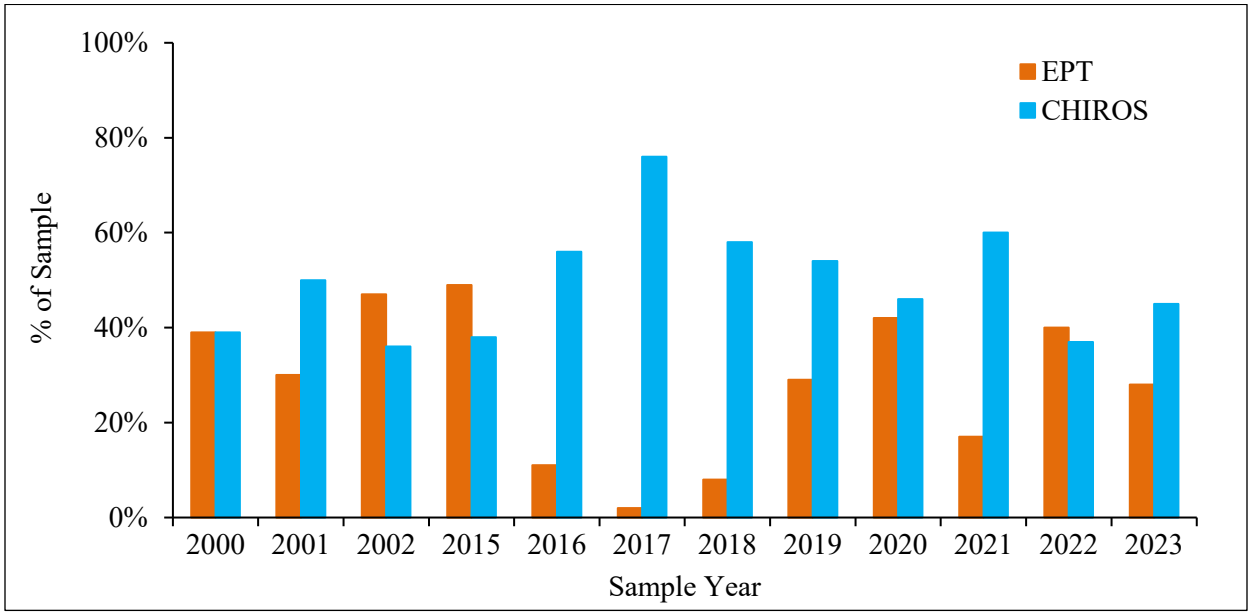

Figure 52.–Percent CHIROS and EPT in Sled Creek.

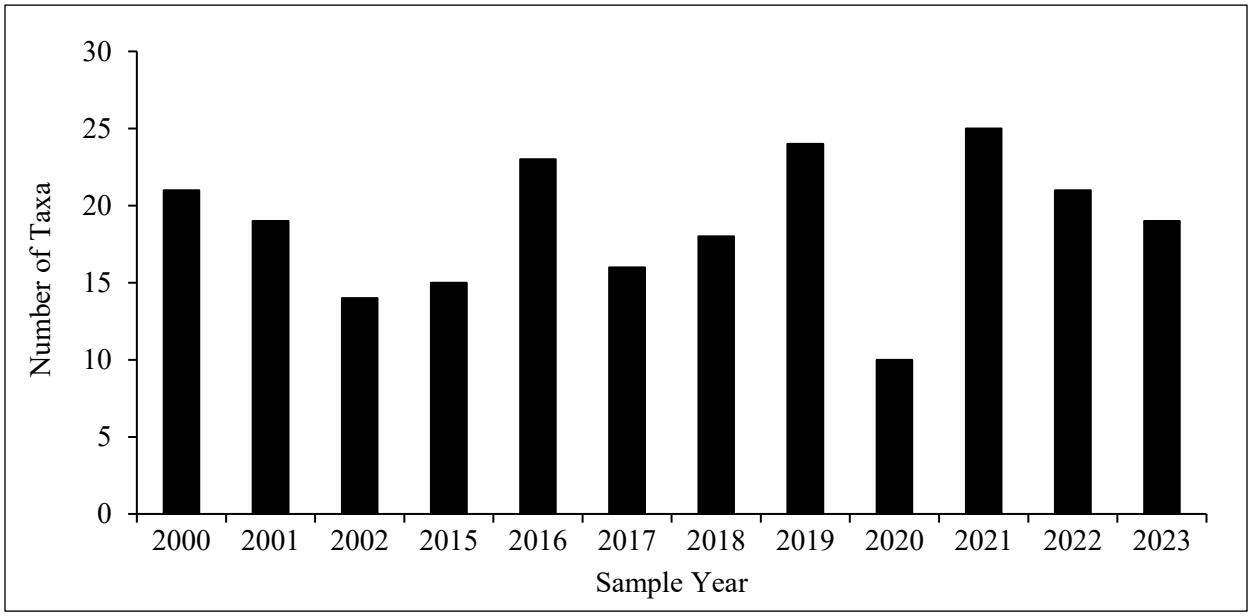

Figure 53.–Benthic macroinvertebrate taxa richness in Sled Creek.

Fish

Fish sampling with minnow traps and visual observations was conducted in Sled Creek from 2000–2002 and again in 2015. No fish were caught, and none were seen. Fish sampling has not occurred

since. Fish do not have access to the creek because it is not connected by surface flow to Ikalukrok Creek during the ice-free season.

VOLCANO CREEK

Water Quality

Volcano Creek is a clearwater tributary to Ikalukrok Creek and the farthest downstream sample site in the Ikalukrok Creek drainage. Visual observations and biological data indicate that Volcano Creek is a productive aquatic system despite orange staining on the substrate (Figure 54). Volcano Creek was not sampled from 2000–2002 but was sampled from 2014–2023. In July 2023, pH was neutral at 7.89, specific conductance was 620 µs/cm, and turbidity was low at 1.27 NTU (Appendix 3).

