Appendix 35

Whale Tail EEM Cycle 1 Interpretive Report

ENVIRONMENTAL EFFECTS MONITORING: WHALE TAIL PIT CYCLE 1 BIOLOGICAL STUDY INTERPRETIVE REPORT

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Submitted To:

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EXECUTIVE SUMMARY

Introduction

Agnico Eagle Mines Ltd Whale Tail Mine began discharging treated effluent during dyke construction in 2018 and was subsequently required under the Metal Mining Effluent Regulations (MDMER) to monitor effects of that effluent on fish and fish habitat. This is the mine's First Environmental Effects Monitoring (EEM) Biological Study Interpretive Report, and it is submitted to Environment Canada on behalf of Agnico Eagle Mines Limited, Val-d'Or, Québec. This report documents the results of fish population surveys and a benthic invertebrate community survey completed for the mine's Cycle 1 EEM biological monitoring study, as well as the sub-lethal toxicity testing carried out on the Whale Tail Mine effluent since 2018.

Fish Population Survey

Lake Trout was the large-bodied sentinel fish species used in the 2020 Cycle 1 EEM survey, while Slimy Sculpin was the small-bodied sentinel fish species used; other species are not present in sufficient numbers to be feasible study species. Lake Trout and Slimy Sculpin from the exposed area in Mammoth Lake were compared to those from two reference lakes, Lake 8 and Lake D1.

The Lake Trout study used lethal sampling, with a target sample size of 25 fish per lake, and examined weight adjusted for length, liver weight adjusted for weight and length, weight at age and length at age, as well as size distribution and age distribution, for immature and mature fish of both sexes combined.

There are no significant differences ($P>0.05$) in the slopes, but there are significant differences ($P\leq0.10$) in the intercepts of the relationships for weight versus length, liver weight versus weight, and liver weight versus length among lakes. Pairwise comparisons indicate that the intercepts do not differ significantly between Mammoth Lake and reference Lake D1 and the differences in least square means between those two lakes are less than the critical effect sizes. Pairwise comparisons indicate that the slopes differ significantly between Mammoth Lake and reference Lake 8 for the weight versus length and liver weight versus length relationships and the differences in least square means exceed the critical effect sizes.

There are significant differences ($P\leq0.05$) in the slopes of the relationships for weight versus age and length versus age (i.e., non-parallel regression slopes), so effect sizes could not be appropriately estimated using the reduced model. It was apparent that the slope of these relationships was different for Lake D1 than for the other two lakes. Therefore, analyses were conducted using only the data from Mammoth Lake and reference Lake 8. There is no significant difference in either the slopes or the intercepts of between those two lakes. This is consistent with the results of pairwise comparisons of large and small individuals using the data from both reference lakes and the full ANCOVA model. Length and age distributions of Lake Trout did not differ significantly between lakes and weight distribution only differed significantly between Mammoth and Lake 8.

For Lake Trout, considering effect indicators with critical effect sizes, there are no significant differences between Mammoth Lake and reference lake D1 for total body weight at length, liver weight at total body weight, and age, and the differences between the two lakes (6.5%, -1.5%, -0%) are less than the critical effect sizes (10%, 25%, 25%). Total body weight at age comparisons between Mammoth Lake and Lake D1 were confounded by differences in slopes, with young fish lighter and old fish heavier in Lake D1. There is a significant difference between Mammoth Lake and reference Lake 8 for body weight at length that exceeds the critical effect size (difference=13.5%). There is not a significant difference in liver weight at total body weight (difference=12.9%) or age (difference=23.5%). There is no significant difference in weight at age between Mammoth Lake and reference Lake 8 and the difference (14.2%) is less than the critical effect size (25%). In summary, for Lake Trout, Mammoth Lake does not differ significantly from one or both of the reference lakes for each of the key effects indicators.

A non-lethal study of Slimy Sculpin indicated that both the length and the weight distributions of Slimy Sculpin differ between Mammoth Lake and Lake 8 but neither differ significantly between Mammoth Lake and Lake D1. The slopes of the weight versus length relationship differ significantly between Mammoth Lake and both of the reference lakes. The effect size for the weight versus length relationship is -8.6% when Mammoth Lake is compared to Lake D1, -11.7% when Mammoth Lake is compared to Lake 8, and equal to 10% when Mammoth Lake is compared to the reference sites combined.

Benthic Invertebrate Community Survey

This 2020 survey of benthic invertebrates compares an exposure area in Mammoth Lake (MAM), with reference-area data from Lake D1 and Lake 8. This is the first invertebrate community survey for the Whale Tail Pit under the MDMER. Benthos have been sampled from MAM since 2015, while MAM has been exposed to effluent since 2019. Benthos have been collected from Lake D1 and Lake 8 since 2018. Benthic invertebrates were collected in August 2020. Effects assessment involved use of baseline period data dating back to 2015, and testing of before-after-control-impact (BACI) hypotheses.

The benthic community of MAM in 2020 was diverse and consisted largely of chironomids and pisidiid fingernail clams. In terms of composition, the benthic community of MAM was similar to what has been described in Lake D1 and Lake 8. The benthos of MAM, although consistent with what is observed in reference lakes in the area, has changed during the reference period for MAM (i.e., 2015 to 2018), with 2018 seeing the disappearance of Ostracoda. The benthos of MAM is also somewhat unique relative Lake D1 and Lake 8, reflecting natural differences in sediment character. Some of the observed variations in core indices of composition were related to variations in sampling depth and substrate total organic carbon. Testing for spatio-temporal variations, therefore, were carried out on residuals of the core indices, after taking into account the variations related to underlying physical variables.

Variations in residuals of indices of benthic community composition were assessed using specific contrasts designed to develop a burden of evidence that treated mine effluent was (or was not) causing effects on the benthic community of MAM. Generally, some effluent-related hypotheses were rejected providing some evidence of effluent-related effects. Effect sizes were, however, always small and the benthic community of MAM contained a typical Arctic assemblage. Any effluent-related effects were therefore subtle.

ANOVA 1 (H01) tested for differences in the benthic communities between reference (Lake D1 and Lake 8) and exposure (MAM) in 2020. There were significant differences in residuals of two core indices of composition (abundance and evenness), and two non-core indices (NMDS axis 1 and 2 scores). Rejection of that null hypothesis for these indices was consistent with effluent related effects. Effect sizes for core and non-core indices, however, did not exceed the critical effect size (CES) of ± 2 SD.

ANOVA 2 tested for differences in benthic communities in the exposure area (MAM) between its baseline (2015 to 2018) and exposure (H02a: 2019-2020, H02b: 2020) periods. There were significant differences in residuals of abundance, evenness and NMDS axis 1 scores for both H02a and HO2b. There were also significant differences in residuals of richness and NMDS axis 2 scores for H02b only, and in diversity for H02a only. Rejection of the null hypotheses for these indices suggests effluent related effects. Effect sizes only exceeded the CES of ± 2 SD for abundance.

ANOVA 3 used data from 2018 to 2020 from MAM, Lake D1 and Lake 8 in a classic before-after control-impact (BACI) design to test for differences in benthic communities. There were significant differences in residuals of richness (H03a) and evenness (H03a,b). Effect sizes did not exceed the CES of ± 2 SD, and means of residuals for both richness and evenness at MAM in 2020 fell within the normal ranges of variation of reference data.

Despite the generally higher numbers of benthic organisms in the MAM sampling area, the composition of benthic community was very similar to what has been observed in the reference lakes. NMDS axis scores in 2020 for MAM were within the range of values from reference lakes. Further, the benthic taxa do not indicate degraded conditions and contained an assemblage of organisms that are typical for these Arctic systems. MAM benthos contained 7 genera of chironomid in 2020, similar to what had been observed in the other lakes including the dominant forms *Corynocera*, *Micropsectra*, *Paratanytarsus*, *Stichtochironomus*, and *Tanytarsus*.

Sediments in MAM have around 9 to 10% TOC, whereas Lake 8 and Lake D1 have had around 1 to 4% TOC. That difference alone would be sufficient to result in the benthos of MAM being different from the reference lakes. Reference-condition models were used here to 'adjust' indices to a more common set of conditions in terms of substrate. Multiple regression models determined that substrate TOC explained a significant amount of variation in abundance, evenness, NMDS axis 1 scores and diversity. Sampling depth also explained a significant amount of variation in richness, evenness and NMDS axis 2 scores. Over, the models explained between 13% and 45% of the variation in the data.

Each of the three sampling areas had concentrations of metals and nutrients that are well below CCME water quality guidelines, and near detection limits. There has been some elevation of cations (Ca, K, Na) in MAM, reflecting the slightly higher hardness which is probably associated with effluent treatment, but the changes are trivial relative to the concentrations that would be required in order to elicit a toxicity response (Mount *et al*., 1997, 2019).

Mercury and Selenium in Fish Flesh

The mercury concentration and the selenium concentration in the effluent have consistently been less than the concentrations that would require a fish tissue study; therefore, a study respecting fish tissue mercury or fish tissue selenium was not required.

Sub-Lethal Toxicity

Cycle 1 effluent samples produced no effect on survival or growth of exposed fathead minnows. There was no mortality of *Ceriodaphnia dubia* in tests conducted during Cycle 1, however measurable reproductive inhibition was observed in three samples tested and IC25 estimates for these were 51.3%, 41.0%, and 64.0%. No inhibitory effects were observed for *Pseudokirchneriella subcapitata* exposed to effluent samples. Inhibitory effects on *Lemna minor* were observed during one test where IC25 estimates for frond growth (dry weight) and frond number were 84.9% and 51.2%, respectively.

Future EEM Schedule

The next EEM cycle should be completed within 36 months of this submission. Cycle 2 fish population and benthic invertebrate surveys, if required, will be completed in August 2023, with the interpretive report submitted by July 27, 2024. During Cycle 1, the largest effluent stream was via diffusers into Mammoth Lake and, based on its composition, this is the effluent that has the greatest potential to cause harm to the environment and, therefore, was the focus of this EEM field study. Agnico will continue to monitor the volume and quality of the mine effluents. These data will be used to determine the effluent that will be the focus of the Cycle 2 EEM field study. Provided that the effluent discharge location does not change, it is recommended that the fish and benthic invertebrate studies for the next EEM biological study at Whale Tail follow the same designs that were used in this study.

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1.0 INTRODUCTION

1.1 Whale Tail Mine

Whale Tail Mine is a satellite deposit located approximately 50 km northwest of the main Meadowbank Mine site, which, in turn, is located approximately 75 km north of the hamlet of Baker Lake, Kivalliq District, Nunavut (Figure 1). Ore from Whale Tail Mine is transported to the Meadowbank Mine for processing. The Type A water license for Meadowbank was amended to License 2AM-MEA1526 and the mine continues to operate by using ore from the Whale Tail site. On July 11, 2018, Type A Water License 2AM-WTP1826 was approved by the Minister to begin construction and operation of the Whale Tail Mine and hauling ore to the Meadowbank Mill. Meadowbank (2AM-MEA1530) and Whale Tail (2AM-WTP1830) Water Licenses were then amended again in 2020 to allow for the expansion of Whale Tail. Fisheries and Oceans Canada Authorization 16-HCAA-00370, issued on July 23, 2018, allowed for works or undertakings affecting fish habitat at the Whale Tail Mine. Another Fisheries Act Authorization 20-HCAA-00275 was received on July 17, 2020 to allow work associated with the Whale Tail expansion project.

Construction activities for Whale Tail included the isolation of the north portion of Whale Tail Lake using dykes and dewatering of the impoundment into adjacent lakes. During Whale Tail dike construction, water was pumped from the area enclosed by sediment curtains to create an inflow and thus minimize dispersal of water with increased suspended sediment concentrations from within the enclosed area into the rest of Whale Tail Lake. That pumping began on July 27, 2018, at which time Whale Tail Pit was deemed by Environment and Climate Change Canada to be subject to the Metal Mining Effluent Regulations (MDMER) under the Fisheries Act. Open pit and underground mining at Whale Tail have occurred at two deposits (Whale Tail and IVR).

1.2 Regulatory Background

The MDMER, under the Fisheries Act, imposes liquid effluent limits for pH, cyanide, metals and suspended solids, and prohibits the discharge of a liquid effluent that is acutely lethal to fish. The MDMER also requires mines to conduct Environmental Effects Monitoring (EEM) studies of fish, fish habitat and the use of fisheries resources in aquatic receiving environments. Under the MDMER, Agnico Eagle Mines Limited (Agnico) is required to conduct aquatic monitoring studies on the potential effects of the Whale Tail Pit's final liquid effluent on Mammoth Lake.

Schedule 5, Parts 1 and 2, of the MDMER requires each operating mine to conduct an EEM program consisting of the following components:

- **Effluent characterization and water quality monitoring** studies including sublethal toxicity testing; and,

- **Biological monitoring studies** consisting of a study design, field studies, data assessment and reporting.

This is the first biological monitoring study for Whale Tail Mine. It includes collecting fish and benthos from the exposure area in Mammoth Lake (MAM) and from two reference areas, one each in Lake D1 and

Lake 8 (Figure 2). A study design for the proposed Cycle 1 EEM study was submitted to Environment and Climate Change Canada (ECCC) on July 26, 2019 (C. Portt and Associates and Kilgour & Associates, 2019). The Technical Advisory Panel (TAP) reviewed the study design and provided comments to Agnico Meadowbank Division. These comments were addressed by Agnico, and a revised fish survey study design was submitted to ECCC on June 7, 2020 (C. Portt and Associates and Kilgour & Associates, 2020). The Cycle 1 study design was accepted by ECCC on July 3, 2020. (Appendix 1). This report describes the results of the First Biological study undertaken August 15-28, 2020, pursuant to Agnico's requirement under MDMER.

Figure 1. Location of Whale Tail Mine.

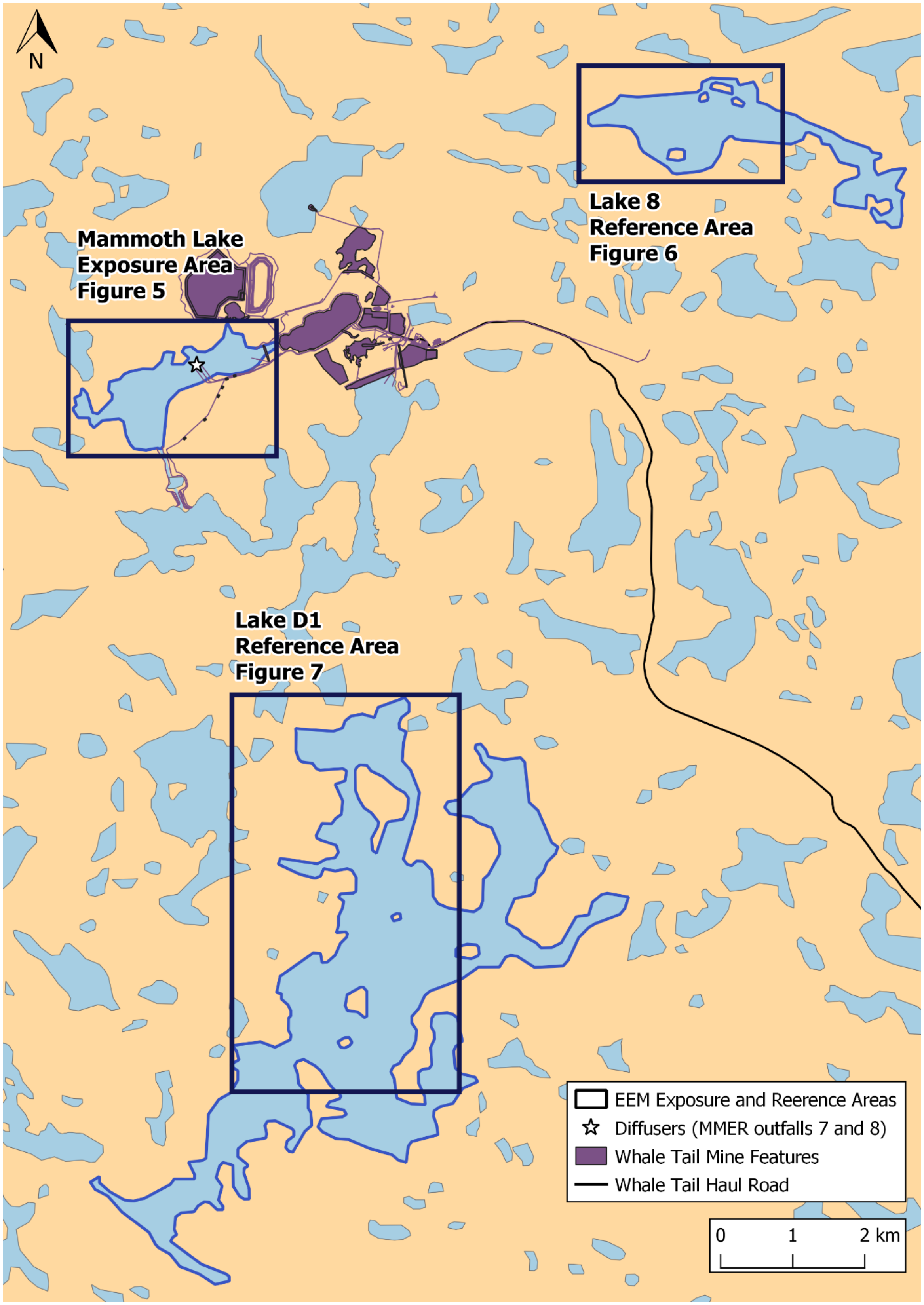

Figure 2. Map of the study area.

1.3 Concordance with Requirements

The Concordance Table (Table 1) provides a list of the MDMER Interpretative Report requirements, and identifies where in this document the required information can be found.

Table 1. Concordance table identifying the sections of this report that address specific MDMER reporting requirements.

MDMER Requirement	Where Found in the Document
12(a) description of any deviation from the study design that occurred while the biological monitoring studies were being conducted and any impact that the deviation had on the studies.	Section 2.3
12(b) the latitude and longitude of sampling areas and a description of the sampling areas sufficient to identify the location of the sampling areas.	Digital data submission, Section 5 for sediment and water, Appendix 3 for fish
12(c) the dates and times when the samples were collected.	Section 5 for sediment and water Appendix 3 for fish
12(d) the sample sizes.	Section 3 to Section 5
12(e) (i) in the case of the study respecting fish population, the mean, median, standard deviation standard error, minimum, and maximum values for effect indicators of growth, reproduction, condition and survival that include, if practicable, the length, total body weight, and age of the fish, the weight of its liver or hepatopancreas and, if the fish are sexually mature, the egg weight, fecundity, and gonad weight of the fish.	Section 3 for Lake Trout Section 4 for Slimy Sculpin
12(e) (ii) in the case of the study respecting the benthic community, the mean, median, standard deviation, standard error, minimum and maximum values for effect indictors for the total benthic invertebrate density, evenness index, taxa richness, and, if the study is conducted in an area where it is possible to sample sediment, total organic carbon content of sediment and particle size distribution of sediment.	Section 5
12(f) in the case of a study respecting the benthic invertebrate community, a calculation of the similarity index effect indicator.	Section 5
12(g) an identification of the sex of the fish sampled and of the presence of any lesions, tumours, parasites or other abnormalities.	Section 3 for Lake Trout Section 4 for Slimy Sculpin
12(h) determination as to whether there is a statistically significant difference between the sampling areas, with statistical comparisons made separately and independently for each effect indicator.	Section 3 to Section 5
12(i) a statistical analysis of the results of calculations that indicates the probability of correctly detecting an effect of a pre-defined size and the degree of confidence that can be placed in the calculations.	Section 3 for Lake Trout Section 4 for Slimy Sculpin Section 5 for invertebrates
12(j) for an effect indicator with an assigned critical effect size, a comparison on the magnitude of the effect to its critical effect size.	Section 3 for Lake Trout Section 4 for Slimy Sculpin Section 5 for invertebrates
12(k) any supporting data, including raw data for the information provided under (e) to (j)	Appendix 3 and Appendix 4 for fish Section 5 and Appendix 6 for invertebrates
12(l) a description of any quality assurance or quality control measures that were implemented, and the data related to the implementation of those measures.	Section 5 for description Appendix 5 for water quality data Appendix 7 for invertebrate data
12(m) based on the information referred to in paragraphs (e) to (k), the identification of (i) any effect on the fish population and (ii) any benthic invertebrate community.	Section 3 and Section 4 for fish Section 5 for invertebrates
12(n) for an effect indicator with an assigned critical effect size, a statement as to whether the absolute value of the magnitude of the effect is greater than the absolute value of the critical effect size.	Section 3 for Lake Trout Section 4 for Slimy Sculpin Section 5 for invertebrates

MDMER Requirement	Where Found in the Document
12(o) a summary of the results of effluent characterization, sublethal toxicity testing and water quality monitoring beginning on the day on which the mine becomes subject to section 7 of these Regulations.	Section 2 for effluent characterization and water quality, Section 7 for sublethal toxicity testing
12(p) the conclusions of the biological monitoring studies, and a description of how the conclusions will impact the study design for subsequent biological monitoring studies.	Section 3.4.1 for Lake Trout Section 4.4.1 for Slimy Sculpin Section 5.4.1 for invertebrates
12(q) the month in which the next biological monitoring studies will start, if any biological monitoring studies are required.	Executive Summary Section 8
12(r) the date when the next interpretive report is required to be submitted.	Executive Summary Section 8

2.0 STUDY DESIGN UPDATE

2.1 Mining and Wastewater Management Overview

A detailed description of the Meadowbank Mine wastewater treatment system is provided in the EEM Cycle 1 Study Design (C. Portt and Associates, Kilgour & Associates Ltd., 2019). During operations, non-contact water is diverted from the site through a combination of channels, dikes, and pumps. Contact water from the major mine infrastructure is directed to the Whale Tail Attenuation Pond, which is located in the dewatered north basin of Whale Tail Lake (Figure 3). Contact water consists primarily of water from the Whale Tail Waste Rock Storage Facility (WRSF) Pond and runoff water in the open pit, which are collected by sumps and pumped to the Whale Tail Attenuation Pond. Camp sewage is treated in a Newterra™ domestic sewage treatment plant and pumped to the Whale Tail Attenuation Pond where it is mixed with contact water. Other sources of water directed to the Whale Tail Attenuation Pond include runoff from developed ground (main sector, industrial sector), and runoff from stockpiles (clean materials and ore).

The water from the attenuation pond is treated in an Arsenic Water Treatment Plant (AsWTP) to comply with the quality criteria in Type A Water Licence 2AM-WTP1830 and MDMER prior to discharge. The AsWTP has a capacity of 1,600 m^3/hr and is composed of two Actiflo® to remove total suspended solids (TSS) and one arsenic removal unit (pH adjustment, As oxidation, As precipitation).

Treated effluent is discharged to the east end of Mammoth Lake via diffusers (Figure 3). During the open water period (approximately June to October) the treated effluent is directed to a pair of permanent, submerged MDMER diffusers (MDMER 7 and 8) with a maximum flow capacity of 800 m^3/hr (1,600 m^3/hr total). The diffusers are anchored on the bottom of Mammoth Lake with boulders. In 2019 a temporary diffuser (MDMER 6) was installed in Mammoth Lake to discharge water from Whale Tail North Basin dewatering activities. Two diffusers (MDMER 5 and MDMER 11) are also installed in Whale Tail South Basin (Figure 3). MDMER 5 is a temporary diffuser, which discharged water from Whale Tail North Basin during dewatering activities in 2019 and 2020. In 2020 MDMER 5 discharged water from the Whale Tail Attenuation Pond, and Lake A53 during dewatering. MDMER 11 is a permanent diffuser that discharged water from the Whale Tail Attenuation Pond in 2020. A summary of MDMER effluent volumes discharged to Mammoth Lake and Whale Tail Lake South basin is presented in Table 2. Daily effluent volumes for MDMER 6, MDMER 7, and MDMER 8 are provided in Table 3, Table 4, and Table 5, respectively. Effluent mixing in the Mammoth Lake receiving environment is discussed in Section 2.2. It should be noted that Figure 3 illustrates conditions when the field investigations for this study were conducted. An expansion has occurred and Lake A53 was dewatered in September 2020,

Effluent chemistry results for MDMER 6 (2019), MDMER 7 (2019 to 2020), and MDMER 8 (2020) are presented in Table 6, Table 7, and Table 8, respectively. There have been no exceedances of the MDMER effluent discharge limits for deleterious substances at the Whale Tail Pit Mine up to December 2020. Toxicity test results for sublethal endpoints are discussed in Section 7.0. Receiving environment water quality results for Mammoth Lake are presented in Table 9 (MDMER 6) and Table 10 (MDMER 7 and 8). Reference area water quality monitoring results for Third Portage Lake South are presented in Table 11.

Table 2. Annual effluent volumes and discharge sources for MDMER diffusers for Mammoth Lake and Whale Tail Lake South Basin.

Receiving Lake	Diffuser	Year	Discharge Source	Volume (m^3)
Mammoth Lake	MDMER 6	2019	Whale Tail North Basin dewatering	2,915,472
	MDMER 7	2019	Quarry 1	474,805
		2020	Quarry 1 Whale Tail Attenuation Pond	544,326
	MDMER 8	2020	Whale Tail Attenuation Pond	1,161,165
			Mammoth Lake Total	**5,095,767**
Whale Tail South Basin	MDMER 5	2019	Whale Tail North Basin dewatering	3,085,651
		2020	Whale Tail North Basin dewatering Whale Tail Attenuation Pond	1,153,785
			Lake A53 dewatering	146,293
	MDMER 11	2020	Whale Tail Attenuation Pond	341,420
			Whale Tail South Basin Total	**4,727,150**

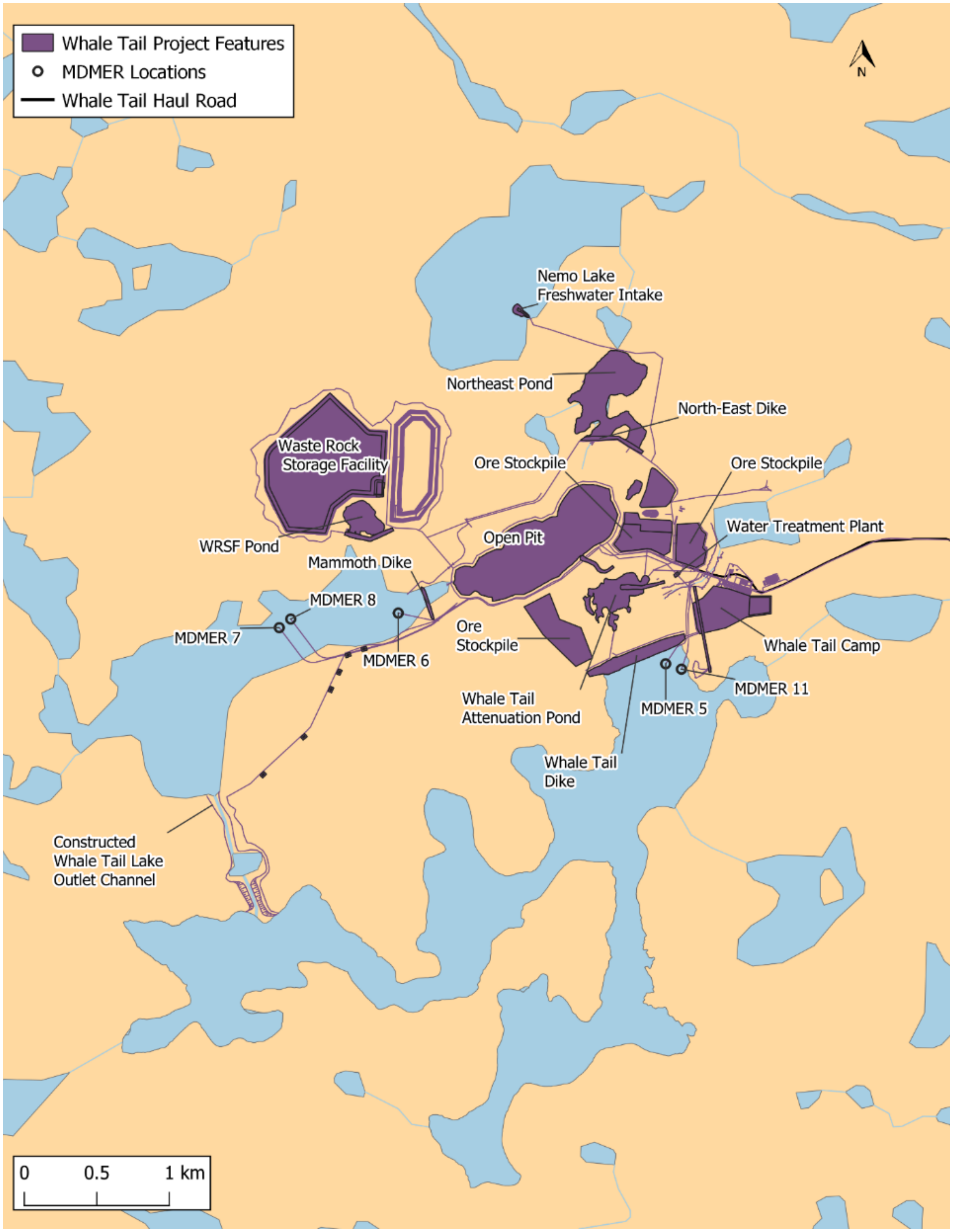

Figure 3. Whale Tail Mine infrastructure and effluent discharge locations.

Table 3. Whale Tail Mine effluent volume (m^3) to Mammoth Lake via outfall MDMER 6 (temporary diffuser) from Whale Tail North Basin dewatering.

Date	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19
1	0	0	0	0	0	0	14,707	29,712	6,931	0	0	0
2	0	0	0	0	0	0	22,477	20,680	27,688	16,002	0	0
3	0	0	0	0	0	0	17,136	5,392	32,567	13,983	0	0
4	0	0	0	0	0	0	23,531	0	28,427	30,858	0	0
5	0	0	0	0	0	0	23,107	26,840	32,075	34,819	0	0
6	0	0	0	0	0	0	7,107	32,088	32,207	32,879	0	0
7	0	0	0	0	0	0	16,417	31,632	30,555	35,783	0	0
8	0	0	0	0	0	0	19,731	31,680	30,153	32,830	0	0
9	0	0	0	0	0	0	0	31,680	31,286	34,204	0	0
10	0	0	0	0	0	0	0	31,704	25,668	31,887	0	0
11	0	0	0	0	0	0	0	31,800	32,023	22,813	0	0
12	0	0	0	0	0	0	0	31,752	32,272	33,806	0	0
13	0	0	0	0	0	0	3,112	31,752	33,087	29,139	0	0
14	0	0	0	0	0	0	20,957	26,989	30,049	23,822	0	0
15	0	0	0	0	0	0	12,616	4,948	29,868	32,980	0	0
16	0	0	0	0	0	0	12,616	27,168	31,369	27,518	0	0
17	0	0	0	0	0	2,500	14,215	28,947	29,916	29,935	0	0
18	0	0	0	0	0	0	14,215	23,393	33,837	28,002	0	0
19	0	0	0	0	0	0	14,215	34,621	38,980	26,040	0	0
20	0	0	0	0	0	0	24,069	34,097	37,790	16,928	0	0
21	0	0	0	0	0	0	22,581	10,414	37,457	17,648	0	0
22	0	0	0	0	0	15,543	30,523	22,240	37,668	14,474	0	0
23	0	0	0	0	0	16,452	25,080	24,691	35,793	15,920	0	0
24	0	0	0	0	0	16,576	23,726	26,739	30,939	11,294	0	0
25	0	0	0	0	0	19,307	28,688	26,626	27,859	8,317	0	0
26	0	0	0	0	0	20,348	28,309	26,319	31,175	2,257	0	0
27	0	0	0	0	0	20,823	28,309	25,350	34,552	0	0	0
28	0	0	0	0	0	20,624	29,781	25,240	23,091	0	0	0
29	0		0	0	0	2,839	28,001	17,285	0	0	0	0
30	0		0	0	0	12,540	17,941	15,561	0	0	0	0
31	0		0		0		14,830	23,164		0		0
Total	**0**	**0**	**0**	**0**	**0**	**147,552**	**537,996**	**760,504**	**865,282**	**604,138**	**0**	**0**

Table 4. Whale Tail Mine effluent volume (m^3) to Mammoth Lake via outfall MDMER 7 (west diffuser) from Quarry 1 (up to end of April 2020) and Whale Tail Attenuation Pond (beginning May 2020).

Date	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19
1	0	0	0	0	0	0	0	0	5,812	10,800	0	0
2	0	0	0	0	0	0	0	0	5,526	10,812	0	0
3	0	0	0	0	0	0	0	0	6,608	10,340	0	0
4	0	0	0	0	0	0	0	0	6,052	6,120	0	0
5	0	0	0	0	0	0	0	0	6,819	150	0	0
6	0	0	0	0	0	0	0	0	3,692	11,376	0	0
7	0	0	0	0	0	0	0	0	3,289	8,971	0	0
8	0	0	0	0	0	0	0	0	6,671	5,586	0	0
9	0	0	0	0	0	0	0	0	2,972	4,608	0	0
10	0	0	0	0	0	0	0	0	11,928	1,960	0	0
11	0	0	0	0	0	0	0	0	14,742	9,968	0	0
12	0	0	0	0	0	0	0	0	14,487	8,957	0	0
13	0	0	0	0	0	0	0	0	14,372	11,640	0	0
14	0	0	0	0	0	0	0	0	4,434	11,520	0	0
15	0	0	0	0	0	0	0	0	0	10,440	0	0
16	0	0	0	0	0	0	0	0	13,146	7,944	0	0
17	0	0	0	0	0	0	0	0	11,694	10,380	0	0
18	0	0	0	0	0	0	0	0	12,130	10,320	0	0
19	0	0	0	0	0	0	0	0	14,598	10,407	0	0
20	0	0	0	0	0	0	0	0	14,277	11,256	0	0
21	0	0	0	0	0	0	0	0	7,581	10,440	0	0
22	0	0	0	0	0	0	0	0	10,139	4,912	0	0
23	0	0	0	0	0	0	0	0	7,856	1,141	0	0
24	0	0	0	0	0	0	0	0	7,716	0	0	0
25	0	0	0	0	0	0	0	0	5,101	0	0	0
26	0	0	0	0	0	0	0	9,880	5,880	0	0	0
27	0	0	0	0	0	0	0	9,288	6,764	0	0	0
28	0	0	0	0	0	0	0	4,451	5,960	0	0	0
29	0		0	0	0	0	0	9,288	6,038	0	0	0
30	0		0	0	0	0	0	6,768	2,027	0	0	0
31	0		0		0		0	6,768		0		0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**46,443**	**238,312**	**190,050**	**0**	**0**

Table 4. (continued)

Date	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20
1	0	0	0	0	0	0	0	0	10,352	0	0	0
2	0	0	0	0	0	0	0	0	11,698	0	0	0
3	0	0	0	0	0	0	0	0	11,710	0	0	0
4	0	0	0	0	0	0	0	0	11,334	0	0	0
5	0	0	0	0	0	0	0	0	11,678	0	0	0
6	0	0	0	0	0	0	0	0	10,626	0	0	0
7	0	0	0	0	0	0	0	0	9,143	0	0	0
8	0	0	0	0	0	0	0	0	10,182	0	0	0
9	0	0	0	0	0	0	0	0	8,268	0	0	0
10	0	0	0	0	0	0	0	0	8,501	0	0	0
11	0	0	0	0	0	0	0	0	8,208	0	0	0
12	0	0	0	0	0	0	0	0	8,056	0	0	0
13	0	0	0	7,186	0	0	0	0	7,426	0	0	0
14	0	0	0	11,976	0	9,708	0	0	8,932	0	0	0
15	0	0	0	8,383	0	12,673	0	0	2,787	0	0	0
16	0	0	0	0	0	11,191	0	0	11,678	0	0	0
17	0	0	0	0	0	10,010	0	0	13,946	0	0	0
18	0	0	0	0	0	9,183	0	0	13,260	0	0	0
19	0	0	0	0	0	7,304	0	0	13,364	0	0	0
20	0	0	0	0	244	7,553	0	0	6,723	0	0	0
21	0	0	0	0	4,512	0	0	0	0	0	0	0
22	0	0	0	0	5,811	0	0	0	0	0	0	0
23	0	0	0	0	13,446	5,326	0	3,384	0	0	0	0
24	0	0	0	0	16,296	9,273	0	11,348	0	0	0	0
25	0	0	0	8,376	16,020	10,069	0	10,179	0	0	0	0
26	0	0	0	11,368	15,636	8,087	0	8,917	0	0	0	0
27	0	0	0	11,966	17,919	0	0	8,273	0	0	0	0
28	0	0	0	10,770	7,672	0	0	6,305	0	0	0	0
29	0		0	4,787	0	0	0	7,507	0	0	0	0
30	0		0	0	0	0	0	9,360	0	0	0	0
31	0		0		0		0	8,438		0		0
Total	**0**	**0**	**0**	**74,812**	**97,556**	**100,375**	**0**	**73,711**	**197,871**	**0**	**0**	**0**

Table 5. Whale Tail Mine effluent volume (m^3) to Mammoth Lake from Whale Tail Attenuation Pond via outfall MDMER 8 (east diffuser) for 2020.

Date	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20
1	0	0	0	0	0	0	3,875	8,220	10,895	9,726	0	0
2	0	0	0	0	0	0	9,777	6,474	12,543	9,650	0	0
3	0	0	0	0	0	0	13,189	5,863	12,650	9,581	0	0
4	0	0	0	0	0	0	14,788	6,372	12,140	9,526	0	0
5	0	0	0	0	0	0	14,836	4,728	12,548	8,768	0	0
6	0	0	0	0	0	0	0	0	11,685	9,193	0	0
7	0	0	0	0	0	0	15,175	4,044	10,340	8,389	0	0
8	0	0	0	0	0	0	16,524	8,044	10,348	0	0	0
9	0	0	0	0	0	0	16,268	11,263	7,988	0	0	0
10	0	0	0	0	0	0	16,749	11,117	8,341	0	0	0
11	0	0	0	0	0	0	16,848	11,002	7,902	0	0	0
12	0	0	0	0	0	0	15,012	9,010	7,738	0	0	0
13	0	0	0	0	0	0	12,729	8,675	3,465	0	0	0
14	0	0	0	0	0	0	13,194	10,813	0	0	0	0
15	0	0	0	0	0	0	12,582	14,588	2,724	0	0	0
16	0	0	0	0	0	0	12,694	12,504	11,512	0	0	0
17	0	0	0	0	0	9,451	12,566	14,633	13,835	0	0	0
18	0	0	0	0	0	10,131	12,867	13,202	13,231	0	0	0
19	0	0	0	0	0	8,933	10,037	13,426	13,318	0	0	0
20	0	0	0	0	0	13,210	9,803	11,250	12,114	0	0	0
21	0	0	0	0	0	14,397	5,047	11,644	12,761	0	0	0
22	0	0	0	0	0	10,996	7,645	13,081	14,452	0	0	0
23	0	0	0	0	0	11,397	2,644	12,447	15,085	0	0	0
24	0	0	0	0	0	11,787	0	12,479	13,792	0	0	0
25	0	0	0	0	0	11,245	2,352	10,777	11,605	0	0	0
26	0	0	0	0	0	14,342	7,066	9,249	8,140	0	0	0
27	0	0	0	0	0	14,233	7,968	8,596	7,514	0	0	0
28	0	0	0	0	0	13,820	9,852	6,377	9,127	0	0	0
29	0		0	0	0	13,744	10,679	7,719	9,675	0	0	0
30	0		0	0	0	13,698	9,397	9,728	9,721	0	0	0
31	0		0		0		9,442	8,835		0		0
Total	**0**	**0**	**0**	**0**	**0**	**171,383**	**321,603**	**296,160**	**307,187**	**64,832**	**0**	**0**

Table 6. Analytical results for effluent discharged to Mammoth Lake via outfall MDMER 6 in 2019.

Date (dd-mm-yyyy)	23-06-2019	02-07-2019	05-08-2019	07-10-2019
Parameter				
Alkalinity (mg $CaCO_3$/L)	12	9	74	24
Aluminum (mg/L)	0.107	0.025	0.190	0.050
Ammonia nitrogen (NH3-NH4) (mg N/L)	0.19	0.08	0.01	0.11
Cadmium (mg/L)	<0.00002	<0.00002	<0.00002	<0.00002
Hardness (mg $CaCO_3$/L)	113	43	54	84
Iron (mg/L)	0.31	0.52	0.50	0.49
Mercury (mg/L) (max allowance of 0.10µg/L)	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (mg/L)	<0.0005	0.0009	0.0022	0.0015
Nitrate (mg N/L)	0.73	0.27	0.15	0.24
Selenium (mg/L)	<0.0005	0.0009	<0.0005	<0.003
Chloride (mg/L)	65.3	26.9	34.5	43.3
Chromium (mg/L)	<0.0006	<0.0006	0.0018	<0.005
Cobalt (mg/L)	0.0015	0.0005	0.0006	<0.001
Sulphate (mg/L)	13.1	6.4	4.7	13.9
Thallium (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002
Uranium (mg/L)	<0.001	<0.001	<0.001	<0.001
Phosphorus (mg/L)	0.02	<0.01	0.02	<0.01
Manganese (mg/L)	0.3340	0.1924	0.1642	0.51
Conductivity (µs/cm)	333.2	175.1	174.9	240.3
Temperature (°C)	6.44	6.55	14.26	5.69

Table 7. Analytical results for effluent discharged to Mammoth Lake via outfall MDMER 7 in 2019 and 2020.