Figure 54.–Volcano Creek in July 2022 (left) and in July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in Volcano Creek in 2023 was 0.87 mg/m^2 (SD = 1.03). Chlorophyll-a concentrations were consistent from 2014–2017, then steadily decreased from 2018–2021, and have remained relatively low since (Figure 55). Mean chlorophyll-a concentrations in Volcano Creek range from a low of 0.32 mg/m^2 in 2021 to a high of 6.32 mg/m^2 in 2014.

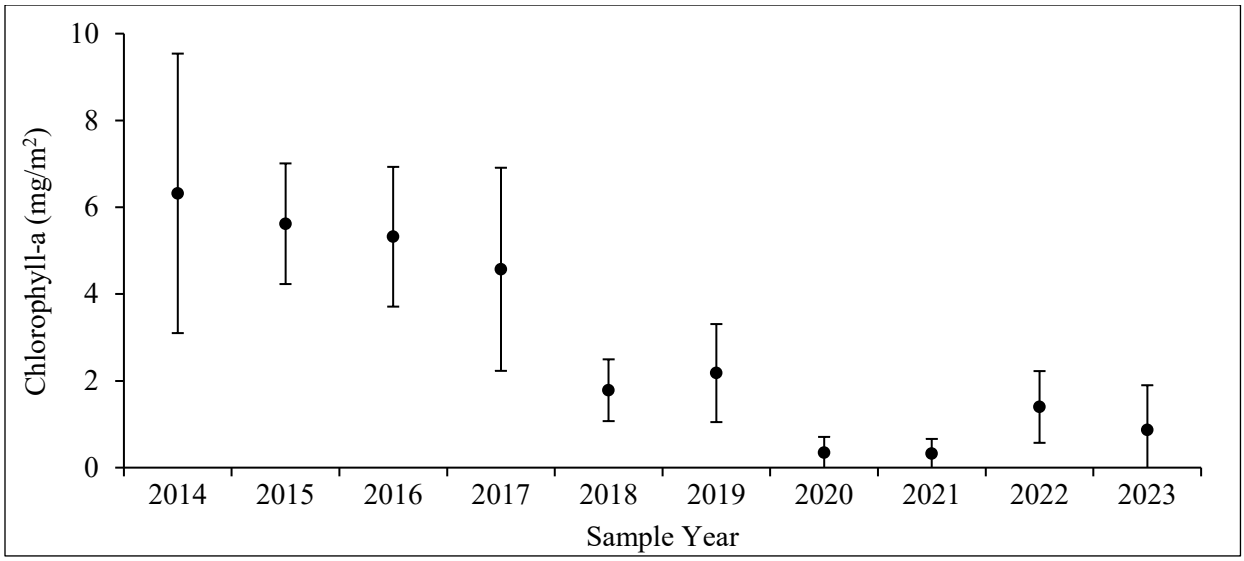

Figure 55.–Mean concentration of chlorophyll-a (± 1 SD) in Volcano Creek.

Macroinvertebrates

The benthic macroinvertebrate density in Volcano Creek in 2023 was 409 BMI/m^2 (SD = 87). The percent EPT was lower in 2023 than in 2022, but similar to previous years at 24.43% (Figure 56). EPT were present in all sample years with Ephemeroptera and Plecoptera represented, but percent CHIROS exceeded percent EPT in all years (Figure 56). Taxa richness ranged from a low of 8 in 2023 to a high of 25 in 2017 (Figure 57). The contrast with previous results may be due to the change in sampling methods from drift nets to Hess samplers beginning in 2022.

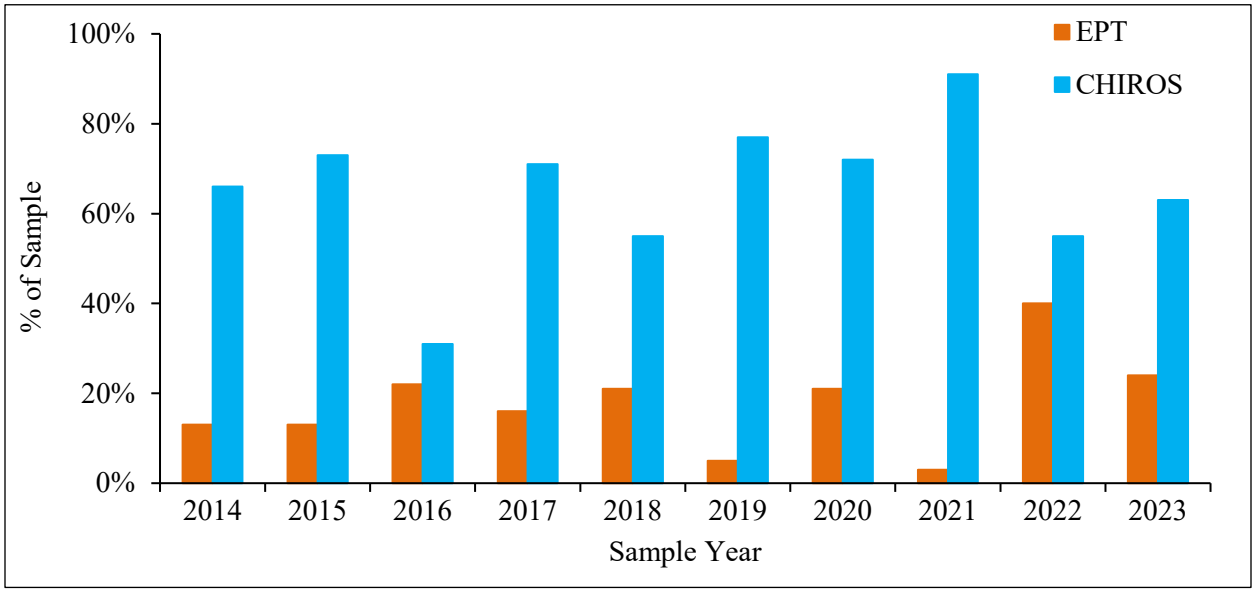

Figure 56.–Percent CHIROS and EPT in Volcano Creek.

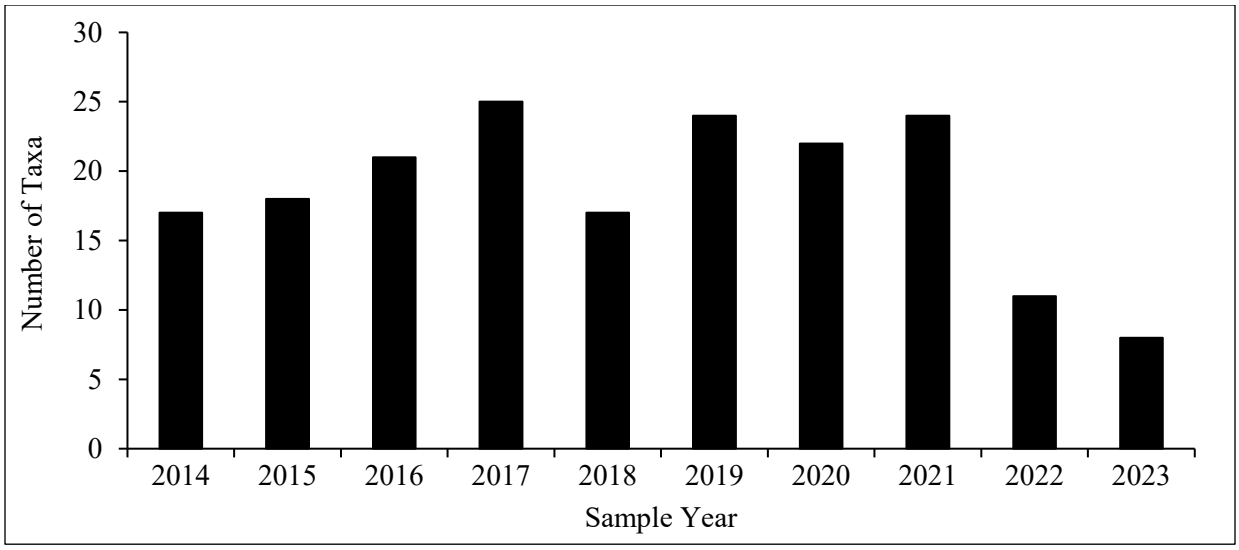

Figure 57.–Benthic macroinvertebrate taxa richness in Volcano Creek.

Fish

Fish sampling with minnow traps and visual observations was conducted in Volcano Creek from 2014–2023. Dolly Varden were captured in most years and slimy sculpin were captured in 2017, 2018, and 2019. CPUE was the second highest on record in 2022 and was the highest since 2015 (Figure 58). However, only one Dolly Varden was captured in 2023. The length frequency distribution of all Dolly Varden captured is presented in Figure 59. There are at least two year-classes (likely 1+ and 2+) which dominate the catch, and a small number of larger fish likely made up of multiple age classes.

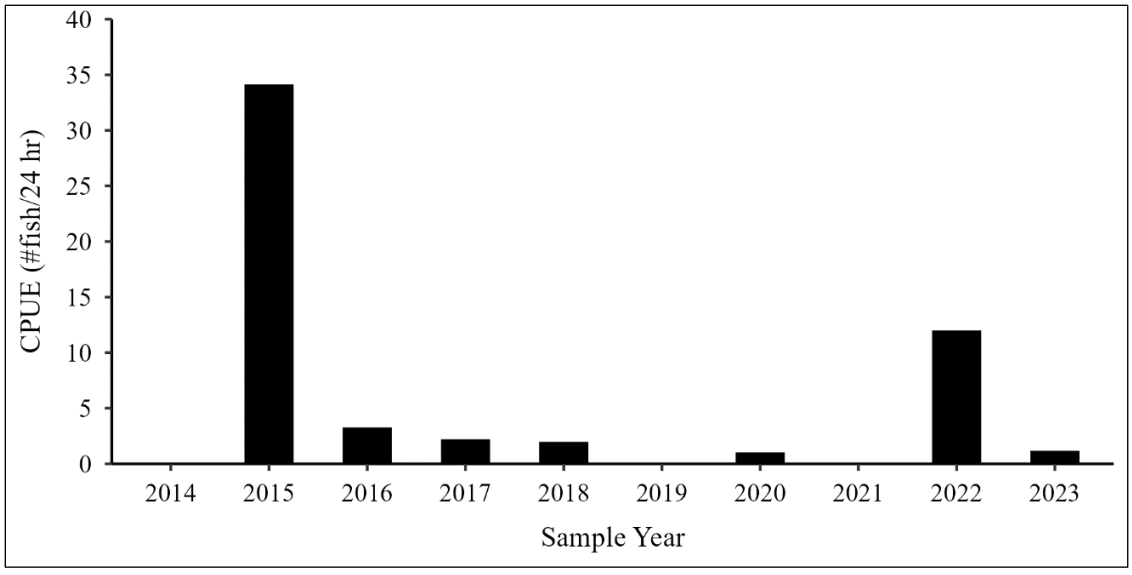

Figure 58.–Catch per unit of effort for juvenile Dolly Varden in Volcano Creek.