Date (dd-mm-yyyy)	27-08-2019	29-09-2019	07-10-2019	27-04-2020	25-05-2020	14-06-2020	24-08-2020
Parameter							
Alkalinity (mg $CaCO_3$/L)	46	42	45	75	51	21	49
Aluminum (mg/L)	0.311	0.113	0.150	0.070	0.038	0.010	0.009
Ammonia nitrogen (NH3-NH4) (mg N/L)	1.17	1.12	1.21	1.68	1.98	0.90	1.11
Cadmium (mg/L)	<0.00002	<0.00002	<0.0002	<0.00002	<0.00002	0.0006	<0.00002
Hardness (mg $CaCO_3$/L)	184	236	194	419	143	85	203
Iron (mg/L)	0.54	0.32	0.30	0.10	0.63	0.21	0.68
Mercury (mg/L) (max allowance of 0.10µg/L)	<0.00001	<0.00001	<0.0001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (mg/L)	0.0118	0.0104	0.0098	0.0179	0.0079	0.0017	<0.0005
Nitrate (mg N/L)	6.33	6.78	8.76	10.90	3.93	2.52	2.23
Selenium (mg/L)	0.0017	0.0019	<0.003	0.002	<0.001	<0.001	<0.001
Chloride (mg/L)	45.4	68.8	69.0	213.6	76.9	38.0	66.4
Chromium (mg/L)	0.0063	0.0011	<0.005	0.0011	0.0011	<0.0006	<0.0006
Cobalt (mg/L)	0.0020	0.0021	0.0016	0.0029	0.0008	0.0022	0.0027
Sulphate (mg/L)	70.8	68.6	59.8	60.9	23.0	36.1	51.5
Thallium (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Uranium (mg/L)	0.004	0.005	0.005	0.009	0.002	<0.001	<0.001
Phosphorus (mg/L)	0.03	0.03	0.01	<0.01	<0.01	<0.01	<0.01
Manganese (mg/L)	0.2610	0.3028	0.3100	0.5131	0.2159	0.3309	0.4632
Conductivity (µs/cm)	482.3	547.5	559.7	1010.0	462.7	262.0	402.0
Temperature (°C)	8.85	3.16	2.27	0.60	0.70	2.50	8.40

Table 8. Analytical results for effluent discharged to Mammoth Lake via outfall MDMER 8 in 2020.

Date (dd-mm-yyyy)	17-06-2020	22-06-2020	07-07-2020	26-07-2020	01-09-2020	05-10-2020
Parameter						
Alkalinity (mg $CaCO_3$/L)	34	38	44	42	53	54
Aluminum (mg/L)	0.036	0.020	<0.006	<0.006	0.033	0.045
Ammonia nitrogen (NH3-NH4) (mg N/L)	1.15	2.01	1.80	1.30	1.03	0.92
Cadmium (mg/L)	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Hardness (mg $CaCO_3$/L)	146	157	162	151	195	NA
Iron (mg/L)	0.54	0.38	0.59	0.41	0.38	0.64
Mercury (mg/L) (max allowance of 0.10µg/L)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (mg/L)	<0.0005	0.0032	0.0035	0.0049	0.0048	0.0035
Nitrate (mg N/L)	3.05	2.96	3.39	2.29	2.33	1.43
Selenium (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005
Chloride (mg/L)	46.2	52.3	61.7	48.3	66.7	54.2
Chromium (mg/L)	<0.0006	<0.0006	<0.0006	<0.0006	0.0011	0.0014
Cobalt (mg/L)	<0.0005	0.0021	0.0027	0.0017	0.0029	NA
Sulphate (mg/L)	34.6	35.8	39.0	46.3	60.7	43.5
Thallium (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Uranium (mg/L)	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Phosphorus (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese (mg/L)	0.4723	0.5255	0.5438	0.3755	0.5683	0.4777
Conductivity (µs/cm)	307	376	424	353	428	359
Temperature (°C)	2.3	3.7	10.5	12.0	7.5	2.1

Table 9. Chemical and physical parameters for the MDMER 6 exposure area at Mammoth Lake in 2019

Parameter	CCME (2020) Guideline[1]	2019 17-Jul	2019 3-Sep
MMT (Exposure Area)			
Alkalinity (mg $CaCO_3$/L)	NG	6	12
Aluminium-Total (mg/L)[2]	0.100 - 0.100	0.022	<0.005
Ammonia-Total (mg/L)[2,3]	1.2 - 19	<0.01	0.02
Arsenic-Total (mg/L)	0.005	<0.0005	0.0009
Cadmium-Total (mg/L)[4]	0.00004	<0.00002	<0.00002
Chloride-Total (mg/L)	120	15.9	20.7
Chromium-Total (mg/L)	NG	0.001	<0.0006
Cobalt-Total (mg/L)	NG	<0.0005	<0.0005
Copper-Total (mg/L)[4]	0.002 - 0.002	<0.0005	0.0022
Cyanide-Total (mg/L)	0.005	<0.001	<0.001
Dissolved oxygen-Field (mg/L)	6.5 - 9.5	9.44	11.03
Hardness (mg $CaCO_3$/L)	NG	25	52
Iron-Total (mg/L)	0.3	0.04	0.08
Lead-Total (mg/L)[4]	0.001 - 0.001	<0.0003	<0.0003
Manganese-Total (mg/L)[2,4]	0.430 - 0.590	0.0081	0.0218
Mercury-Total (mg/L)	0.000026	<0.00001	<0.00001
Molybdenum-Total (mg/L)	0.073	<0.0005	0.001
Nickel-Total (mg/L)[4]	0.025 - 0.025	0.0012	0.0016
Nitrate-Total (mg N/L)	13.0	<0.01	0.35
Phosphorus-Total (mg/L)	NG	<0.01	0.01
pH-Field	6.5 - 9.0	6.86	6.96
Radium-226 (Bq/L)	NG	<0.002	<0.002
Selenium-Total (mg/l)	0.001	<0.0005	<0.0005
Sulphate-Total (mg/L)	NG	4.0	10.3
Temperature-Field (^{o}C)	NG	14.33	7.25
Thalium-Total (mg/L)	0.0008	<0.0002	<0.0002
Total suspended solid (mg/L)	5 - 25	1	1
Uranium-Total (mg/L)	0.015	<0.001	<0.001
Zinc-Total (mg/L)	NG	<0.001	<0.001
Conductivity (µs/cm)	NG	106.4	140.2

Notes: NG = no guideline; 1 CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 2020; 2 Guideline is pH dependent; 3 Guideline is temperature dependent; 4 Guideline is hardness dependent; 5 Guideline is relative to background values; Shaded values exceed the CCME guideline.

Table 10. Chemical and physical parameters for the MDMER 7 and MDMER 8 exposure area at Mammoth Lake from 2019-2020.

Parameter	CCME (2020) Guideline[1]	2019 03-Sep	2020 26-Apr	24-May	2-Aug	2-Sep
MMT (Exposure Area)						
Alkalinity (mg $CaCO_3$/L)	NG	10	25	27	47	51
Aluminium-Total (mg/L)[2]	0.100 - 0.100	<0.005	0.006	<0.006	<0.006	<0.006
Ammonia-Total (mg/L)[2,3]	1.2 - 19	0.02	0.2	0.25	0.11	0.11
Arsenic-Total (mg/L)	0.005	0.0013	0.0015	0.0015	0.0018	<0.0005
Cadmium-Total (mg/L)[4]	0.00012 - 0.00015	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Chloride-Total (mg/L)	120	20.3	45.0	46.6	23.8	25.2
Chromium-Total (mg/L)	NG	<0.0006	0.0017	0.0008	<0.0006	<0.0006
Cobalt-Total (mg/L)	NG	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper-Total (mg/L)[4]	0.002 - 0.004	0.0020	0.0011	0.0013	0.0007	<0.0005
Cyanide-Total (mg/L)	0.005	<0.001	0.003	0.004	0.001	<0.001
Dissolved oxygen-Field (mg/L)	6.5 - 9.5	11.68	12.42	12.69	9.97	10.29
Hardness (mg $CaCO_3$/L)	NG	49	87	92	68	71
Iron-Total (mg/L)	0.3	0.06	0.02	0.04	0.05	0.04
Lead-Total (mg/L)[4]	0.002 - 0.007	<0.0003	<0.0003	<0.0003	<0.0003	<0.00017
Manganese-Total (mg/L)[2,4]	0.430 - 0.590	0.0012	0.0721	0.0610	0.0216	0.0483
Mercury-Total (mg/L)	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum-Total (mg/L)	0.073	<0.0005	0.0012	0.0014	0.0012	<0.0005
Nickel-Total (mg/L)[4]	0.065 - 0.150	0.0019	0.0033	0.0036	0.0031	0.0013
Nitrate-Total (mg N/L)	13.0	0.4	1.15	1.05	0.85	0.89
Phosphorus-Total (mg/L)	NG	0.01	<0.01	<0.01	0.01	<0.01
pH-Field	6.5 - 9.0	7.00	6.85	6.75	7.37	7.46
Radium-226 (Bq/L)	NG	<0.002	0.005	0.005	0.005	<0.002
Selenium-Total (mg/l)	0.001	0.0011	<0.001	<0.001	<0.001	<0.001
Sulphate-Total (mg/L)	NG	8.8	16.6	18.0	14.4	17.5
Temperature-Field (^{o}C)	NG	6.95	0.72	0.78	14.82	10.20
Thalium-Total (mg/L)	0.0008	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Total suspended solid (mg/L)[5]	5 - 25	1	2	<1	2	1
Uranium-Total (mg/L)	0.015	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc-Total (mg/L)	NG	<0.001	<0.001	<0.001	<0.001	<0.001
Conductivity (µs/cm)	NG	138.1	251.1	278.7	146.8	164.6

Notes: NG = no guideline; 1 CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 2020; 2 Guideline is pH dependent; 3 Guideline is temperature dependent; 4 Guideline is hardness dependent; 5 Guideline is relative to background values; Shaded values exceed the CCME guideline.

Table 11. Chemical and physical parameters for the MDMER 6, 7, and 8 reference area at Third Portage Lake South from 2019-2020.

	CCME (2020)	2019		2020			
Parameter	**Guideline[1]**	**17-Jul**	**04-Sep**	**26-Apr**	**24-May**	**02-Aug**	**02-Sep**
TPS (Reference Area)							
Alkalinity (mg $CaCO_3$/L)	NG	7	10	10	10	10	43
Aluminium-Total (mg/L)[2]	0.100 - 0.100	<0.005	<0.005	<0.006	<0.006	0.082	<0.006
Ammonia-Total (mg/L)[2,3]	6 - 19	0.02	0.01	0.01	<0.01	<0.01	0.01
Arsenic-Total (mg/L)	0.005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Cadmium-Total (mg/L)[4]	0.00004	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Chloride-Total (mg/L)	120	0.6	0.9	0.9	1.0	<0.5	0.7
Chromium-Total (mg/L)	NG	0.0008	<0.0006	0.0009	<0.0006	<0.0006	<0.0006
Cobalt-Total (mg/L)	NG	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper-Total (mg/L)[4]	0.002 - 0.004	<0.0005	<0.0005	0.0006	<0.0005	<0.0005	<0.0005
Cyanide-Total (mg/L)	0.005	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Dissolved oxygen-Field (mg/L)	6.5 - 9.5	14.15	10.22	16.76	16.04	12.16	11.78
Hardness (mg $CaCO_3$/L)	NG	6	9	13	9	<1	9
Iron-Total (mg/L)	0.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead-Total (mg/L)[4]	0.001 - 0.007	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.00017
Manganese-Total (mg/L)[2,4]	0.230 - 0.260	<0.0005	0.0012	0.0011	<0.0005	<0.0005	0.0011
Mercury-Total (mg/L)	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum-Total (mg/L)	0.073	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel-Total (mg/L)[4]	0.025 - 0.150	<0.0005	<0.0005	0.0005	<0.0005	<0.0005	<0.0005
Nitrate-Total (mg N/L)	13.0	0.01	<0.01	0.01	<0.01	<0.01	<0.01
Phosphorus-Total (mg/L)	NG	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
pH-Field	6.5 - 9.0	6.68	6.78	6.87	6.92	7.32	6.69
Radium-226 (Bq/L)	NG	<0.002	<0.002	0.011	<0.002	<0.002	<0.002
Selenium-Total (mg/l)	0.001	<0.0005	0.0005	<0.001	<0.001	<0.001	<0.001
Sulphate-Total (mg/L)	NG	2	3	5.4	5.1	<0.6	3.5
Temperature-Field (^{o}C)	NG	4	11.9	0.29	1.29	8.84	10.09
Thalium-Total (mg/L)	0.0008	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Total suspended solid (mg/L)[5]	5 - 25	1	<1	<1	<1	<1	1
Uranium-Total (mg/L)	0.015	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc-Total (mg/L)	NG	<0.001	0.002	0.002	<0.001	<0.001	<0.001
Conductivity (µs/cm)	NG	25.8	27.6	32.2	30.5	26.0	26.4

Notes: NG = no guideline; 1 CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 2020; 2 Guideline is pH dependent; 3 Guideline is temperature dependent; 4 Guideline is hardness dependent; 5 Guideline is relative to background values; Shaded values exceed the CCME guideline.

2.2 Effluent Mixing in the Receiving Environment

Effluent is discharged via two diffusers to the east half of Mammoth Lake (MDMER 7 and MDMER 8; Figure 3). Modeling using the CORMIX model indicated that, during the open water season, the effluent would be fully mixed and a dilution of 27, which equals an effluent concentration of 3.7%, will be achieved within 37 m of each diffuser at a discharge rate of 400 m^3/hr and within 59 m at the maximum discharge rate of 800 m^3/hr (Golder, 2019). Additional plume modeling suggested that two weeks after effluent discharge begins, the extent of the 1% effluent plume at bottom includes the eastern half of Mammoth Lake (Golder, 2020).

A field investigation of the Mammoth Lake effluent plume was conducted as part of the Cycle 1 EEM field investigations, using specific conductance as an effluent tracer. At multiple locations, depth, temperature, conductivity and specific conductance profiles, from lake surface to lake bottom, were collected using a SonTek Castaway©-CTD (Xylem Inc.; refer to Table 12 for specifications). Specific conductance of the effluent was determined from effluent collected at the effluent pump. The effluent was generally completely or nearly completely mixed vertically and there was no thermal stratification (see Appendix 2 for representative plots). The average specific conductance recorded for each profile was used in the calculation of effluent concentrations. The specific conductance at the profile located farthest from the diffuser was assumed to represent the background specific conductance of Mammoth Lake. Effluent concentration was calculated using the formula:

$$K_x = \frac{K_L \times (100 - x) + (K_e \times x)}{100}$$

where K_X=specific conductance of solution containing X% effluent,
K_L= base line specific conductance of Mammoth Lake, and
K_e= specific conductance of the effluent.

To solve for x, this equation is rearranged as:

$$x = \frac{(K_x - K_L)}{(K_e - K_L)} \times 100$$

The results of the plume delineation, conducted on August 25, 2020, are presented in Figure 4 as effluent concentrations (see Appendix 2 for specific conductance values). The effluent concentration within the immediate vicinity of the diffusers exceeded 12%. The effluent plume was detectable in the eastern half of Mammoth Lake, with concentrations above 8% of effluent. Effluent concentrations declined rapidly within the western half of Mammoth Lake, with the specific conductance in the far western portion of Mammoth Lake used as a baseline value. Additional specific conductance measurements were collected along the south-eastern shoreline of the Lake on August 30, 2020 (Figure 4), to confirm shoreline electrofishing was conducted within the 1% effluent plume. Shoreline concentrations typically exceeded 10% effluent. All specific conductance measurements were greater than 1% effluent, with the exception of a small shoreline area where subsurface inflow from a pond created a localized area of low specific conductance (-7.9%, i.e., below baseline specific conductance).

Table 12. Sontek Castaway-CTD specifications.

Parameter	Range	Resolution	Accuracy
Temperature	-5 to +45°C	0.01°C	±0.05°C
Conductivity	0 to 100,000 µS/cm	1 µS/cm	0.25% ±5 µS/cm
Depth	0 to 100 m	0.01 m	±0.25% FS

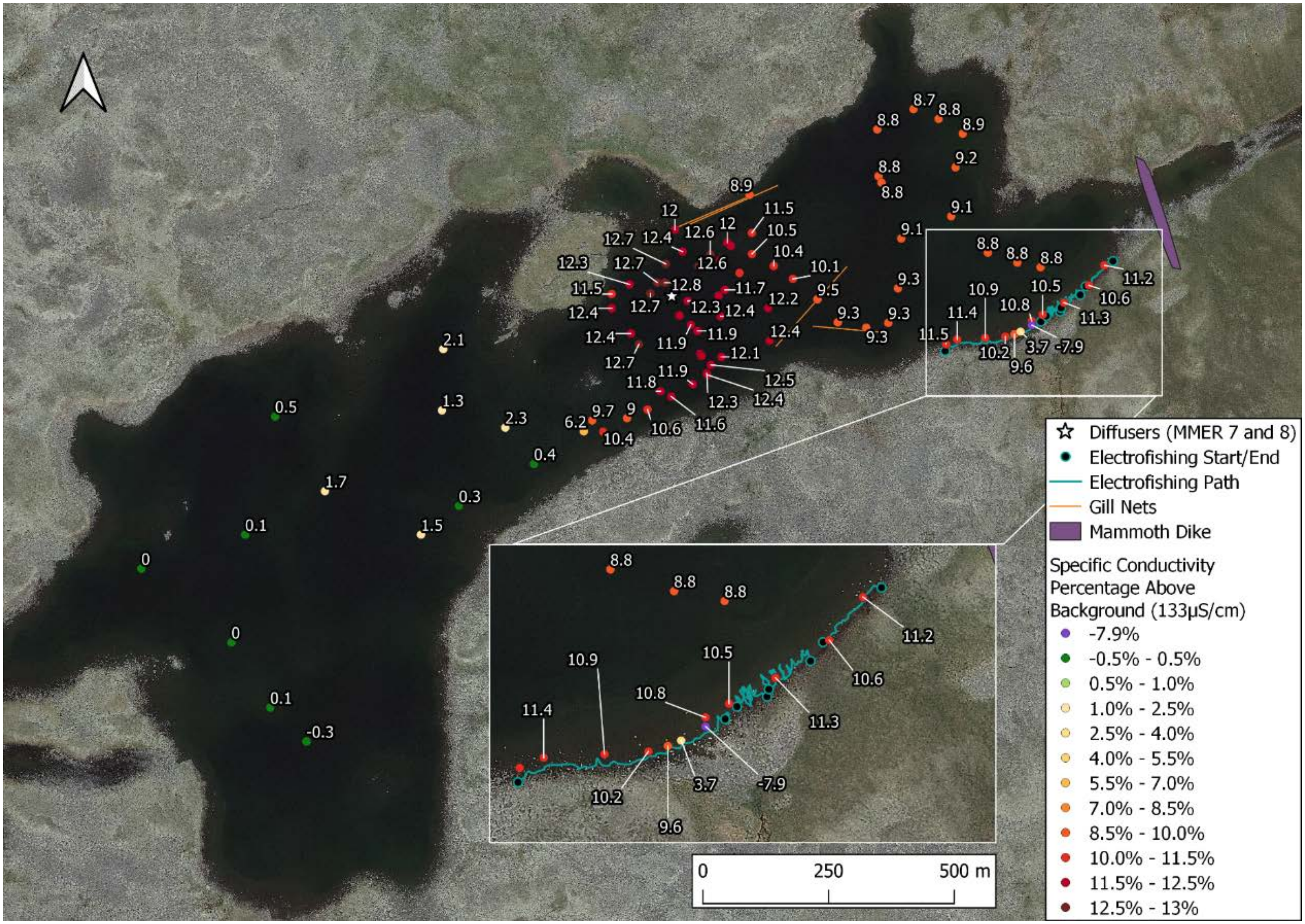

Figure 4. Effluent concentrations in Mammoth Lake on August 25, 2020 (shoreline measurements taken on August 30, 2020).

2.3 Overview of Study Design and Changes

2.3.1 Adult Lake Trout Fish Survey

The Cycle 1 revised study design (C. Portt and Associates, and Kilgour & Associates Ltd., 2020) described a lethal study of Lake Trout (*Salvelinus namaycush*) to be captured by gill netting in one exposure area (Mammoth Lake; (Figure 5) and two reference areas (Lake 8 and Lake D1; Figure 6 and Figure 7, respectively) with a target sample size of 25 fish per area. The following information was to be determined for each Lake Trout that was part of the lethal sample:

- fork length in millimetres
- total weight in grams
- liver weight in grams
- sex, gonad condition and gonad weight in grams
- mean egg weight for mature females that will spawn in the current year
- presence of internal or external deformities, lesions, tumours, or parasites
- age, determined from otoliths

ANCOVA would be used to investigate whether or not significant differences occur in the following relationships:

- total weight versus length
- liver weight versus total weight
- liver weight versus length
- length versus age
- total weight versus age
- gonad weight versus total weight, if more than 5 individuals of one sex that will spawn in the current year are collected from more than 1 site
- egg weight versus total weight, if more than 5 females that will spawn in the current year are collected from more than 1 site

Using log-transformed values, ANCOVA was used to test for significant differences ($P>0.05$) in slopes between the two reference areas. If none existed, then ANCOVA was used to test for significant differences ($P>0.1$) in intercepts between the two reference areas. In cases where the interaction term accounts for < 2% of the total variation in the response variable, the reduced model was considered appropriate and used to assess significance, as per Barrett *et al*. (2010). If there were no significant differences in either slopes or intercepts between the reference areas, the reference areas data were pooled for comparisons to the exposure area. Comparison of the exposure area (Mammoth Lake) to the reference areas, was completed using the ANCOVA steps described above for the reference site comparison. If there were significant differences between the reference areas then the exposure area and each of the reference areas were included in the ANCOVA (i.e., not pooled), then pair-wise comparisons were used to determine if there were significant differences ($P>0.1$) between the exposure area and each of the reference areas.

Residuals from each ANCOVA were examined for normality and outliers. Observations producing large Studentized residuals (i.e., > 4) were removed from the data set, and the analyses repeated and any changes in conclusions considered. This process was continued until no additional outliers are identified.

The two-sample Kolmogorov-Smirnov (K-S) test, which is recommended for comparing length-frequency distributions between areas (Environment Canada, 2012), was used to compare length, weight, and age distributions between pairs of areas.

2.3.2 Slimy Sculpin Fish Survey

The Cycle 1 revised study design report (C. Portt and Associates, and Kilgour & Associates Ltd., 2020) described a non-lethal study of Slimy Sculpin (C*ottus cognatus*) to be captured by electrofishing in one exposure area (Mammoth Lake; Figure 5) and two reference areas (Lake 8 and Lake D1; Figure 6 and Figure 7, respectively) with a target sample size of 100 fish per area. Length and weight were determined for all Slimy Sculpin captured. The first 30 individuals that were captured from each area were to be retained and provided, frozen, to the University of Waterloo for an ongoing study.

The study design also stated that the 10 largest males and 10 largest females from each study area would be lethally sampled, if they were larger than 45 mm. External sexing of individuals in the field was inconclusive, and therefore 20 individuals larger than 45 mm were targeted from each study area for lethal sampling. The following information was to be determined for each Slimy Sculpin that was part of the lethal sample:

- fork length in millimetres
- total weight in grams
- liver weight, in grams
- sex, gonad condition and gonad weight in grams
- presence of internal or external deformities, lesions, tumours, or parasites
- weight of parasites, if present
- age, as determined from otoliths

Ovaries are not well developed in late August and therefore fecundity and egg weight were not determined.

Length and weight data were compared among lakes using an ANOVA. Since the first age class was clearly defined by the length-frequency distribution, the length of fish in that age class were compared among sites using an ANOVA. Assumptions of data normality and homogeneity of variance were assessed as were the distribution of the residuals.

ANCOVA was used to investigate whether significant differences occur among lakes occur in the total weight versus length relationship. Using log-transformed values, ANCOVA was used to test for significant differences (P>0.05) in slopes between the two reference areas. If none exist, then ANCOVA was used to test for significant differences (P>0.05) in intercepts between the two reference areas. In cases where the interaction term accounts for < 2% of the total variation in the response variable, the reduced model was considered appropriate and used to assess significance, as per Barrett *et al*. (2010). If there were no significant differences in either slopes or intercepts between the reference areas, the reference areas data were pooled for comparisons to the exposure area. Comparison of the exposure area (Mammoth Lake) to the reference areas, was completed using the ANCOVA steps outlined above for the reference site comparison. If there were significant differences between the reference areas then the exposure area and each of the reference areas were included in the ANCOVA (i.e., not pooled), then pair-wise comparisons were used to determine if there were significant differences (P>0.1) between the exposure area and each of the reference areas.

Residuals from each ANCOVA were examined for normality and outliers. Observations producing large Studentized residuals (i.e., > 4) were removed from the data set, and the analyses repeated and any changes in conclusions considered. This process was continued until no additional outliers are identified.

2.3.3 Benthic Invertebrate Community Survey

The Cycle 1 EEM benthic invertebrate community study utilized one exposure area (Mammoth Lake; Figure 5) and two reference areas (Lake 8; Figure 6 and Lake D1; Figure 7) and a before-after-control-impact (BACI) design. Sample collection and processing followed the methodology used by the Core Receiving Environment Monitoring Program (CREMP), which allowed the extensive data collected for that program, including data collected for Mammoth Lake prior to it becoming an exposure area, to be used in the statistical analyses. Within each exposure and reference area were five sampling stations, where two sub-samples of the benthic community were collected and composited. However, at the request of Environment Canada, the two grabs composited from one station in Mammoth Lake were processed separately and those data were used to assess if composites of 2 subsamples per benthic station properly characterize each station. Locations and water depths in the two reference areas, and depth in the exposure area, were targeted to be 7 to 8 m, with sampling stations minimally 20 m apart to ensure a minimum of statistical independence among stations.

Indices of benthic community composition were computed for each sample; total abundance, taxa richness, and Simpson’s Evenness (Equitability) were calculated, per the Guidance Document (Environment Canada, 2012). Bray-Curtis distances were computed and non-metric multidimensional scaling (NMDS) were used to ordinate the benthic community data.

To determine if variation in benthic community structure is potentially associated with mine effluent, a combination of graphical and hypothesis testing procedures were used. Analysis of variance (ANOVA) was used to test multiple hypotheses with respect to differences in density and compositional indices between the reference areas and the exposure area. Prior to ‘running’ ANOVA’s, the associations between benthos and potential modifying factors (e.g., water depth, substrate texture, sediment TOC) were examined. If variations in benthic community composition were influenced by a modifying factor, benthos indices were standardized using general linear models based on reference data, with application of the models to exposure data. Effect sizes were calculated, where appropriate. The number of replicates required to achieve a precision of 0.2 was also estimated.

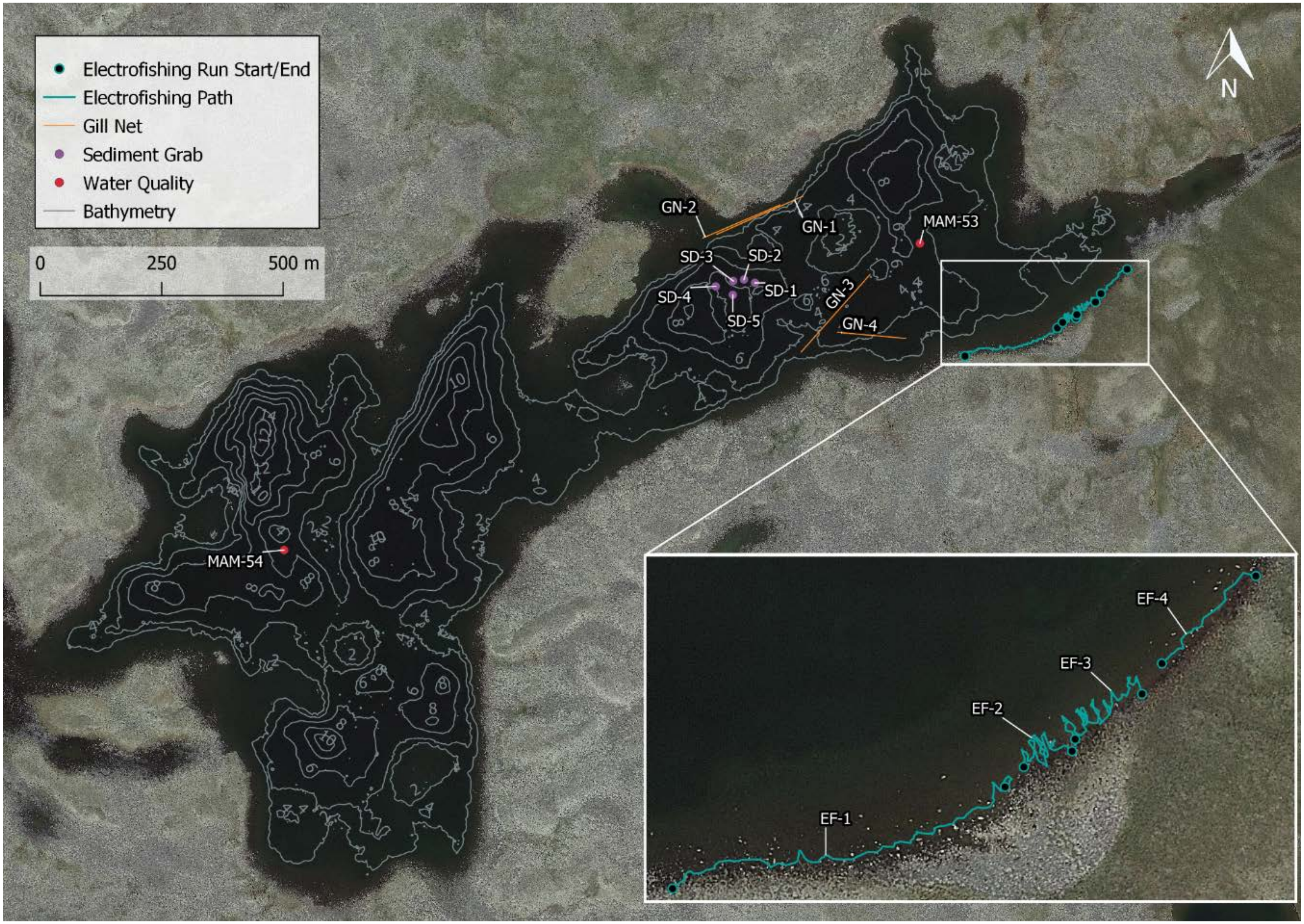

Figure 5. Mammoth Lake exposure area (MAM).

Figure 6. Lake 8 reference area.

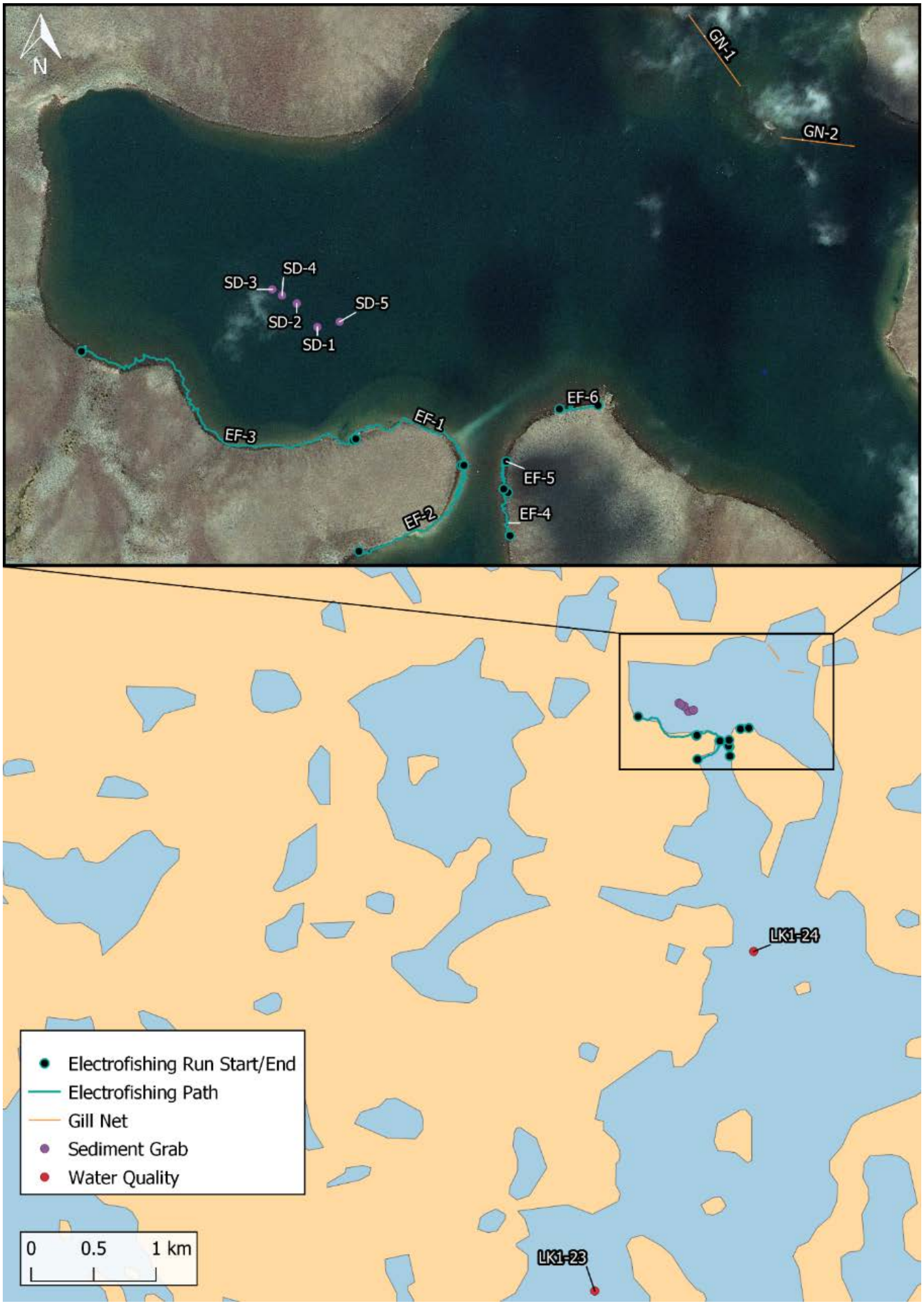

Figure 7. Lake D1 reference area.

3.0 ADULT LAKE TROUT FISH SURVEY

3.1 Introduction

The adult Lake Trout fish survey was completed during the period August 18 – 26, 2020. There were no major deviations from the proposed study design.

3.2 Materials and Methods

3.2.1 Field Work

3.2.1.1 Fish Collections and Measurements

Lake Trout were collected in the exposure area (MAM) in Mammoth Lake from August 18 to August 19, and from August 25 to August 26, from the reference area in Lake 8 from August 23 to August 24, and from the reference area in Lake D1 from August 18 to 19, 2020. Index gill nets comprised of six panels of stretched mesh (sizes 126, 102, 76, 51, 38, and 25 mm) were the only means of fish capture for this study. Each panel of gill net was 1.8 m (6 feet) deep by 22.7 m (25 yards) long, so that the length of a six-panel gang was 136.4 m (150 yards). Gill nets were set within each sampling area, with the specific locations determined based on local habitat conditions and winds. During previous EEM studies at the nearby Meadowbank mine, shallow nearshore or shoal areas yielded the greatest number of Lake Trout and those areas were targeted in this study.

Most Lake Trout were collected using overnight gill net sets. The initial gill net set was overnight in Mammoth Lake, but in order to minimize unnecessary Lake Trout mortality and mortality of non-target species, shorter-duration daytime sets were used to collect the additional Lake Trout required to reach the target sample size of 25. The date and time of gill net deployments and lifts were recorded. The UTM coordinates of each end of each net were determined using a Garmin model GPSmap 76CSx, and the depth, temperature, and specific conductance were determined using a CastAway-CTD® (Xylem Inc.).

The number of individuals of each species captured that were dead, or killed and retained in the case of Lake Trout, and the number that were alive and released was recorded for each net set. All dead Lake Trout were retained and Lake Trout captured alive were euthanized and retained until it was clear that the target sample size of 25 fish would be acquired for each lake. Once the target sample size was reached, or it was apparent that it would be, Lake Trout that were alive were released. Dead Lake Trout were taken to the laboratory at the mine site for processing. Each fish was examined externally and any lesions or other anomalies that were not consistent with gillnet capture were recorded. Fork length was determined to the nearest mm using a standard fish measuring board. The weight of each fish weighing less than 200 grams was determined to the nearest 0.01 gram using an Ohaus Scout Pro Model SP202 electronic balance. Fish weighing between 200 and 6,000 grams were weighed to the nearest gram using an Ohaus Scout Pro Model SP6001 electronic balance. Fish weighing more than 6,000 grams were weighed to the nearest 10 grams using a Rapala digital hanging scale.

The body cavity of each fish was opened and the viscera were examined for any anomalies or parasites. The gonads were examined to determine the sex, maturity, and gonad condition of the specimen. Females with opaque ovaries containing developing eggs visible with the naked eye were considered to be sexually mature. Females with translucent ovaries that did not contain eggs which were visible to the naked eye were considered to be immature. Mature females with opaque ovaries, and in some cases atretic eggs from the previous spawning season, but which did not appear to be developing eggs to spawn in the fall of 2020 are referred to as resting females. Mature females with large eggs that appeared to be ready to spawn in the current year were termed ripe females. Males with opaque testes were considered to be mature, and males with small translucent testes were considered to be immature.

The liver and gonads were removed and weighed to the nearest 0.01 g using an Ohaus Scout Pro Model SP202 electronic balance or, if they weighed more than 200 grams, to the nearest 0.1 g using an Ohaus Scout Pro Model SP6001 electronic balance. A sample of eggs was taken from each ripe female and weighed to the nearest 0.01 g using an Ohaus Scout Pro Model SP202 electronic balance. The eggs in each sample were counted twice. If the counts differed, the eggs were recounted until two identical counts occurred. Egg weight was determined by dividing the weight of the egg sample by the number of eggs. Fecundity was estimated by dividing the ovary weight by egg weight.

3.2.1.2 Supporting Environmental Variables

Depth (m), Specific conductivity (µS/cm), and temperature (°C) profiles were collected from lake surface to lake bottom at sub-0.5 metre intervals using a SonTek CastAway-CTD® (Xylem Inc.). Collection occurred at each end of a gill net, either during net set or net lift. Parameter resolution and accuracy are provided in Table 12.

3.2.2 Age Determination

Aging of fish was completed by Louise Stanley, a fish aging expert who provides consulting services. Otoliths were mounted whole on a glass slide with CrystalBond thermoplastic adhesive. Otoliths which could not be aged whole were ground to the core on one side, flipped to adhere the core area to the glass, and then ground to a thin section on the other side. Age was estimated based on the number of annuli counted using transmitted light and a Leica GZ6 Stereo Zoom microscope. Age was independently estimated by C. Portt from otoliths from 10 randomly selected fish.

3.2.3 Lake Trout Data Analysis

Data for individual fish were entered into an Excel spreadsheet, and the entered values were compared with the original data sheets. Data entry errors were corrected.

Condition (K) was calculated using the formula:

$$K = \frac{total\ weight}{fork\ length^3} \times 100{,}000.$$

Gonado-somatic index (GSI) was calculated using the formula:

$$GSI = \frac{gonad\ weight}{total\ weight} \times 100.$$

Hepato-somatic index (HSI) was calculated using the formula:

$$HSI = \frac{liver\ weight}{total\ weight} \times 100.$$

Box plots or scatterplots of the data were examined. Aberrant values were compared to the original data sheets to ensure they were not data entry errors. Statistical analyses were carried out using R version 3.6.2 (R Core Team, 2021). Summary statistics (sample size, mean, median, minimum, maximum, standard deviation, standard error) were generated for length, weight, condition, HSI and GSI for all Lake Trout pooled by lake, and for Lake Trout separated by maturity, sex, and lake. Analyses were conducted on pooled Lake Trout data (i.e., sex and maturity combined).

A summary of statistical analyses conducted to compare fish populations between the exposure and reference areas is provided in Table 13. Age distributions and length distributions were analyzed using the two-sample Kolmogorov-Smirnov test of raw data to compare each pair of sites. Analysis of covariance (ANCOVA) was performed on log-transformed data. An ANCOVA comparing reference areas was completed first. If there were no significant differences in either slopes or intercepts ($P \leq 0.05$) between the reference areas, the reference areas data were pooled for comparisons to the exposure area. If there were significant differences between the reference areas then the exposure area and each of the reference areas were included in the ANCOVA. A complete ANCOVA model, which includes the interaction term (Lake area x independent variable), was run first, followed by the reduced model, which excludes the interaction term. Significant interactions can be difficult to interpret, and complicate the computation of effect size. In cases where there were differences in slopes ($P \leq 0.05$) but the interaction term accounted for < 2% of the total variation in the response variable the reduced model was considered to be appropriate and was used to assess significance and effect sizes, as per Barrett *et al*. (2010). Residuals from each ANCOVA were examined for normality and outliers. Observations producing large Studentized residuals (i.e., > 4) were removed from the data set, and the analyses were repeated and variations in conclusions considered. Differences in intercepts were considered significant at the 10% level (i.e., $P \leq 0.10$).

The percent difference in least-square means between Mammoth Lake and each of the two reference lakes was calculated as:

$$\%\,Difference = \frac{\bar{x}_{exposure} - \bar{x}_{reference}}{\bar{x}_{reference}}$$

When log transformed data were analyzed, the least-mean square values used were antilogs of the calculated values.

Table 13. Statistical analyses conducted to compare fish populations between the Exposure and Reference Areas

Dependent variable	Independent variable	Statistical technique
Body weight	Length	ANCOVA
Liver weight	Body weight, length	ANCOVA
Length	Age	ANCOVA
Body weight	Age	ANCOVA
Gonad weight (male)	Body weight	ANCOVA
Length Distribution		Kolmogorov-Smirnov
Age Distribution		Kolmogorov-Smirnov

3.2.4 Power Analysis

Power analysis was used to determine, *a posteriori*, the probability of detecting a 10% (weight versus length) or 25% (length versus age, weight versus age, liver weight) increase in the parameters of interest, assuming a 10% probability of committing a Type I error, and given the sample sizes, mean values, and the unexplained variability (i.e. the population standard deviation) from this study. Power was calculated by re-arranging the following power equation (Green, 1989):

$$n = \frac{1.5(t_\alpha + t_\beta)^2 \sigma^2}{\delta^2}$$

where:

- n is the number of fish,
- σ is the population standard deviation,
- δ is the specified effect size,
- t_α is the Students t statistic for a two-tailed test with significance level α,
- t_β is the Students t statistic for a one-tailed test with significance level β.

3.3 Results

3.3.1 Physico-Chemical Character of Capture Areas

The locations of the sampling areas are shown in Figure 2, and the locations of individual nets are shown for each Area in Figure 5, Figure 6, and Figure 7. The range of temperature and specific conductance at each end of gill nets, collected either when the nets were set or lifted, are provided in Table 14 for Lake 8 and Mammoth Lake. Profiles were not taken at Lake D1 due to weather conditions. The lakes were essentially isothermal at the time of the fish collections and there was no indication of chemical stratification, although there were small differences in specific conductance with depth in Mammoth Lake, indicating that the effluent concentration was not completely homogenous from the surface to the bottom. The general limnology and water chemistry of the sampling areas are provided in Section 5.0 of this report.

Table 14. Minimum and maximum temperature and specific conductance measurements for gill net sets collected at either net set or net lifts.