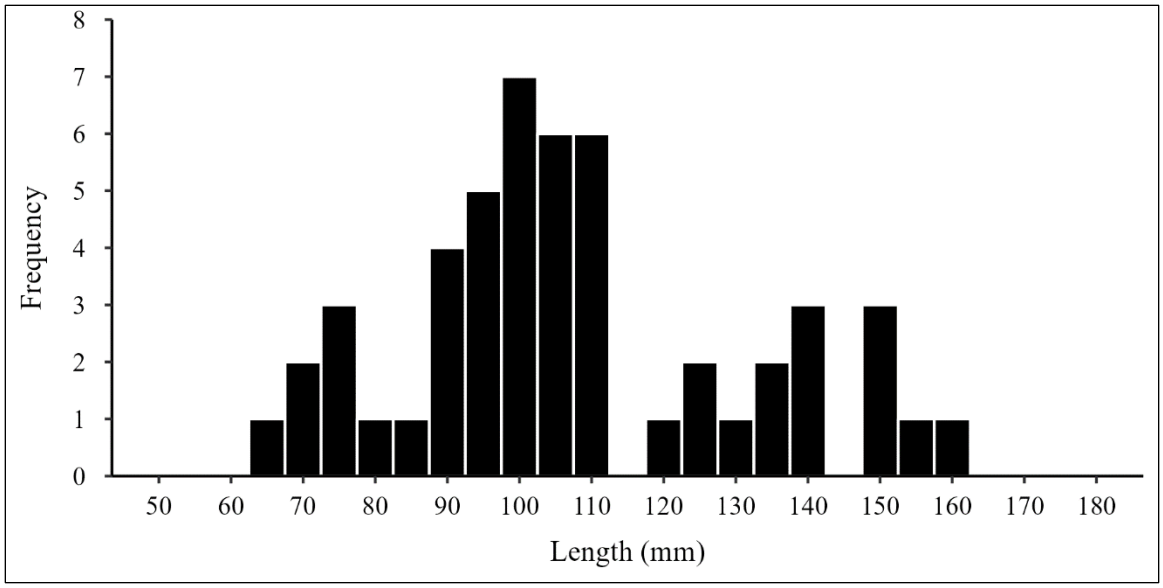

Figure 59.–Length frequency distribution (n = 62, bin width = 5) of Dolly Varden in Volcano Creek, all years.

UPPER VOLCANO CREEK

Water Quality

Upper Volcano Creek is a clearwater creek with dense overhanging riparian vegetation. This site was not sampled from 2000–2002 but was sampled in 2016 for fish and again in 2022 and 2023 for periphyton, benthic macroinvertebrates, and fish. Visual observations and biological data collected indicate that Upper Volcano Creek is a productive aquatic system (Figure 60). In situ water quality data was not collected at this site in 2023.

Figure 60.–Upper Volcano Creek in July 2022 downstream (left) and lateral view (right).

Periphyton

Mean chlorophyll-a concentration in Upper Volcano Creek increased in 2023 to 12.6 mg/m^2 (SD = 6.41) from 8.54 mg/m^2 (SD = 5.25) in 2022.

Macroinvertebrates

The benthic macroinvertebrate density in Upper Volcano Creek in 2023 was 1,516 BMI/m^2 (SD = 813), down from 4,684 BMI/m^2 (SD = 1,979) in 2022. The percent EPT was 17%, percent CHIROS was 58%, and a total of 12 taxa were present in 2023. Conversely, in 2022 the percent EPT was 68% and percent CHIROS was 27%.

Fish

No fish were captured in minnow traps in 2022 and 2023 at Upper Volcano Creek. Four Dolly Varden were captured in 2016.

WARF CREEK (STATION 233)

Water Quality

Warf Creek is a clearwater tributary to West Fork Ikalukrok Creek. There is some orange staining on the substrate and a steep bank of loose shale on river right at the sample site (Figure 61). In July 2023, specific conductance was high at 1,527 µs/cm and the pH was acidic at 3.67 (Appendix 3).

Figure 61.–Warf Creek upstream in July 2021 (left) and July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in Warf Creek in 2023 was 0.14 mg/m^2 (SD = 0.11). Mean chlorophyll-a concentrations have been variable since sampling began in 2021 ranging from 0.14–2.26 mg/m^2 (Figure 62).

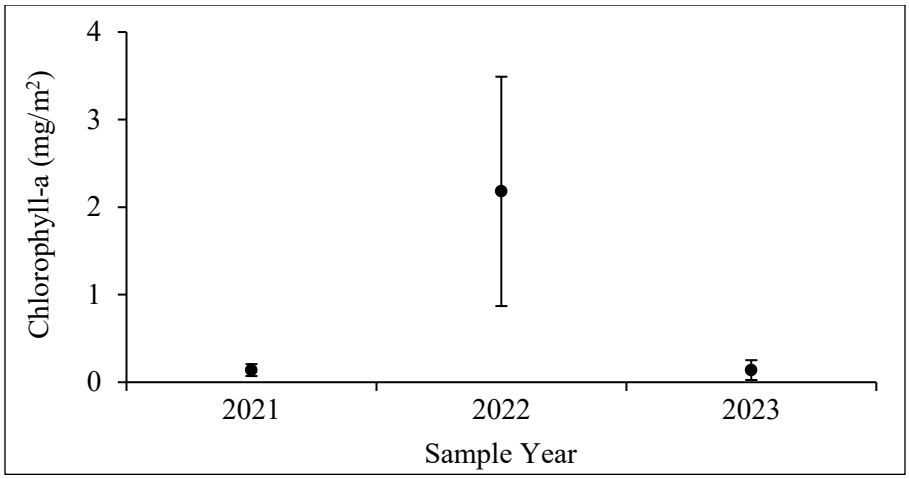

Figure 62.–Mean concentration of chlorophyll-a (± 1 SD) in Warf Creek.

Macroinvertebrates

The benthic macroinvertebrate density in Warf Creek in 2023 was 12 BMI/m^2 (SD = 14), down from 72 BMI/m^2 (SD = 48) in 2022. In 2022, the percent EPT was 7% and 8 taxa were identified. No EPT were present in the 2023 sample and a total of 2 taxa were identified, CHIROS and Collembola. The percent CHIROS was similar in 2022 and 2023 at 67% and 60%, respectively.

IKALUKROK CREEK (BELOW WEST FORK IKALUKROK; STATION 230)

Water Quality

Ikalukrok Creek (below West Fork Ikalukrok Creek) has clear water but some white staining was observed in shallow areas in 2022 (Figure 63). In July 2023, the pH was neutral at 7.06 and specific conductance was 393.1 µs/cm (Appendix 3). Water quality data collected by Teck in 2023 are presented in Appendix 2.


Figure 63.–White staining in a shallow area of Ikalukrok Creek in July 2022 (left) and Ikalukrok Creek in July 2023 (right).

Periphyton

Mean chlorophyll-a concentration in Ikalukrok Creek in 2023 was relatively low at 0.02 mg/m^2 (SD = 0.04), down from 0.05 mg/m^2 (SD = 0.06) in 2022.

Macroinvertebrates

The benthic macroinvertebrate density in Ikalukrok Creek below West Fork Ikalukrok Creek in 2023 was 247 BMI/m^2 (SD = 134), down from 637 BMI/m^2 (SD = 706) in 2022. In 2023, the percent EPT was 20% and percent CHIROS was 68%, similar to 2022 when percent EPT was 20% and percent CHIROS was 79%. A total of 10 taxa were present in the 2023 samples.

East Fork Grayling Junior Creek

Water Quality

East Fork Grayling Junior Creek is a clearwater tributary that flows into Grayling Junior Creek. Sampling has occurred in slightly different areas of East Fork Grayling Junior Creek among years. In 2023, the sample site was located just upstream of the mouth of a red stained tributary. However, in August 2022 minnow traps were set below the mouth of the red stained tributary. In the future, all sampling will take place downstream of the red stained tributary in order to capture any water quality impacts on the main creek (Figure 64). In situ water quality data was not collected at this site in 2023, but the pH in July 2022 was 8.05.

Figure 64.–East Fork Grayling Junior Creek looking downstream of the confluence with the red stained tributary in July 2022 (left) and at the confluence with the tributary in August 2023 (right).

Periphyton

Mean chlorophyll-a concentration in East Fork Grayling Junior Creek in 2023 was 0.85 mg/m^2 (SD = 0.27), similar to the mean concentration of 1.02 mg/m^2 (SD = 0.73) in 2022.

Macroinvertebrates

The benthic macroinvertebrate density in East Fork Grayling Junior Creek in 2023 was 591 BMI/m^2 (SD = 238), down from 1,358 BMI/m^2 (SD = 397) in 2022. The percent EPT was 55%, percent CHIROS was 30%, and a total of 11 taxa were present in the 2023 sample. In 2022 the percent EPT and percent CHIROS were 40% and 49%, respectively.

Fish

One Dolly Varden was captured in East Fork Grayling Junior Creek in 2023, for a total of two Dolly Varden captured over the last three years. No fish were captured in 2022 when sampling occurred downstream of the red stained tributary input.

UPPER NORTH FORK RED DOG CREEK SOUTH

Water Quality

Upper North Fork Red Dog Creek South (previously referred to as Upper North Fork Red Dog Creek 1) is a small clearwater tributary to North Fork Red Dog Creek. The creek is approximately 4.5 km east of the Red Dog open pit mine. There are no visual indicators to suggest that water quality is impaired (Figure 65). No in situ water quality data was collected in July 2023, but the pH was 7.97 in July 2022.

Figure 65.–Upper North Fork Red Dog Creek South in August 2021 (left) and in July 2023 (right).

Periphyton

No periphyton sampling occurred in 2023. Mean chlorophyll-a concentration in Upper North Fork Red Dog Creek South in 2022 was 2.08 mg/m^2 (SD = 0.86).

Macroinvertebrates

No benthic macroinvertebrate sampling occurred in 2023. The benthic macroinvertebrate density in Upper North Fork Red Dog Creek South in 2022 was 3,921 BMI/m^2 (SD = 1,677). The percent EPT was 24% and a total of 18 taxa were present in the 2022 sample.

Fish

Four Dolly Varden were captured in Upper North Fork Red Dog Creek South in 2023, for a total of 6 Dolly Varden captured since sampling began in 2021.

North Fork Grayling Junior Creek

Water Quality

North Fork Grayling Junior Creek is a clearwater tributary that flows into Grayling Junior Creek. There are no visual indicators to suggest that water quality is impaired (Figure 66). No sampling occurred at North Fork Grayling Junior Creek in 2023 but sampling efforts will resume in 2024.

Figure 66.–North Fork Grayling Junior Creek upstream in August 2021 (left) and August 2022 (right).

Fish

Length frequency distribution of juvenile Dolly Varden caught in previous years (2021 and 2022) is presented in Figure 67. Age1 and age-2 fish dominated the catch, and one larger, likely older fish was captured in 2022.

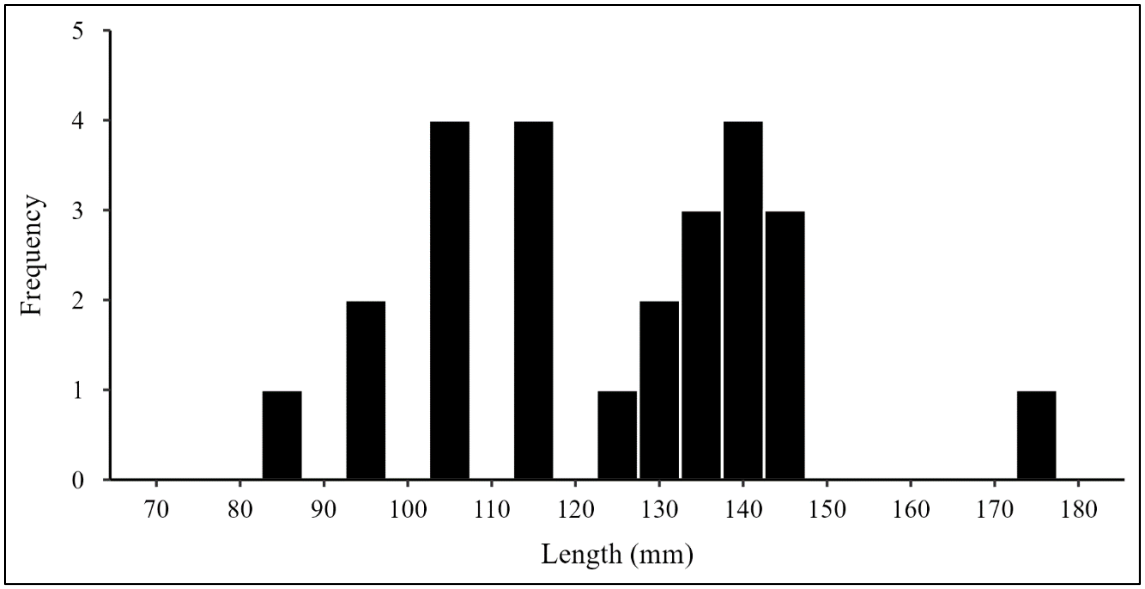

Figure 67.–Length frequency distribution (n = 25, bin width = 5) of Dolly Varden in North Fork Grayling Junior, 2021–2022.