Lake	Set	Location	Depth (m)	Temperature (°C)		Specific Conductance (µS/cm)	
				Min.	Max.	Min.	Max.
Lake 8	GN-1	Start	1.8	11.83	11.85	8.84	8.84
		End	3.3	11.78	11.98	8.84	8.91
	GN-2	Start	1.2	12.10	12.11	8.92	8.93
		End	1.6	12.09	12.10	8.87	8.89
Lake D1†	GN-1	Start	1.2	NA	NA	NA	NA
		End	1.6	NA	NA	NA	NA
	GN-2	Start	1.6	NA	NA	NA	NA
		End	4.1	NA	NA	NA	NA
Mammoth	GN-1	Start	1.5	12.64	12.66	116.13	116.17
		End	4.5	12.26	12.30	110.41	112.22
	GN-2	Start	1.5	10.11	10.15	116.30	117.39
		End	1.7	10.69	10.75	112.41	112.67
	GN-3	Start	3.6	10.70	10.83	115.63	117.16
		End	5.7	11.03	11.10	114.61	114.85
	GN-4	Start	3.4	11.39	11.43	116.17	116.47
		End	4.4	11.35	11.37	116.43	116.70

† Due to inclement weather during net lifts, temperature and specific conductance profile measurements could not be collected.

3.3.2 Sampling Effort and Catches

3.3.2.1 Gill Net Catches

Gill nets were set overnight at two locations in Lake 8 and in Lake D1 (Figure 5, Figure 6). One overnight net set and three daytime sets were conducted in Mammoth Lake (Figure 7). The mean soak time was 18.1 hours in Lake 8, 16.6 hours in Lake D1, and 8.7 hours in Mammoth Lake. The locations, depths and set and lift dates and times for each gill net set are provided in Appendix 3.

The gill net catches are summarized in Table 15. Lake Trout were the most abundant species in the catches in all three lakes with a total of 90 captured. Round Whitefish (*Prosopium cylindraceum*) were captured in Lake D1 and Mammoth Lake, and Arctic Char (*Salvelinus alpinus*) were captured in all three lakes. A single Slimy Sculpin (*Cottus cognatus*) was captured in Lake D1. Lake Trout CPUE in overnight sets was highest in Mammoth Lake and lowest in Lake D1 (Table 16). Daytime Lake Trout CPUE in Mammoth Lake was much lower than the overnight CPUE.

Table 15. Numbers of fish that were released alive or were dead in gill net catches, by lake and species.

Lake	Lake Trout		Arctic Char		Round Whitefish		Slimy Sculpin	
	Alive	Dead	Alive	Dead	Alive	Dead	Alive	Dead
Lake 8	6	32	1	1	0	0	0	0
Lake D1	0	27	0	23	0	17	0	1
Mammoth	0	25	1	1	14	4	0	0
Total	**6**	**84**	**2**	**25**	**14**	**21**	**0**	**1**

Table 16. Mean catch-per-unit-effort (CPUE; number of Lake Trout captured per hour of soak time) for daytime and overnight gill net sets, by lake.

Set Type	CPUE (fish/hr net set)		
	Lake 8	Lake D1	Mammoth
Daytime	-	-	0.24
Overnight	1.05	0.82	1.39
Total	**1.05**	**0.82**	**0.72**

3.3.3 Lake Trout Characteristics

3.3.3.1 Overview

The numbers of Lake Trout processed by lake, sex, and maturity are presented in Table 17. The target sample size of 25 individuals per lake was achieved, with 32 Lake Trout from Lake 8, 27 Lake Trout from Lake D1, and 25 Lake Trout from Mammoth Lake processed. The data for each specimen are provided in Appendix 4. Individuals that were too small for their sex to be determined accounted for between 12% (Mammoth Lake) and 26% (Lake D1) of the catch at each site. Of the individuals for which sex could be determined, the proportion of the female Lake Trout that were mature ranged from 0.14 in Lake 8 to 0.41 in Mammoth Lake. The proportion of males that were mature ranged from 0.64 in Lake 8 to 0.80 in Mammoth.

Table 17. Number of Lake Trout examined from each waterbody, by sex and maturity.

Waterbody	Sex	Maturity		Total
		Immature	Mature	
Lake 8	Female	12	2	14
	Male	4	7	11
	Unknown	7	-	7
	Total	23	9	32
Lake D1	Female	7	4	11
	Male	3	6	9
	Unknown	7	-	7
	Total	17	10	27
Mammoth	Female	10	7	17
	Male	1	4	5
	Unknown	3	-	3
	Total	14	11	25
Total		**54**	**30**	**84**

Based on the stage of egg development, five (5) of the 13 mature females (38%) were ripe and would have spawned in the current year (Table 18). All 17 of the mature males captured appeared to have developing testes in preparation for spawning in the current year (Table 18). The numbers of mature females that were developing gonads in preparation to spawn in the current year were too low to permit meaningful comparisons of gonad weights among lakes. However, since more than 5 mature males from at least two lakes were developing gonads in preparation to spawn in the current year, a comparison of testes weight among lakes was investigated.

Table 18. Number of mature individuals that were developing gonads to spawn in the current year (ripe) and that were not sufficiently developed to spawn in the current year (resting).

Waterbody	Female		Male	
	Resting	Ripe	Resting	Ripe
Lake 8	0	2	0	7
Lake D1	4	0	0	6
Mammoth	4	3	0	4
Total	**8**	**5**	**0**	**17**

Summary statistics (sample size, mean, median, minimum, maximum, standard deviation, standard error) were generated for length, weight, condition, HSI and GSI for all Lake Trout processed, by lake (Table 19), and for Lake Trout separated by maturity and sex, by lake (Table 20).

Table 19. Lake Trout summary statistics by lake.

Variable	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
Fork Length (mm)	Lake 8	32	150	660	413	457	124.2	22.0
	Lake D1	27	169	876	490	425	240.3	46.2
	Mammoth	25	176	855	474	408	212.9	42.6
Weight (g)	Lake 8	32	32.97	3263	904	1025	654.5	115.7
	Lake D1	27	48.74	9530	2446	865	2985.8	574.6
	Mammoth	25	64.40	6750	2043	648	2280.8	456.2
Condition	Lake 8	32	0.80	1.24	1.03	1.02	0.099	0.017
	Lake D1	27	0.87	1.53	1.11	1.10	0.157	0.030
	Mammoth	25	0.93	1.61	1.18	1.17	0.131	0.026
Gonad Weight (g)	Lake 8	29	0.02	156.87	20.08	5.59	36.28	6.74
	Lake D1	27	0.03	350	49.87	1.42	91.16	17.54
	Mammoth	23	0.03	454	72.18	9.08	127.51	26.59
GSI	Lake 8	29	0.02	11.27	1.64	0.51	2.824	0.524
	Lake D1	27	0.03	3.94	1.01	0.29	1.184	0.228
	Mammoth	23	0.02	11.58	2.32	0.91	3.494	0.729
Liver Weight (g)	Lake 8	32	0.30	26.78	7.73	7.42	5.753	1.017
	Lake D1	27	0.49	108.19	24.43	7.42	30.139	5.800
	Mammoth	25	0.56	67.46	20.15	8.53	23.172	4.634
LSI	Lake 8	32	0.57	1.25	0.87	0.90	0.190	0.034
	Lake D1	27	0.70	1.49	0.99	0.92	0.223	0.043
	Mammoth	25	0.64	1.48	0.98	0.93	0.245	0.049
Otolith Age (years)	Lake 8	32	4	43	17	14	10.0	1.8
	Lake D1	27	5	50	21	19	12.3	2.4
	Mammoth	25	3	42	21	21	12.9	2.6

Table 20. Lake Trout summary statistics by maturity, sex, and lake.

Variable	Maturity	Sex	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
Fork Length (mm)	Immature	Female	Lake 8	12	286	522	413	453	90.0	26.0
			Lake D1	7	247	638	404	367	152.8	57.7
			Mammoth	10	265	600	373	343	118.8	37.6
		Male	Lake 8	4	458	614	531	525	71.9	35.9
			Lake D1	3	375	486	432	435	55.6	32.1
			Mammoth	1	494	494	494	494	-	-
		Unknown	Lake 8	7	150	364	248	212	83.4	31.5
			Lake D1	7	169	458	255	226	104.6	39.5
			Mammoth	3	176	232	208	217	29.0	16.7
	Mature	Female	Lake 8	2	473	498	486	486	17.7	12.5
			Lake D1	4	792	853	828	833	25.7	12.8
			Mammoth	7	356	855	687	705	160.3	60.6
		Male	Lake 8	7	430	660	489	462	77.7	29.3
			Lake D1	6	422	876	667	725	197.9	80.8
			Mammoth	4	341	807	546	518	225.8	112.9
Weight (g)	Immature	Female	Lake 8	12	236	1290	800	972	435.2	125.6
			Lake D1	7	160.12	3171	979	477	1127.0	426.0
			Mammoth	10	197	2468	741	495	719.6	227.6
		Male	Lake 8	4	997	1862	1366	1303	383.5	191.8
			Lake D1	3	613	1051	844	867	219.9	127.0
			Mammoth	1	1219	1219	1219	1219	-	-
		Unknown	Lake 8	7	32.97	523	213	96.33	209.9	79.3
			Lake D1	7	48.74	895	249	140.33	304.6	115.1
			Mammoth	3	64.40	141	108	119.6	39.5	22.8
	Mature	Female	Lake 8	2	1165	1392	1279	1278.5	160.5	113.5
			Lake D1	4	5400	7890	6448	6250	1176.7	588.4
			Mammoth	7	588	6750	4420	4110	2043.9	772.5

Variable	Maturity	Sex	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
		Male	Lake 8	7	891	3263	1400	1132	830.2	313.8
			Lake D1	6	807	9530	4856	5090.5	3575.5	1459.7
			Mammoth	4	543	6570	2797	2037	2854.7	1427.3
Condition	Immature	Female	Lake 8	12	0.90	1.13	1.01	1.01	0.060	0.017
			Lake D1	7	0.87	1.22	1.04	1.06	0.136	0.052
			Mammoth	10	0.93	1.26	1.13	1.15	0.104	0.033
		Male	Lake 8	4	0.80	1.04	0.91	0.91	0.123	0.062
			Lake D1	3	0.92	1.16	1.04	1.05	0.124	0.071
			Mammoth	1	1.01	1.01	1.01	1.01	-	-
		Unknown	Lake 8	7	0.94	1.13	1.03	1.02	0.071	0.027
			Lake D1	7	0.93	1.22	1.06	1.07	0.090	0.034
			Mammoth	3	1.13	1.18	1.16	1.17	0.027	0.016
	Mature	Female	Lake 8	2	1.10	1.13	1.11	1.11	0.019	0.013
			Lake D1	4	0.94	1.27	1.13	1.16	0.140	0.070
			Mammoth	7	1.08	1.61	1.24	1.17	0.178	0.067
		Male	Lake 8	7	0.97	1.24	1.12	1.14	0.097	0.037
			Lake D1	6	1.07	1.53	1.27	1.25	0.183	0.075
			Mammoth	4	1.19	1.37	1.25	1.22	0.082	0.041
Gonad Weight (g)	Immature	Female	Lake 8	12	0.41	26.45	6.24	3.56	7.827	2.260
			Lake D1	7	0.28	22.76	7.06	1.39	8.913	3.369
			Mammoth	10	0.10	9.08	2.04	0.56	3.251	1.028
		Male	Lake 8	4	0.87	3.40	2.20	2.27	1.212	0.606
			Lake D1	3	1.29	1.42	1.35	1.34	0.066	0.038
			Mammoth	1	1.42	1.42	1.42	1.42	-	-
		Unknown	Lake 8	4	0.02	0.25	0.15	0.16	0.101	0.051
			Lake D1	7	0.03	0.52	0.16	0.06	0.180	0.068
			Mammoth	1	0.03	0.03	0.03	0.03	-	-
	Mature	Female	Lake 8	2	125.13	156.87	141.00	141.00	22.444	15.870
			Lake D1	4	65.59	104.46	79.64	74.26	17.211	8.605

Variable	Maturity	Sex	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
			Mammoth	7	51.78	454	185.20	101.49	173.885	65.722
		Male	Lake 8	7	21.84	43.53	30.86	31.79	8.722	3.297
			Lake D1	6	17.68	350	162.25	141.00	140.133	57.209
			Mammoth	4	17.53	220	85.49	52.22	94.288	47.144
GSI	Immature	Female	Lake 8	12	0.10	2.06	0.58	0.40	0.575	0.166
			Lake D1	7	0.17	1.35	0.53	0.29	0.447	0.169
			Mammoth	10	0.05	1.08	0.24	0.07	0.357	0.113
		Male	Lake 8	4	0.09	0.27	0.16	0.14	0.082	0.041
			Lake D1	3	0.13	0.23	0.17	0.15	0.055	0.032
			Mammoth	1	0.12	0.12	0.12	0.12	-	-
		Unknown	Lake 8	4	0.02	0.06	0.04	0.04	0.018	0.009
			Lake D1	7	0.03	0.19	0.08	0.05	0.056	0.021
			Mammoth	1	0.02	0.02	0.02	0.02	-	-
	Mature	Female	Lake 8	2	10.74	11.27	11.01	11.01	0.374	0.264
			Lake D1	4	0.98	1.51	1.25	1.25	0.225	0.112
			Mammoth	7	0.91	11.58	5.48	2.61	4.841	1.830
		Male	Lake 8	7	0.99	3.84	2.55	2.52	0.983	0.371
			Lake D1	6	2.04	3.94	2.93	2.81	0.757	0.309
			Mammoth	4	2.37	3.62	3.14	3.29	0.538	0.269
Egg Weight (g)	Mature	Female	Lake 8	2	0.093	0.101	0.097	0.097	0.0059	0.0041
			Lake D1	0	-	-	-	-	-	-
			Mammoth	3	0.087	0.119	0.106	0.113	0.0169	0.0098
Fecundity (# of eggs/female)	Mature	Female	Lake 8	2	1236	1688	1462	1462	319.5	225.9
			Lake D1	0	-	-	-	-	-	-
			Mammoth	3	503	5223	3130	3664	2404.8	1388.4
Liver Weight (g)	Immature	Female	Lake 8	12	1.73	14.52	7.08	6.45	4.488	1.295
			Lake D1	7	1.39	47.22	12.28	3.77	17.083	6.457
			Mammoth	10	1.83	30.29	7.44	3.89	8.632	2.730
		Male	Lake 8	4	5.82	13.08	9.72	9.99	3.111	1.556

Variable	Maturity	Sex	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
			Lake D1	3	7.01	8.70	8.01	8.33	0.888	0.513
			Mammoth	1	8.88	8.88	8.88	8.88	-	-
		Unknown	Lake 8	7	0.30	3.90	1.61	1.06	1.302	0.492
			Lake D1	7	0.49	7.90	2.20	1.16	2.611	0.987
			Mammoth	3	0.56	1.47	1.03	1.06	0.456	0.263
	Mature	Female	Lake 8	2	13.23	14.52	13.88	13.88	0.912	0.645
			Lake D1	4	55.43	74.50	61.34	57.72	8.895	4.447
			Mammoth	7	8.53	67.46	46.11	51.47	19.830	7.495
		Male	Lake 8	7	7.29	26.78	12.09	9.42	6.740	2.547
			Lake D1	6	7.10	108.19	48.15	49.87	38.628	15.770
			Mammoth	4	4.08	62.84	23.68	13.90	27.397	13.699
LSI	Immature	Female	Lake 8	12	0.63	1.13	0.87	0.88	0.181	0.052
			Lake D1	7	0.79	1.49	1.04	0.89	0.272	0.103
			Mammoth	10	0.64	1.29	0.99	0.98	0.203	0.064
		Male	Lake 8	4	0.58	1.14	0.73	0.60	0.275	0.137
			Lake D1	3	0.81	1.36	1.00	0.83	0.312	0.180
			Mammoth	1	0.73	0.73	0.73	0.73	-	-
		Unknown	Lake 8	7	0.57	1.10	0.89	0.91	0.186	0.070
			Lake D1	7	0.70	1.41	0.99	1.00	0.228	0.086
			Mammoth	3	0.87	1.04	0.93	0.89	0.095	0.055
	Mature	Female	Lake 8	2	0.95	1.25	1.10	1.10	0.209	0.148
			Lake D1	4	0.72	1.38	0.99	0.92	0.286	0.143
			Mammoth	7	0.76	1.48	1.13	1.18	0.320	0.121
		Male	Lake 8	7	0.64	1.06	0.88	0.89	0.131	0.049
			Lake D1	6	0.82	1.14	0.95	0.93	0.113	0.046
			Mammoth	4	0.65	1.00	0.81	0.80	0.192	0.096
Otolith Age (years)	Immature	Female	Lake 8	12	8	39	16	14	9.0	2.6
			Lake D1	7	9	33	18	14	9.4	3.6
			Mammoth	10	7	26	15	13	7.5	2.4

Variable	Maturity	Sex	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
		Male	Lake 8	4	19	39	28	27	8.3	4.2
			Lake D1	3	10	22	15	13	6.2	3.6
			Mammoth	1	22	22	22	22	-	-
		Unknown	Lake 8	7	4	11	7	6	2.6	1.0
			Lake D1	7	5	13	10	9	2.7	1.0
			Mammoth	3	3	6	5	5	1.5	0.9
	Mature	Female	Lake 8	2	19	22	21	21	2.1	1.5
			Lake D1	4	36	50	40	36	7.0	3.5
			Mammoth	7	14	42	35	40	9.7	3.7
		Male	Lake 8	7	13	43	21	15	10.9	4.1
			Lake D1	6	20	37	29	30	7.1	2.9
			Mammoth	4	12	33	24	26	9.5	4.7

3.3.3.2 Ageing QA/QC

The differences between the ages estimated by the primary aging expert (L. Stanley) and those estimated by C Portt are provided in Table 21. The resulting otolith ages were identical for 5 of the 10 fish that were checked. The QA/QC ages were one less than assigned by the primary aging expert for 2 of the 10 fish. The remaining fish ages differed by +2, +3, and -5 years.

Table 21. Magnitude of differences between age estimations by two different investigators (original-QA/QC age).

Fish #	Otolith age (years)		
	Original Reading	QA/QC Reading	Difference
6	37	32	-5
7	22	22	0
19	5	5	0
23	36	35	-1
27	13	15	2
34	33	33	0
60	23	23	0
65	9	12	3
83	40	39	-1
84	14	14	0

3.3.3.3 Lesions, Deformities and Parasites

No lesions were observed that were not consistent with having occurred while the fish was entangled in a gill net. Encysted cestodes were observed on the stomachs of 5 (16%) of the Lake Trout from Lake 8, 14 (52%) of the Lake Trout from Lake D1 and 3 (12%) of the Lake Trout from Mammoth Lake.

3.3.3.4 Stomach Contents

The stomachs of 62 (74%) of the Lake Trout examined were empty. Seven Lake Trout stomachs contained fish remains, included two containing two Slimy Sculpin, two containing Round Whitefish, two containing Lake Trout, and one containing unidentified fish remains. The remaining stomachs contained aquatic insects and/or zooplankton which were also present in one of the stomachs that contained fish.

3.3.3.5 Among lake comparisons

The results of comparisons between reference lakes, using ANCOVA, to determine if reference data could be pooled is summarized in Table 22. No data were excluded from the analyses.

The results of among-lake comparisons, using ANCOVA, are summarized in Table 23 and the results of each analysis are discussed in the sub-sections below. Least square (LS) mean estimates were determined for each model, and percent differences between each reference area and the exposure area were calculated (Table 24). All models with significant results for non-parallel regression slopes (i.e., interaction term is significant) had coefficients of determination (r^2) that differed by more than 0.02, suggesting that the reduced model was not an appropriate approximation of the relationship. For these comparisons, LS mean estimates were calculated for the lowest common minimum and highest common maximum value of the independent variable (Table 24). The results of pairwise comparisons are provided in Table 25 and Table 26.

Condition

Fish weight is plotted against fork length in Figure 8. There is no significant difference in the slopes of the log of weight versus log of fork length relationship among lakes (p = 0.28), however there is a significant difference in the intercepts (p = 0.0004). When adjusted for length, Lake Trout from Mammoth Lake are heavier than Lake Trout from Lake 8 (+13.4%) and from Lake D1 (+6.6%). Pairwise comparisons indicate that there is a significant difference in the intercepts between the two reference lakes (p = 0.0961) and between Mammoth Lake and Lake 8 (p = 0.0002) but not between Mammoth Lake and Lake D1 (p = 0.1125).

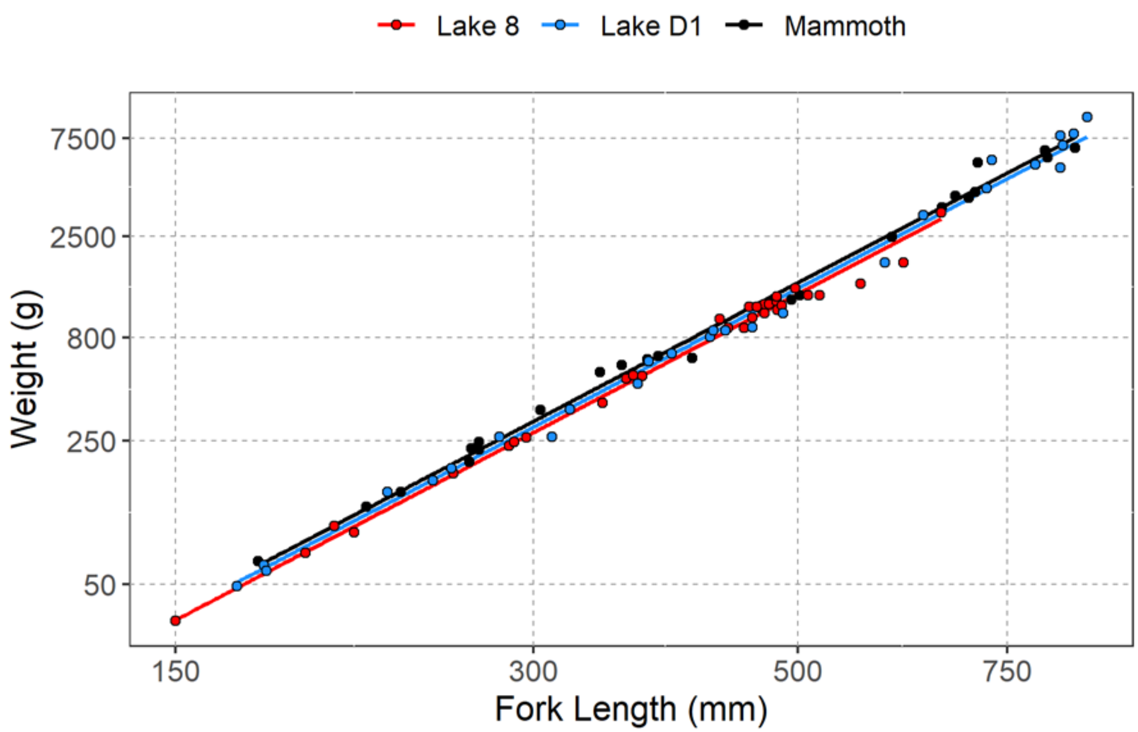

Figure 8. Plot of total weight versus fork length (log scales).

Liver weight

A plot of liver weight versus body weight is presented in Figure 9. There is no significant difference in the slopes of the log of liver weight versus log of body weight relationship among lakes (p = 0.67), however there is a significant difference in the intercepts (p = 0.0521). When adjusted for body weight, the liver weight of Lake Trout from Mammoth Lake is greater than the liver weight Lake Trout from Lake 8 (+12.8%), but slightly less than the liver weight of Lake Trout from Lake D1 (-1.5%). Pairwise comparisons indicate that there is a significant difference in the intercepts between the two reference lakes (p = 0.0696) but not between Mammoth Lake and Lake 8 (p = 0.1313) or between Mammoth Lake and Lake D1 (p = 0.9691).

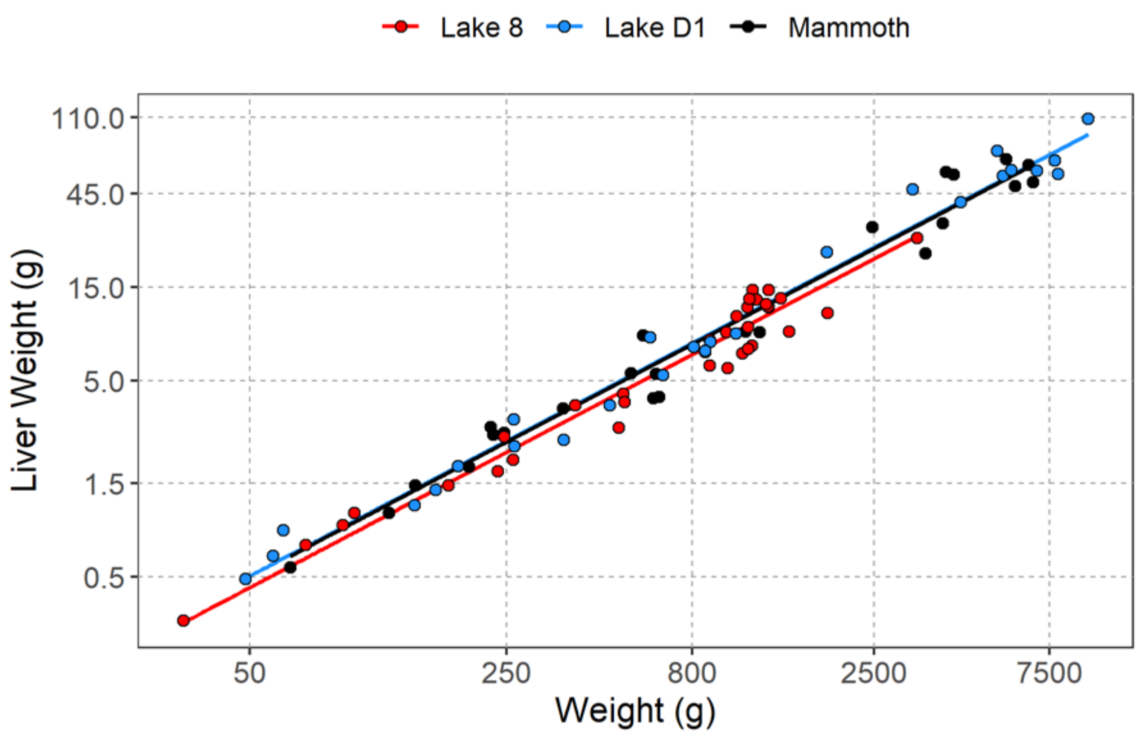

Figure 9. Plot of liver weight versus weight (log scales).

A plot of liver weight versus fork length is presented in Figure 10. There is no significant difference in the slopes of the log of liver weight versus log of fork length relationship among lakes (p = 0.42), however there is a significant difference in the intercepts (p = 0.0025). When adjusted for fork length, the liver weight of Lake Trout from Mammoth Lake is greater than the liver weight of Lake Trout fish from Lake 8 (+27.9%) and of Lake Trout from Lake D1 (+4.9%). Pairwise comparisons indicate that there is a significant difference in the intercepts between the two reference lakes (p = 0.0212) and between Mammoth Lake and Lake 8 (p = 0.0039) but not between Mammoth Lake and Lake D1 (p = 0.8091).

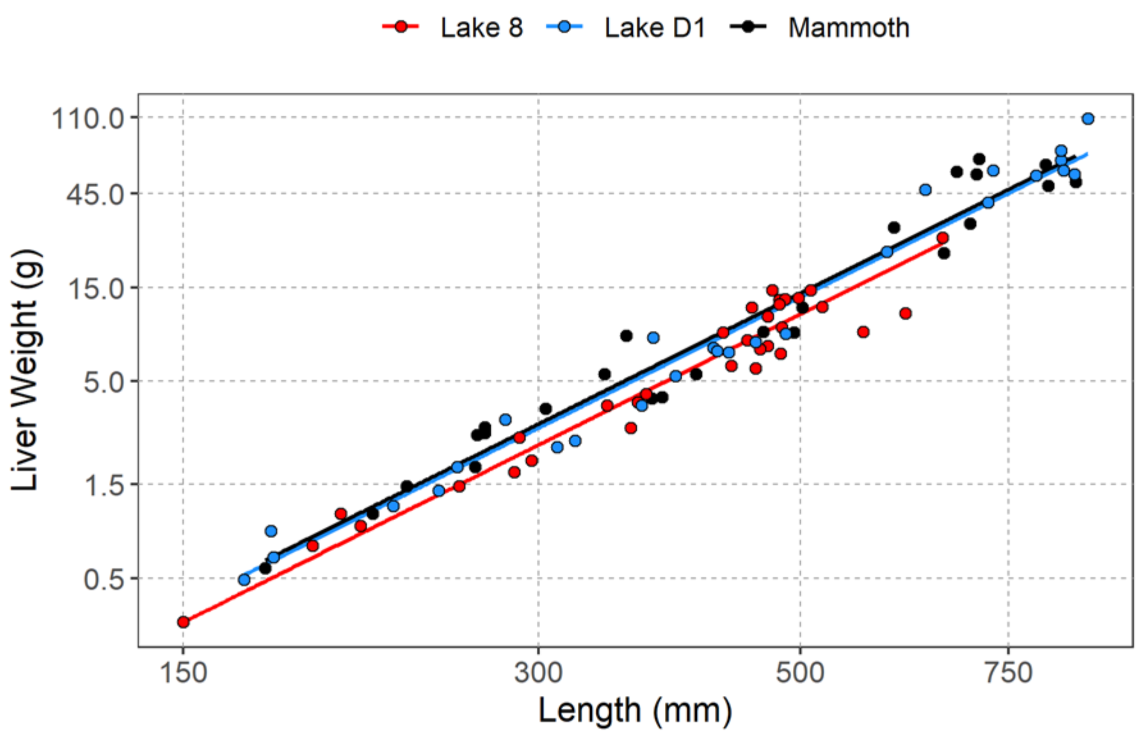

Figure 10. Plot of liver weight versus fork length (log scales).

Gonad Weight

A plot of gonad weight versus body weight for mature male Lake Trout that would spawn in the current year is presented in Figure 11. The range of the covariate (weight) differs among lakes, particularly for Lake 8 compared to Lake D1 and Mammoth Lake. No large (i.e., > 3,400 g) or small (i.e., <890 g) ripe males were captured in Lake 8, and the relationship between gonad weight and weight for Lake 8 is not significant (P=0.80, r^2=0.01). It is therefore not appropriate to include Lake 8 in the analysis (neither on its own, nor pooled with Lake D1). An ANCOVA comparing the relationship between gonad weight and weight between Lake D1 to Mammoth Lake would include only 6 data points for Lake D1 and 4 data points for Mammoth Lake and these data points are poorly distributed across the range of the covariate. It was concluded that would not be appropriate to conduct statistical comparisons with the limited data available.

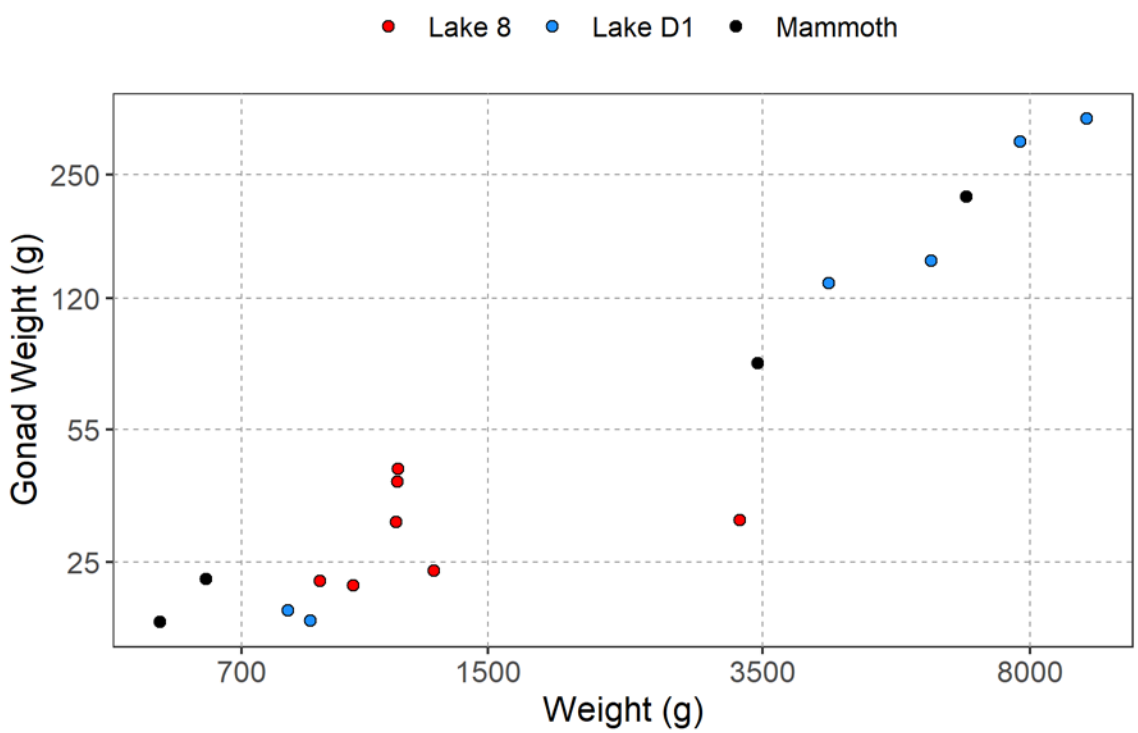

Figure 11. Plot of gonad weight versus body weight (log scales) for mature male Lake Trout spawning in the current year.

Growth

Weight Versus Age

A plot of weight versus age is presented in Figure 12. There is a significant difference in the slopes of the log of body weight versus log of age relationship among lakes (p = 0.0010) and the difference in r^2 between the full and reduced ANCOVA is >0.02, indicating that use of the reduced model is not appropriate. LS mean comparisons based on the full model indicate that young lake trout (age 5) in Mammoth Lake have a lower body weights (-7.0%) compared to those in Lake 8, but a higher body weights (+176.4%) compared to those in Lake D1. This relationship is reversed for old Lake Trout (age 42) in Mammoth Lake, which have higher body weights (+37.8%) compared to those in Lake 8, but lower body weights (-36.4%) compared to those in Lake D1.

It is apparent from the plot of weight versus age that the slope of the relationship is different for Lake D1. Therefore, ANCOVA was conducted with Lake D1 excluded. There was no significant difference in slopes (p = 0.3022) or intercepts (p = 0.2673). Lake Trout from Mammoth Lake have a 14.2% higher body weight when adjusted for age than those from Lake 8. This result is consistent with the pairwise comparisons based on the full model with all three sites included, which indicate that weight adjusted for age does not differ significantly between Mammoth and Lake 8 for either young (p = 0.9583) or old individuals (p = 0.3863); Table 26).

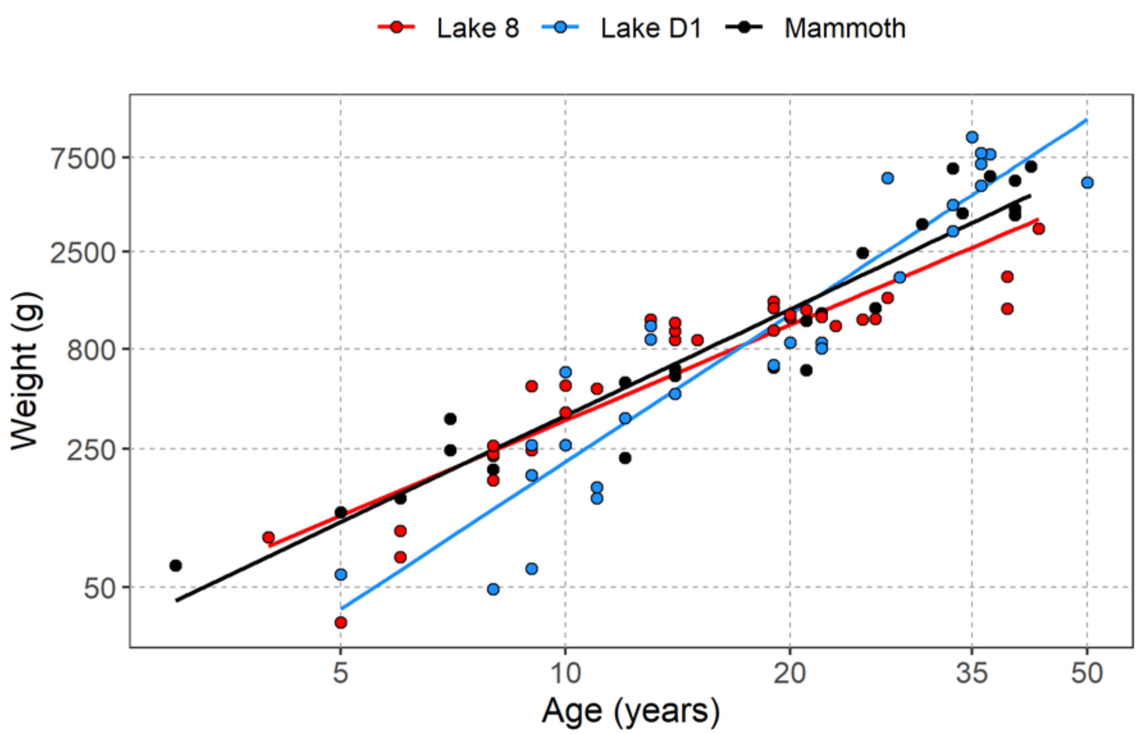

Figure 12. Plot of weight versus age (log scales).

Fork Length Versus Age

A plot of fork length versus age is presented in Figure 13. There is a significant difference in the slopes of the log of fork length versus log of age relationship among lakes ($p = 0.0003$) and the difference in r^2 between the full and reduced ANCOVA is >0.02, indicating that use of the reduced model is not appropriate. LS means indicate that young lake trout (age 5) in Mammoth Lake are smaller (-6.3%) than those in Lake 8, but larger (32.3 %) compared to those in Lake D1. This relationship is reversed for old Lake Trout (age 42) in Mammoth Lake, which are larger (+6.0%) than to those in Lake 8, but smaller (-13.7 %) than those in Lake D1.

It is apparent from the plot of length versus age that the slope of the relationship is different for Lake D1. Therefore, ANCOVA was conducted with Lake D1 excluded. There was no significant difference in slopes ($p = 0.3147$) or intercepts ($p = 0.9796$). Lake Trout from Mammoth Lake are 0.2% longer when adjusted for age than those from Lake 8. This result is consistent with the pairwise comparisons based on the full model with all three sites included, which indicate that length adjusted for age does not differ significantly between Mammoth and Lake 8 for either young ($p = 0.7363$) or old individuals ($p = 0.7341$); Table 26).

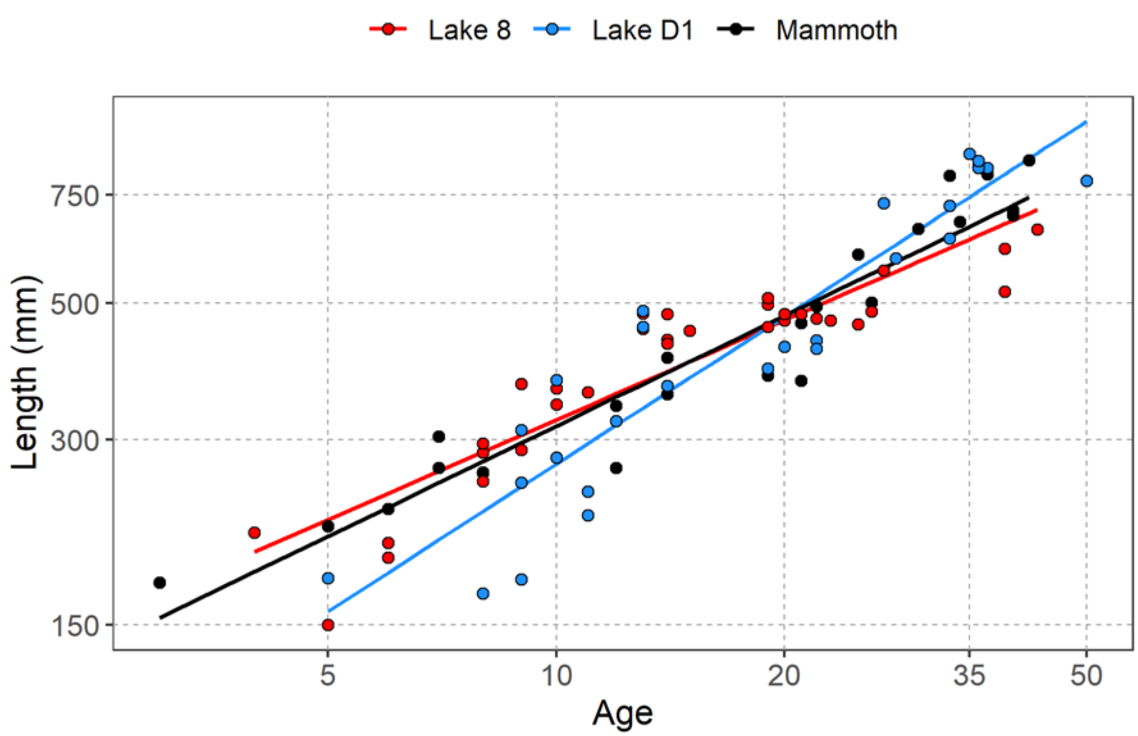

Figure 13. Plot of fork length versus age (log scales).

Table 22. Summary of between-reference lake comparisons using ANCOVA to determine if reference areas could be pooled for comparison to the exposure area. P-values ≤0.10 are in bold.

Variable		Data Excluded	ANCOVA Procedure	Error MS	p-value		Adjusted r^2	References Pooled / Not Pooled
Dependent	Independent				Interaction	Lake		
Weight ($\log_{10}$)	Length ($\log_{10}$)	None	Full	0.0023	0.2573	-	0.993	Not Pooled
			Reduced	0.0025	-	**0.0499**	0.993	
Liver Weight ($\log_{10}$)	Weight ($\log_{10}$)	None	Full	0.0092	0.3749	-	0.974	Not Pooled
			Reduced	0.0092	-	**0.0227**	0.974	
Liver Weight ($\log_{10}$)	Length ($\log_{10}$)	None	Full	0.0128	0.1731	-	0.964	Not Pooled
			Reduced	0.0130	-	**0.0062**	0.963	
Weight ($\log_{10}$)	Age ($\log_{10}$)	None	Full	0.0534	**0.0004**	-	0.848	Not Pooled
			Reduced	0.0662	-	0.6294	0.812	
Length ($\log_{10}$)	Age ($\log_{10}$)	None	Full	0.0056	**0.0010**	-	0.850	Not Pooled
			Reduced	0.0067	-	0.3375	0.821	

Table 23. Summary of among lake comparisons using ANCOVA. P-values ≤0.10 are in bold.