UPPER NORTH FORK RED DOG CREEK NORTH

Water Quality

Upper North Fork Red Dog Creek North (previously referred to as Upper North Fork Red Dog Creek 2) is a small clearwater tributary to Red Dog Creek. There are no visual indicators to suggest that water quality is impaired (Figure 68). No sampling occurred at this site in 2023 but sampling efforts will resume in 2024.

Figure 68.–Upper North Fork Red Dog Creek North in August 2021 (left) and August 2022 (right).

Fish

No fish were captured in minnow traps in 2021 or 2022 at Upper North Fork Red Dog Creek North, but one large adult Arctic grayling was visually observed in 2022.

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APPENDIX 1. Total catch and catch per unit effort (CPUE) of Dolly Varden juveniles and other fish captured in minnow traps at various streams near the AAEP.

SS = Slimy Sculpin and AG = Arctic grayling.

Site	Station	Date	Catch	Effort (hours)	CPUE	Other Fish
East Fork Grayling Junior		8/7/2021	7	20.6	8.2	
East Fork Grayling Junior		8/5/2022	18	22.25	19.4	
East Fork Ikalukrok	208	7/8/2000	0	27	0	
East Fork Ikalukrok	208	7/29/2000	1	23	1	
East Fork Ikalukrok	208	7/8/2001	0	46	0	
East Fork Ikalukrok	208	8/3/2001	0	54	0	
East Fork Ikalukrok	208	7/12/2002	0	27	0	
East Fork Ikalukrok	208	8/1/2002	3	23	3.1	
East Fork Ikalukrok	208	8/5/2016	11	22.86	11.5	2 SS
East Fork Ikalukrok	208	8/7/2017	4	23.75	4	
East Fork Ikalukrok	208	8/3/2018	1	22.83	1.1	
East Fork Ikalukrok	208	8/5/2019	4	24	4	
East Fork Ikalukrok	208	8/3/2020	0	22.5	0	
East Fork Ikalukrok	208	8/7/2021	0	20.5	0	
East Fork Ikalukrok	208	8/25/2021	0	25.25	0	
East Fork Ikalukrok	208	8/5/2022	0	23	0	
East Fork Ikalukrok	208	8/4/2023	0	23.75	0	
Grayling Junior	209	7/11/2000	14	23	14.6	
Grayling Junior	209	7/29/2000	8	28	6.9	
Grayling Junior	209	7/10/2001	5	42	2.9	
Grayling Junior	209	8/1/2001	12	46	6.3	
Grayling Junior	209	7/12/2002	0	26	0	
Grayling Junior	209	8/1/2002	44	24	44	
Grayling Junior	209	8/27/2004	20	24.02	20	5 AG, 2 SS
Grayling Junior	209	8/5/2016	4	27.75	3.5	3 SS
Grayling Junior	209	8/7/2017	2	24	2	1 SS
Grayling Junior	209	8/3/2018	0	23	0	6 SS
Grayling Junior	209	8/5/2019	5	24.25	4.9	2 SS

Site	Station	Date	Catch	Effort (hours)	CPUE	Other Fish
Grayling Junior	209	8/3/2020	6	23	6.3	
Grayling Junior	209	8/7/2021	1	20.75	1.2	
Grayling Junior	209	8/24/2021	1	23.83	1	
Grayling Junior	209	8/5/2022	4	24.25	4	
Grayling Junior	209	8/4/2023	3	22	3.3	
Lower Competition	202	7/9/2000	4	32	3	
Lower Competition	202	7/29/2000	2	24	2	
Lower Competition	202	7/30/2000	2	24	2	
Lower Competition	202	7/6/2001	1	24	1	
Lower Competition	202	8/4/2001	11	28	9.4	
Lower Competition	202	7/9/2002	1	27	0.9	
Lower Competition	202	8/3/2002	33	24	33	
Lower Competition	202	7/31/2014	13	23	13.6	
Lower Competition	202	8/1/2015	35	26	32.3	
Lower Competition	202	8/5/2016	44	22.5	46.9	
Lower Competition	202	8/6/2017	22	27.25	19.4	
Lower Competition	202	8/3/2018	11	24.08	11	
Lower Competition	202	8/5/2019	21	23.75	21.2	
Lower Competition	202	8/8/2021	0	25.83	0	
Lower Competition	202	8/25/2021	0	26.33	0	
Lower Competition	202	8/4/2022	0	22.5	0	
Lower Competition	202	8/6/2023	0	22.1	0	
Lower Ikalukrok	207	7/8/2000	0	24.5	0	
Lower Ikalukrok	207	7/29/2000	0	23	0	
Lower Ikalukrok	207	7/7/2001	0	23.5	0	
Lower Ikalukrok	207	8/3/2001	0	53.5	0	
Lower Ikalukrok	207	7/12/2002	0	46.5	0	
Lower Ikalukrok	207	8/2/2002	0	25	0	
Moil	211	7/10/2000	0	27	0	
Moil	211	7/30/2000	0	23	0	
Moil	211	7/10/2001	0	22	0	
Moil	211	8/5/2001	0	24	0	

Site	Station	Date	Catch	Effort (hours)	CPUE	Other Fish
Moil	211	8/1/2002	0	24	0	
Noa	210	7/10/2000	0	28	0	
Noa	210	7/30/2000	0	23	0	
Noa	210	7/10/2001	0	22	0	
Noa	210	8/1/2001	0	46	0	
Noa	210	8/1/2002	0	22.5	0	
North Fork Grayling Junior		8/6/2021	1	20.75	1.2	
North Fork Grayling Junior		8/24/2021	0	24	0	
North Fork Grayling Junior		8/6/2022	0	22.25	0	
North Fork Grayling Junior		8/5/2023	1	22.5	1.1	
Sled	212	7/9/2000	0	26	0	
Sled	212	7/29/2000	0	25	0	
Sled	212	7/10/2001	0	24	0	
Sled	212	8/5/2001	0	24	0	
Sled	212	7/31/2002	0	23.5	0	
Sled	212	7/31/2015	0	22	0	
Sourdock	204	7/9/2000	52	30	41.6	
Sourdock	204	7/28/2000	20	24	20	
Sourdock	204	7/7/2001	26	48	13	
Sourdock	204	8/4/2001	8	28	6.9	
Sourdock	204	7/9/2002	1	28.5	0.8	
Sourdock	204	8/3/2002	3	24	3	
Sourdock	204	7/31/2014	0	21	0	
Sourdock	204	7/31/2015	0	20	0	
Sourdock	204	8/5/2016	1	23.5	1	
Sourdock	204	8/6/2017	0	25	0	
Sourdock	204	8/3/2018	0	24	0	
Sourdock	204	8/6/2019	0	23.75	0	
Sourdock	204	8/8/2021	0	24.5	0	
Sourdock	204	8/4/2022	0	22.25	0	
Sourdock	204	8/6/2023	0	23.3	0	
Upper Competition	203	7/28/2000	5	23	5.2	

Site	Station	Date	Catch	Effort (hours)	CPUE	Other Fish
Upper Competition	203	7/7/2001	0	47	0	
Upper Competition	203	8/4/2001	0	28	0	
Upper Competition	203	8/3/2002	3	24	3	
Upper Competition	203	7/31/2014	0	19	0	
Upper Competition	203	7/31/2015	0	19.5	0	
Upper Competition	203	8/5/2016	0	23	0	
Upper Competition	203	8/6/2017	0	25.5	0	
Upper Competition	203	8/3/2018	0	22.66	0	
Upper Competition	203	8/5/2019	0	24	0	
Upper Competition	203	8/8/2021	0	24.5	0	
Upper Competition	203	8/4/2022	0	22.25	0	
Upper Competition	203	8/6/2023	0	23.3	0	
Upper Ikalukrok	206	7/28/2000	0	28	0	
Upper Ikalukrok	206	7/7/2001	0	24	0	
Upper Ikalukrok	206	8/3/2001	0	54	0	
Upper Ikalukrok	206	7/11/2002	0	26.5	0	
Upper Ikalukrok	206	8/2/2022	0	26	0	
Upper Ikalukrok	206	8/1/2015	0	26.5	0	
Upper Ikalukrok	206	8/5/2016	0	23	0	
Upper Ikalukrok	206	8/7/2017	0	27	0	
Upper Ikalukrok	206	8/3/2018	0	21.33	0	
Upper Ikalukrok	206	8/5/2019	0	23.8	0	
Upper Ikalukrok	206	8/3/2020	0	20.5	0	
Upper Ikalukrok	206	8/8/2021	0	24	0	
Upper Ikalukrok	206	8/5/2022	0	23.5	0	
Upper Ikalukrok	206	8/5/2023	0	22	0	
Upper NF Red Dog 1		8/11/2021	2	24.5	2	
Upper NF Red Dog 1		8/4/2022	0	22.25	0	
Upper NF Red Dog 1		8/5/2023	4	22.5	4.3	
Upper NF Red Dog 2		8/11/2021	0	24.8	0	
Upper NF Red Dog 2		8/5/2022	0	22.5	0	
Upper NF Red Dog Tributary		8/11/2021	1	25.4	0.9	

Site	Station	Date	Catch	Effort (hours)	CPUE	Other Fish
Upper NF Red Dog Tributary		8/5/2022	0	22.25	0	
Upper Volcano		8/6/2016	4	22	4.4	
Upper Volcano		8/3/2022	0	26.2	0	
Upper Volcano		8/6/2023	0	20.3	0	
Volcano		7/30/2014	0	26	0	
Volcano		8/1/2015	32	22.5	34.1	
Volcano		8/6/2016	3	22	3.3	
Volcano		8/6/2017	2	21.75	2.2	2 SS
Volcano		8/3/2018	2	24.34	2	1 SS
Volcano		8/7/2019	0	31	0	2 SS
Volcano		8/5/2020	1	23.3	1	
Volcano		8/9/2021	0	25.8	0	
Volcano		8/3/2022	13	26	12	
Volcano		8/6/2023	1	20.4	1.2	
West Fork Ikalukrok	205	7/8/2000	0	24	0	
West Fork Ikalukrok	205	7/28/2000	0	28	0	
West Fork Ikalukrok	205	7/7/2001	0	25	0	
West Fork Ikalukrok	205	8/3/2001	0	54	0	
West Fork Ikalukrok	205	7/11/2002	0	27	0	
West Fork Ikalukrok	205	8/2/2002	0	26	0	
West Fork Ikalukrok	205	8/1/2015	0	27	0	
West Fork Ikalukrok	205	8/5/2016	0	23	0	
West Fork Ikalukrok	205	8/7/2017	0	27	0	
West Fork Ikalukrok	205	8/3/2018	0	21.08	0	
West Fork Ikalukrok	205	8/5/2019	0	24	0	
West Fork Ikalukrok	205	8/3/2020	0	20.5	0	
West Fork Ikalukrok	205	8/8/2021	0	24.25	0	
West Fork Ikalukrok	205	8/5/2022	0	23.25	0	
West Fork Ikalukrok	205	8/5/2023	0	22	0	

APPENDIX 2. Water quality and metal concentration data at various streams near the Aktigiruq-Anarraaq Extension Project throughout the 2023 open water season.