Variable		Data Excluded	ANCOVA Procedure	Error MS	p-value		Adjusted R^2
Dependent	Independent				Interaction	Lake	
Weight (log_{10})	Length (log_{10})	None	Full	0.0024	0.2847	-	0.993
			Reduced	0.0024	-	**0.0004**	0.993
Liver Weight (log_{10})	Weight (log_{10})	None	Full	0.0100	0.6686	-	0.872
			Reduced	0.0099	-	**0.0521**	0.973
Liver Weight (log_{10})	Length (log_{10})	None	Full	0.0144	0.4238	-	0.960
			Reduced	0.0144	-	**0.0025**	0.960
Weight (log_{10})	Age (log_{10})	None	Full	0.0468	**0.0003**	-	0.870
			Reduced	0.0562	-	0.5902	0.843
		Lake D1	Full	0.0370	0.3022	-	0.873
			Reduced	0.0371	**-**	0.2673	0.873
Length (log_{10})	Age (log_{10})	None	Full	0.0048	**0.0010**	-	0.873
			Reduced	0.0056	-	0.6807	0.852
		Lake D1	Full	0.0037	0.3147	-	0.884
			Reduced	0.0037	-	0.9796	0.884
			Reduced	0.0107	-	0.4096	0.951

Table 24. Summary of LS mean results of significant ANCOVA models, and % difference of reference areas compared to the exposure area.

Variable		ANCOVA Procedure	LS Mean				% Difference	
Dependent	Independent		Taken At	Lake 8	Lake D1	Mammoth	Lake 8	Lake D1
Weight (log_{10})	Length (log_{10})	Reduced	-	734 g	782 g	833 g	13.5	6.5
Liver Weight (log_{10})	Weight (log_{10})	Reduced	-	6.61 g	7.57 g	7.46 g	12.9	-1.5
Liver Weight (log_{10})	Length (log_{10})	Reduced	-	6.24 g	7.61 g	7.98 g	27.9	4.9
Weight (log_{10})	Age (log_{10})	Full	5 years	114.7 g	38.6 g	106.7 g	-7.0	176.4
			42 years	3506 g	7601 g	4832 g	37.8	-36.4
		Reduced (Lake D1 Excluded)	-	691 g	-	789 g	14.2	-
Length (log_{10})	Age (log_{10})	Full	5 years	223 mm	158 mm	209 mm	-6.3	32.3
			42 years	701 mm	861 mm	743 mm	6.0	-13.7
		Reduced (Lake D1 Excluded)	-	406 mm	-	407 mm	0.2	-

Table 25. Tukey Honest Significant Difference (HSD) pairwise comparison results and associated p-values for reduced models. Bolded values are significant (P<0.10)

Comparison	Tukey HSD (adjusted p-value)		
	Weight vs. Length	Liver Weight vs. Weight	Liver Weight vs. Length
Lake 8 - Lake D1	**-0.0271 (0.0961)**	**-0.0587 (0.0696)**	**-0.0859 (0.0212)**
Lake 8 - Mammoth	**-0.0548 (0.0002)**	-0.0521 (0.1313)	**-0.1065 (0.0039)**
Lake D1 - Mammoth	-0.0277 (0.1125)	0.0066 (0.9691)	-0.0207 (0.8091)

Table 26. Tukey Honest Significant Difference (HSD) pairwise comparison results and associated p-values for full models. Bolded values are significant (P<0.10)

Comparison	Tukey HSD (adjusted p-value)			
	Weight vs. Age		Length vs. Age	
	5 Years	42 Years	5 Years	42 Years
Lake 8 - Lake D1	**0.4731 (0.0007)**	**-0.3360 (0.0070)**	**0.1490 (0.0009)**	**-0.0893 (0.0310)**
Lake 8 - Mammoth	0.0313 (0.9583)	-0.1390 (0.3863)	0.0270 (0.7363)	-0.0254 (0.7341)
Lake D1 - Mammoth	**-0.4418 (0.0022)**	0.1970 (0.1275)	**-0.1120 (0.0096)**	0.0639 (0.1223)

<u>Length, Weight, and Age Distributions</u>

The fork length-, weight-, and age-frequency distributions for each lake are shown in Figure 14, Figure 15, and Figure 16, respectively. The distributions were compared between pairs of lakes using the two-sample Kolmogrov-Smirnov test, which indicated that was no significant difference in length or age distributions between any of the three lakes (i.e., p >0.10) (Table 27). There is a significant difference in the weight distribution between Lake 8 and Mammoth Lake (p = 0.096), however, the weight distributions of Lake D1 and Mammoth Lake are not significantly different (p = 0.873).

Although the distributions were not significantly different, the percent difference in mean age between Mammoth Lake and Lake 8 was 23.5 %. There was no difference in mean age between Mammoth Lake at Lake D1.

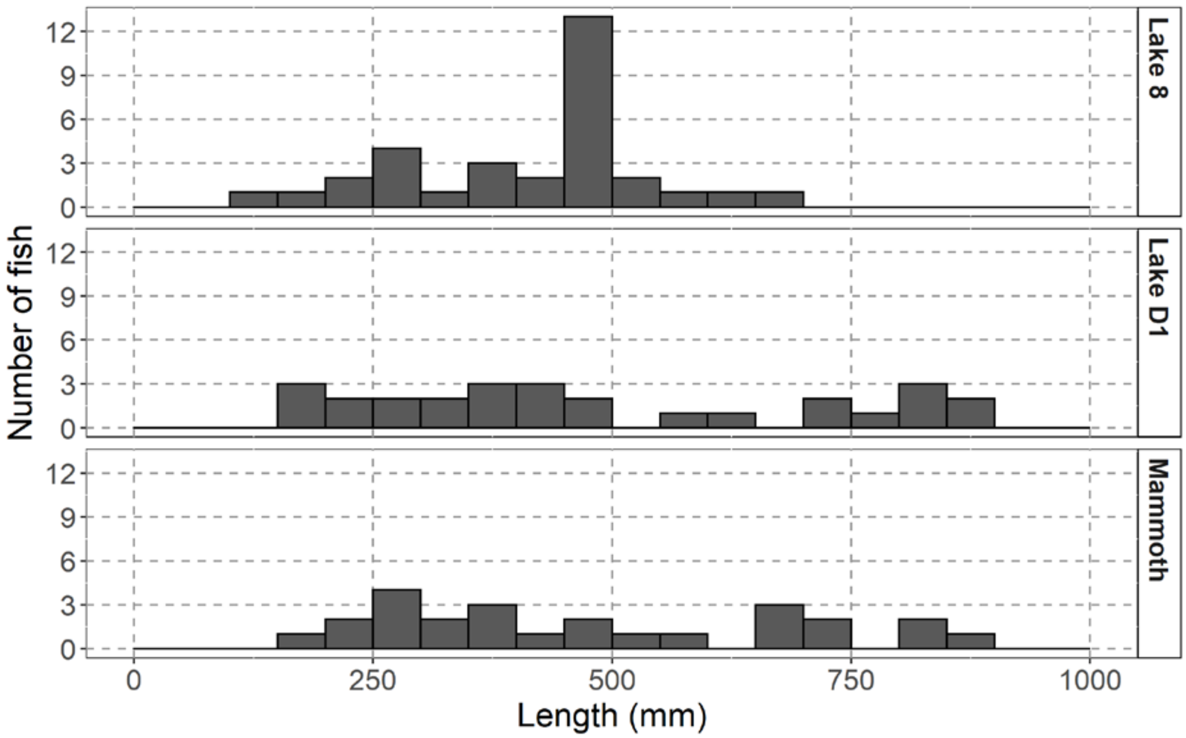

Figure 14. Length-frequency distributions for each lake.

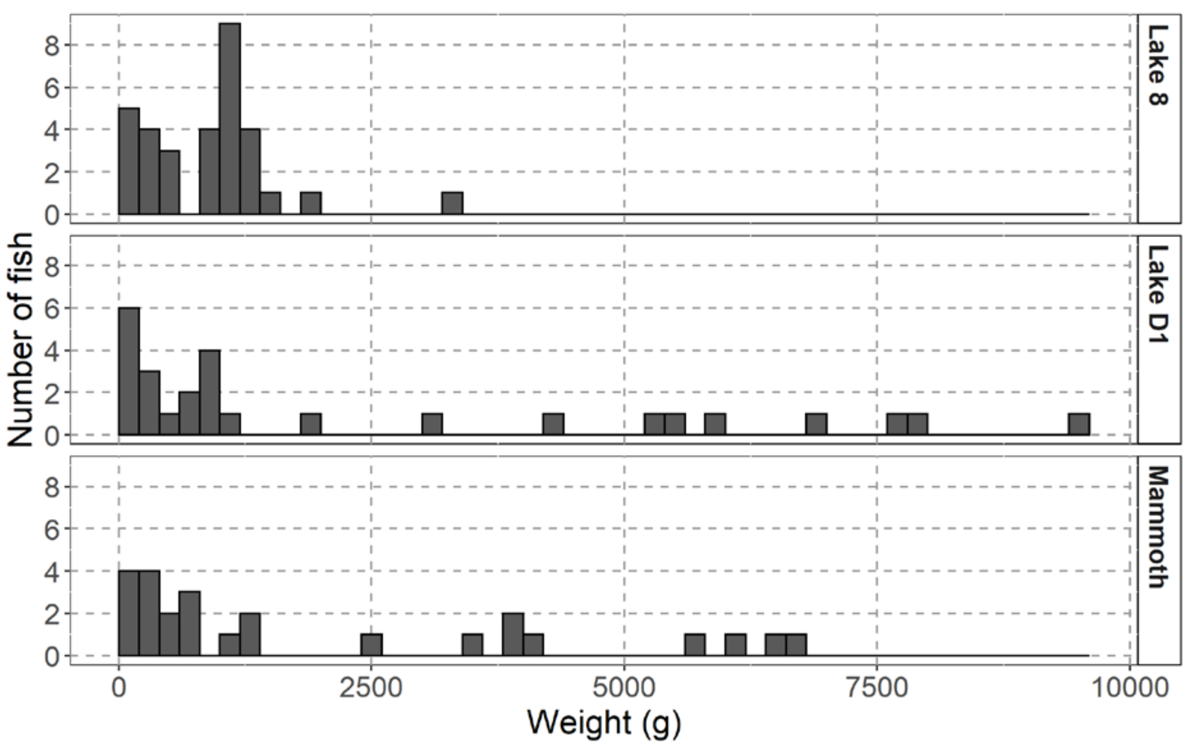

Figure 15. Weight-frequency distributions for each lake.

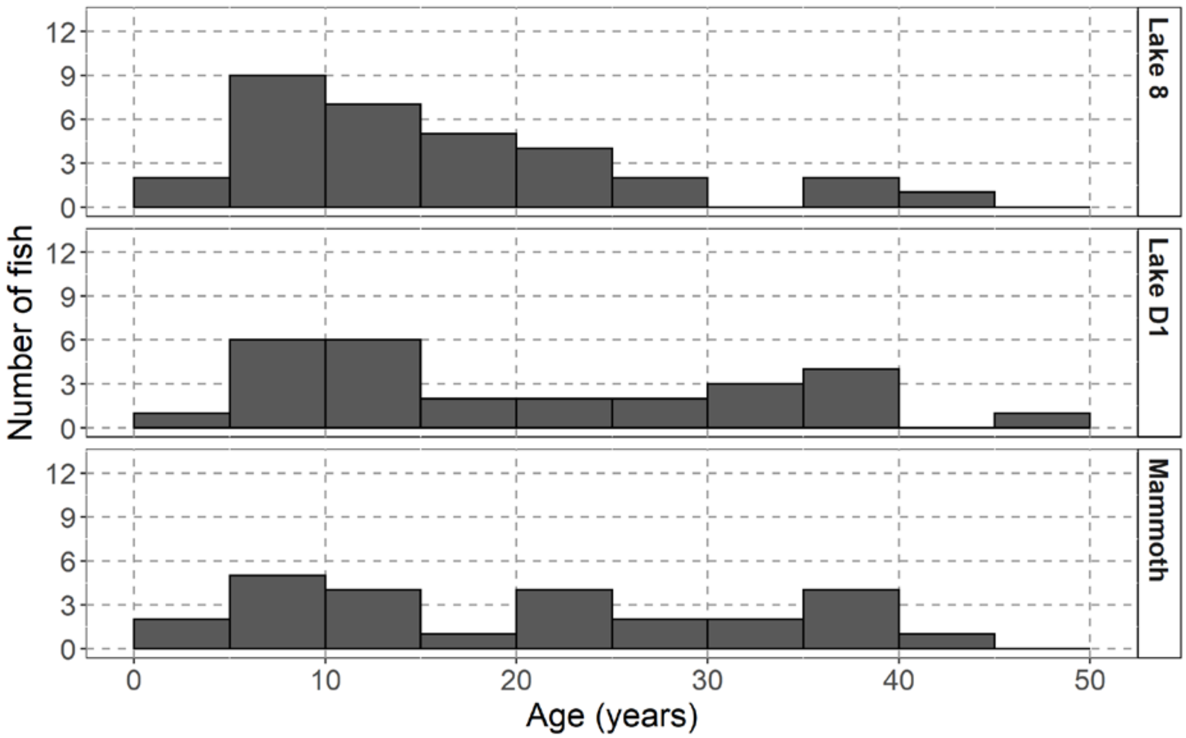

Figure 16. Age-frequency distributions for each lake.

Table 27. Kolmogorov-Smirnov two-sided probabilities of differences in the distributions between each pair of lakes for length, weight, and age. Significant results (P<0.10) are bolded.

Parameter	Lake	Lake		
		Lake 8	Lake D1	Mammoth
Length	Lake 8	1	-	-
	Lake D1	0.341	1	-
	Mammoth	0.400	0.641	1
Weight	Lake 8	1	-	-
	Lake D1	0.124	1	-
	Mammoth	**0.096**	0.873	1
Age	Lake 8	1	-	-
	Lake D1	0.125	1	-
	Mammoth	0.113	0.815	1

3.3.4 Power Analysis

The probability of detecting effects as large as or larger than the critical effect sizes, for each of the calculated fish endpoints examined with ANCOVA, based on the variance and sample sizes in this study (of the reduced models), is provided in Table 28, as is the number of fish required to detect a difference equal to the critical effect size based on the error mean square from this study. Power was greater than 90% except for the length versus age relationship, which had a power of 53.7. The body weight versus age relationships would require the fewest fish (9) to detect the critical effect size followed by, in order of increasing sample size requirements, liver weight versus body weight (15), weight versus length (19), liver weight versus length (21), and length versus age (78). The revised study design (C. Portt and Associates and Kilgour and Associates, 2020) predicted that the power of tests involving length versus age comparisons would be low, but concluded that an unacceptable number of fish would have to be killed in order to achieve the desired statistical power.

Table 28. Power analysis results. P is the probability that the effect size, from Environment Canada (2012), could be detected with the sample sizes and variance observed in the present study, and assuming a 10% Type-II error rate. N is the number of samples per site required to detect a difference equal to the critical effect size assuming the variance observed in this study and a 10% Type II error rate.

Relationship	Critical Effect Size (%)	Probability of effects detection (P)	Samples per site required (N)
Body weight versus length	10	97.3	19
Liver weight versus body weight	25	99.3	15
Liver weight versus length	25	96.3	21
Length versus age	25	53.7	78
Body weight versus age	25	100	9

3.4 Summary and Discussion

The results of the ANCOVA analyses comparing the between lake relationships for the EEM endpoints examined in this study are summarized in Table 29. There were significant differences (P≤0.10) in the intercepts of the relationships for weight versus length, liver weight versus weight, and liver weight versus length among lakes. These relationships were not significantly different between Mammoth Lake and Lake D1 and the differences in the dependent variables between those two lakes were less than the critical effect sizes. There were significant differences in intercepts for the weight versus length, liver weight versus weight, and liver weight versus length relationships between Mammoth Lake and Lake 8 and the critical effect sizes were exceeded for weight adjusted for length and liver weight adjusted for length.

There were significant differences (P≤0.10) in the slopes of the relationships for weight versus age and length versus age (i.e., non-parallel regression slopes), so effect sizes could not be appropriately estimated using the reduced model; therefore, effects were estimated for both smaller and larger fish using methods outlined in Environment Canada 2012. Plots indicated that growth rate in Lake D1 differed from the other two lakes. ANCOVA comparing Mammoth Lake to Lake 8 indicate that there was no difference in the age versus weight or age versus length relationships between those two lakes.

Length and age distributions did not differ significantly between lakes and weight distribution only differed significantly between Mammoth and Lake 8.

Table 29. Summary of between-lake comparisons calculated with full or reduced ANCOVA models, as appropriate, with no outliers removed. Critical effect sizes are from Environment Canada (2012). Bolded % differences indicate that pair-wise comparisons indicated the differences were significant (P≤0.10).

Dependent variable	Independent variable	p-value	% Difference		Critical effect size
			MMT vs LK8	MMT vs LKD1	
log of body weight	log of length	0.0004	**13.5**	6.5	10%
log of liver weight	log of body weight	0.0521	12.9	-1.5	25%
log of liver weight	log of length	0.0025	**27.9**	4.9	25%
log of weight	log of age	0.0003	-7.0 to 37.8	**176.4** to -36.4	25%
Lake D1 data excluded		0.2673	14.2		
log of length	log of age	0.0010	-6.3 to 6.0	**32.2** to -13.7	25%
Lake D1 data excluded		0.9796	0.2		

3.4.1 Recommendations for Future Fish Surveys, If Required

Based on the lower catch-per-unit effort of other fish species in this cycle, Lake Trout are the only feasible large-bodied sentinel fish species. A large number of lethally-sampled Lake Trout would be required in order to assess reproductive investment because only a portion of the Lake Trout captured are mature and only a portion of mature females will spawn in any given year. The adult fish survey for this study was therefore limited to examining relationships based on length, weight, liver weight, male gonad weight, and age. Power analysis based on the results of this study indicate that a sample size of 21 Lake Trout per site would be adequate to detect the critical effect sizes for the weight versus length, liver weight versus weight, liver weight versus length and length versus age relationships with α and β both equal to 0.1. Nearly four times as many fish per site would be required to achieve this power for the length versus age relationships (Table 28). It is recommended that a lethal study using Lake Trout as the large-bodied sentinel fish species, with a sample size of 25 individuals per sampling area, be used in any future EEM adult fish surveys that are required at the Whale Tail Pit.

4.0 SLIMY SCULPIN FISH SURVEY

4.1 Introduction

The Slimy Sculpin fish survey was conducted during the period August 21 – 27, 2020. There were no major deviations from the proposed study design. However, the study design stated that the 10 largest males and 10 largest females from each study area would be lethally sampled, if they were larger than 45 mm. The 20 samples were exclusive of the first 30 fish that were captured, as those were retained for the University of Waterloo study following the collection of length and weight measurements (as per the study design). External sexing of live individuals was inconclusive. Therefore 20 individuals larger than 45 mm from each study area were lethally sampled.

4.2 Materials and Methods

4.2.1 Field Work

4.2.1.1 Electrofishing Collection and Measurements

Slimy Sculpin were collected in the exposure area in Mammoth Lake on August 21 and August 25, from reference Lake 8 on August 23 and August 24, and from reference Lake D1 on August 22 and August 27. Electrofishing was conducted along the shorelines using a Halltech Model HT 2000B Mrk 5 backpack electrofisher. Frequency was set at 60 hertz and voltage settings were adjusted in each area so that a current of approximately 4.0 Amps was achieved. As a measure of fishing effort, the number of electroseconds (length of time that current was generated) was recorded and the start and stop locations and the electrofishing path (i.e., distance electrofished) were determined and recorded using a Garmin GPSmap76CSx GPS unit for each electrofishing event.

The number of individuals of each species captured was recorded for each electrofishing run. Electrofishing continued at each lake until the target sample size of 100 Slimy Sculpin was captured. Non-target species were released immediately.

The first 30 Slimy Sculpin captured from each lake were also being utilized in a study conducted by the University of Waterloo which required their carcasses to be retained for analysis. These fish were retained for lethal sampling. Each fish was euthanized by a concussive blow to the head, measured (total length) to the nearest 1 mm using a standard fish measuring board, and weighted to the nearest 0.001 g using an Ohaus Adventure Pro AV53 electronic balance. Each fish was examined externally, and any lesions or other anomalies were recorded.

The remainder of the Slimy Sculpin collected from each sample area were measured, weighed, and examined for external anomalies in the same manner. Up to twenty of the largest individuals, if they were were longer than 45 mm, from each sampling area were retained for lethal sampling. These fish were euthanized with a concussive blow to the head. Their otoliths were removed and stored for subsequent aging in the laboratory. One was stored dry in a standard coin envelope and the other was stored in glycerin. The carcasses were preserved in 10% buffered formalin for subsequent processing in the laboratory.

In the laboratory, the lethally sampled fish were remeasured to the nearest mm and reweighed to the nearest 0.0001 g using a Mettler Toledo Model AB 104-S balance. The body cavity was opened and examined for abnormalities, lesions, tumours and parasites. If one or more tapeworms were present they were removed, counted and weighed (in aggregate) to the nearest 0.0001 g. Livers were extracted and weighed (± 0.0001 g). Gonads were extracted and weighed (± 0.0001 g). Ovaries were not well developed in late August, as expected. All gonads were squash mounted between glass microscope slides and examined at up to 60X magnification. If eggs were observed the sex was recorded as female and if typical lobular testicular structure was observed the sex was recorded as male. Otherwise sex was recorded as immature. As eggs were not visible to the naked eye, fecundity and egg weight were not determined.

4.2.2 Age Determination

Aging of fish was completed by Louise Stanley, a fish aging expert who provides consulting services. Age was estimated based on the number of annuli counted using transmitted light and a Leica GZ6 Stereo Zoom microscope. Age was independently estimated by C. Portt from otoliths from 7 randomly selected fish.

4.2.3 Slimy Sculpin Data Analysis

Data for individual fish were entered into an Excel spreadsheet, and the entered values were compared with the original data sheets. Data entry errors were corrected.

Condition (K) was calculated using the formula:

$$K = \frac{total\ weight}{fork\ length^3} \times 100{,}000.$$

For lethally sampled individuals, gonado-somatic index (GSI) was calculated using the formula:

$$GSI = \frac{gonad\ weight}{total\ weight} \times 100.$$

For lethally sampled individuals, hepato-somatic index (HSI) was calculated using the formula:

$$HSI = \frac{liver\ weight}{total\ weight} \times 100.$$

Box plots or scatterplots of the data were examined. Aberrant values were compared to the original data sheets to ensure they were not data entry errors. Statistical analyses were carried out using R version 3.6.2 (R Core Team, 2021). Summary statistics (sample size, mean, median, minimum, maximum, standard deviation, standard error) were generated for length, weight, and condition for all Slimy Sculpin from each lake. Those same summary statistics were generated for length, weight, condition, liver weight, HIS, gonad weight and GSI by maturity, sex, and lake for the lethally sampled individuals from each lake.

A summary of statistical analyses conducted to compare fish populations between the exposure and reference areas is provided in Table 30. Length distributions and weight distributions were analyzed using analysis of variance (ANOVA) of $\log_{10}$ transformed data. If ANOVA results were significant, pair-wise comparisons were made using Tukey's honestly significant difference test. Analysis of covariance

(ANCOVA) was performed on log-transformed length and weight. For the ANCOVA analysis, both the complete model, which includes the interaction term (Lake area x independent variable) and the reduced model, which excludes the interaction term, were run. When comparing reference sites, differences in slopes or intercepts were considered significant at the 5% level (i.e., $P \leq 0.05$). If there were no significant differences, the reference site data were pooled and ANCOVA was used to compare the exposed area to the combined reference data. Significant interactions can be difficult to interpret, and complicate the computation of effect size. In cases where the interaction term accounted for < 2% of the total variation in the response variable the reduced model was considered to be appropriate and was used to assess significance and effect sizes, as per Barrett *et al*. (2010). When there were significant differences in intercepts ($P \leq 0.10$), pair-wise comparisons were made using Tukey's honestly significant difference test.

Residuals from each ANCOVA were examined for normality and outliers. Observations producing large Studentized residuals (i.e., > 4) were removed from the data set, and the analyses were repeated and variations in conclusions considered.

The percent difference in least-square means between Mammoth Lake and each of the two reference lakes was calculated as:

$$\% \, Difference = \frac{\bar{x}_{exposure} - \bar{x}_{reference}}{\bar{x}_{reference}}$$

When log transformed data were analyzed, the least-mean square values used were antilogs of the calculated values.

Table 30. Statistical analyses conducted to compare Slimy Sculpin populations between the Exposure and Reference Areas

Dependent variable	Independent variable	Statistical technique
Body weight	Length	ANCOVA
Length Distribution		ANOVA
Weight Distribution		ANOVA

4.2.4 Power Analysis

Power analysis was used to determine, *a posteriori*, the probability of detecting a 10% increase in weight versus length assuming a 10% probability of committing a Type I error, and given the sample sizes, mean values, and the unexplained variability (i.e. the population standard deviation) from this study. Power was calculated by re-arranging the following power equation (Green, 1989):

$$n = \frac{1.5(t_\alpha + t_\beta)^2 \sigma^2}{\delta^2}$$

where:

- *n* is the number of fish,
- σ is the population standard deviation,
- δ is the specified effect size,
- t_α is the Students *t* statistic for a two-tailed test with significance level α,
- t_β is the Students *t* statistic for a one-tailed test with significance level β.

4.3 Results

4.3.1 Sampling Effort and Catches

The locations of the sampling areas are shown in Figure 2, and the location of individual electrofishing runs for Mammoth Lake, Lake 8, and Lake D1 are shown in Figure 5, Figure 6, and Figure 7, respectively. Electrofishing catches and effort are summarized in Table 30. Slimy Sculpin were the most abundant species in the catches in all three lakes with a total of 303 captured. Small Lake Trout were also captured in all three lakes. Ninespine Stickleback (*Pungitius pungitius*) were captured in Lake D1 and Mammoth Lake, Round Whitefish were captured in Mammoth Lake, and a Burbot (*Lota lota)* were captured in Lake D1. Average Slimy Sculpin CPUE (# of fish/ 1,000 e-seconds) by lake is provided in Table 32. The sampling effort required to collect Slimy Sculpin varied considerably by lake and ranged from 17.8 fish/1,000 e-seconds in Lake 8 to 6.6 fish/1,000 e-seconds in Lake D1.

Table 31. Electrofishing effort and catch summary.

Lake	Electrofishing Run	Date	Distance (m)	E-seconds	Catch Summary				
					Slimy Sculpin	Ninespine Stickleback	Lake Trout	Round Whitefish	Burbot
Lake 8	EF-1	23-Aug-20	399	2,338	53	0	1	0	0
	EF-2	23-Aug-20	64	329	2	0	0	0	0
	EF-3	24-Aug-20	40	425	2	0	0	0	0
	EF-4	24-Aug-20	122	2,646	45	0	9	0	0
Lake 8 Total			**625**	**5,739**	**102**	**0**	**10**	**0**	**0**
Lake D1	EF-1	22-Aug-20	368	3,124	10	0	2	0	0
	EF-2	22-Aug-20	422	4,791	51	0	13	0	0
	EF-3	22-Aug-20	718	5,138	17	0	23	0	0
	EF-4	27-Aug-20	147	1,032	7	1	3	0	0
	EF-5	27-Aug-20	102	934	7	0	5	0	0
	EF-6	27-Aug-20	98	330	9	2	3	0	1
Lake D1 Total			**1855**	**15,349**	**101**	**3**	**49**	**0**	**1**
Mammoth	EF-1	21-Aug-20	276	2,554	5	2	2	2	0
	EF-2	21-Aug-20	165	2,421	42	2	3	0	0
	EF-3	21-Aug-20	241	2,478	36	4	2	0	0
	EF-4	25-Aug-20	86	1,526	17	1	0	1	0
Mammoth Total			**768**	**8,979**	**100**	**9**	**7**	**3**	**0**

Table 32. Slimy Sculpin electrofishing mean catch-per-unit-effort (CPUE) by lake.

Lake	Distance (m)	E-seconds	Count of Slimy Sculpin Captured	CPUE	
				fish/100 m	fish/1,000 e-seconds
Lake 8	625	5,739	102	16.3	17.8
Lake D1	1,855	15,349	101	5.4	6.6
Mammoth	768	8,979	100	13.0	11.1

4.3.2 Slimy Sculpin Characteristics

4.3.2.1 Overview

The numbers of Slimy Sculpin processed by lake, sampling method, and sex are presented in Table 33. A total of 102 Slimy Sculpin from Lake 8, 102 Slimy Sculpin from Lake D1, and 100 Slimy Sculpin from Mammoth Lake were non-lethally sampled. Lethal sampling of Slimy Sculpin with a total length of greater than 45 mm was completed for 14 individuals from Lake 8, 22 individuals from Lake D1, and 24 individuals from Mammoth Lake. Gonads were not well developed in late August and therefore, spawning status, fecundity, and egg weight could not be determined.

Table 33. Number of Slimy Sculpin examined from each lake, by sampling method and sex.

Lake	Count				
	Non- Lethal Sampling	Lethal Sampling			
		Male	Female	Unknown	Total
Lake 8	102	5	7	2	14
Lake D1	102	5	11	6	22
Mammoth	100	12	9	3	24

The summary statistics for each parameter measured or calculated as part of the non-lethal study are presented by lake in Table 34. Summary statistics for each parameter measured or calculated as part of the non-lethal study are presented in Table 35 by sex, and lake. The gonads could not be discerned in some immature individuals; consequently, there are no weights for these. The data for each specimen are provided in Appendix 4.

Table 34. Slimy Sculpin summary statistics by lake.

Variable	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
Fork Length (mm)	Lake 8	102	27	65	40	40	8.4	0.8
	Lake D1	102	34	78	50	48	10.2	1.0
	Mammoth	100	34	71	48	48	9.5	1.0
Weight (g)	Lake 8	102	0.210	2.63	0.67	0.57	0.449	0.044
	Lake D1	102	0.337	4.81	1.22	0.92	0.848	0.084
	Mammoth	100	0.349	3.03	1.02	0.87	0.620	0.062
Condition	Lake 8	102	0.656	1.572	0.956	0.937	0.1841	0.0182
	Lake D1	102	0.647	1.335	0.892	0.856	0.1506	0.0149
	Mammoth	100	0.645	1.165	0.812	0.811	0.0851	0.0085

Table 35. Summary statistics by maturity, sex, and lake for lethally sampled Slimy Sculpin.

Variable	Maturity	Sex	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
Fork Length (mm)	Mature	Female	Lake 8	5	46	50	48	48	1.8	0.8
			Lake D1	5	49	61	56	56	4.7	2.1
			Mammoth	12	46	71	56	55	7.9	2.3
		Male	Lake 8	7	46	65	55	51	7.8	2.9
			Lake D1	11	56	72	65	66	5.6	1.7
			Mammoth	9	52	67	59	61	5.7	1.9
	Immature	Unknown	Lake 8	2	50	59	55	55	6.4	4.5
			Lake D1	6	48	52	50	50	1.6	0.7
			Mammoth	3	46	54	49	46	4.6	2.7
Weight (g)	Mature	Female	Lake 8	5	0.8870	1.3100	1.0820	0.9830	0.2064	0.0923
			Lake D1	5	0.9290	2.5830	1.7114	1.5170	0.6589	0.2947
			Mammoth	12	0.7920	3.0340	1.5300	1.2805	0.7446	0.2150
		Male	Lake 8	7	1.0350	2.6290	1.5994	1.4780	0.6459	0.2441
			Lake D1	11	1.7820	3.2540	2.4552	2.5520	0.5279	0.1592
			Mammoth	9	1.2320	2.5220	1.7517	1.6530	0.4188	0.1396
	Immature	Unknown	Lake 8	2	1.4460	2.2360	1.8410	1.8410	0.5586	0.3950
			Lake D1	6	0.8770	1.2590	1.0603	1.0545	0.1339	0.0547
			Mammoth	3	0.7890	1.3970	1.0143	0.8570	0.3331	0.1923
Condition	Mature	Female	Lake 8	5	0.89	1.05	0.96	0.91	0.080	0.036
			Lake D1	5	0.79	1.26	0.95	0.87	0.184	0.082
			Mammoth	12	0.71	0.96	0.82	0.82	0.073	0.021
		Male	Lake 8	7	0.78	1.17	0.95	0.95	0.154	0.058
			Lake D1	11	0.72	1.21	0.89	0.85	0.137	0.041
			Mammoth	9	0.67	0.98	0.83	0.85	0.105	0.035
	Immature	Unknown	Lake 8	2	1.09	1.16	1.12	1.12	0.048	0.034
			Lake D1	6	0.78	0.95	0.86	0.87	0.065	0.027
			Mammoth	3	0.81	0.89	0.86	0.88	0.042	0.024

Variable	Maturity	Sex	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
Gonad Weight (g)	Mature	Female	Lake 8	5	0.00750	0.01830	0.01120	0.00940	0.00459	0.00205
			Lake D1	5	0.01430	0.03870	0.02562	0.02870	0.00985	0.00440
			Mammoth	12	0.00630	0.04570	0.01788	0.01175	0.01400	0.00404
		Male	Lake 8	7	0.01160	0.04430	0.02113	0.01830	0.01170	0.00442
			Lake D1	11	0.01810	0.06580	0.03855	0.03920	0.01558	0.00470
			Mammoth	9	0.00600	0.02780	0.01646	0.01570	0.00691	0.00230
	Immature	Unknown	Lake 8	2	0.00150	0.00360	0.00255	0.00255	0.00148	0.00105
			Lake D1	6	0.00210	0.01090	0.00570	0.00415	0.00361	0.00147
			Mammoth	3	0.00120	0.00440	0.00250	0.00190	0.00168	0.00097
GSI	Mature	Female	Lake 8	5	0.718	1.862	1.052	0.857	0.4656	0.2082
			Lake D1	5	0.554	2.128	1.647	1.873	0.6240	0.2790
			Mammoth	12	0.516	2.206	1.098	1.014	0.4651	0.1343
		Male	Lake 8	7	1.041	1.685	1.276	1.238	0.2127	0.0804
			Lake D1	11	0.911	2.170	1.520	1.536	0.3546	0.1069
			Mammoth	9	0.471	1.503	0.947	0.932	0.3633	0.1211
	Immature	Unknown	Lake 8	2	0.104	0.161	0.132	0.132	0.0405	0.0286
			Lake D1	6	0.239	0.989	0.536	0.380	0.3384	0.1382
			Mammoth	3	0.086	0.513	0.280	0.241	0.2164	0.1250
Liver Weight (g)	Mature	Female	Lake 8	5	0.0121	0.0200	0.0172	0.0191	0.00336	0.00150
			Lake D1	5	0.0173	0.0761	0.0384	0.0358	0.02248	0.01005
			Mammoth	12	0.0147	0.1485	0.0487	0.0341	0.04010	0.01157
		Male	Lake 8	7	0.0117	0.0933	0.0375	0.0215	0.02977	0.01125
			Lake D1	11	0.0311	0.1024	0.0536	0.0421	0.02401	0.00724
			Mammoth	9	0.0175	0.0564	0.0316	0.0295	0.01133	0.00378
	Immature	Unknown	Lake 8	2	0.0167	0.0350	0.0259	0.0259	0.01294	0.00915
			Lake D1	6	0.0112	0.0196	0.0165	0.0168	0.00313	0.00128
			Mammoth	3	0.0172	0.0259	0.0225	0.0244	0.00465	0.00269
LSI	Mature	Female	Lake 8	5	1.30	2.03	1.61	1.49	0.288	0.129

Variable	Maturity	Sex	Lake	n	Min.	Max.	Mean	Median	Standard Deviation	Standard Error
			Lake D1	5	1.41	3.52	2.22	1.94	0.800	0.358
			Mammoth	12	0.99	5.02	2.94	2.90	1.003	0.289
		Male	Lake 8	7	1.02	3.55	2.12	1.62	1.009	0.381
			Lake D1	11	1.55	3.15	2.12	1.87	0.534	0.161
			Mammoth	9	0.90	2.59	1.85	1.69	0.587	0.196
	Immature	Unknown	Lake 8	2	1.15	1.57	1.36	1.36	0.290	0.205
			Lake D1	6	1.28	1.75	1.54	1.56	0.184	0.075
			Mammoth	3	1.75	3.28	2.35	2.01	0.822	0.475
Otolith Age (years)	Mature	Female	Lake 8	5	1	3	2	2	0.7	0.3
			Lake D1	5	2	4	3	3	0.8	0.4
			Mammoth	12	1	6	3	3	1.4	0.4
		Male	Lake 8	7	1	5	3	3	1.3	0.5
			Lake D1	11	3	6	4	3	1.1	0.3
			Mammoth	9	2	4	3	2	1.0	0.3
	Immature	Unknown	Lake 8	2	2	4	3	3	1.4	1.0
			Lake D1	6	2	3	2	2	0.4	0.2
			Mammoth	3	2	2	2	2	0.0	0.0

4.3.2.2 Ageing QA/QC

The differences between the ages estimated by the primary aging expert (L. Stanley) and those estimated by C Portt are provided in Table 36. The resulting otolith ages were identical for 4 of the 7 fish that were checked. The QA/QC ages were one less than assigned by the primary aging expert for 2 of the 7 fish and one year more for one fish.

Table 36. Magnitude of differences between age estimations by two different investigators (original-QA/QC age).

Fish #	Otolith age (years)		
	Original Reading	QA/QC Reading	Difference
SC-070	3	2	-1
SC-095	4	4	0
SC-100	3	3	0
SC-102	2	2	0
SC-115	3	3	0
SC-258	1	2	1
SC-262	4	3	-1

4.3.2.3 Lesions, Deformities, and Parasites

No lesions or deformities were observed. Of the Slimy Sculpin that were retained for dissection, tapeworms were observed in 6 (43%) of the individuals from Lake 8, 3 (14%) of the individuals from Lake D1, and 3 (13%) of the individuals from Mammoth Lake. Each of these fish had one tapeworm, with the exception of one Slimy Sculpin from Lake 8, which had four, and one Slimy Sculpin from Mammoth Lake, which had two. A summary of tapeworm data, including number, weight, and percentage of fish total weight are presented in Table 37.

Table 37. Tapeworm counts, weights, and weight as a percent of fish weight for individual Slimy Sculpin from each lake.

Lake	Total Length (mm)	Total Weight (g)	Tapeworms		
			Count	Weight (g)	Percent of Total Weight
Mammoth	54	1.397	1	0.1770	12.7
	58	1.671	1	0.2358	14.1
	61	1.934	2	0.3597	18.6
Lake 8	46	1.143	1	0.2584	22.6
	46	0.887	1	0.1179	13.3
	47	0.930	1	0.1007	10.8
	48	0.983	4	0.1638	16.7
	50	1.310	1	0.1875	14.3
	59	2.236	1	0.4307	19.3
Lake D1	50	1.136	1	0.0628	5.5
	51	1.259	1	0.2208	17.5
	59	2.583	1	0.2630	10.2

4.3.2.4 Among Lake Comparisons

Length and Weight Distributions

The length- and weight-frequency distributions for each lake are shown in Figure 17 and Figure 18, respectively. Analysis of variance (ANOVA) using log10 transformed data was used to assess differences among lakes. Assumptions of normality and homogeneity of the input data and distribution of the residuals were assessed. Homogeneity of variance and distribution of the residuals met assumptions, and only small, acceptable deviations from normality were observed for the transformed data. Analysis of variance (ANOVA) indicates that mean log10 transformed length is significantly different among lakes. ANOVA results for mean log10 transformed weight also indicates that there are significant differences among lakes. Post-hoc pairwise comparisons using the Tukey Honest Significance Difference (HSD) test show that both mean log10 length and mean log10 weight are significantly different for Slimy Sculpin from Lake 8 compared to Slimy Sculpin from Lake D1 and Mammoth Lake (Table 39). Mean log10 length and mean log10 weight are not significantly different between Lake D1 and Mammoth Lake.

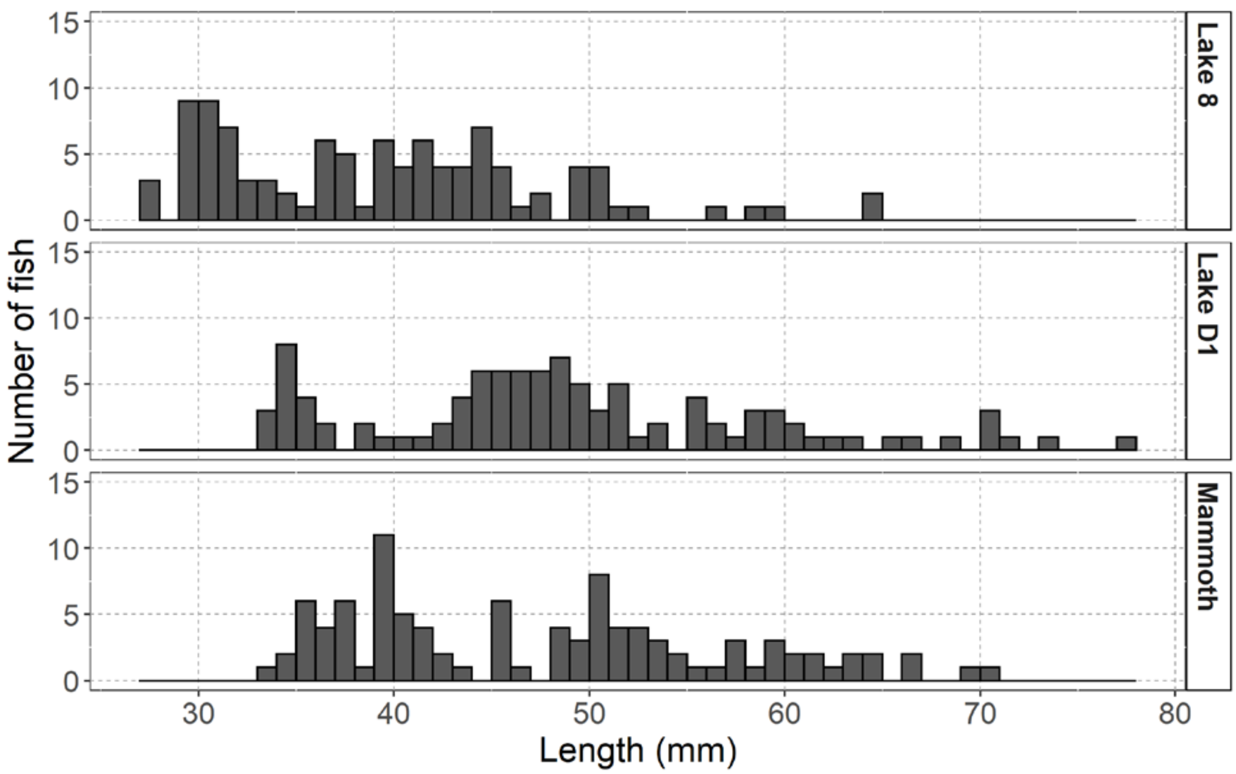

Figure 17. Length-frequency distributions for each lake.