Station numbers are in parentheses by the stream name. Samples were collected by Teck and analyzed by external labs. Seasonal means are presented in shaded rows.

	EF Ikalukrok (208)	Grayling Jr (209)	Upper Ikalukrok (206)	Lower Ikalukrok (207)	Ikalukrok (230)	Moil (211)	Noa (210)	WF Ikalukrok (205)
pH	7.54 (n = 11)	7.49 (n = 11)	6.08 (n = 8)	6.35 (n = 11)	6.27 (n = 5)	3.71 (n = 11)	4.72 (n = 4)	4.40 (n = 7)
Min	6.57	6.10	4.11	5.75	5.82	3.39	3.53	3.36
Max	8.11	8.20	6.95	7.13	7.03	4.43	7.97	6.08
Temperature (°C)	5.92 (n = 11)	6.11 (n = 11)	4.66 (n = 8)	5.81 (n = 11)	4.82 (n = 5)	3.59 (n = 11)	3.98 (n = 4)	4.36 (n = 7)
Min	-0.10	-0.10	0	-0.10	-0.10	0.20	-0.20	0
Max	11.40	11.50	10.50	11.30	10.90	8.40	12.00	8.00
Conductivity (uS/cm	200.46 (n = 11)	459.45 (n = 11)	349.56 (n = 8)	398.60 (n = 11)	350.98 (n = 5)	852.90 (n = 11)	739.35 (n = 4)	522.43 (n = 7)
Min	72.70	115.60	90.70	109.0	114.50	236.90	481.40	84.0
Max	287.40	698.0	785.0	590.0	586.0	1182.0	994.0	754.0
TDS (mg/L)	1.39 (n = 4)	7.36 (n = 4)	14.2 (n = 1)	25.1 (n = 4)	5.37 (n = 5)	134.75 (n = 4)	8.99 (n = 4)	
Min	0.78	1.74	14.20	20.70	2.09	102.00	1.01	
Max	2.83	15.10	14.20	35.20	9.88	170.00	13.00	
Zinc (mg/L)	0.091 (n = 11)	0.134 (n = 13)	0.546 (n = 8)	2.457 (n = 11)	0.637 (n = 5)	4.287 (n = 11)	5.324 (n = 4)	1.251 (n = 7)
Min	0.009	0.013	0.093	0.369	0.254	0.802	0.896	0.380
Max	0.744	0.298	2.460	4.000	1.180	6.760	10.600	2.260
Lead (mg/L)	0.0005 (n = 11)	0.0007 (n = 13)	0.0006 (n = 8)	0.0051 (n = 11)	0.0005 (n = 5)	0.0006 (n = 11)	0.0009 (n = 4)	0.0004 (n = 7)
Min	0.0001	0.0005	0.0001	0.0037	0.0002	0.0002	0.0003	0.0001
Max	0.0014	0.0021	0.0015	0.0112	0.0013	0.0020	0.0016	0.0008
Aluminum (mg/L)	0.0645 (n = 4)	0.5375 (n = 6)	2.20 (n = 1)	1.8630 (n = 4)	1.1908 (n = 5)	23.350 (n = 4)	10.7840 (n = 4)	
Min	0.0362	0.0150	2.20	0.9720	0.421	9.0000	0.7160	
Max	0.1230	1.140	2.20	2.5400	2.270	31.80	20.00	
Cadmium (mg/L)	0.0001 (n = 4)	0.0001 (n = 6)	0.0009 (n = 1)	0.01146 (n = 4)	0.0032 (n = 5)	0.0221 (n = 4)	0.0153 (n = 4)	
Min	0.0001	0.0003	0.0009	0.0042	0.001	0.0110	0.0038	
Max	0.0001	0.0018	0.0009	0.0161	0.006	0.0277	0.0272	
Nickel (mg/L)	0.0153 (n = 4)	0.0688 (n = 6)	0.1020 (n = 1)	0.4668 (n = 4)	0.3922 (n = 5)	1.6385 (n = 4)	3.1995 (n = 4)	
Min	0.0048	0.0010	0.1020	0.1790	0.138	0.8040	0.1580	
Max	0.040	0.1340	0.1020	0.770	0.692	2.020	6.730	
Turbidity (NTU)	1.3850 (n = 4)	7.360 (n = 4)	14.20 (n = 1)	25.10 (n = 4)	5.370 (n = 5)	134.750 (n = 4)	8.990 (n = 4)	
Min	0.780	1.740	14.20	20.70	2.09	102.0	1.01	
Max	2.830	15.10	14.20	35.20	9.88	170.0	13.0	

APPENDIX 3. In situ water quality data collected in July 2023.

Site	Station	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductivity (µs/cm)	Conductivity (µs/cm)	pH	Turbidity (NTU)
Upper Competition	203	7/11	2.9	12.5	1011	585	5.4	18.73
Sourdock	204	7/11	3.5	12.4	613	361.5	7.55	12.2
Lower Competition	202	7/12	3.3	12.55	708	414.5	6.85	13.46
WF Ikalukrok	205	7/8	2.2	12.71	725	408.8	5.02	0.6
Upper Ikalukrok	206	7/8	3	12.48	314.6	182.7	-	2.34
Lower Ikalukrok	207	7/9	3	12.69	446.9	258.9	6.93	4
EF Ikalukrok	208	7/8	2.7	12.98	222.5	127.9	8.5	1.19
Grayling Jr	209	7/8	4.2	12.24	463.2	279.3	8	3.48
Noa	210	7/9	1.5	13.04	1334	736	4.1	0.46
Moil	211	7/9	2.8	12.84	1210	697	3.92	16.83
Sled	212	7/9	3.4	12.07	267.1	156.5	7.9	3.66
Volcano		7/9	2.4	12.77	620	352.5	7.89	1.27
Warf		7/12	3.7	11.6	1527	905	3.67	0.7
Ikalukrok	230	7/8	3.7	12.34	393.1	232.9	7.06	2.28