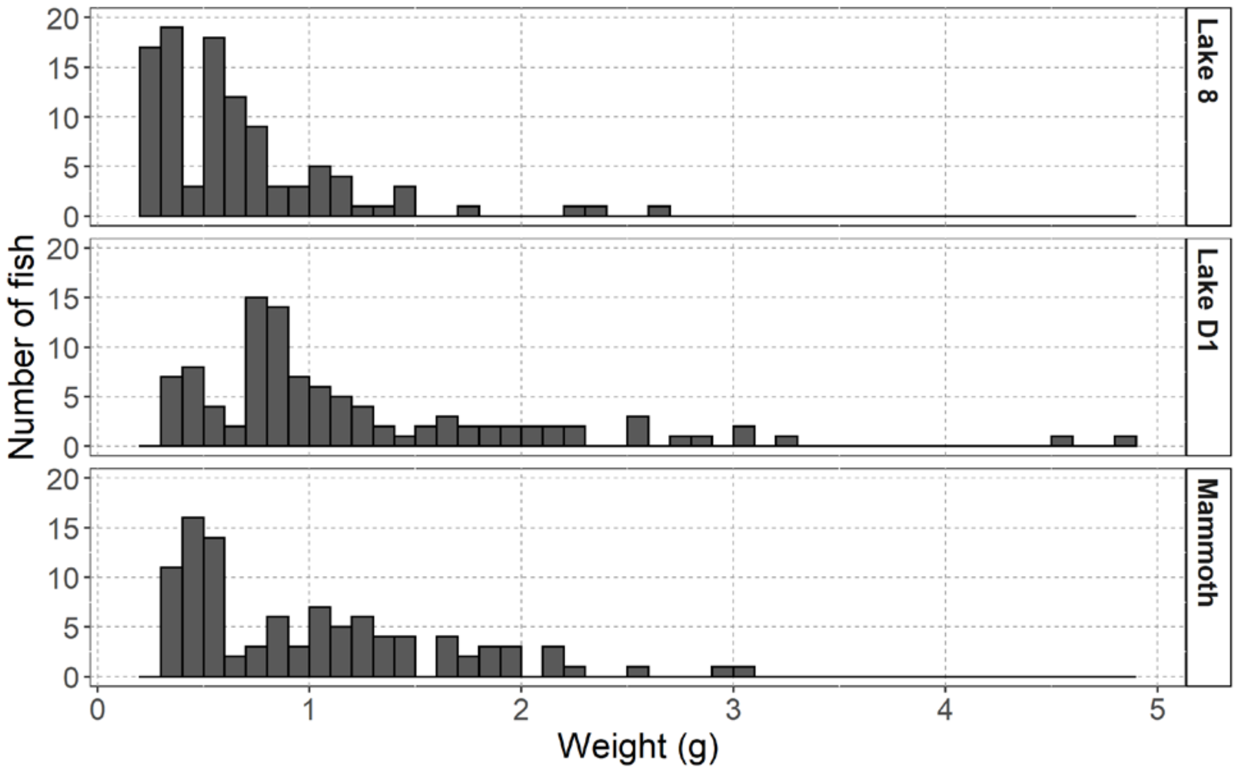

Figure 18. Weight-frequency distributions for each lake.

Table 38. ANOVA results for log_{10} transformed length and weight distributions.

Variable	Error MS	F-Value	p-value	df
Length (log_{10})	0.0076	34.79	<0.0001	2,301
Weight (log_{10})	0.0662	25.81	<0.0001	2,301

Table 39. Tukey Honest Significant Difference (HSD) pairwise comparison results and associated p-values. Bolded values are significant (P<0.10).

Comparison	Tukey HSD (adjusted p-value)	
	Length (mm) (Log_{10})	**Weight (g) (Log_{10})**
Lake D1 - Lake 8	**0.093 (<0.0001)**	**0.251 (<0.0001)**
Mammoth - Lake 8	**0.082 (<0.0001)**	**0.180 (<0.0001)**
Mammoth - Lake D1	-0.011 (0.623)	-0.072 (0.120)

<u>First Age Class – Analysis of Length</u>

Based on the length-frequency distributions (Figure 17), the youngest age class of captured fish was identified as those ≤ 35 mm in Lake 8, ≤ 37 mm in Lake D1, and ≤38 mm in Mammoth Lake. Note that these are presumed to be year 1 fish, as young-of-year are typically too small to be captured at this time of year (see C. Portt and Associates and Kilgour & Associates, 2020, Appendix A; Gray et al. 2018). The length-frequency distribution of the youngest age class, by lake, is presented in Figure 19. The mean length of year 1 fish differs significantly among lakes (ANOVA, F-value = 90.36, $p < 0.0001$, df = 2,69). Pairwise comparisons using Tukey HSD test indicates that there are significant differences between each pair of lakes (Table 40).

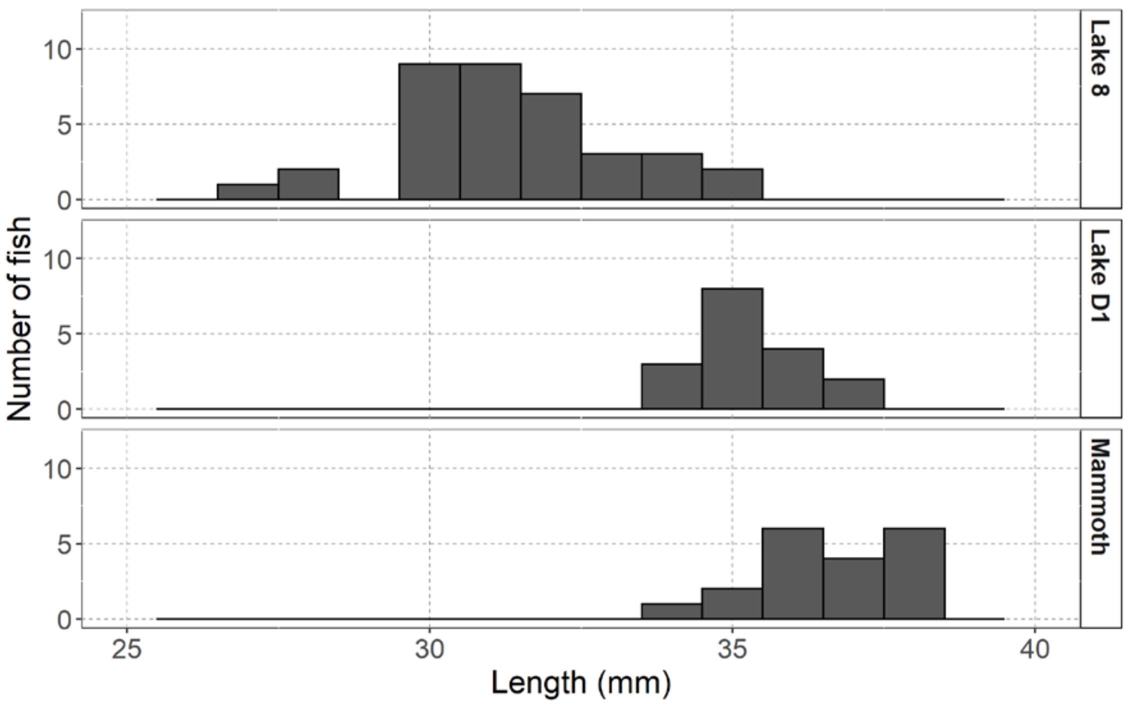

Figure 19. Length-frequency distribution of the youngest age class of Slimy Sculpin captured.

Table 40. Tukey Honest Significant Difference (HSD) pairwise comparison results and associated p-values for mean length of the youngest age class of Slimy Sculpin. Bolded values are significant (P<0.10).

Comparison	Tukey HSD (adjusted p-value)
Lake 8 - Lake D1	**-3.99 (<0.0001)**
Lake 8 - Mammoth	**-5.33 (<0.0001)**
Lake D1 - Mammoth	**-1.34 (0.0266)**

Size and Age at Maturity

Size and age at maturity were estimated by constructing logistic regressions using data collected from lethally sampled fish. Maturity was identified as the age or length value at which 50% of individuals are predicted to be mature. Based on the regression, Slimy Sculpin have a probability of maturity of 0.5 or greater at age 1 (Figure 20), and at a length of 46 mm (Figure 21).

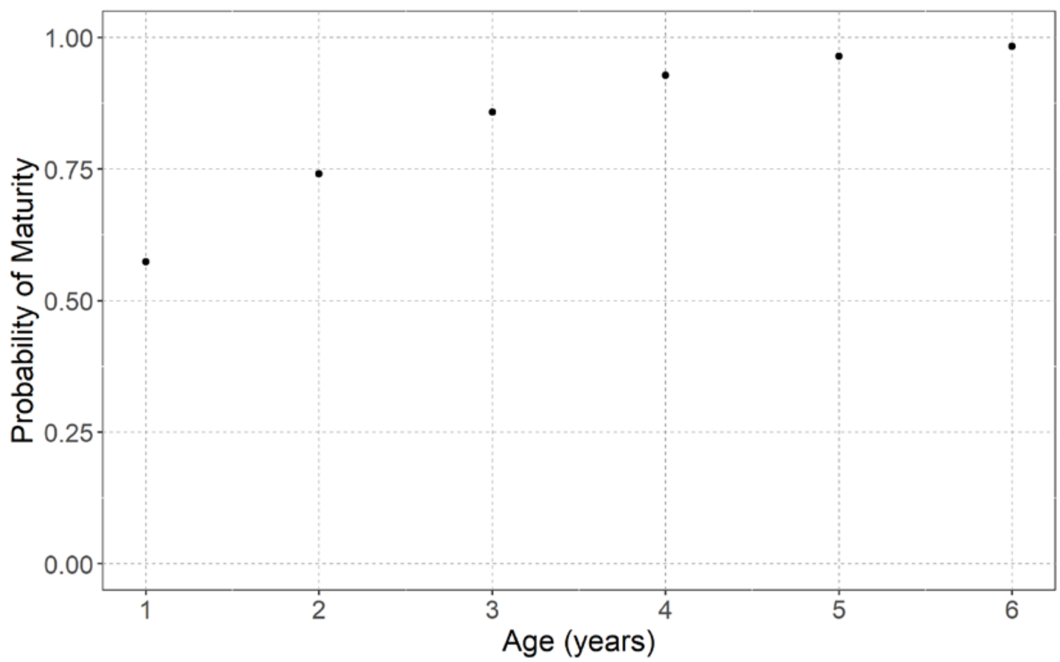

Figure 20. Probability of maturity of Slimy Sculpin by age.

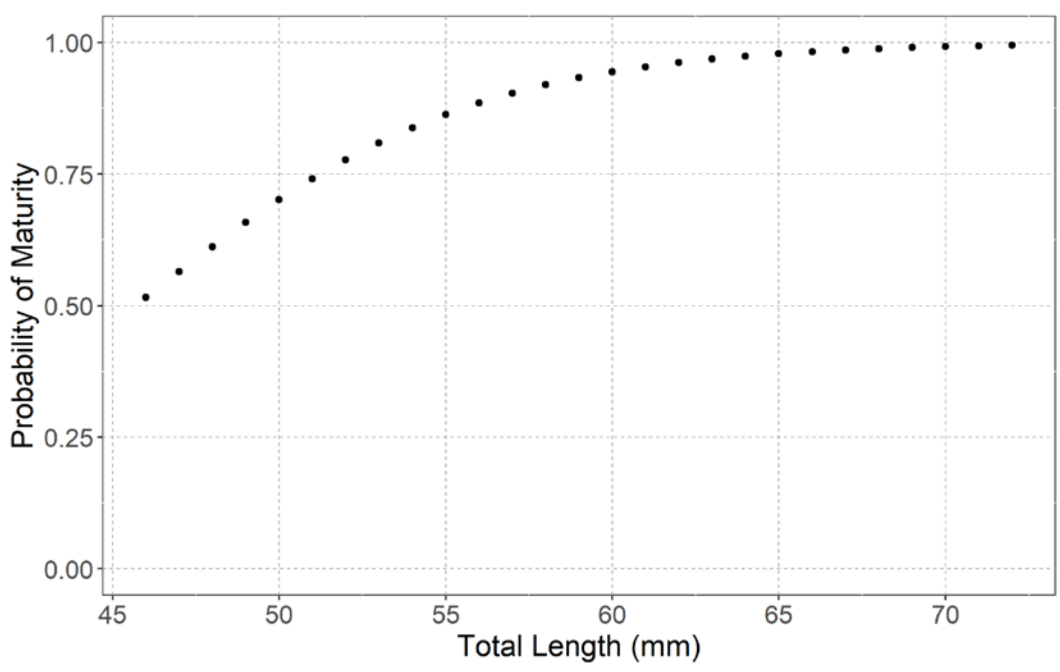

Figure 21. Probability of maturity of Slimy Sculpin by length.

Condition

There was no significant differences in either slopes or intercepts (P≥0.05) between reference lakes for the weight versus length relationship (Table 41). Therefore, data from reference lakes were pooled for comparison to the exposure lake (Mammoth). The results of the ANCOVA analyses of weight versus length for both pooled and unpooled reference lakes are summarized in Table 42. Least square (LS) mean estimates were determined for the reduced model and percent differences between each reference areas and the exposure area were calculated (Table 51).

There was a significant difference in the slopes of the log of weight versus log of fork length relationship among lakes for both the pooled analysis (p= 0.0060) and unpooled analysis (p = 0.0066). There was also a significant difference in the intercepts of the reduced models (p < 0.0001). Since the difference in the coefficient of determination between the full and reduced model is less than 0.02, the reduced models are a reasonable approximation of the relationship. LS mean values were determined for both pooled and unpooled reduced models. At a given length, the body weight of a fish from Mammoth Lake is lower than that of a fish from Lake 8 (-11.7 %) and a fish from Lake D1 (-8.6 %). For pooled reference data, at a given length, the body weight of a fish from the exposure area (Mammoth Lake) is lower than a fish from the reference area (-10.0 %). Pairwise comparisons using Tukey HSD test indicates that there are significant differences between Mammoth Lake and the reference lakes, both when they are pooled, and assessed individually (Table 44).

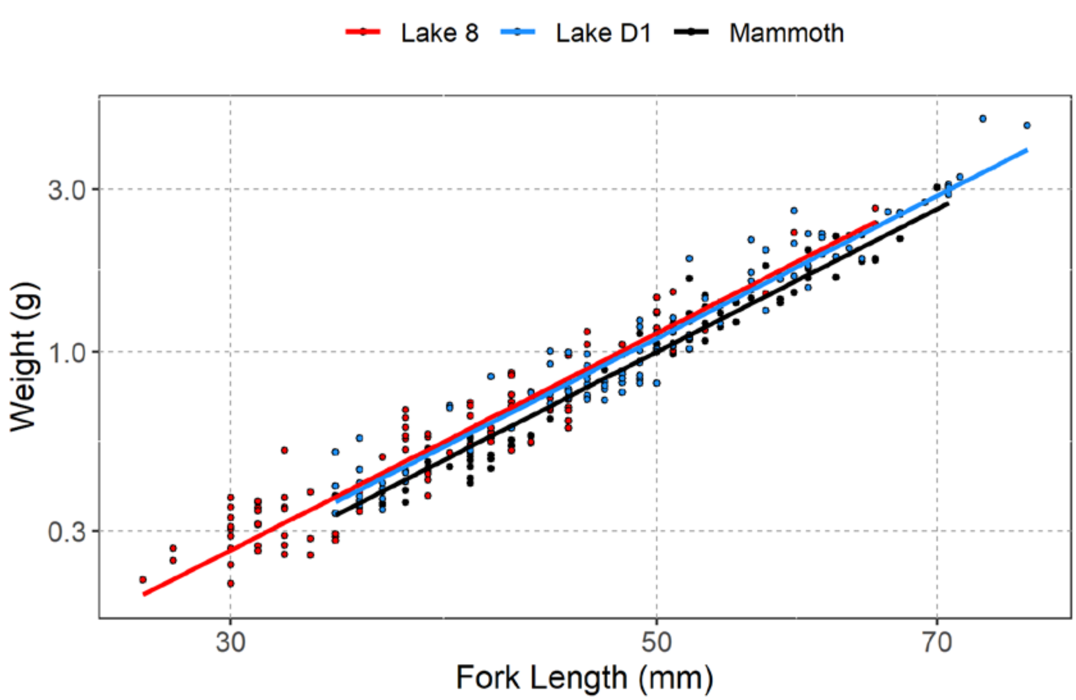

Figure 22. Plot of fish weight versus fork length for the reduced model (log scales) with individual reference lake data.

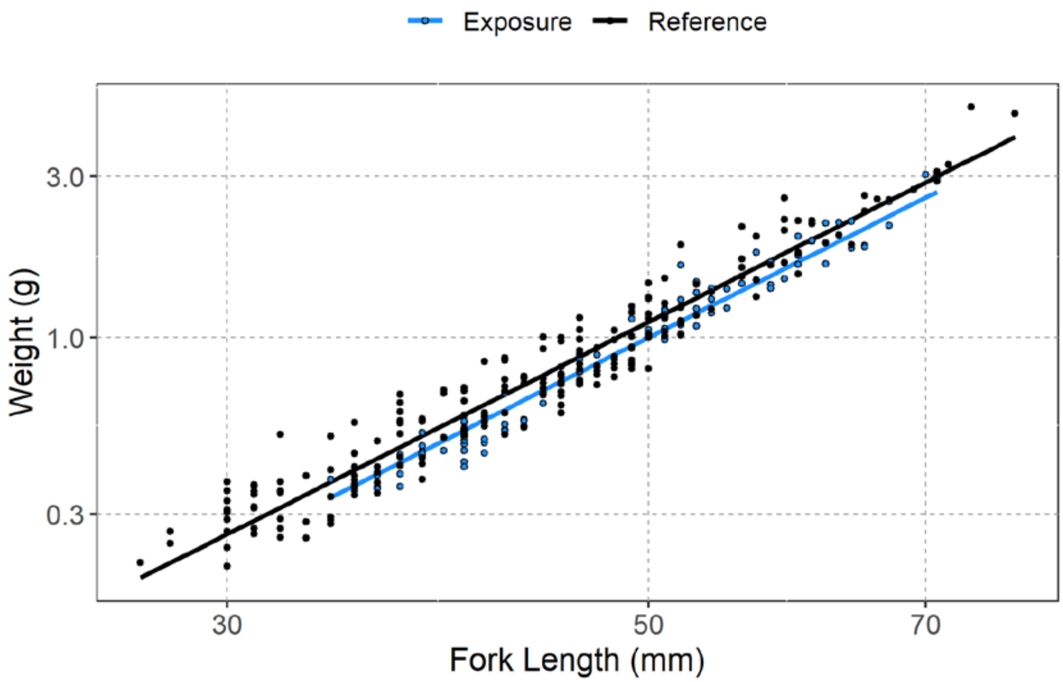

Figure 23. Plot of fish weight versus fork length for the reduced model (log scales) with reference lake data pooled.

Table 41. Summary of between-reference lake comparisons using ANCOVA to determine if reference areas could be pooled for comparison to the exposure area. P-values ≤0.05 are in bold.

Variable		Data Excluded	ANCOVA Procedure	Error MS	p-value		Adjusted r^2	References Pooled / Not Pooled
Dependent	Independent				Interaction	Lake		
Weight ($\log_{10}$)	Length ($\log_{10}$)	None	Full	0.0054	0.0724	-	0.933	Pooled
			Reduced	0.0055	-	0.4741	0.943	

Table 42. Summary of among lake comparisons using ANCOVA. P-values ≤0.10 are in bold.

Variable		Reference Lakes	ANCOVA Procedure	Error MS	p-value		Adjusted R^2
Dependent	Independent				Interaction	Lake	
Weight ($\log_{10}$)	Length ($\log_{10}$)	Not Pooled	Full	0.0043	**0.0066**	-	0.944
			Reduced	0.0044	-	**<0.0001**	0.943
		Pooled	Full	0.0043	**0.0060**	-	0.944
			Reduced	0.0044	-	**<0.0001**	0.943

Table 43. Summary of LS mean results of reduced ANCOVA models, and % difference of reference areas compared to the exposure area.

Variable		Reference Lakes	LS Means			% Difference	
Dependent	Independent		Lake 8	Lake D1	Mammoth	Lake 8	Lake D1
Weight (log_{10})	Length (log_{10})	Not Pooled	0.826 g	0.797 g	0.729 g	-11.7	-8.6
		Pooled	0.811 g		0.730 g	-10.0	

Table 44. Tukey Honest Significant Difference (HSD) pairwise comparison results and associated p-values for unpooled and pooled analyses of the weight versus length relationship. Bolded values are significant (P<0.10).

Comparison	Tukey HSD (adjusted p-value)
Lake 8 - Lake D1	0.0151 (0.2978)
Lake 8 - Mammoth	**0.0542 (<0.0001)**
Lake D1 - Mammoth	**0.0391 (0.0001)**
Exposure - Reference	**-0.0457 (<0.0001)**

4.3.3 Power Analysis

The probability of detecting effects as large as or larger than the critical effect size (10%), for weight versus length was calculated based on the variance and sample size of the reduced model (Table 45). The number of fish required to detect a difference equal to the critical effect size based on the error mean square was also determined. The power to detect a critical effect size of 10% for the weight versus length relationship is 100%. Forty fish are required per site to detect the critical effect size, based on the error mean squares from this study if the reference data are not pooled.

Table 45. Power analysis results. P is the probability that the effect size, from Environment Canada (2012), could be detected with the sample sizes and variance observed in the present study, and assuming a 10% Type-II error rate. N is the number of samples per site required to detect a difference equal to the critical effect size assuming the variance observed in this study and a 10% Type II error rate.

Relationship	Reference Lakes	Critical Effect Size (%)	Probability of effects detection (P)	Samples per site required (N)
Body weight versus length	Not Pooled	10	100	40
	Pooled	10	95.9	34

4.4 Summary and Discussion

The length and weight distributions of Slimy Sculpin differ between Mammoth Lake and Lake 8 but neither differ significantly between Mammoth Lake and Lake D1. The results of the ANCOVA analyses comparing slopes of the relationships for the EEM endpoints examined in this study are summarized in Table 46. In their comments on design of the fish study, Environment and Climate Change Canada stated that if there were no significant differences between reference areas the data should be pooled and the exposure area should be compared to the combined reference areas. We conducted that analysis, as directed, but in our opinion the approach is not appropriate. No two reference sites are identical; the size of a difference calculated from LS means using combined data will always be between the effect sizes calculated for the two reference sites individually. That is the case for this study (refer to Table 45). The slopes of the weight versus length relationship differ significantly between Mammoth Lake and both of the reference lakes. The effect size for the weight versus length relationship is less than the critical effect size of 10% when Mammoth Lake is compared to Lake D1, greater that 10% when compared to Lake 8, and equal to 10% when the reference sites are combined.

In summary, for Slimy Sculpin, there are no differences between Mammoth Lake and Lake D1, that exceed the critical effect size, but there were between Mammoth Lake and Lake 8.

Table 46. Summary of between-lake comparisons calculated with reduced ANCOVA (i.e. comparison of intercepts), with no outliers removed. Critical effect sizes are from Environment Canada (2012).

Dependent variable	Independent variable	Reference Lakes	p-value	% Difference			Critical effect size
				MMT vs LK8	MMT vs LKD1	Exp vs Ref	
log of body weight	log of length	Not pooled	<0.0001	**-11.7**	-8.6	-	10%
		Pooled	<0.0001	-	-	**-10.0**	10%

4.4.1 Recommendations for Future Fish Surveys

Slimy Sculpin is the small-bodied species for which CPUE is highest and the only species that it is feasible to obtain the necessary sample sizes in Mammoth Lake and both of the reference lakes. It is recommended that the same study design be used in the next EEM biological study.

5.0 BENTHIC INVERTEBRATE COMMUNITY SURVEY

5.1 Introduction

This Cycle 1 EEM benthic invertebrate community study compares benthic communities in Mammoth Lake (MAM; Figure 5) and two reference areas (Lake 8; Figure 6 and Lake D1; Figure 7). Five sampling stations were nested within each sampling area. Sampling depths were targeted to be 7 to 8 m, with sampling stations minimally 20 m apart to ensure a minimum of statistical independence among stations.

Sample collection and processing followed the methodology used by the Core Receiving Environment Monitoring Program (CREMP). Two sub-samples (grabs) of the benthic community were collected from each sampling station and composited. Two grabs were collected from one station at MAM and kept separate for sorting and identification, in order to support estimation of within-area variance and precision of core indices of composition, and to evaluate the precision provided by the two-grab samples.

Variability in core indices of composition among stations was used to judge the significance of variations among areas. Stations were therefore the unit of replication.

5.2 Materials and Methods

5.2.1 Benthic Sample Collection

Benthic invertebrates were collected on August 15 (MAM; exposure area), August 19 (Lake D1; reference area) and August 28 (Lake 8; reference area), 2020, with five sampling stations nested within each of these areas (Table 47). Water depth at the point of sampling was determined using an electronic sonar device. The coordinates of the sampling stations were determined using a handheld GPS. The locations of the sampling stations are shown for Mammoth Lake, Lake 8 and Lake D1 in Figure 5, Figure 6, and Figure 7, respectively. The coordinates and depths of the sampling locations are presented in Table 47.

Samples were collected from a boat using a cleaned, stainless steel petite Ponar grab (0.023 m^2). Samples were washed on site using a 500-µm Nitex bag, transferred to a 1 L plastic bottle, and preserved with 10% buffered formalin. Sample sediments were always sieved down such that the residue (sediments and animals) amounted to less than approximately 100 ml of material. Duplicate samples per station, were combined in the field. Duplicates from MAM station 5 were kept separate in the field for individual analysis by the taxonomist. Sample containers were packed in coolers/plastic totes and transported to Zaranko Environmental Assessment Services (ZEAS), who provided taxonomic services for these and all previous CREMP samples collected since 2006.

Table 47. Benthos collection sample location coordinates and depths, Whale Tail Mine 2020.

Area	Station	Depth (m)	Latitude (dd mm ss)	Longitude (dd mm ss)	Zone	Easting (m)	Northing (m)
Lake D1	1	8.3	65°21'0.08"N	96°41'54.61"W	14W	607090	7249420
	2	7.8	65°21'1.38"N	96°41'57.43"W	14W	607052	7249459
	3	7.0	65°21'2.18"N	96°42'0.69"W	14W	607009	7249482
	4	7.4	65°21'1.83"N	96°41'59.41"W	14W	607026	7249472
	5	7.9	65°21'0.39"N	96°41'51.64"W	14W	607128	7249431
Lake 8	1	7.8	65°25'40.00"N	96°35'35.59"W	14W	611656	7258264
	2	7.5	65°25'39.57"N	96°35'35.09"W	14W	611663	7258251
	3	7.5	65°25'40.60"N	96°35'38.95"W	14W	611612	7258281
	4	7.4	65°26'13.96"N	96°35'27.12"W	14W	611725	7259319
	5	7.9	65°25'41.25"N	96°35'41.30"W	14W	611581	7258300
MAM	1	7.9	65°23'58.83"N	96°44'16.11"W	14W	605063	7254885
	2	7.7	65°23'59.05"N	96°44'17.88"W	14W	605040	7254891
	3	7.9	65°23'58.92"N	96°44'19.60"W	14W	605018	7254886
	4	7.9	65°23'58.57"N	96°44'22.42"W	14W	604982	7254874
	5	8.6	65°23'58.01"N	96°44'19.60"W	14W	605019	7254858

5.2.2 Supporting Environmental Variables

5.2.2.1 Water

Water samples were collected the same day that benthic samples were collected from two randomly selected locations situated near the benthos sampling areas in Mammoth Lake and within each of the reference lakes. The locations of the water sampling locations are shown for Mammoth Lake, Lake 8 and Lake D1 in Figure 5, Figure 6, and Figure 7, respectively. The coordinates of the sampling locations are presented in Table 48.

Water depth at the point of sampling was determined using an electronic sonar device. The lakes were not thermally or chemically (determined by specific conductance) stratified, so water was collected from 3 m below surface. Samples collected in the past for CREMP have all similarly been collected from 3 m below surface. The samples were shipped to ALS Environmental Ltd., Burnaby, British Columbia, for analysis. The analytes and their detection limits are provided in Table 49.

Specific conductance (µS/cm), pH, dissolved oxygen (mg/L) and temperature (°C) were determined at the time of benthic invertebrate sample collection with an YSI Professional Plus. Meter calibration was undertaken daily following the methods in the user manual. Parameter resolution and accuracy are as follows:

- Specific conductance; resolution: 1 µS/cm, accuracy: the greater of ±1% of reading or 1 µS/cm.
- pH; resolution: 0.01 units, accuracy: ±0.2 units.
- Dissolved oxygen; resolution: 0.1 mg/L, accuracy: the greater of ±2% of reading or 0.2 mg/L.
- Temperature; resolution: 0.1°C, accuracy: ±0.2°C.

These parameters were measured at 1 m intervals from surface to 1 m off bottom, at the water quality stations, to document the level of stratification at the time of benthic invertebrate sampling.

Table 48. Location coordinates of water chemistry samples, Whale Tail Mine 2020.

Area	Water Sample	Depth (m)	Latitude (dd mm ss)	Longitude (dd mm ss)	Zone	Easting (m)	Northing (m)
Lake D1	LK1-23	13.1	65°18'28.25"N	96°42'49.36"W	14W	606553	7244696
	LK1-24	9.6	65°19'57.48"N	96°41'12.28"W	14W	607708	7247503
Lake 8	LK8-17	9.5	65°25'44.82"N	96°33'35.13"W	14W	613202	7258473
	LK8-18	12.5	65°25'39.70"N	96°35'21.34"W	14W	611840	7258262
MAM	MAM-53	5.8	65°24'1.60"N	96°43'49.51"W	14W	605403	7254983
	MAM-54	5.5	65°23'39.05"N	96°45'31.70"W	14W	604110	7254238

Table 49. Water Quality Parameters and associated Detection Limits, Whale Tail Mine 2020.

Parameter	Detection Limit	Units
Conductivity	2	µS/cm
Hardness	0.5	mg/L
pH	0.1	-
Total Suspended Solids	1	mg/L
Total Dissolved Solids	3	mg/L
Turbidity	0.1	NTU
Alkalinity	1	mg/L
Ammonia	0.005	mg/L
Bromide	0.05	mg/L
Chloride	0.1	mg/L
Fluoride	0.02	mg/L
Nitrate	0.005	mg/L
Nitrite	0.001	mg/L
Total Kjeldahl Nitrogen	0.05	mg/L
Ortho Phosphate	0.001	mg/L
Total Phosphorus	0.002	mg/L
Silicate	0.5	mg/L
Sulfate	0.3	mg/L
Total Cyanide	0.001	mg/L
Free Cyanide	0.001	mg/L
Dissolved Organic Carbon	0.5	mg/L
Total Organic Carbon	0.5	mg/L
Aluminum	0.003	mg/L
Antimony	0.0001	mg/L
Arsenic	0.0001	mg/L
Barium	0.00005	mg/L
Beryllium	0.0001	mg/L
Bismuth	0.00005	mg/L
Boron	0.01	mg/L
Cadmium	0.000005	mg/L

Parameter	Detection Limit	Units
Calcium	0.05	mg/L
Chromium[4]	0.0001	mg/L
Cobalt	0.0001	mg/L
Copper	0.0005	mg/L
Iron	0.01	mg/L
Lead	0.00005	mg/L
Lithium	0.001	mg/L
Magnesium	0.1	mg/L
Manganese	0.0001	mg/L
Mercury	0.000005	mg/L
Molybdenum	0.00005	mg/L
Nickel	0.0005	mg/L
Phosphorus	0.05	mg/L
Potassium	0.1	mg/L
Selenium	0.00005	mg/L
Silicon	0.1	mg/L
Silver	0.00001	mg/L
Sodium	0.05	mg/L
Strontium	0.0002	mg/L
Sulfur	0.5	mg/L
Thallium	0.00001	mg/L
Tin	0.0001	mg/L
Titanium	0.0003	mg/L
Uranium	0.00001	mg/L
Vanadium	0.0005	mg/L
Zinc	0.003	mg/L
Radium-226	0.002	Bq/L

5.2.2.2 Sediment

Similar to benthic sample collection, sediment samples were collected using a petite Ponar (0.023 m^2). The top 3-5 cm from two independent grabs per station were homogenized in a bowl then scooped into a sample jar for submission to the laboratory. Sediment samples were analyzed for:

- Total organic carbon (%) and,
- Sediment particle size (% gravel, sand, silt, clay), per the Wentworth Classification.

Detection limits for sediment quality measures are provided in Table 50 below.

Table 50. Sediment Measures Detection Limits.

Parameter	Detection Limit	Units
% Gravel (> 2 mm)	1	%
% Sand (2 mm to 0.063 mm)	1	%
% Silt (0.063 mm to 4 μm)	1	%
% Clay (<4 μm)	1	%
Total Organic Carbon	0.1	%

Grain size data were used to compute an overall summary variable describing geometric mean particle size (GMP).

$$GMP = \left[{d_g}^{w_g}\right] * \left[{d_{sa}}^{w_{sa}}\right] * \left[{d_{si}}^{w_{si}}\right] * \left[{d_c}^{w_c}\right]$$

where, d is the midpoint diameter of particles retained by a given sieve for gravel (g), sand (sa), silt (si) and clay (c), and w is the decimal fraction by weight of particles retained by a given sieve.

5.2.3 Data Analysis

5.2.3.1 Data

The data utilized in the analyses included all prior annually collected benthic invertebrate community samples from 2015 to 2020 for MAM and from 2018 to 2020 for Lake D1 and Lake 8. There were always five sample stations per area per year, as per Agnico's CREMP sampling design. In total, there were 60 two-grab benthos samples in the data set per Table 51 below.

Table 51. Summary of number of benthos stations per sample area, by year, Whale Tail Mine.

Exposure Period	Year	Area			Grand Total
		MAM	Lake D1	Lake 8	
Baseline Period	2015	5			5
	2016	5			5
	2017	5			5
	2018	5	5	5	15
Exposure Period	2019	5	5	5	15
	2020	5	5	5	15
Grand Total		30	15	15	60

5.2.3.2 Descriptors of Benthic Community Composition

Organisms were identified to lowest practical level. The data were 'rolled up' to the level of Family for this analysis. Acarina were identified to genus in 2017, and only identified to Acarina in other previous years. The 2017 genera were rolled up to Acarina to be consistent with the level of identification in other years.

For each sample, the following core descriptors of community composition and indices were calculated, as per the federal guidance for metal mining EEM (Environment Canada, 2012):

- Density (total number of animals per m^2);
- Taxon Richness (number of Families),
- Evenness (E), where,

$$E = 1/\sum(p_i)^2\ /S;$$

where pi is the proportion that taxon i contributes to the total number of invertebrates in a sample, and S is the number of families.

- Bray-Curtis Distance Index, where,

$$BC = \frac{\sum|y_{i1} - y_{i2}|}{\sum(y_{i1} - y_{i2})}$$

Where, y_{i1} = abundance of family *i* in sample 1, y_{i2} = abundance of family *i* in sample 2.

Bray-Curtis distances were computed between all pairs of the n=60 samples. Abundances were log transformed to provide reasonable NMDS scores. The Bray-Curtis distance matrix was used as the input distance matrix for an NMDS-based ordination carried out in SYSTAT. Two NMDS axes were produced by the ordination. Pearson correlations between raw taxa (family) abundances and sample scores on each of the NMDS axes were computed. A scatterplot of taxa correlations was produced in order to illustrate the relationship between taxa abundances and NMDS axis scores. Scatterplots of NMDS sample scores, by year, were produced in order to illustrate variations in benthic community composition among sample areas, over time.

In addition, the following index was calculated:

- Simpson's Diversity (D), where,

$$D = 1 - \sum(p_i)^2$$

Simpson's diversity is used as a 'supporting' variable in the analysis.

Sample area means, medians, standard deviations, standard errors, minimum and maximum values for abundance, family richness and evenness were computed for 2020 data. The mean, median, SD, SE, minimum and maximum Bray-Curtis distances within MAM, LK1 and LK8, and between MAM and LK1 and LK8, were also computed using only the 2020 data

5.2.3.3 Testing for Effluent Related Effects

To determine if variations in benthic community structure are associated with mine effluent, a combination of graphical and hypothesis testing procedures (ANOVA) were used. Classical ANOVA was used to test for changes in differences in average values of compositional indices between reference and exposure areas.

With this study, sampling areas represent two levels of exposure: (1) reference and (2) exposure. There are also two time periods to consider: (1) Baseline Period and (2) Effluent Exposure Period in MAM (i.e., 2019 to present). As natural differences among lakes can be anticipated (Underwood, 1989, 1991, 1993, 1994), the full complement of baseline and exposure period data (see Table 51) were used in an ANOVAs with Planned Linear Orthogonal Contrasts (or PLOC; see Hoke et al., 1990; Environment Canada and Department of Fisheries and Oceans, 1995). PLOC can test very specific hypotheses that are likely to be of interest and that take into account that within a time period there are likely to be natural differences between reference and exposure areas. Hypotheses 1, 2a, 2b, 3a and 3b were the tested contrasts as illustrated in Table 52, below.

ANOVA 1 tested the hypothesis that there are no differences in indices of benthic community composition between Mammoth Lake and the two reference lakes in 2020 (H01). This is the conventional EEM ANOVA. Data from all other baseline periods were used to put observed differences, if significant, into context. Acceptance of the null hypothesis, i.e., no significant differences, would support a conclusion that there are no effluent-related effects. Rejection of the null hypothesis would suggest the potential for effluent related effects, prompting ANOVA 2.

ANOVA 2 used data only from Mammoth Lake to compare the baseline period to the exposure period in a before-after context. Hypothesis 2a (H02a) was tested using MAM data from the baseline period (2015 to 2018) with contrast to the exposure period (2019 and 2020), while hypothesis 2b (H02b) was tested using MAM data from the baseline period (2015 to 2018) with contrasts to exposure in 2020 only. This second hypothesis (H02b) was used because data in 2019 represented a newly exposed condition that may not have fully reflected the degree of effects that may have occurred. Hypothesis 2a (H02a) may therefore not demonstrate effects because of a potential dilution of effects from 2019. It should be noted that flow into from Whale Tail Lake into Mammoth Lake ceased with the construction of the dikes isolating the north basin of Whale Tail Lake in 2019; the discharge of effluent was not the only change.

ANOVA 3 used data from Mammoth Lake and both reference lakes in all years in a classic before-after-control-impact (BACI) design. Data from 2018 to 2020 were used, as there are no data for 2015, 2016 or 2017 for the reference lakes. Hypothesis 3a (H03a) was tested using MAM data from the baseline period (2018) and exposure period (2019 to 2020) with contrasts to the reference lakes, while hypothesis 3b (H03b) was tested using MAM data from the baseline period (2018) and the 2020 exposure period only.

For these ANOVAs, the variation among stations was used to judge the significance of the contrasts. The mean squared error term (MSE) was estimated through an omnibus ANOVA that incorporates data from all sample areas and years. Doing that ensures the most robust estimate of among station variability (i.e., among station SD), and therefore the most robust evaluation of the hypotheses.

Table 52. Linear contrasts (and associated coefficients) that were used to analyze the 2020 benthic community data from MAM, Lake D1 and Lake 8 (Whale Tail Mine).

Year	Exposure Period	ANOVA 1			ANOVA 2a			ANOVA 2b		
		Exposure vs Reference in 2020			Before-After in the Exposure			Before-After in the Exposure		
		Reference		Exposure	Reference		Exposure	Reference		Exposure
		Lake D1	Lake 8	MAM	Lake D1	Lake 8	MAM	Lake D1	Lake 8	MAM
2015	Baseline	no data	no data		no data	no data	0.25	no data	no data	0.25
2016							0.25			0.25
2017							0.25			0.25
2018							0.25			0.25
2019	Exposure						-0.5			0
2020		0.5	0.5	-1			-0.5			-1
Power		0.96			0.98			0.90		
Year	Exposure Period				ANOVA 3a			ANOVA 3b		
					Before-After/Control-Impact (BACI)			Before-After/Control-Impact (BACI)		
					Reference		Exposure	Reference		Exposure
					Lake D1	Lake 8	MAM	Lake D1	Lake 8	MAM
2015	Baseline				no data	no data		no data	no data	
2016										
2017										
2018					0.25	0.25	-0.5	0.25	0.25	-0.5
2019	Exposure				-0.125	-0.125	0.25	0	0	0
2020					-0.125	-0.125	0.25	-0.25	-0.25	0.5
Power					0.90			0.81		

Table Notes: Statistical power (probability of detecting an effect when the effect size is ±2x reference area standard deviation) is also provided for each contrast.

5.2.3.4 Assessment of Covariable Effects

Prior to running ANOVAs, the associations between benthos and potential modifying factors (i.e., depth, substrate texture, sediment TOC) using backwards, stepwise, multiple regression were examined. For indices that were significantly influenced by a modifying factor, the data were standardized using general linear models based on reference data, with application of the models to exposure data (per Bailey et al., 1998; Kilgour et al., 2018). Standardized benthic indices (i.e., standardized to a common depth, grain size, and/or TOC, as appropriate) were then the inputs to the ANOVAs.

5.2.3.5 Assessment of Bray-Curtis Distances

Mantel tests were used to test the hypotheses listed in Table 52, and using the methods described by Borcard and Legendre (2013). Mantel tests were completed in *R* Software. As there is no simple way in a Mantel test to partial-out the effects of covariables such as depth, grain size and/or TOC, the Bray-Curtis distances were used to compute NMDS axis scores which were modelled in a similar fashion as the other core and supporting indices of composition.

5.2.3.6 Comparison to Reference Normal

Variations tested by HO1, HO2a,b and HO3a,b were put into context using normal ranges computed from reference data. Normal ranges are conventionally thought of as the range of data that captures 95% of observations (from a reference condition), and are approximated by:

$$95\%\ region = \bar{x} \pm 2SD$$

Where, $\bar{x}$ is the reference data mean, and SD is the standard deviation of the reference data (Kilgour et al., 1998; 2017). The value “2” is rounded up from the standard normal deviate of 1.96 for the 97.5th percentile for a normal distribution. In EEMs, the SD term is normally that for replicates (typically 5) within the reference sampling area (typically only 1 area). In the case here, of Mammoth Lake, it was desired to estimate the normal range of reference data for the two reference lakes Lake D1 and Lake 8 (considered ‘randomly’ chosen from a statistical perspective). There were also multiple years (3) of data from each reference lake (with years also considered ‘random’). Within each year and lake there were 5 replicate benthic samples (with replicate samples considered ‘random’). The calculation of SD for cases like this, when there are nested random effects (i.e., replicates within areas within times), is somewhat more involved if it is to be done with accuracy. The Parametric Bootstrap Method was used, as described by Smith (2002). [Note: the study design indicated the Bagui Method would be used, as described by Smith, 2002, but it was found that the Bootstrap Method more accurately determined the limits of the normal ranges via a simulation experiment (B. Kilgour, unpublished data)].

The Parametric Bootstrap Method involves the following general steps (from Smith, 2002):

1. Compute the following variance terms from an analysis of variance of the reference data from Lake D1 and Lake 8 with the following source terms: Year, Lake, Error;
    a. Variance among replicates (i.e., error);
    b. Variance among years;
    c. Variance among lakes.
2. Use the variance terms to set up a simulation exercise (here with 100 ‘runs’) that draws random samples for Lake D1 and Lake 8 given the observed variance terms.
3. For each ‘run’, do the following:
    a. Compute variance components for ‘lake’ (S_L^2), ‘year’ (S_Y^2), and sample or ‘error’ (S_E^2);
    b. Compute the standard deviation of replicates, (S_x^2) considering sample, year, and lake terms, as $S_x = \sqrt{S_L^2 + S_Y^2 + S_E^2}$;
    c. Compute estimated tolerance limits for the reference data as $tolerance\ limits = \bar{x} \pm kSD_x$, where k is a tolerance factor for the 97.5th percentile with *n*-1 degrees of freedom (and where *n* is the total sample size across lakes and years).
4. From the 100 simulated upper tolerance limits, compute the 95th percentile as the bound for the upper end of reference data; and,
5. From the 100 simulated lower tolerance limits, compute the 5th percentile of as the bound for the lower end of reference data.

The calculations of normal ranges were applied to 'residuals' of the core indices of composition, since (and as is shown later) variations in the core indices varied significantly with underlying co-variables (total organic carbon, water depth, grain size). The limits as calculated represent the range within which it can be anticipated with 95% likelihood that a new reference sample (from either lake or any time period) would occur (Smith, 2002).

5.2.3.7 Effect Sizes

The general equation for effect sizes that applied to all hypotheses, was the following:

$$ES_{HO} = \frac{\sum c_i \bar{x}_i}{SD_x}$$

Where;

- c_i are the contrast coefficients indicated in Table 6 for each lake x time combination (*i*) ;
- $\bar{x}_i$ are the lake x time means; and,
- SD_x is as defined above.

An effect size for the Mantel tests was not computed on Bray-Curtis distances since there is no guidance on how to do so and further no guidance on how to interpret the relevance of the Mantel correlation (Environment Canada, 2012; Borcard and Legendre, 2013).

The ability to detect an effect depends on sample size; where the study relies on a contrast of reference versus exposure locations, sample sizes refer to the number of replicate stations within both reference and exposure areas. Environment Canada (2012) has deemed that effects that exceed two times the standard deviation of reference-station values (i.e., ±2SD_r) will require further investigation. Therefore, it is necessary to calculate the probability that a difference of ± 2SD_r could be detected with a certain number of stations in both control and impact sampling areas.

In this study, power for each of the contrasts was computed in PASS 2020 v20.0.1, following Desu and Raghavarao (1990), Fleiss (1986) and Kirk (1982), with the critical effect size being 2SD_r in magnitude, and with SD_r being the equivalent of the SD_E described earlier.

5.2.3.8 Precision

Statistical power is a function of the underlying true effect size (or correlation) and number of replicate samples. In this EEM study, stations were considered the unit of replication, so it was the number of replicate stations within each area that was of critical importance in determining the power of the study. An additional factor indirectly influencing the power of a study is the degree of precision with which descriptors of community composition have been estimated. In benthic ecology, it is generally recommended that descriptors of community composition be estimated to within ± 20% of the actual (true) value (Elliott, 1977), which is what is stated in Environment Canada's (2012) guidance document.

The precision (*P*) of within-station estimates can be estimated as:

$$P = \frac{S}{\sqrt{n}\bar{x}}$$

where *s* is the within-station standard deviation, n is the number of replicate (field) sub-samples, and $\bar{x}$ is the estimated mean of the community descriptor. This equation can be re-arranged to solve for the number of replicate samples required to achieve the desired precision (*P*) of 0.2 (i.e., 20%):

$$n = \frac{S^2}{P^2 \bar{x}^2}$$

The standard deviation can be estimated for each station separately, resulting in an estimated number of samples required to achieve the desired precision for the next study.

5.3 Results

5.3.1 Supporting Environmental Variables

5.3.1.1 General Limnology

Temperatures were homogeneous from surface to bottom in all three lakes (Figure 24). Dissolved oxygen profiles were similar, with about 8.9-9.9 mg/L from surface to 1 m off bottom in each area (Figure 24). There was no indication of an oxygen depression near the sediments in any of the three lakes. In MAM there was a slight increase in dissolved oxygen concentrations near the sediment-water interface. Specific conductivity profiles in all three areas were also homogeneous from surface to bottom, with the highest conductivity in MAM (129 µS/cm and 147 µS/cm), followed by Lake 8 (16.1-16.7 µS/cm) and Lake D1 (14.7-14.8 µS/cm).

The benthos sampling stations in each lake were of similar depths, averaging 7.7 m in Lake D1, 7.6 m in Lake 8 and 8.0 m in MAM. Water depths for stations in 2020 were similar to previous years (Figure 25).

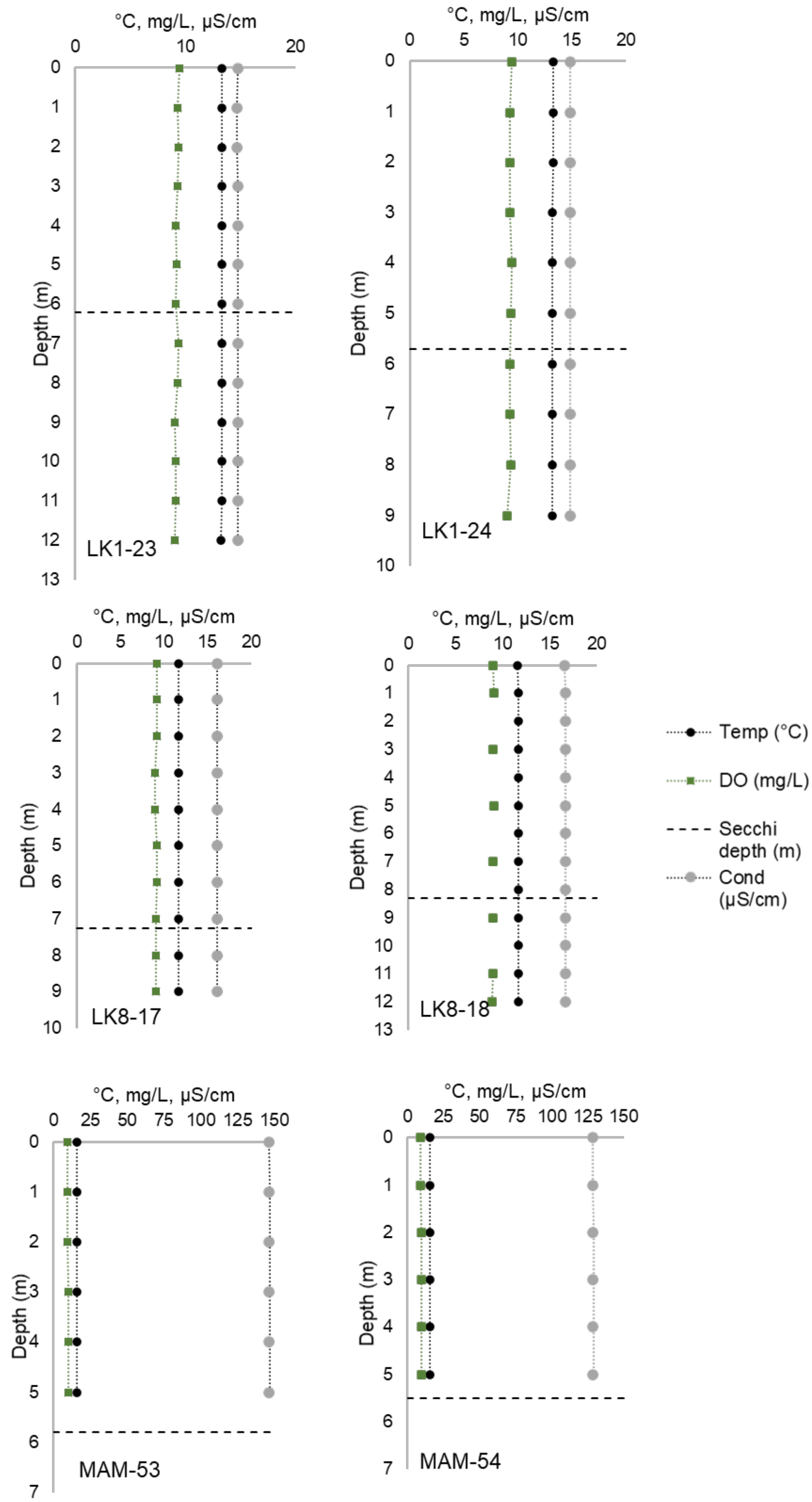

Figure 24. Depth profiles for water temperature, dissolved oxygen (DO) and specific conductivity (Cond), in each of the three benthos sampling areas, Lake D1, Lake 8 and MAM, Whale Tail Mine 2020.

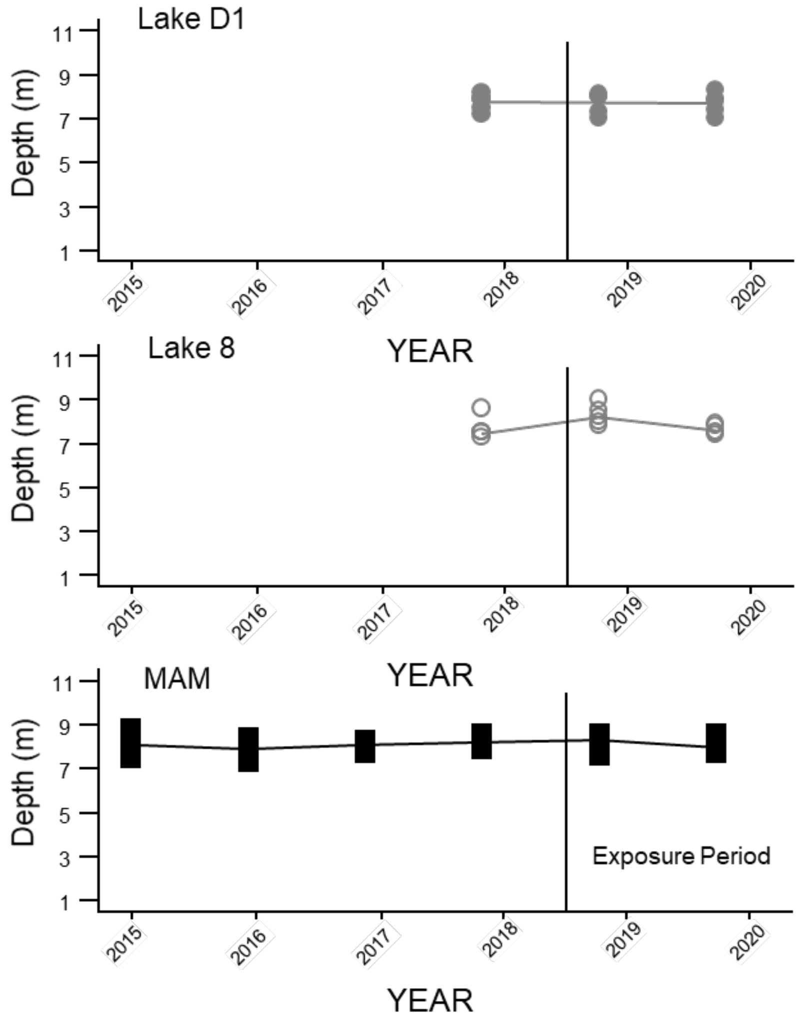

Figure 25. Water depth at the benthic sampling stations, by year, for Lake D1, Lake 8 and MAM, Whale Tail Mine 2020.

Figure Note: the line illustrates Locally Weighted Scatterplot Smoothing (LOWESS)-smoothed variations in annual averages.

5.3.1.2 Laboratory Water Chemistry

The water chemistry results for the benthos sampling areas are provided in Table 53 below.

The waters from the two control lakes were very soft, with hardness values of around 14 mg/L at LK1 and LK8. Hardness at MAM was higher, ranging from 130 to 147 mg/L. Total ammonia concentrations were detectable, ranging from <0.005 to 0.009 mg/L in the reference lakes and from 0.02 to 0.07 mg/L in MAM. Chloride concentrations in MAM were around 21 mg/L, higher than what was measured in LK1 (0.68 mg/L) and LK8 (0.57 mg/L), but very low relative to the CCME (2011) water quality guideline of 120 mg/L. Orthophosphate and total phosphorus were at non-detectable concentrations in all three lakes. Sulphate concentrations were 1.0 mg/L in LK1, 1.6 mg/L in LK8, and about 12.5 mg/L in MAM.

Measured concentrations of total metals never exceeded CCME guidelines for the protection of aquatic life (Table 53) in any of the lakes. Many of the metals were at or near non-detectable concentrations in all three lakes, including Sb, Be, Bi, B, Cr, Co, Cu, Pb, Hg, Mo, Ni, Se, Ag, Tl, Sn, Ti, V and Zn. Concentrations of the metals As, Ba, Mg, Mn, Si, Sr, and U were modestly higher in MAM than in the reference lakes.

Concentrations of the cations Ca, K, Na were higher in MAM than the two reference lakes, reflecting the higher hardness in MAM. Sulfur was at non-detectable concentration in LK1 and LK8 (i.e., < 0.5 mg/L), and was over 6x the detection limit in MAM (~ 4 mg/L).

Table 53. Detailed water quality for the benthos monitoring areas, Whale Tail Mine 2020.

Variable	Units	CCME	LK1-23	LK1-24	LK8-17	LK8-18	MAM-53	MAM-54
Physical Tests								
Conductivity	µS/cm		14.1	14.2	14.0	13.9	147.0	130.0
Hardness (as $CaCO_3$)	mg/L		5.38	5.37	5.24	5.25	50.30	43.50
pH (Laboratory)			6.71	6.74	6.75	6.75	7.24	7.21
Total Suspended Solids	mg/L		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Dissolved Solids	mg/L		12.6	12.4	10.6	11.6	114.0	101.0
Turbidity	NTU		0.22	0.23	0.13	0.16	0.28	0.25
Anions and Nutrients								
Alkalinity, Total	mg/L		2.7	4.7	4.4	4.5	14.9	13.6
Ammonia, Total (as N)	mg/L	equation[1]	<0.0050	0.009	0.0086	<0.0050	0.0757	0.0249
Bromide (Br)	mg/L		<0.050	<0.050	<0.050	<0.050	0.206	0.176
Chloride (Cl)	mg/L	120	0.69	0.67	0.56	0.58	22.20	20.10
Fluoride (F)	mg/L	0.12	0.04	0.035	0.028	0.027	0.051	0.051
Nitrate (as N)	mg/L	3	<0.0050	<0.0050	<0.0050	<0.0050	0.78	0.565
Nitrite (as N)	mg/L	0.06	<0.0010	<0.0010	<0.0010	<0.0010	0.012	0.0065
Total Kjeldahl Nitrogen	mg/L		0.105	0.129	0.113	0.099	0.29	0.204
Orthophosphate-Dissolved (as P)	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total Dissolved	mg/L		<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Phosphorus (P)-Total	mg/L	0.004	0.0021	<0.0020	<0.0020	0.0026	<0.0020	0.0024
Silicate (as SiO_2)	mg/L		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Sulfate (SO_4)	mg/L		1.05	1.08	1.50	1.49	13.70	11.10
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		2.16	2.02	1.57	1.75	2.53	2.15
Total Organic Carbon	mg/L		1.86	1.98	1.63	1.63	2.20	2.02
Plant Pigments								
Chlorophyll-*a*	µg/L		0.412	0.564	0.458	0.386	1.090	1.150
Total Metals								
Aluminum (Al)-Total	mg/L	equation	0.0062	0.007	0.0046	0.0048	0.0057	0.0051
Antimony (Sb)-Total	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	0.00076	0.00049
Arsenic (As)-Total	mg/L	0.005	0.00014	0.00016	0.00018	0.00017	0.00124	0.00111
Barium (Ba)-Total	mg/L		0.00311	0.00329	0.00219	0.00246	0.0245	0.0211
Beryllium (Be)-Total	mg/L		<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100

Variable	Units	CCME	LK1-23	LK1-24	LK8-17	LK8-18	MAM-53	MAM-54
Bismuth (Bi)-Total	mg/L		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	1.5	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	equation	0.0000067	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Total	mg/L		1.26	1.27	1.04	1.10	15.00	13.50
Chromium (Cr)-Total	mg/L	0.001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Cobalt (Co)-Total	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	0.00011	<0.00010
Copper (Cu)-Total	mg/L	equation	<0.00050	<0.00050	<0.00050	<0.00050	0.00069	0.00062
Iron (Fe)-Total	mg/L	0.3	0.022	0.025	<0.010	<0.010	0.020	0.017
Lead (Pb)-Total	mg/L	equation	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Total	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	0.0026	0.0024
Magnesium (Mg)-Total	mg/L		0.521	0.564	0.547	0.608	3.640	3.160
Manganese (Mn)-Total	mg/L		0.00285	0.00401	0.00126	0.00138	0.0129	0.00462
Mercury (Hg)-Total	mg/L	0.000026	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.073	<0.000050	<0.000050	<0.000050	<0.000050	0.00114	0.000814
Nickel (Ni)-Total	mg/L	equation	<0.00050	<0.00050	<0.00050	<0.00050	0.00147	0.00108
Phosphorus (P)-Total	mg/L		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Potassium (K)-Total	mg/L		0.287	0.314	0.295	0.331	3.650	3.100
Selenium (Se)-Total	mg/L	0.001	<0.000050	<0.000050	<0.000050	<0.000050	0.000113	0.000081
Silicon (Si)-Total	mg/L		0.32	0.32	0.30	0.31	0.69	0.64
Silver (Ag)-Total	mg/L	0.0001	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	mg/L		0.571	0.601	0.424	0.491	2.320	2.020
Strontium (Sr)-Total	mg/L		0.00789	0.00818	0.00495	0.00543	0.10100	0.08860
Sulfur (S)-Total	mg/L		<0.50	<0.50	<0.50	<0.50	4.54	3.69
Thallium (Tl)-Total	mg/L	0.0008	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L		<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Uranium (U)-Total	mg/L	0.015	0.00005	0.00005	0.00002	0.00002	0.00016	0.00011
Vanadium (V)-Total	mg/L		<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	0.03	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Radium-226	Bq/L		<0.002	<0.002	<0.002	<0.002	0.005	<0.002

[1]"equation" means that CCME guidelines (or thresholds) are calculated based on an equation which is either pH or hardness dependent. The ammonia and aluminum guidelines vary with pH; the cadmium, copper, lead, manganese, nickel and zinc guidelines vary with hardness. < indicates below detection limits.

5.3.1.3 Sediment Character

Grain size analysis and summary statistics collected from all the reference and exposure areas are provided in Table 54 and Table 55. Grain size of sediments collected from all lakes were similar in that they were all dominated by silt material, accounting for between 78% and 81% in MAM, between 76% and 83% in Lake D1, and between 65% and 74% in Lake 8. Moderate amounts of clay (7% to 20%) and sand (1% to 20%) were also present in all lakes, with negligible gravel (<1%). The mean particle size (GMP) of sediment for stations in 2020 were similar to what was observed in previous years (Figure 26).

Total organic carbon (TOC) in sediments ranged from 9.4% and 9.9% in MAM, from 1.6% and 4.3% in Lake D1, and from 1.2% to 2.6% in Lake 8, in 2020 (Table 54). TOC for stations in 2020 were similar to previous years (Figure 27).

Table 54. Variations in sample depth, TOC, sand, silt, and clay, Whale Tail Mine 2020.

Area	Station	Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	TOC (%)
Lake D1 (2020)	1	8.3	1.0	7.6	75.8	16.6	1.6
	2	7.8	1.0	6.3	79.9	13.8	1.8
	3	7.0	1.0	7.7	76.6	15.7	4.0
	4	7.4	1.0	6.0	78.8	15.2	4.3
	5	7.9	1.0	9.4	82.8	7.8	3.0
Lake 8 (2020)	1	7.8	1.0	20.8	71.5	6.9	1.2
	2	7.5	1.0	23.0	67.8	9.2	2.6
	3	7.5	1.0	27.5	65.2	7.3	1.3
	4	7.4	1.0	16.8	74.0	9.2	1.2
	5	7.9	1.0	18.3	69.8	11.9	1.2
MAM (2020)	1	7.9	1.0	1.1	79.6	19.3	9.6
	2	7.7	1.0	1.2	81.0	17.8	9.9
	3	7.9	1.0	5.9	78.6	15.5	9.6
	4	7.9	1.0	4.1	78.3	17.6	9.4
	5	8.6	1.0	1.8	79.9	18.3	9.5

Table 55. Summary statistics of sediment grain size and TOC of benthic invertebrate stations at the reference and exposure lakes, Whale Tail Mine 2020.

Area	Metric	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	GMP (mm)	TOC (%)
Lake D1 (2020)	Min	1.0	6.0	75.8	7.8	0.027	1.6
	Max	1.0	9.4	82.8	16.6	0.038	4.3
	Median	1.0	7.6	78.8	15.2	0.028	3.0
	Mean	1.0	7.4	78.8	13.8	0.030	2.9
	SD	0.0	1.4	2.8	3.5	0.004	1.2
	SE	0.0	0.6	1.2	1.6	0.002	0.6
Lake 8 (2020)	Min	1.0	16.8	65.2	6.9	0.045	1.2
	Max	1.0	27.5	74.0	11.9	0.071	2.6
	Median	1.0	20.8	69.8	9.2	0.057	1.2
	Mean	1.0	21.3	69.7	8.9	0.056	1.5
	SD	0.0	4.2	3.4	2.0	0.010	0.6
	SE	0.0	1.9	1.5	0.9	0.005	0.3
MAM (2020)	Min	1.0	1.1	78.3	15.5	0.020	9.4
	Max	1.0	5.9	81.0	19.3	0.027	9.9
	Median	1.0	1.8	79.6	17.8	0.022	9.6
	Mean	1.0	2.8	79.5	17.7	0.023	9.6
	SD	0.0	2.1	1.1	1.4	0.003	0.2
	SE	0.0	0.9	0.5	0.6	0.001	0.1

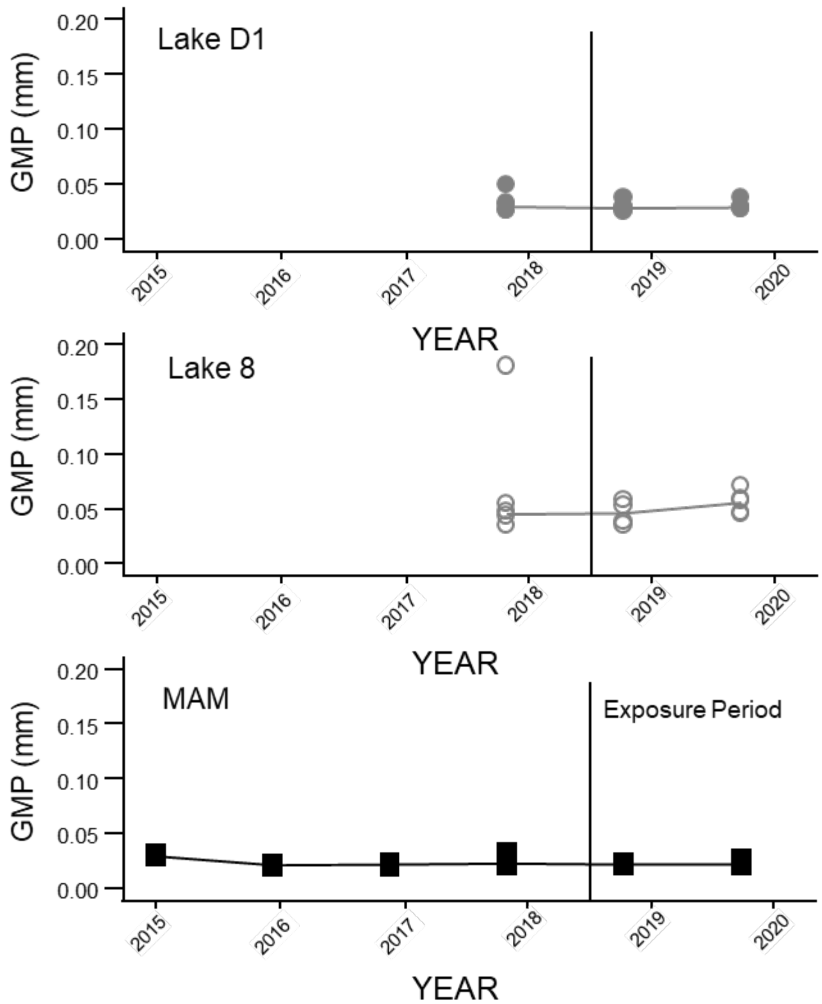

Figure 26. Geometric mean particle (GMP) size of sediment by year for Lake D1, Lake 8 and MAM, Whale Tail Mine.

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

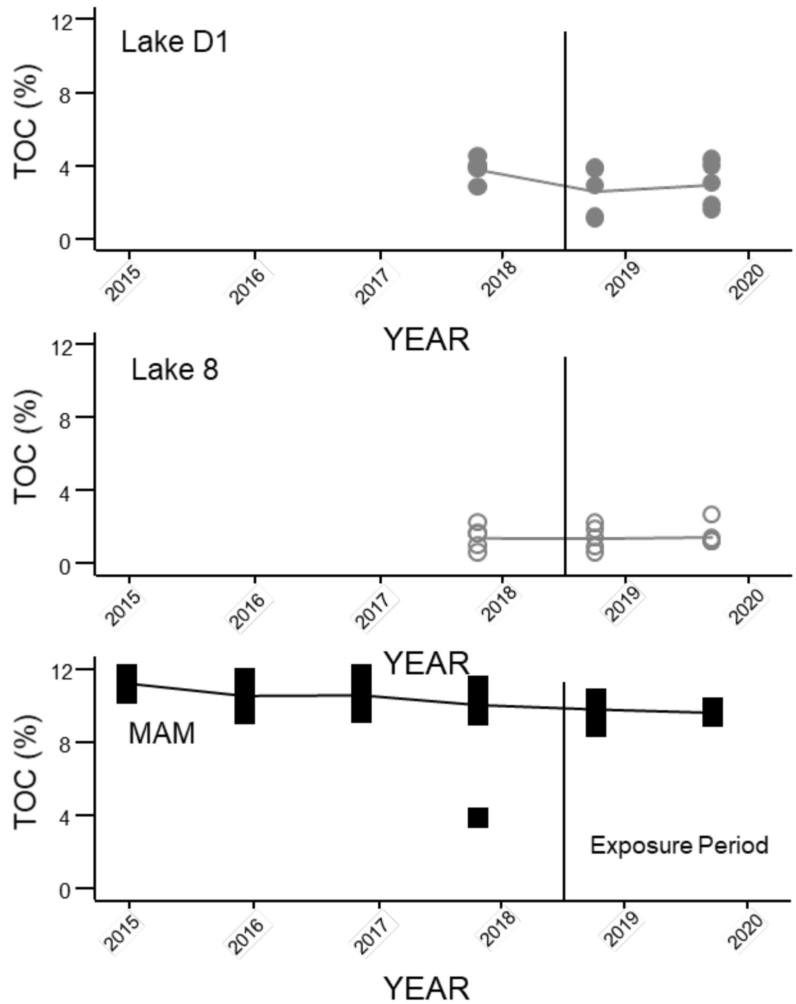

Figure 27. Total organic carbon (TOC) in sediment by year for Lake D1, Lake 8 and MAM, Whale Tail Mine.

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

5.3.2 Invertebrate Community Composition

5.3.2.1 General Description

Relative abundances of benthos families in each of the lakes from the start of CREMP monitoring through to and including this 2020 survey are presented in Table 56. Summary statistics for each of the core indices of composition are provided in Table 57 (Abundance, Family Richness, Evenness) and Table 58 (Bray-Curtis distances).

Benthic communities of the three study areas were generally similar in 2020. The benthos of MAM was numerically dominated by non-biting midges (Chironomidae 71%), with freshwater clams Pisidiidae subdominant (18%, Table 56). The benthos of Lake D1 and Lake 8 were also dominated by Chironomidae (76% and 48%, respectively), with freshwater clams subdominant (Pisidiidae 15% and 24%, respectively).

There were 7 chironomid genera in the MAM stations in 2020. The following chironomid genera were numerically dominant not only in MAM, but also in Lake D1 and Lake 8: *Corynocera*, *Micropsectra*, *Paratanytarsus*, *Stichtochironomus*, and *Tanytarsus*. All of these genera are commonly distributed in the Holarctic.

Quality assurance for the laboratory sorting of invertebrate samples is provided in Appendix 7. Sorting always produced > 95% of individuals in the samples, and was therefore acceptable.

Variations in total abundance and indices of composition (richness, evenness, diversity) over time and within sample areas are illustrated in Figure 28 through Figure 31. Abundances in samples from MAM in 2020 varied between about 5,800 and 9,600 individuals per m^2. Abundances in samples from Lake D1 varied between about 2,100 and 5,400 individuals per m^2, while abundances in Lake 8 varied between about 2,900 and 5,300 individuals per m^2. Historically, abundances in MAM have typically averaged 4,600 to 7,900 individuals per m^2. Abundances in 2020 were higher in MAM, Lake D1 and Lake 8, compared to previous years.

In 2020, benthic samples from MAM produced between 8 and 9 families per sample (i.e., per pair of Ponar grabs; see Figure 29), while samples from Lake D1 and Lake 8 produced between 6 and 9 families per sample. Those family richness values were consistent with the range of values historically reported.

Evenness values in 2020 in MAM varied between 0.2 and 0.3 in 2020. The range of values at MAM was within the range of values that was historically reported for that lake, which have averaged from 0.2 to 0.4. Values reported in 2020 were 0.2 to 0.3 at Lake D1 and 0.4 to 0.8 at Lake 8, with historical values ranging between 0.2 to 0.6 at Lake D1 and 0.4 to 0.6 at Lake 8 (Figure 30).

Diversity values averaged ~ 0.6 in 2020 in MAM, compared to an average of ~ 0.4 in 2019, and averages that ranged between 0.74 and 0.43 in the baseline period (2015 to 2018). Diversity values in Lake D1 in 2020 (~ 0.4) were modestly lower than MAM, while diversity in Lake 8 in 2020 (0.74) was modestly higher than MAM.

The results of the NMDS ordination are illustrated in Figure 32 (taxa correlations with axis scores) and Figure 33 (sample scores). Nemata abundances were most strongly and positively associated with Axis 1 scores, whereas Ostracoda were most strongly and negatively associated with Axis 1 scores. Thus, samples with higher Axis 1 scores had higher numbers of Nemata, while samples with lower Axis 1 scores had higher numbers of Ostracoda. Naididae abundances were most strongly and positively associated with Axis 2 scores, such that samples with higher Axis 2 scores had higher numbers of Naididae. Figure 33 illustrates the variations over time in axis scores. In 2020, benthic community data from MAM produced similar Axis 1 and Axis 2 scores when compared to Lake D1 and Lake 8. These scores reflect similar relative abundances of taxa. During baseline years (2015-2018) however, MAM produced lower Axis 1 scores, ranging between -1.6 and -1.0. MAM produced Axis 2 scores ranging between –1 and 1 in both baseline years and exposure years, and had axis 2 scores similar to the two reference lakes (Lake D1 and Lake 8).

Table 56. Relative abundances (%) of benthos taxa (families or higher level) and average of indices by year for Lake D1, Lake 8 and MAM, Whale Tail Mine.

Taxon	Lake D1			Lake 8			MAM					
	2018	2019	2020	2018	2019	2020	2015	2016	2017	2018	2019	2020
Nemata	3	2	2	8	4	5	1	2	0	7	1	2
Platyhelminthes	<1	<1	<1	<1	<1		<1	<1	<1	1		<1
Naididae	<1	1	1	1	1	1	1	1	1	1	<1	1
Lumbriculidae	2	1	1	1	1	1	1	<1	<1	2	1	1
Acarina	3	1	1	3	7	4	2	2	2	2	<1	1
Ostracoda			<1				6	16	13			
Notostraca							<1	<1	<1			
Limnephilidae			<1		<1	<1	<1	<1	<1			
Chironomidae	69	71	76	39	48	48	76	66	64	61	81	71
Empididae				<1								
Pisidiidae	18	22	15	25	28	24	14	13	18	17	12	18
Indices												
Density	2,317	2,957	3,491	3,296	4,074	4,317	4,813	4,843	5,148	4,604	7,983	6,878
Family Richness	5.8	6.6	6.8	6.8	7.8	6.8	7.2	6.6	7.0	7.6	5.8	7.4
Family Diversity	0.50	0.42	0.39	0.71	0.66	0.66	0.44	0.52	0.54	0.59	0.33	0.47
Family Evenness	0.37	0.27	0.25	0.53	0.39	0.45	0.27	0.37	0.32	0.33	0.26	0.26

Table 57. Mean, median, minimum, maximum, standard deviation (SD) and standard error (SE) for core indices of benthic community composition for Lake D1, Lake 8 and MAM in 2020.

Area	Metric	Density	Family Richness	Family Evenness
Lake D1 (2020)	Min	2,130	7.0	0.19
	Max	5,370	9.0	0.28
	Mean	2,826	8.0	0.21
	Median	3,491	7.8	0.23
	SD	1,492	0.8	0.04
	SE	667	0.4	0.02
Lake 8 (2020)	Min	2,913	6.0	0.43
	Max	5,348	8.0	0.83
	Mean	4,457	7.0	0.62
	Median	4,317	6.8	0.63
	SD	920	0.8	0.19
	SE	412	0.4	0.09
MAM (2020)	Min	5,783	8.0	0.19
	Max	9,652	9.0	0.33
	Mean	6,283	8.0	0.32
	Median	6,878	8.4	0.28
	SD	1,582	0.55	0.06
	SE	707	0.24	0.03

Table 58. Mean, median, minimum, maximum, standard deviation (SD) and standard error (SE) for Bray-Curtis distances for Lake D1, Lake 8 and MAM in 2020.

Metric	Within Reference (LK1 & LK8)	Within MAM Exposure	Between Reference (LK1 & LK8) and Exposure (MAM)	Between Reference (LK1) and Exposure (MAM)	Between Reference (LK8) and Exposure (MAM)
Count	20	10	50	25	25
Minimum	0.02	0.02	0.04	0.04	0.04
Maximum	0.24	0.09	0.24	0.24	0.17
Median	0.10	0.06	0.12	0.16	0.12
Mean	0.12	0.06	0.12	0.13	0.11
SD	0.06	0.02	0.05	0.07	0.04
SE	0.014	0.006	0.008	0.013	0.007

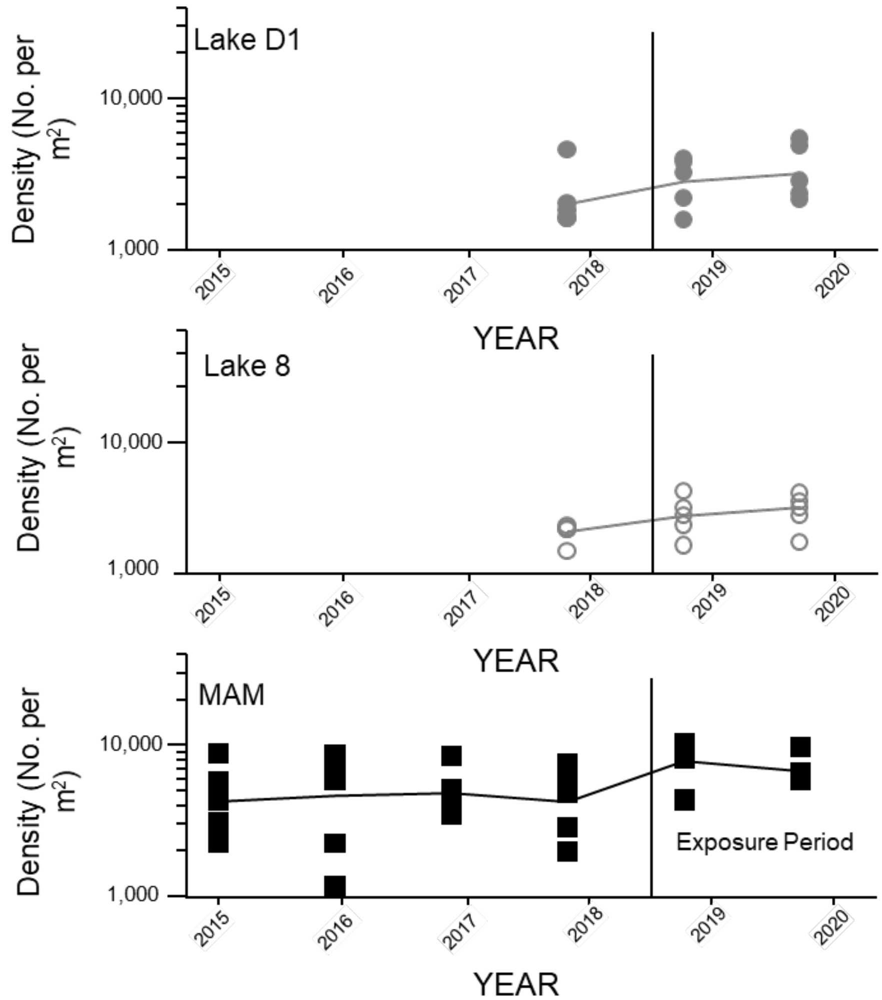

Figure 28. Number of organisms per m^2 among years for Lake D1, Lake 8 and MAM, Whale Tail Mine.

Figure Note: the line illustrates LOWESS-smoothed annual averages.

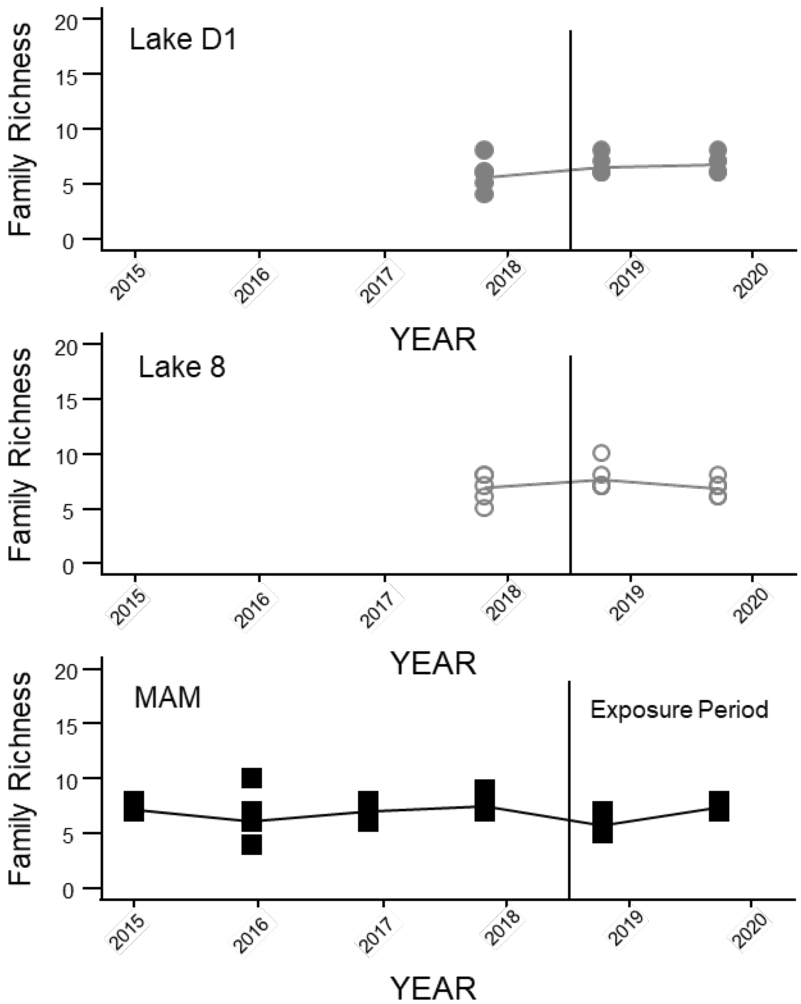

Figure 29. Taxa richness (number of families) among years for Lake D1, Lake 8 and MAM, Whale Tail Mine.

Figure Note: the line illustrates LOWESS-smoothed annual averages.

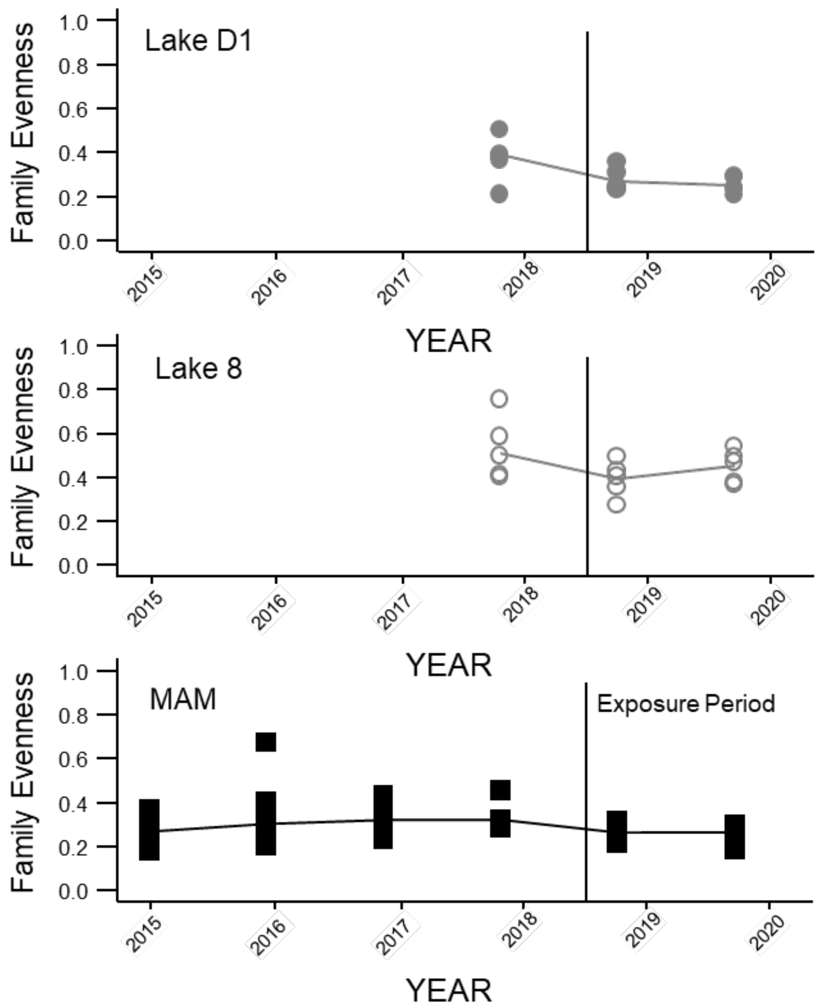

Figure 30. Evenness among years for Lake D1, Lake 8 and MAM, Whale Tail Mine.

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

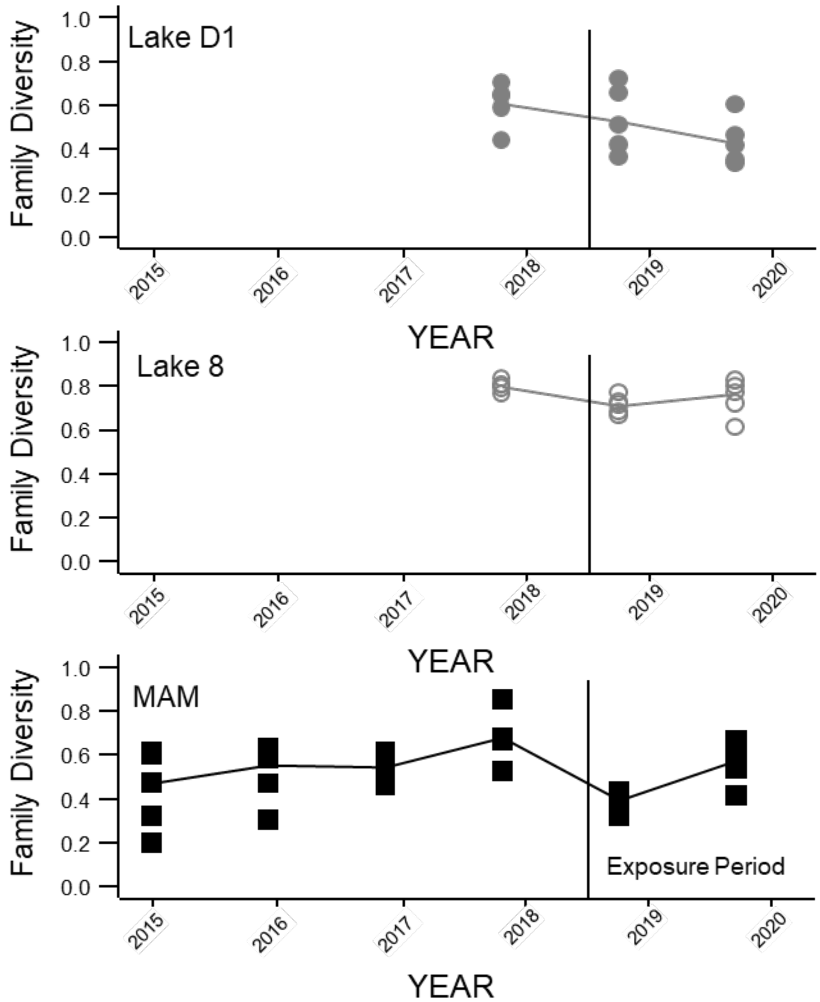

Figure 31. Diversity among years for Lake D1, Lake 8 and MAM, Whale Tail Mine.

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

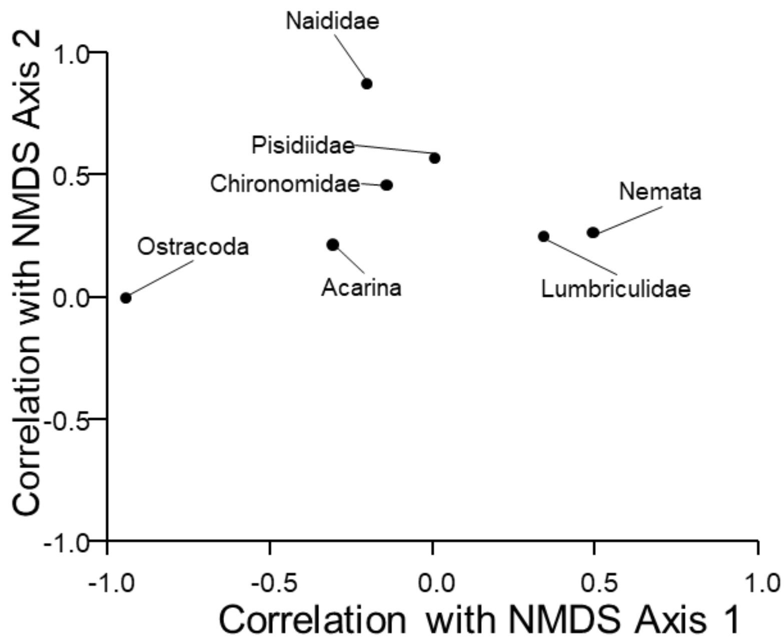

Figure 32. Scatter plot of axis 1 and 2 scores and associated taxa scores for Non-Metric Multidimensional Scaling (NMDS) analysis, Whale Tail Mine.

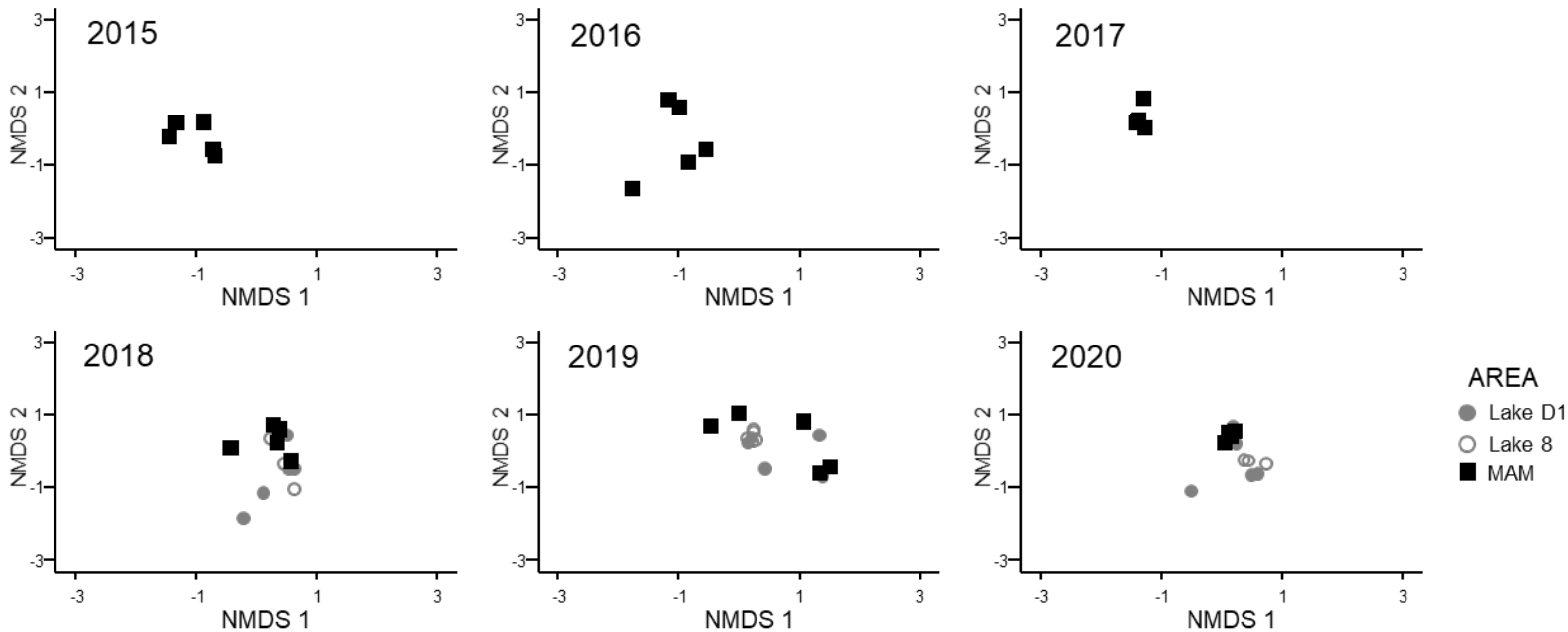

Figure 33. Scatterplots of NMDS axis scores for benthos community samples from Lake D1, Lake 8 and MAM by year, Whale Tail Mine.

5.3.2.2 Controlling Variation in Benthic Indices

Backward, stepwise multiple regression was used to identify variables that explained variation in the indices of benthic community composition in MAM (baseline period), Lake D1 and Lake 8. The results of the stepwise regressions are provided in Table 59 (ANOVA table) and Table 60 (reference models) below.

Depth explained a significant amount of variation in family richness, family evenness and NMDS axis 2 scores, while TOC explained a significant amount of variation in abundance, evenness, NMDS axis 1 scores, and diversity (Table 60). The coefficients in Table 60 can be used to infer the nature of the association between indices and predictors. Depth had a positive coefficient (slope) for family richness (1.03) and NMDS axis 2 scores (11.4), indicating that the response variables increased in relation to depth. Depth had a negative coefficient with evenness (-4.0), indicating that the response variables decreased in relation to depth. TOC had a negative coefficient for density (-0.4), evenness (-0.6) and diversity (-0.4), but a positive coefficient for NMDS axis 1 (0.3). Geometric mean particle size (GMP) did not explain significant amounts of variation for any core or supporting index of composition.

Table 59. ANOVA table for multiple regression models developed for each of the core and supporting indices of benthic community composition, Whale Tail Mine.

Index of Composition	Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
Core Variables						
Log of Density	Regression	0.244	1	0.244	12.4	0.001
	Residual	0.550	28	0.020		
Log of Family Richness	Regression	0.020	1	0.020	5.4	0.028
	Residual	0.106	28	0.004		
Evenness	Regression	0.705	2	0.353	11.4	<0.001
	Residual	0.834	27	0.031		
NMDS Axis 1	Regression	0.218	1	0.218	1.7	0.204
	Residual	3.610	28	0.129		
NMDS Axis 2	Regression	2.530	1	2.530	7.4	0.011
	Residual	9.540	28	0.341		
Supporting Variable						
Diversity	Regression	0.257	1	0.257	16.1	<0.001
	Residual	0.447	28	0.016		

Table 60. Multiple regression model parameter estimates and percent of variation explained for each of the core indices of benthic community composition, in addition to NMDS axes.

Index of Composition	Model Parameter Estimates			
	Constant	Log of Depth	Log of TOC	Model R^2
Core Variables				
Log of Density	3.60		-0.35	0.28
Log of Family Richness	-0.06	1.03		0.13
Evenness	4.21	-4.00	-0.61	0.42
NMDS Axis 1	0.30		0.33	0.02
NMDS Axis 2	-10.28	11.40		0.18
Supporting Variable				
Diversity	0.74		-0.36	0.34

5.3.2.3 Hypothesis Tests

This analysis focused on the assessment of spatio-temporal variations in residuals of the core and supporting indices of benthic community composition, after taking into account the variations related to depth and TOC (Table 60). Results for the ANOVAs and computed effect sizes are provided below in Table 61. Scatterplots of variations in residuals of core indices of composition are illustrated in Figure 34 to Figure 39. In addition to illustrating the individual residuals, the graphs also illustrate the normal range of variation for residuals based on the range observed for the reference data (i.e., Lake D1 and Lake 8 from 2018 to 2020).

ANOVA 1 (H01) tested for differences in the benthic communities between reference (Lake D1 and Lake 8) and exposure (MAM) in 2020. There were significant differences in two core indices of composition (abundance residuals, p < 0.001; and, evenness residuals, p < 0.001), and in three non-core indices (diversity residuals, p<0.001; NMDS axis 1 residuals, p < 0.001; and NMDS axis 2 residuals, p = 0.208). Abundance, NMDS Axis 2 and diversity residuals were significantly higher in MAM than in the reference lakes, while evenness and NMDS Axis 1 residuals were significantly lower in MAM than in the reference lakes. Observed variations were relatively small for abundances (+1.38 SD), evenness (+0.59 SD) and diversity (+0.54 SD), not exceeding the CES of ±2SD (relative to the reference lakes). There is no CES for Bray-Curtis distance, or the summary metrics of NMDS. The observed effect size for NMDS axis 1 scores (i.e., -0.77 SD) and NMDS axis 2 scores (i.e., +0.54 SD) were, however, smaller than the generic CES of ±2SD. There was no significant difference in the richness residuals for H01.

ANOVA 2 (HO2a,b) tested for differences in benthic communities between the exposure area (MAM) during its baseline period (2015 to 2018) and exposure period (H02a: 2019-2020, H02b: 2020). MAM exposure period residuals were higher than baseline residuals for abundance (both H02a p = 0.004, ES = +0.61; H02b p = 0.050, ES = +0.53 SD), richness (only H02b p = 0.021, ES = +0.29 SD), NMDS axis 1 (both H02a p < 0.001, ES = +2.28 SD; H02b p < 0.001, ES = +1.76 SD), NMDS axis 2 (only H02b p = 0.082, ES = +0.69 SD) and diversity (only H02a p = 0.066, ES = -0.18 SD). Observed variations in NMDS axis 1 scores were large (i.e., > 2SD), while observed variations for abundance, richness, evenness, and NMDS axis 2 scores were small (i.e., < 2SD).

ANOVA 3 (H03a,b) used data from 2018 to 2020 from MAM, Lake D1 and Lake 8 in a classic before-after control-impact (BACI) design to test for differences in benthic communities. Hypothesis H03a used exposure data in 2019 and 2020, while hypothesis H03b used only 2020 exposure data. Significant differences were observed in richness residuals (H03a p =0.019 ES = +0.38 SD) and evenness residuals (H03a p =0.004 ES = -0.14 SD, H03b p = 0.021 ES = -0.12 SD). Observed variations in the two indices were small (i.e., < 2SD) in all instances.

Detailed results for the Mantel tests are provided in Table 62. Results of the Mantel tests determined there were significant differences in Bray-Curtis distances based on all possible pairs between baseline MAM (2015-2018) and exposure MAM (2019-2020) (Mantel r = 0.230, p-value = 0.001). No differences were detected for H01, H02b, H03a or H03b.

The ANOVAs are one way to examine the variations in core and supporting indices. Normal ranges of reference data (station-level observations) provide another means of examining the significance of variations. The average for abundance residuals for MAM fell just outside (above) the normal ranges of reference data in 2020 (Figure 34), as well as in the baseline years 2016 and 2018. Abundances of benthos in MAM therefore were higher than the two reference lakes in not only the exposure period, but also the baseline period. Abundance residuals for the exposure period data for MAM, however, fell within the normal range for the abundance residuals for the baseline period for MAM, indicating that there have generally been small variations in the exposure period. The average of residuals for family richness, evenness, NMDS axis 1 and 2 scores and diversity in 2020 for MAM all fell within normal ranges for the two reference lakes (Figure 35 to Figure 39) indicating variations in those indices that were small.

Table 61. Results of analysis of variance (ANOVA) for the five specified hypotheses, for core and supporting indices of benthic community composition at Lake D1, Lake 8 and MAM, Whale Tail Mine 2020.

Index of Composition	Test	*SS*	*df*	*MSE*	*F* ratio	*p*-Value	Difference	Effect Size (SDs)
Log of Density Residuals	Omnibus	3.540	11	0.322	8.908	**<0.001**		
	HO1	0.834	1	0.834	23.077	**<0.001**	0.50	1.38
	HO2a	0.322	1	0.322	8.908	**0.004**	0.22	0.61
	HO2b	0.146	1	0.146	4.028	**0.050**	0.19	0.53
	HO3a	0.005	1	0.005	0.151	0.699	-0.17	-0.46
	HO3b	0.001	1	0.001	0.025	0.875	-0.14	-0.38
	Error	1.734	48	0.036				
Log of Richness Residuals	Omnibus	0.089	11	0.008	2.333	**0.022**		
	HO1	0.006	1	0.006	1.807	0.185	0.04	0.18
	HO2a	0.001	1	0.001	0.243	0.624	0.01	0.05
	HO2b	0.020	1	0.020	5.694	**0.021**	0.07	0.29
	HO3a	0.021	1	0.021	5.895	**0.019**	0.09	0.38
	HO3b	0.005	1	0.005	1.424	0.239	0.03	0.14
	Error	0.167	48	0.003				
Family Evenness Residuals	Omnibus	2.377	11	0.216	20.679	**<0.001**		
	HO1	0.409	1	0.409	39.107	**<0.001**	0.35	0.59
	HO2a	0.038	1	0.038	3.631	**0.063**	-0.08	-0.13

Index of Composition	Test	*SS*	*df*	*MSE*	*F* ratio	*p*-Value	Difference	Effect Size (SDs)
	HO2b	0.030	1	0.030	2.866	**0.097**	-0.09	-0.15
	HO3a	0.097	1	0.097	9.272	**0.004**	-0.08	-0.14
	HO3b	0.059	1	0.059	5.693	**0.021**	-0.07	-0.12
	Error	0.502	48	0.010				
NMDS Axis 1 Residuals	Omnibus	34.871	11	3.170	19.742	**<0.001**		
	HO1	0.560	1	0.560	3.486	**0.068**	-0.41	-0.77
	HO2a	9.877	1	9.877	61.507	**<0.001**	1.22	2.28
	HO2b	3.555	1	3.555	22.141	**<0.001**	0.94	1.76
	HO3a	0.002	1	0.002	0.013	0.909	-0.10	-0.19
	HO3b	0.002	1	0.002	0.011	0.916	0.17	0.32
	Error	7.708	48	0.161				
NMDS Axis 2 Residuals	Omnibus	4.601	11	0.418	1.509	**0.159**		
	HO1	0.452	1	0.452	1.632	**0.208**	0.37	0.54
	HO2a	0.718	1	0.718	2.591	0.114	0.33	0.49
	HO2b	0.875	1	0.875	3.157	**0.082**	0.47	0.69
	HO3a	0.342	1	0.342	1.234	0.272	0.21	0.31
	HO3b	0.073	1	0.073	0.264	0.609	0.07	0.10
	Error	13.306	48	0.277				
Family Diversity Residuals	Omnibus	0.747	11	0.068	6.611	**<0.001**		
	HO1	0.165	1	0.165	16.032	**<0.001**	0.22	0.54
	HO2a	0.036	1	0.036	3.537	**0.066**	-0.07	-0.18
	HO2b	0.001	1	0.001	0.052	0.821	0.01	0.03
	HO3a	0.006	1	0.006	0.560	0.458	0.05	0.13
	HO3b	0.022	1	0.022	2.116	0.152	-0.03	-0.08
	Error	0.493	48	0.010				

Table 62. Results from the Mantel tests testing for spatial and temporal variations in Bray-Curtis distances, Whale Tail Mine EEM.

Test	Hypothesis	Mantel *r*	*p-value*
HO1	Exposure (MAM) vs. Reference (Lake D1 & Lake 8) in 2020	0.039	0.360
HO2a	Exposure (MAM) Before (2015-2018) vs. After (2019-2020)	0.230	**0.001**
HO2b	Exposure (MAM) Before (2015-2018) vs. After (2020)	0.045	0.255
HO3a	BACI Exposure (2018 vs. 2019-2020) and Reference (2018 vs. 2019-2020)	0.042	0.184
HO3b	BACI Exposure (2018 vs. 2020) and Reference (2018 vs. 2020)	-0.030	0.836

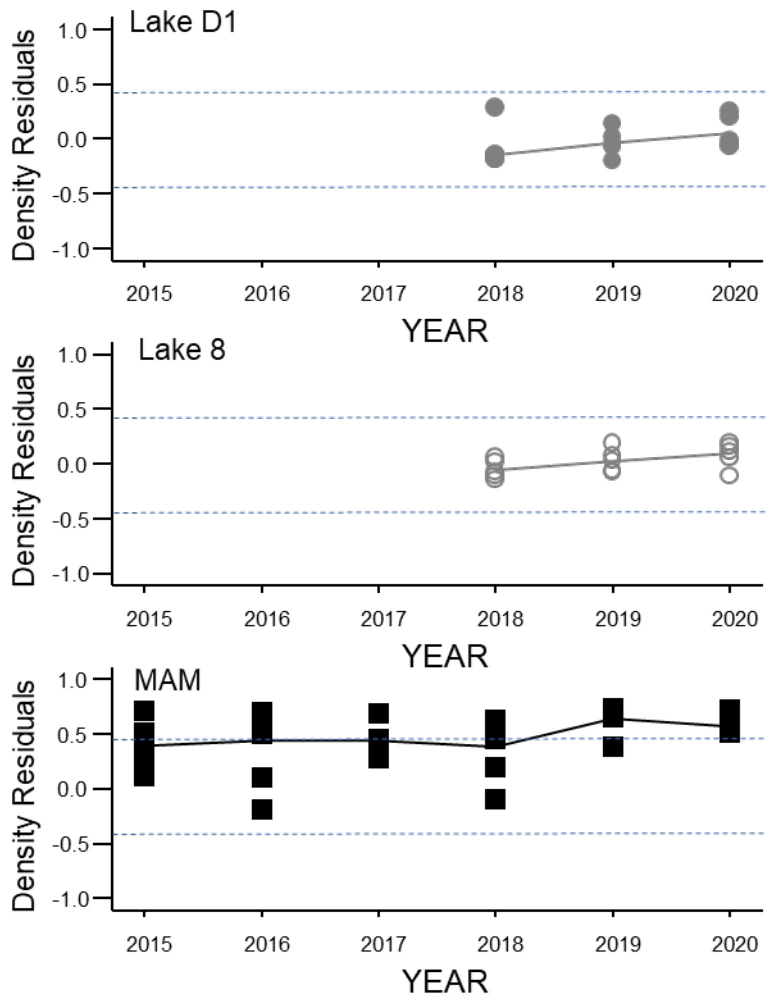

Figure 34. Residuals of total density, among years for Lake D1, Lake 8 and MAM.

Figure Note: the solid line illustrates LOWESS-smoothed variations in annual averages, while the dashed lines illustrate normal ranges of variation under reference conditions.

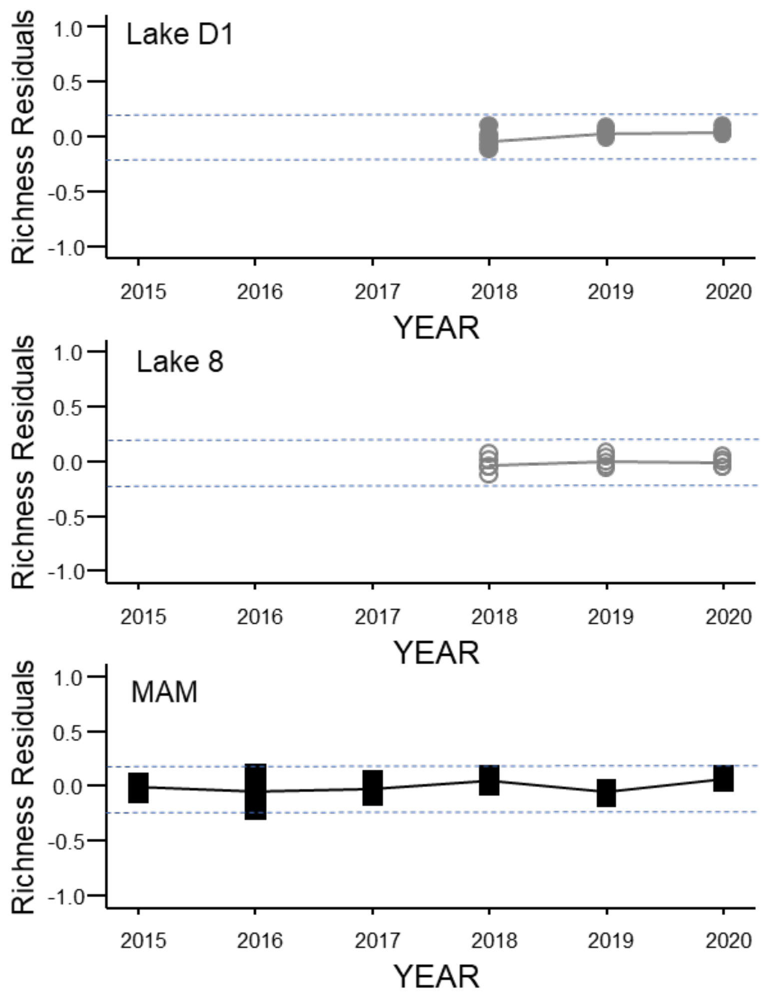

Figure 35. Residuals of family richness, among years for Lake D1, Lake 8 and MAM.

Figure Note: the solid line illustrates LOWESS-smoothed variations in annual averages, while the dashed lines illustrate normal ranges of variation under reference conditions.

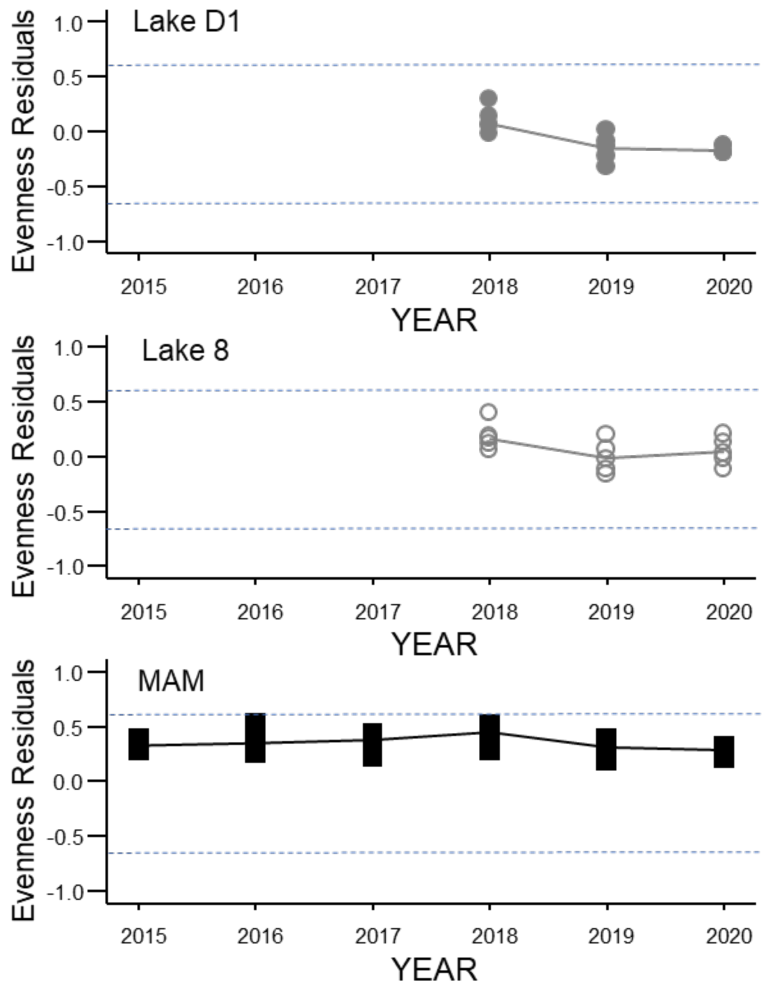

Figure 36. Residuals of evenness, among years for Lake D1, Lake 8 and MAM.

Figure Note: the solid line illustrates LOWESS-smoothed variations in annual averages, while the dashed lines illustrate normal ranges of variation under reference conditions.

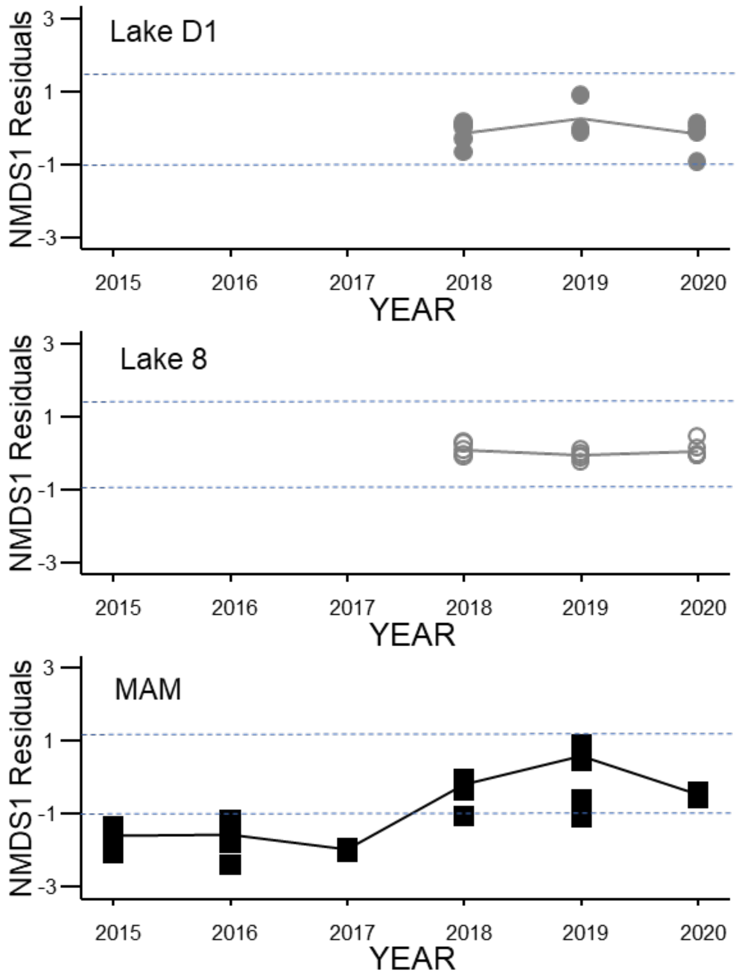

Figure 37. Residuals of NMDS Axis 1 Scores, among years for Lake D1, Lake 8 and MAM.

Figure Note: the solid line illustrates LOWESS-smoothed variations in annual averages, while the dashed lines illustrate normal ranges of variation under reference conditions.

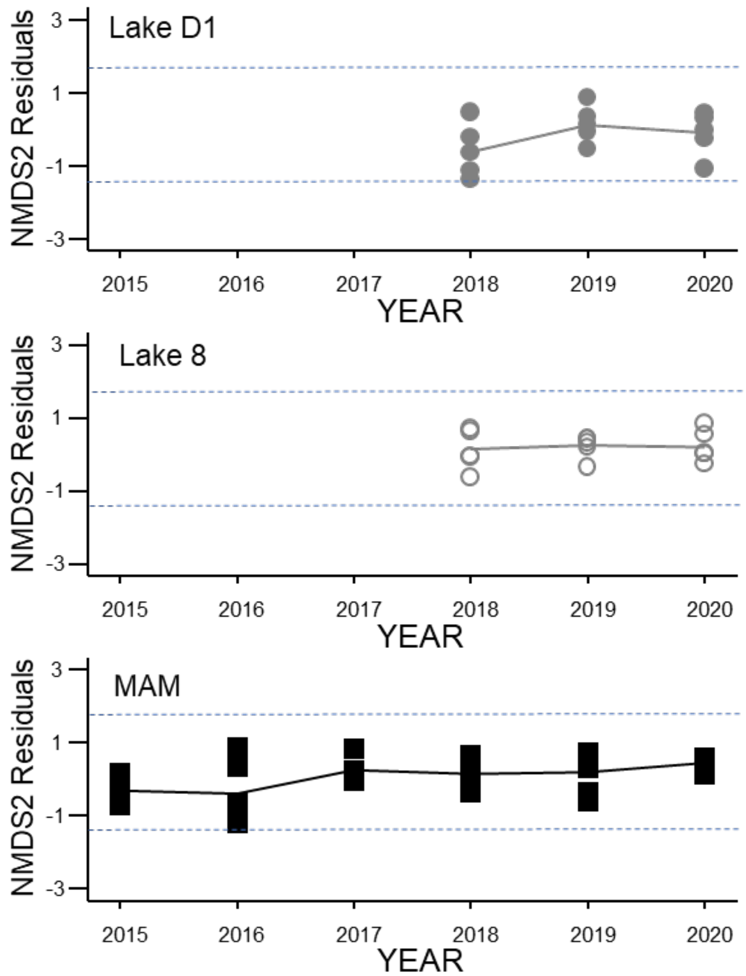

Figure 38. Residuals of NMDS Axis 2 Scores, among years for Lake D1, Lake 8 and MAM.

Figure Note: the solid line illustrates LOWESS-smoothed variations in annual averages, while the dashed lines illustrate normal ranges of variation under reference conditions.

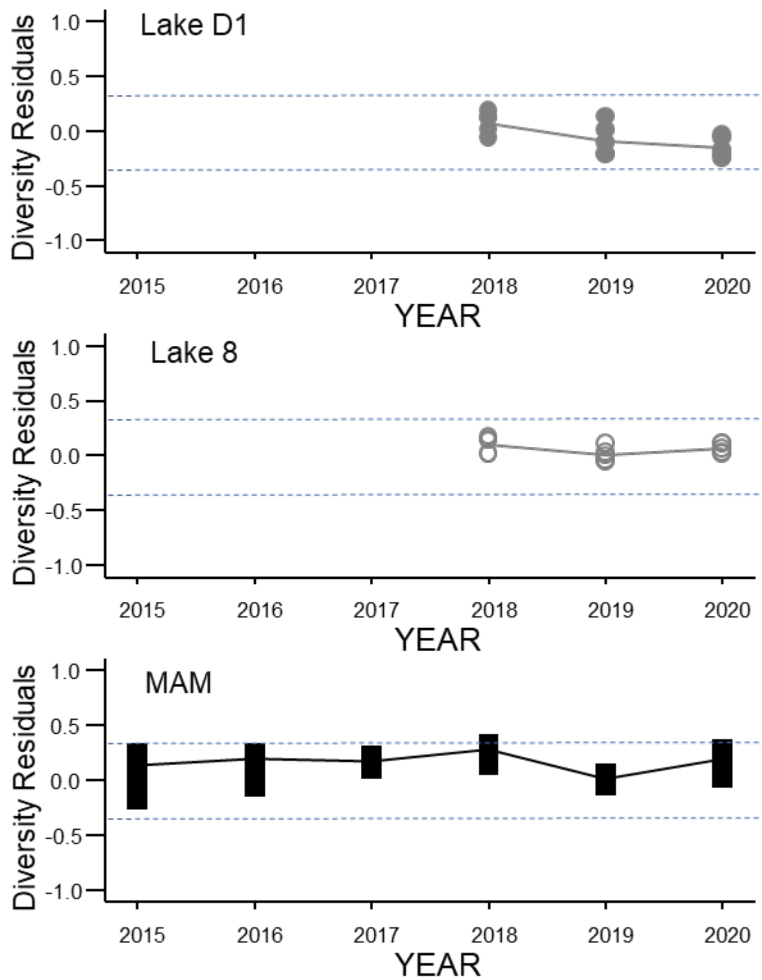

Figure 39. Residuals of diversity, among years for Lake D1, Lake 8 and MAM.

Figure Note: the solid line illustrates LOWESS-smoothed variations in annual averages, while the dashed lines illustrate normal ranges of variation under reference conditions.

5.3.2.4 Precision

Estimated sample sizes required to obtain a precision of 0.2 (station values estimated to within ± 20% of their true values) are provided in Table 63 below. Precision estimates vary depending on the mean, with smaller means generally requiring a larger number of samples to get the estimates within 20% of the mean value. That said, density, family richness and family evenness can be estimated to within 20% of the observed true means in MAM with single Ponar grabs. Having two grabs from those lakes will produce estimates for those variables that are even more precise than required.

Table 63. Sample sizes required to produce estimates of core and supporting indices of benthic invertebrate community composition that are within ±20% of the true values at a 'station' level.

Variable	Dispersion	S	S^2	mean	Sample Size	
					n	Rounded Up
Log Density	0.2	0.04	0.00	3.99	0.002	<1
Log Richness	0.2	0.00	0.00	0.85	0.000	<1
Evenness	0.2	0.03	0.00	0.23	0.368	<1

Table Notes: S = standard deviation; S^2 = variance; $\bar{x}$ = station mean; $\hat{n}$=estimated number of samples required.

5.4 Discussion

The benthic community of MAM in 2020 was diverse and dominated by chironomids and pisidiid fingernail clams. In terms of composition, the community of MAM was similar to Lake D1 and Lake 8. The benthos of MAM, although consistent with what is observed in reference lakes in the area, changed during the reference period for MAM (i.e., 2015 to 2018), with 2018 seeing the disappearance of Ostracoda. The benthos of MAM is also somewhat unique relative Lake D1 and Lake 8, reflecting natural differences in sediment character. Some of the observed variations in core indices of composition were related to variations in sampling depth and substrate total organic carbon. Testing for spatio-temporal variations, therefore, were carried out on residuals of the core indices, after taking into account the variations related to underlying physical variables.

Variations in residuals of indices of benthic community composition were assessed using specific contrasts designed to develop a burden of evidence that treated mine effluent was (or was not) causing effects on the benthic community of MAM. Some effluent-related null hypotheses were rejected may be evidence of effluent-related effects (Table 64). Effect sizes were, however, always small and the benthic community of MAM contained a typical Arctic assemblage. Effluent-related effects, if real, were therefore subtle.

Sediments in MAM have 9 to 10% TOC, whereas Lake 8 and Lake D1 have 1 to 4% TOC. That difference alone would be sufficient to result in the benthos of MAM being different from what is observed in the reference lakes. Reference-condition models were used here to 'adjust' indices to a more common set of conditions in terms of substrate. Multiple regression models determined that substrate TOC explained a significant amount of variation in density, evenness, NMDS axis 1 scores and diversity. Sampling depth also explained a significant amount of variation in richness, evenness and NMDS axis 2 scores. Overall, the models explained between 13% and 45% of the variation in the data.

ANOVA 1 (H01) tested for differences in the benthic communities between reference (Lake D1 and Lake 8) and exposure (MAM) in 2020. There were significant differences in four core indices of composition: abundance, evenness and NMDS axis 1 and 2 scores. Rejection of the null hypothesis for these indices is consistent with effluent related effects. Effect sizes, however, did not exceed the CES of ± 2 SD.

ANOVA 2 tested for differences in benthic communities between the exposure area (MAM) during its baseline period (2015 to 2018) and exposure period (H02a: 2019-2020, H02b: 2020). There were significant differences in abundance, evenness and NMDS axis 1 scores for both H02a and b. There were also significant differences in richness and NMDS axis 2 scores for H02b only, and in diversity for H02a only. Rejection of the null hypotheses for these indices suggests effluent related effects. Again, effect sizes only exceeded the CES of ± 2 SD for abundance.

ANOVA 3 used data from 2018 to 2020 from MAM, Lake D1 and Lake 8 in a classic before-after control-impact (BACI) design to test for differences in benthic communities. There were significant differences in richness (H03a) and evenness (H03a,b) residuals. Effect sizes did not exceed the CES of ± 2 SD and both richness and evenness values at MAM in 2020 fell within the normal ranges of variation of reference data.

Despite the generally higher numbers of benthic organisms in the MAM sampling area, the composition of the benthic community was very similar to what has been observed in the reference lakes. NMDS axis scores in 2020 for MAM were within the range of values from reference lakes. Further, the benthic taxa do not indicate degraded conditions and contained an assemblage of organisms that are typical for these Arctic systems. MAM benthos contained 7 genera of chironomid in 2020, similar to what had been observed in the other lakes, including the dominant forms *Corynocera*, *Micropsectra*, *Paratanytarsus*, *Stichtochironomus*, and *Tanytarsus*.

Each of the three sampling areas had concentrations of metals and nutrients that are well below CCME water quality guidelines, and near detection limits. There has been some elevation of cations (Ca, K, Na) in MAM, reflecting the slightly higher hardness in MAM which is associated with effluent treatment, but the changes are trivial relative to the concentrations that would be required in order to elicit a toxicity response (Mount *et al*., 1997, 2019).

Table 64. Summary of observed significant differences, expressed in standard deviations (SDs), for indices of benthic invertebrate community composition, Whale Tail EEM Cycle 1.

Test	Hypothesis	Density	Richness	Evenness	NMDS 1	NMDS 2	Diversity
HO1	Exposure (MAM) vs. Reference (Lake D1 & Lake 8) in 2020	1.38		0.59	-0.77	0.54	0.54
HO2a	Exposure (MAM) Before (2015-2018) vs. After (2019-2020)	0.61		-0.13	2.28		-0.18
HO2b	Exposure (MAM) Before (2015-2018) vs. After 2020)	0.53		-0.15	1.76	0.69	
HO3a	BACI Exposure (2018 vs. 2019-2020) and Reference (2018 vs. 2019-2020)		0.29	-0.14			
HO3b	BACI Exposure (2018 vs. 2020) and Reference (2018 vs. 2020)		0.38	-0.12			

5.4.1 Recommendations for Next Cycle

Agnico Eagle will continue to conduct the CREMP annually as part of its commitment. Barring changes in the location of effluent discharge, it is recommended that the second EEM biological study utilize the same design as this study. This will allow use of the data that are collected by the CREMP.

6.0 FISH TISSUE SURVEY

Mercury and selenium concentrations in the effluent were both consistently less than the concentrations that would require a fish tissue study; therefore, a study respecting fish tissue mercury or fish tissue selenium was not required during Cycle 1.

7.0 SUBLETHAL TOXICITY TESTING

7.1 Introduction

Sub-lethal toxicity testing must be carried out two times per year for the first three years on the final discharge point that has potentially the most adverse environmental impact on the environment. After three years, the tests are to be conducted once per quarter on the species whose results produced the lowest geometric mean concentration having an effect (i.e., the species that is determined to be most affected by effluent). A summary of the results of the toxicological tests carried out on Whale Tail Pit effluent are presented here.

7.2 Materials and Methods

Laboratory testing of Whale Tail Pit final effluent was undertaken using four different tests: Fathead Minnow (*Pimephales promelas*) 7-Day Survival and Growth Test (EPS 1/RM/22, 2nd ed., Environment Canada, 2011), *Ceriodaphnia dubia* Survival and Reproduction Test (EPS 1/RM/21, Environment Canada, 2007a), the *Pseudokirchneriella subcapitata* 72-hour Growth Inhibition Test (EPS 1/RM/25, Environment Canada, 2007b), and the growth inhibition test with *Lemna minor* (EPS 1/RM/37, Environment Canada, 2007c). All four test protocols were run on final effluent samples at times of normal mine operation.

7.3 Results

Two samples of final effluent were submitted in each year during Cycle 1 for the suite of four sublethal tests as outlined above. In 2019 effluent samples from MDMER 6 were collected, while in 2020 samples from MDMER 8 were collected. Results of these tests are presented in Table 65.

Cycle 1 effluent samples produced no effect on survival of exposed fathead minnows and no measurable growth impairment in fathead minnows was observed.

There was no mortality among any of the organisms exposed in tests conducted with *Ceriodaphnia dubia* during cycle 1, however measurable reproductive inhibition was observed in three samples tested and IC25 estimates for these were 51.3%, 41.0%, and 64.0%.

No inhibitory effects were observed for *Pseudokirchneriella subcapitata* exposed to effluent samples. Inhibitory effects on *Lemna minor* were observed during one test where IC25 estimates for frond growth (dry weight) and frond number were 84.9% and 51.2%, respectively.

The EEM guidance document suggests that mines estimate the potential extent of the 25% effects zone in the receiving environment where the IC25 is less than 30% effluent concentration. No estimates were made because no test exceeded the 30% IC25 toxicity threshold.

Table 65. Sublethal toxicity data for 2019 and 2020.

Sample Date	Sample Site	Test Species and Endpoint						
		Pimephales promelas		*Ceriodaphnia dubia*		*Pseudokirchneriella subcapitata*	*Lemna minor*	
		LC50	Growth IC25	LC50	Reproduction IC25	Growth IC25	Frond growth (dry wt.) IC25	Frond No. IC25
02-07-2019	MDMER6	>100%	>100%	>100%	51.3%	>90.9%	>97%	>97%
05-08-2019	MDMER6	>100%	>100%	>100%	>100%	>90.9%	>97%	>97%
26-07-2020	MDMER8	>100%	>100%	>100%	41.0%	>90.9%	>97%	>97%
01-09-2020	MDMER8	>100%	>100%	>100%	64.0%	>90.9%	84.9%	51.2%

Table Notes: Values represent percent effluent required to cause the effect; LC50 = concentration causing 50% mortality; IC25 = concentration causing 25% reduction in the sub-lethal endpoint, either growth, reproduction, frond number or frond weight.

8.0 SUMMARY AND CONCLUSIONS

There were significant differences ($P \leq 0.10$) in the intercepts of the relationships for weight versus length, liver weight versus weight, and liver weight versus length among lakes. These relationships, however, were not significantly different between Mammoth Lake and reference Lake D1 and the differences for that comparison were less than the critical effect sizes. There were significant differences ($P \leq 0.10$) in the slopes of the relationships for weight versus age and length versus age (i.e., non-parallel regression slopes), so effect sizes could not be appropriately estimated using the reduced model; therefore, effects were estimated for both smaller and larger fish using methods outlined in (Environment Canada 2012). Length and age distributions of Lake Trout did not differ significantly between lakes and weight distribution only differed significantly between Mammoth and Lake 8. There were significant differences in intercepts for the weight versus length, liver weight versus weight, and liver weight versus length relationships between Mammoth Lake and Lake 8 and the critical effect sizes were exceeded for weight adjusted for length and liver weight adjusted for length.

The length and weight distributions of Slimy Sculpin differ between Mammoth Lake and Lake 8 but neither differ significantly between Mammoth Lake and Lake D1. The slopes of the weight versus length relationship differ significantly between Mammoth Lake and both of the reference lakes. The effect size for the weight versus length relationship is less than the critical effect size of 10% when Mammoth Lake is compared to Lake D1, greater that 10% when compared to Lake 8, and equal to 10% when the reference sites are combined.

In terms of composition, the benthic community of MAM was similar to Lake D1 and Lake 8. Variations in residuals of indices of benthic community composition were assessed using specific contrasts designed to develop a burden of evidence that treated mine effluent may be, or is not, causing effects on the benthic community of MAM. Some effluent-related null hypotheses were rejected and may be evidence of effluent-related effects (Table 64). Effect sizes were, however, always small and the benthic community of MAM contained a typical Arctic assemblage. Effluent-related effects, if real, were therefore subtle.

Each of the three sampling areas had concentrations of metals and nutrients that are well below CCME water quality guidelines, and near detection limits. There has been some elevation of cations (Ca, K, Na) in MAM, reflecting the slightly higher hardness in MAM which is associated with effluent treatment, but the changes are trivial relative to the concentrations that would be required in order to elicit a toxicity response (Mount *et al*., 1997, 2019).

Cycle 1 effluent samples produced no effect on survival or growth of exposed fathead minnows. There was no mortality of *Ceriodaphnia dubia* in tests conducted during cycle 1, however measurable reproductive inhibition was observed in three samples tested and IC25 estimates for these were 51.3%, 41.0%, and 64.0%. No inhibitory effects were observed for *Pseudokirchneriella subcapitata* exposed to effluent samples. Inhibitory effects on *Lemna minor* were observed during one test where IC25 estimates for frond growth (dry weight) and frond number were 84.9% and 51.2%, respectively.

Provided that the effluent discharge location does not change, it is recommended that the fish and benthic invertebrate studies for the next EEM biological study at Whale Tail follow the same designs that were used in this study. The next EEM biological study interpretive report is required to be submitted by July 27, 2024.

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Appendix 1. Correspondence with Environment Canada

Prairie and Northern Region
Environmental Protection Operations Directorate
Environment and Climate Change Canada
9250 – 49th Street NW
Edmonton, AB T6B 1K5

File #: MM3118

July 3, 2020

via email to: marie-pier.marcil@agnicoeagle.com

Marie-Pier Marcil
Senior Compliance Technician
Agnico-Eagle Mines Ltd. Meadowbank Division
10 200, route de preissac
Rouyn-Noranda, Quebec J0Y 1C0

Dear Marie-Pier Marcil:

Subject: Whale Tail Pit 1st EEM Study Design

Environment and Climate Change Canada (ECCC) has reviewed your "Environmental Effects Monitoring: Agnico Eagle Mines Ltd. – Whale Tail Pit, First Biological Monitoring Study Design", submitted on July 26, 2019 and the addendum submitted on June 19, 2020. Our review took into account requirements of the *Metal and Diamond Mining Effluent Regulations* (MDMER) of the *Fisheries Act*, information in the EEM Technical Guidance Document as well as generally accepted standards of good scientific practice. This review is not a substitute for reading the MDMER and does not in any way supersede or modify the *Fisheries Act* or the MDMER. In the event of an inconsistency between this review and the Act and/or the MDMER, the Act and the Regulations prevail.

Review comments for the mine to consider are attached. No further response to the review comments is required.

ECCC would appreciate receiving a final schedule for the biological monitoring, sent to Jennifer Froese at 780-951-8705 or at jennifer.froese@canada.ca at least two weeks prior to the commencement of field activities. As required under the MDMER, biological monitoring studies must be conducted in accordance with the study design. If it becomes impossible to follow the study design because of unusual circumstances, the mine must inform the Minister of the Environment (c/o Regional Director at ec.drrpn-rdpnr.ec@canada.ca) of those circumstances, without delay, and how the study will be conducted.

ECCC anticipates receiving the 1st interpretive report no later than July 27, 2021. Regulated facilities are required to submit EEM reports and biological monitoring data to the Environmental Effects Monitoring Electronic Reporting system (EEMER) at https://ec.ss.ec.gc.ca/.

If you have any questions or concerns about the EEM program or if you wish to discuss the study design, please contact Regional Coordinator Jennifer Froese at 780-951-8705 or at jennifer.froese@canada.ca. For questions regarding EEMER, please contact ec.esee-eem.ec@canada.ca.

Sincerely,

Margaret Fairbairn
A/ Regional Director

Enclosure: Review comments and recommendations on "Addendum to Whale Tail Pit First Biological Monitoring Study Design", June 2020 submission

cc:	Cristina Ruiu	Environment and Climate Change Canada, Regina
	Erik Allen	Environment and Climate Change Canada, Edmonton
	Jennifer Froese	Environment and Climate Change Canada, Edmonton
	Curtis Didham	Environment and Climate Change Canada, Iqaluit
	Derek Donald	Nunavut Water Board
	Karén Kharatyan	Nunavut Water Board
	Assol Kubeisinova	Nunavut Water Board
	Godwin Okonkwo	Crown Indigenous Relations and Northern Affairs Canada
	David Zhong	Crown Indigenous Relations and Northern Affairs Canada
	Meadowbank Environment Supervisor	Agnico-Eagle Mines Ltd.

Review comments on “Addendum to Whale Tail Pit First Biological Monitoring Study Design”, June 2020 submission

The following comments and recommendations are based on the review of the report by a Technical Advisory Panel (TAP) consisting of representatives from Environment and Climate Change Canada (ECCC), Nunavut Water Board (NWB) and Crown Indigenous Relations and Northern Affairs Canada (CIRNAC).

Action items

None

Other items

1. Appendix A – p. 22 (ECCC): The revised study design for the lake trout survey indicates that summary statistics will be generated for length, weight, condition, HSI and GSI; however, this list does not include all the measurements for which the MDMER require summary statistics. Please note that the MDMER require that the first interpretative report include summary statistics, if practicable, for length, total body weight, age, liver or hepatopancreas weight, egg weight, fecundity and gonad weight (Schedule 5, paragraph 12(1)(e)).
2. Appendix A – pp. 27-28 (ECCC): The revised study design for the slimy sculpin survey indicates that each fish will be measured for length and weight; however, the study design indicates that only the lethally sampled fish will be examined for abnormalities and sex. Please note that the metal mining technical guidance for EEM suggests that non-lethally sampled fish should be measured for length and weight, but also assessed for abnormalities and external sex determination should be made, if possible (EC 2012).
3. Appendix A – pp. 28-29 (ECCC): The revised study design for the slimy sculpin survey indicates that summary statistics will be generated for length, weight, condition, liver weight, HSI, gonad weight and GSI; however, this list does not include all the measurements for which the MDMER require summary statistics. Please note that the MDMER require that the first interpretative report include summary statistics, if practicable, for length, total body weight, age, liver or hepatopancreas weight, egg weight, fecundity and gonad weight (Schedule 5, paragraph 12(1)(e)).
4. Appendix A – p. 29 (ECCC): The revised study design for the slimy sculpin survey indicates that if the first age class is clearly defined by length-frequency, then the length of fish in that age class will be compared between sites. Please note that length of YOY (age 0) at the end of the growth period and weight of YOY (age 0) at the end of the growth period are the effect endpoints for growth in non-lethal fish surveys (EC 2012, Table 8-2). If possible, please compare weight of YOY, as well as length of YOY, between sites to identify effects on growth.
5. Appendix A – p. 29 (ECCC): The revised study design for the slimy sculpin survey does not indicate that length-frequency distribution will be compared among sites. Please note that length-frequency distribution (2-sample Kolmogorov-Smirnov test) is the effect endpoint for survival in non-lethal fish surveys (EC 2012, Table 8-2). If

possible, please compare length-frequency distributions between sites to identify effects on survival.

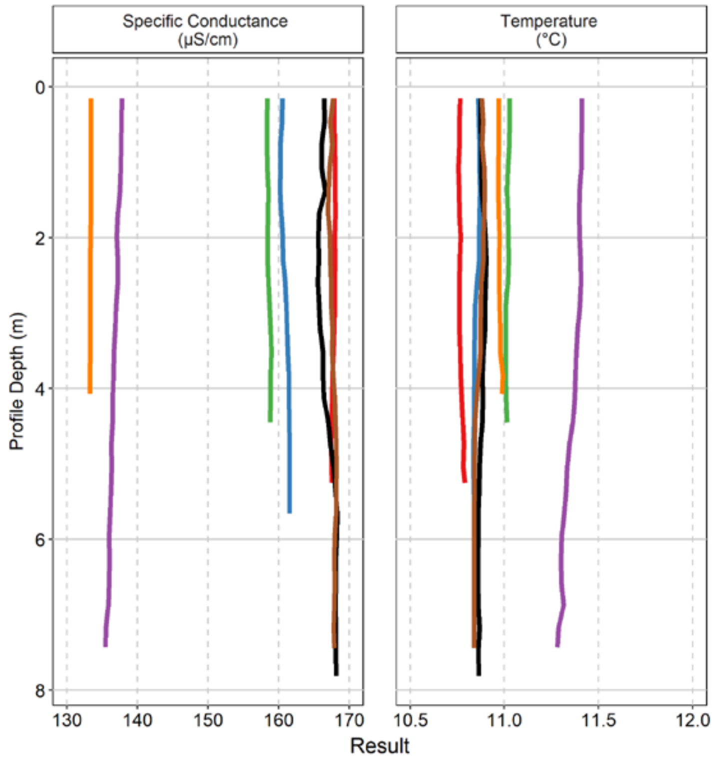
6. Appendix A – p. 29 (ECCC): The revised study design for the slimy sculpin survey does not indicate that relative abundance of YOY will be compared among sites. Please note that relative abundance of YOY is the effect endpoint for reproduction in non-lethal fish surveys (EC 2012, Table 8-2). If possible, please compare relative abundance of YOY between sites to identify effects on reproduction.

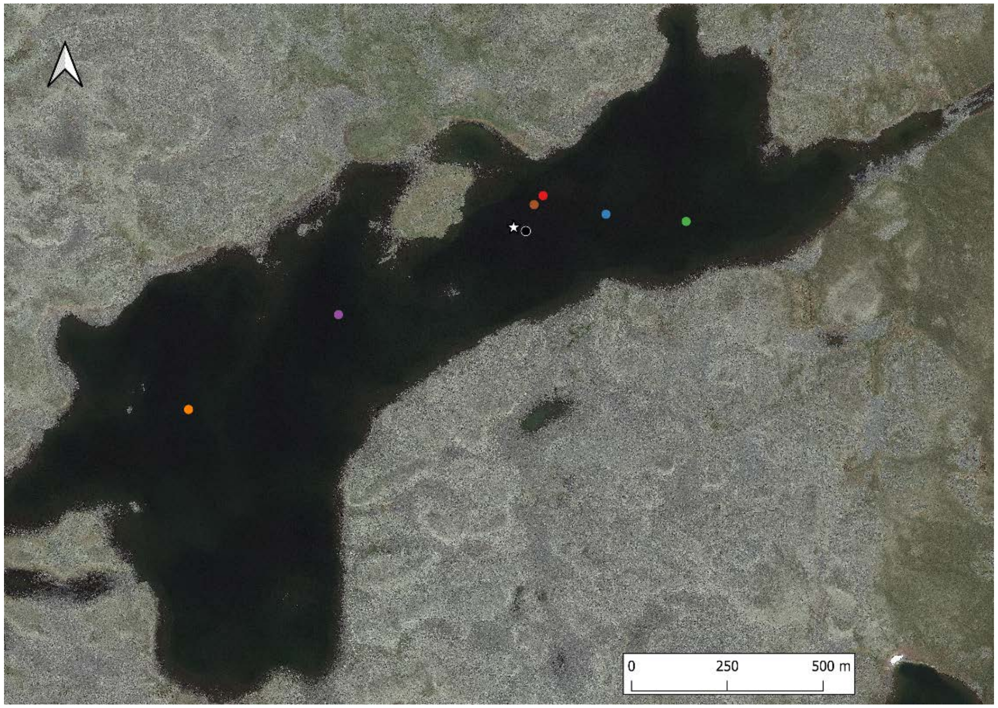
References

Environment Canada (EC) 2012. Metal Mining Technical Guidance for Environmental Effects Monitoring.

Appendix 2. Additional Plume Delineation Data

Figure 2-1. Representative specific conductance and temperature profiles collected during effluent plume modeling on August 25, 2020. Profile colours match the locations marked on the adjacent map. The diffuser locations (MMER 7 and 8) are identified by a white star.





Appendix 3. Additional Gill Net and Electrofishing Data

Table 3-1. Gill net set data and catch. Fish captured alive were released at the point of capture.

Lake	Set	Set Datetime	Lift Datetime	Soak Time (hrs)	Net Start Latitude	Net Start Longitude	Net Start Depth (m)	Net End Latitude	Net End Longitude	Net End Depth (m)	Lake Trout Alive	Lake Trout Dead	Arctic Char Alive	Arctic Char Dead	Round Whitefish Alive	Round Whitefish Dead	Slimy Sculpin Alive	Slimy Sculpin Dead
Lake 8	1	23-Aug-20 16:04	24-Aug-20 10:00	17:56	65.4259	-96.5920	1.8	65.4246	-96.5936	3.3	0	22	1	0	0	0	0	0
	2	23-Aug-20 16:29	24-Aug-20 10:40	18:11	65.4259	-96.5987	1.2	65.4260	-96.6017	1.6	6	10	0	1	0	0	0	0
Lake D1	1	19-Aug-20 17:20	20-Aug-20 9:00	15:40	65.3549	-96.6848	1.2	65.3538	-96.6828	1.6	0	12	0	5	0	9	0	0
	2	19-Aug-20 17:40	20-Aug-20 11:00	17:20	65.3531	-96.6813	1.6	65.3529	-96.6786	4.1	0	15	0	18	0	8	0	1
Mammoth	1	18-Aug-20 17:59	19-Aug-20 8:24	14:25	65.4006	-96.7395	1.5	65.4013	-96.7357	4.5	0	20	1	1	12	3	0	0
	2	25-Aug-20 8:02	25-Aug-20 17:10	09:08	65.4005	-96.7402	1.5	65.4011	-96.7367	1.7	0	4	0	0	2	1	0	0
	3	26-Aug-20 9:00	26-Aug-20 15:55	06:55	65.3984	-96.7357	3.6	65.3998	-96.7326	5.7	0	0	0	0	0	0	0	0
	4	26-Aug-20 16:05	26-Aug-20 20:28	04:23	65.3987	-96.7310	3.4	65.3987	96.7341	4.4	0	1	0	0	0	0	0	0

Table 3-2. Electrofishing catch data.

Lake	Electrofishing Run	Date	Start Location		End Location		Voltage (V)	Frequency (Hz)	Current (Amps)
			Latitude	Longitude	Latitude	Longitude			
Lake 8	EF-1	23-Aug-20	65.43425	-96.58905	65.4349	-96.5880	750	60	4.0
	EF-2	23-Aug-20	65.43538	-96.58754	65.4358	-96.5878	750	60	4.0
	EF-3	24-Aug-20	65.43433	-96.58947	65.4343	-96.5903	750	60	4.0
	EF-4	24-Aug-20	65.43418	-96.58718	65.4344	-96.5882	750	60	4.0
Lake D1	EF-1	22-Aug-20	65.34827	-96.69713	65.3479	-96.6931	750	60	4.0
	EF-2	22-Aug-20	65.34654	-96.69687	65.3479	-96.6930	750	60	4.0
	EF-3	22-Aug-20	65.34829	-96.69704	65.3496	-96.7073	750	60	4.0
	EF-4	27-Aug-20	65.34748	-96.69133	65.3468	-96.6912	750	60	4.0
	EF-5	27-Aug-20	65.34797	-96.69142	65.3475	-96.6915	750	60	4.0
	EF-6	27-Aug-20	65.34886	-96.68801	65.3488	-96.6895	750	60	4.0
Mammoth	EF-1	21-Aug-20	65.39835	-96.72834	65.3989	-96.7242	550	60	4.0
	EF-2	21-Aug-20	65.39908	-96.72339	65.3990	-96.7240	550	60	4.0
	EF-3	21-Aug-20	65.39914	-96.72334	65.3994	-96.7232	550	60	4.0
	EF-4	25-Aug-20	65.40000	-96.72113	65.3995	-96.7223	450	60	4.1

Appendix 4. Individual Fish Data

Table 4-1. Individual Lake Trout data.

Fish ID	Date (2020)	Lake	Net #	Length (mm)	Weight (g)	Liver Weight (g)	Gonad Weight (g)	Sex	Maturity	Gonad Condition	Egg Sample Weight (g)	Egg Count	Age	Stomach Contents	DELTS/Parasites
LT-1	19-Aug	Mammoth	1	855	6750	51.47	101.49	F	M	Resting	NA	NA	42		
LT-2	19-Aug	Mammoth	1	705	4110	56.2	413	F	M	Ripe	57.26	508	40		
LT-3	19-Aug	Mammoth	1	661	3447	22.34	81.75	M	M	Ripe	NA	NA	30		
LT-4	19-Aug	Mammoth	1	807	6570	62.84	220	M	M	Ripe	NA	NA	33	Lake Trout, 410 mm	
LT-5	19-Aug	Mammoth	1	811	6040	49.16	157.52	F	M	Resting	NA	NA	37		
LT-6	19-Aug	Mammoth	1	494	1219	8.88	1.42	M	I	Undeveloped	NA	NA	22		
LT-7	19-Aug	Mammoth	1	374	627	4.08	22.68	M	M	Ripe	NA	NA	21		
LT-8	19-Aug	Mammoth	1	341	543	5.45	17.53	M	M	Ripe	NA	NA	12		
LT-9	19-Aug	Mammoth	1	465	1116	8.93	0.79	F	I	Undeveloped	NA	NA	21		
LT-10	19-Aug	Mammoth	1	356	588	8.53	59.79	F	M	Ripe	59.79	503	14		14 encysted parasites
LT-11	19-Aug	Mammoth	1	270	226	2.91	0.12	F	I	Undeveloped	NA	NA	12		
LT-12	19-Aug	Mammoth	1	265	197	1.83	0.1	F	I	Undeveloped	NA	NA	8		
LT-13	19-Aug	Mammoth	1	266	230	2.66	0.11	F	I	Undeveloped	NA	NA	8		
LT-14	19-Aug	Mammoth	1	502	1290	11.89	9.08	F	I	Undeveloped	NA	NA	26		
LT-15	19-Aug	Mammoth	1	382	648	4.15	7.02	F	I	Undeveloped	NA	NA	19		
LT-16	19-Aug	Mammoth	1	304	355	3.63	0.16	F	I	Undeveloped	NA	NA	7		
LT-17	19-Aug	Mammoth	1	270	246	2.72	0.38	F	I	Undeveloped	NA	NA	7		23 encysted parasites
LT-18	19-Aug	Mammoth	1	232	141	1.47	0.03	U	I	Undeveloped	NA	NA	6		
LT-19	19-Aug	Mammoth	1	217	119.6	1.06	NA	U	I	Undeveloped	NA	NA	5		
LT-20	19-Aug	Mammoth	1	176	64.4	0.56	NA	U	I	Undeveloped	NA	NA	3		
LT-80	25-Aug	Mammoth	2	678	3919	58.17	454	F	M	Ripe	32.25	371	34	2 fish and invertebrates	
LT-81	25-Aug	Mammoth	2	600	2468	30.29	1.91	F	I	Undeveloped	NA	NA	25		
LT-82	25-Aug	Mammoth	2	696	3832	31.76	58.84	F	M	Resting	NA	NA	40		2 encysted parasites
LT-83	25-Aug	Mammoth	2	708	5699	67.46	51.78	F	M	Resting	NA	NA	40	3 whitefish, total 1011 g	
LT-84	26-Aug	Mammoth	4	408	635	5.43	0.74	F	I	Undeveloped	NA	NA	14	Invertebrates	
LT-48	24-Aug	Lake 8	1	458	997	5.82	0.87	M	I	Undeveloped	NA	NA	19	Invertebrates	2 encysted parasites
LT-49	24-Aug	Lake 8	1	437	891	5.99	0.87	F	I	Undeveloped	NA	NA	14		6 encysted parasites
LT-50	24-Aug	Lake 8	1	430	988	8.83	21.84	M	M	Ripe	NA	NA	14	Invertebrates - full	
LT-51	24-Aug	Lake 8	1	482	1132	9.42	40.43	M	M	Ripe	NA	NA	13		
LT-52	24-Aug	Lake 8	1	359	505	2.89	0.25	U	I	Undeveloped	NA	NA	11		
LT-53	24-Aug	Lake 8	1	469	1161	7.55	9.8	F	I	Undeveloped	NA	NA	20		
LT-54	24-Aug	Lake 8	1	473	1165	14.52	125.13	F	M	Ripe	22.98	227	22		

Fish ID	Date (2020)	Lake	Net #	Length (mm)	Weight (g)	Liver Weight (g)	Gonad Weight (g)	Sex	Maturity	Gonad Condition	Egg Sample Weight (g)	Egg Count	Age	Stomach Contents	DELTS/Parasites
LT-55	24-Aug	Lake 8	1	480	1193	12.97	14.32	F	I	Undeveloped	NA	NA	20		
LT-56	24-Aug	Lake 8	1	455	1127	11.89	31.79	M	M	Ripe	NA	NA	13	Invertebrates and sculpin	
LT-57	24-Aug	Lake 8	1	481	1091	6.9	5.59	F	I	Undeveloped	NA	NA	14	Invertebrates	
LT-58	24-Aug	Lake 8	1	498	1392	13.23	156.87	F	M	Ripe	30.02	323	19	Invertebrates	
LT-59	24-Aug	Lake 8	1	660	3263	26.78	32.17	M	M	Ripe	NA	NA	43		
LT-60	24-Aug	Lake 8	1	469	1053	10.7	6.32	F	I	Undeveloped	NA	NA	23	Invert/fish remains	
LT-61	24-Aug	Lake 8	1	522	1282	11.93	26.45	F	I	Undeveloped	NA	NA	39		
LT-62	24-Aug	Lake 8	1	462	1133	7.29	43.53	M	M	Ripe	NA	NA	25		
LT-63	24-Aug	Lake 8	1	370	519	4.31	1.52	F	I	Undeveloped	NA	NA	9	Invertebrates and fish	
LT-64	24-Aug	Lake 8	1	286	236	1.73	0.41	F	I	Undeveloped	NA	NA	8		
LT-65	24-Aug	Lake 8	1	289	246	2.59	0.48	F	I	Undeveloped	NA	NA	9		
LT-66	24-Aug	Lake 8	1	296	260	1.98	0.44	F	I	Undeveloped	NA	NA	8		
LT-67	24-Aug	Lake 8	1	257	173.49	1.47	0.11	U	I	Undeveloped	NA	NA	8		1 encysted parasite
LT-68	24-Aug	Lake 8	1	204	96.33	1.06	0.02	U	I	Undeveloped	NA	NA	6	4 sculpin	
LT-69	24-Aug	Lake 8	1	212	89.56	0.92	NA	U	I	Undeveloped	NA	NA	4	1 sculpin, 39 mm	
LT-70	24-Aug	Lake 8	2	510	1290	14.52	8.07	F	I	Undeveloped	NA	NA	19	Whitefish, ~160mm	
LT-71	24-Aug	Lake 8	2	565	1463	8.89	1.5	M	I	Undeveloped	NA	NA	27		6 encysted parasites
LT-72	24-Aug	Lake 8	2	614	1862	11.08	3.4	M	I	Undeveloped	NA	NA	39		
LT-73	24-Aug	Lake 8	2	485	1143	13.08	3.04	M	I	Undeveloped	NA	NA	26		
LT-74	24-Aug	Lake 8	2	480	1266	12.33	23.85	M	M	Ripe	NA	NA	21	Zooplankton - full	
LT-75	24-Aug	Lake 8	2	451	891	8.11	22.42	M	M	Ripe	NA	NA	15		
LT-76	24-Aug	Lake 8	2	343	383	3.77	0.6	F	I	Undeveloped	NA	NA	10		
LT-77	24-Aug	Lake 8	2	364	523	3.9	0.2	U	I	Undeveloped	NA	NA	10	Dipteran	
LT-78	24-Aug	Lake 8	2	193	70.81	0.73	NA	U	I	Undeveloped	NA	NA	6	Invertebrates	11 encysted parasites
LT-79	24-Aug	Lake 8	2	150	32.97	0.3	NA	U	I	Undeveloped	NA	NA	5		
LT-21	20-Aug	Lake D1		876	9530	108.19	350	M	M	Ripe	NA	NA	35	Lake Trout, 422mm 696g	
LT-22	20-Aug	Lake D1	1 or 2	831	7750	66.44	305	M	M	Ripe	NA	NA	37		
LT-23	20-Aug	Lake D1	1 or 2	835	6920	58.95	104.46	F	M	Resting	NA	NA	36		
LT-24	20-Aug	Lake D1	1 or 2	792	5580	55.43	65.59	F	M	Resting	NA	NA	50		
LT-25	20-Aug	Lake D1	1 or 2	721	4295	40.61	131.6	M	M	Ripe	NA	NA	33		
LT-26	20-Aug	Lake D1	1 or 2	592	1854	22.72	14.95	F	I	Resting	NA	NA	28		20 encysted parasites
LT-27	20-Aug	Lake D1	1 or 2	486	1051	8.7	1.34	M	I	Resting	NA	NA	13		17 encysted parasites
LT-28	20-Aug	Lake D1	1 or 2	375	613	8.33	1.42	M	I	Resting	NA	NA	10	Invertebrates	21 encysted parasites
LT-29	20-Aug	Lake D1	1 or 2	435	867	7.01	1.29	M	I	Resting	NA	NA	22	Invertebrates	42 encysted parasites

Fish ID	Date (2020)	Lake	Net #	Length (mm)	Weight (g)	Liver Weight (g)	Gonad Weight (g)	Sex	Maturity	Gonad Condition	Egg Sample Weight (g)	Egg Count	Age	Stomach Contents	DELTS/Parasites
LT-30	20-Aug	Lake D1	1 or 2	247	160.12	1.39	0.28	F	I	Resting	NA	NA	11		
LT-31	20-Aug	Lake D1	1 or 2	831	5400	74.5	71.32	F	M	Resting	NA	NA	36		
LT-32	20-Aug	Lake D1	1 or 2	728	5886	59.12	150.4	M	M	Ripe	NA	NA	27		
LT-33	20-Aug	Lake D1	1 or 2	853	7890	56.49	77.2	F	M	Resting	NA	NA	36		
LT-34	20-Aug	Lake D1	1 or 2	638	3171	47.22	22.76	F	I	Resting	NA	NA	33		
LT-35	20-Aug	Lake D1	1 or 2	458	895	7.9	0.52	U	I	Undeveloped	NA	NA	13		
LT-36	20-Aug	Lake D1	1 or 2	422	807	7.42	18.8	M	M	Ripe	NA	NA	22	Invertebrates	
LT-37	20-Aug	Lake D1	1 or 2	392	666	5.33	9.02	F	I	Resting	NA	NA	19	Invertebrates	18 encysted parasites
LT-38	20-Aug	Lake D1	1 or 2	425	865	7.1	17.68	M	M	Ripe	NA	NA	20		25 encysted parasites
LT-39	20-Aug	Lake D1	1 or 2	281	261	3.19	0.49	F	I	Undeveloped	NA	NA	10		
LT-40	20-Aug	Lake D1	1 or 2	367	477	3.77	1.39	F	I	Undeveloped	NA	NA	14		33 encysted parasites
LT-41	20-Aug	Lake D1	1 or 2	322	357	2.5	0.15	U	I	Undeveloped	NA	NA	12		25 encysted parasites
LT-42	20-Aug	Lake D1	1 or 2	311	262	2.32	0.52	F	I	Undeveloped	NA	NA	9		11 encysted parasites
LT-43	20-Aug	Lake D1	1 or 2	226	140.33	1.16	0.26	U	I	Undeveloped	NA	NA	11		12 encysted parasites
LT-44	20-Aug	Lake D1	1 or 2	178	61.72	0.87	0.03	U	I	Undeveloped	NA	NA	9		14 encysted parasites
LT-45	20-Aug	Lake D1	1 or 2	179	57.92	0.64	0.03	U	I	Undeveloped	NA	NA	5		4 encysted parasites
LT-46	20-Aug	Lake D1	1 or 2	169	48.74	0.49	0.06	U	I	Undeveloped	NA	NA	8		9 encysted parasites
LT-47	20-Aug	Lake D1	1 or 2	256	184	1.84	0.06	U	I	Undeveloped	NA	NA	9		9 encysted parasites

Table 4-2. Individual Slimy Sculpin data.

Fish ID	Date (2020)	Lake	E-fish Run	Length (mm)	Weight (g)	Liver Weight (g)	Gonad Weight (g)	Sex	Maturity	Age	Parasite Count	Parasite Weight
SC-60	21-Aug	Mammoth	2&3	50	1.054	0.0329	0.0123	F	M	1	0	0
SC-50	21-Aug	Mammoth	2&3	46	0.789	0.0259	0.0019	U	I	2	0	0
SC-59	21-Aug	Mammoth	2&3	62	1.653	0.0362	0.0154	M	M	2	0	0
SC-61	21-Aug	Mammoth	2&3	46	0.792	0.0147	0.0063	F	M	2	0	0
SC-62	21-Aug	Mammoth	2&3	52	1.293	0.0291	0.0157	M	M	2	0	0
SC-65	21-Aug	Mammoth	2&3	52	1.232	0.0199	0.006	M	M	2	0	0
SC-66	21-Aug	Mammoth	2&3	46	0.857	0.0172	0.0044	U	I	2	0	0
SC-68	21-Aug	Mammoth	2&3	53	1.46	0.037	0.0133	M	M	2	0	0
SC-71	21-Aug	Mammoth	2&3	49	0.937	0.0262	0.0075	F	M	2	0	0
SC-72	21-Aug	Mammoth	2&3	60	1.645	0.0277	0.021	M	M	2	0	0
SC-73	21-Aug	Mammoth	2&3	51	1.167	0.035	0.0093	F	M	2	0	0
SC-74	21-Aug	Mammoth	2&3	51	1.06	0.0348	0.0097	F	M	2	0	0
SC-75	21-Aug	Mammoth	2&3	54	1.397	0.0244	0.0012	U	I	2	1	0.177
SC-76	21-Aug	Mammoth	2&3	53	1.079	0.0299	0.0133	F	M	2	0	0
SC-58	21-Aug	Mammoth	2&3	61	1.934	0.0175	0.0091	M	M	3	2	0.3597
SC-63	21-Aug	Mammoth	2&3	57	1.784	0.0689	0.0092	F	M	3	0	0
SC-67	21-Aug	Mammoth	2&3	58	1.671	0.0166	0.0112	F	M	3	1	0.2358
SC-69	21-Aug	Mammoth	2&3	58	1.428	0.0334	0.0315	F	M	3	0	0
SC-70	21-Aug	Mammoth	2&3	58	1.394	0.0376	0.0155	F	M	3	0	0
SC-64	21-Aug	Mammoth	2&3	67	2.522	0.0295	0.0158	M	M	4	0	0
SC-266	25-Aug	Mammoth	4	65	1.85	0.0312	0.0278	M	M	4	0	0
SC-271	25-Aug	Mammoth	4	62	2.176	0.0564	0.024	M	M	4	0	0
SC-280	25-Aug	Mammoth	4	70	3.034	0.106	0.0431	F	M	5	0	0
SC-279	25-Aug	Mammoth	4	71	2.96	0.1485	0.0457	F	M	6	0	0
SC-1	21-Aug	Mammoth	1	40	0.536	NA	NA	NA	NA	NA	NA	NA
SC-2	21-Aug	Mammoth	1	37	0.417	NA	NA	NA	NA	NA	NA	NA
SC-3	21-Aug	Mammoth	1	49	1.131	NA	NA	NA	NA	NA	NA	NA
SC-4	21-Aug	Mammoth	1	40	0.559	NA	NA	NA	NA	NA	NA	NA
SC-5	21-Aug	Mammoth	1	51	1.182	NA	NA	NA	NA	NA	NA	NA
SC-6	21-Aug	Mammoth	2	55	1.222	NA	NA	NA	NA	NA	NA	NA
SC-7	21-Aug	Mammoth	2	52	1.088	NA	NA	NA	NA	NA	NA	NA
SC-8	21-Aug	Mammoth	2	51	0.999	NA	NA	NA	NA	NA	NA	NA
SC-9	21-Aug	Mammoth	2	60	1.989	NA	NA	NA	NA	NA	NA	NA
SC-10	21-Aug	Mammoth	2	59	1.492	NA	NA	NA	NA	NA	NA	NA
SC-11	21-Aug	Mammoth	2	51	0.984	NA	NA	NA	NA	NA	NA	NA
SC-12	21-Aug	Mammoth	2	46	0.74	NA	NA	NA	NA	NA	NA	NA
SC-13	21-Aug	Mammoth	2	65	1.874	NA	NA	NA	NA	NA	NA	NA
SC-14	21-Aug	Mammoth	2	46	0.859	NA	NA	NA	NA	NA	NA	NA
SC-15	21-Aug	Mammoth	2	53	1.354	NA	NA	NA	NA	NA	NA	NA
SC-16	21-Aug	Mammoth	2	37	0.362	NA	NA	NA	NA	NA	NA	NA
SC-17	21-Aug	Mammoth	2	51	1.21	NA	NA	NA	NA	NA	NA	NA
SC-18	21-Aug	Mammoth	2	67	2.144	NA	NA	NA	NA	NA	NA	NA
SC-19	21-Aug	Mammoth	2	38	0.445	NA	NA	NA	NA	NA	NA	NA
SC-20	21-Aug	Mammoth	2	54	1.181	NA	NA	NA	NA	NA	NA	NA
SC-21	21-Aug	Mammoth	2	49	0.855	NA	NA	NA	NA	NA	NA	NA
SC-22	21-Aug	Mammoth	2	40	0.483	NA	NA	NA	NA	NA	NA	NA
SC-23	21-Aug	Mammoth	2	51	1.2	NA	NA	NA	NA	NA	NA	NA
SC-24	21-Aug	Mammoth	2	61	1.93	NA	NA	NA	NA	NA	NA	NA
SC-25	21-Aug	Mammoth	2	44	0.636	NA	NA	NA	NA	NA	NA	NA
SC-26	21-Aug	Mammoth	2	47	0.887	NA	NA	NA	NA	NA	NA	NA
SC-27	21-Aug	Mammoth	2	64	1.837	NA	NA	NA	NA	NA	NA	NA
SC-28	21-Aug	Mammoth	2	43	0.57	NA	NA	NA	NA	NA	NA	NA
SC-29	21-Aug	Mammoth	2	55	1.391	NA	NA	NA	NA	NA	NA	NA
SC-30	21-Aug	Mammoth	2	40	0.427	NA	NA	NA	NA	NA	NA	NA

Fish ID	Date (2020)	Lake	E-fish Run	Length (mm)	Weight (g)	Liver Weight (g)	Gonad Weight (g)	Sex	Maturity	Age	Parasite Count	Parasite Weight
SC-31	21-Aug	Mammoth	2	38	0.457	NA	NA	NA	NA	NA	NA	NA
SC-32	21-Aug	Mammoth	2	35	0.363	NA	NA	NA	NA	NA	NA	NA
SC-33	21-Aug	Mammoth	2	37	0.394	NA	NA	NA	NA	NA	NA	NA
SC-34	21-Aug	Mammoth	2&3	42	0.532	NA	NA	NA	NA	NA	NA	NA
SC-35	21-Aug	Mammoth	2&3	36	0.396	NA	NA	NA	NA	NA	NA	NA
SC-36	21-Aug	Mammoth	2&3	41	0.486	NA	NA	NA	NA	NA	NA	NA
SC-37	21-Aug	Mammoth	2&3	43	0.565	NA	NA	NA	NA	NA	NA	NA
SC-38	21-Aug	Mammoth	2&3	38	0.522	NA	NA	NA	NA	NA	NA	NA
SC-39	21-Aug	Mammoth	2&3	36	0.361	NA	NA	NA	NA	NA	NA	NA
SC-40	21-Aug	Mammoth	2&3	40	0.494	NA	NA	NA	NA	NA	NA	NA
SC-41	21-Aug	Mammoth	2&3	37	0.448	NA	NA	NA	NA	NA	NA	NA
SC-42	21-Aug	Mammoth	2&3	40	0.462	NA	NA	NA	NA	NA	NA	NA
SC-43	21-Aug	Mammoth	2&3	38	0.442	NA	NA	NA	NA	NA	NA	NA
SC-44	21-Aug	Mammoth	2&3	35	0.349	NA	NA	NA	NA	NA	NA	NA
SC-45	21-Aug	Mammoth	2&3	38	0.477	NA	NA	NA	NA	NA	NA	NA
SC-46	21-Aug	Mammoth	2&3	42	0.552	NA	NA	NA	NA	NA	NA	NA
SC-47	21-Aug	Mammoth	2&3	40	0.527	NA	NA	NA	NA	NA	NA	NA
SC-48	21-Aug	Mammoth	2&3	40	0.507	NA	NA	NA	NA	NA	NA	NA
SC-49	21-Aug	Mammoth	2&3	38	0.452	NA	NA	NA	NA	NA	NA	NA
SC-51	21-Aug	Mammoth	2&3	40	0.413	NA	NA	NA	NA	NA	NA	NA
SC-52	21-Aug	Mammoth	2&3	41	0.455	NA	NA	NA	NA	NA	NA	NA
SC-53	21-Aug	Mammoth	2&3	36	0.39	NA	NA	NA	NA	NA	NA	NA
SC-54	21-Aug	Mammoth	2&3	39	0.461	NA	NA	NA	NA	NA	NA	NA
SC-55	21-Aug	Mammoth	2&3	41	0.585	NA	NA	NA	NA	NA	NA	NA
SC-56	21-Aug	Mammoth	2&3	36	0.37	NA	NA	NA	NA	NA	NA	NA
SC-57	21-Aug	Mammoth	2&3	42	0.683	NA	NA	NA	NA	NA	NA	NA
SC-77	21-Aug	Mammoth	2&3	50	1.006	NA	NA	NA	NA	NA	NA	NA
SC-78	21-Aug	Mammoth	2&3	34	0.379	NA	NA	NA	NA	NA	NA	NA
SC-79	21-Aug	Mammoth	2&3	40	0.515	NA	NA	NA	NA	NA	NA	NA
SC-80	21-Aug	Mammoth	2&3	49	0.827	NA	NA	NA	NA	NA	NA	NA
SC-81	21-Aug	Mammoth	2&3	46	0.893	NA	NA	NA	NA	NA	NA	NA
SC-82	21-Aug	Mammoth	2&3	51	1.01	NA	NA	NA	NA	NA	NA	NA
SC-83	21-Aug	Mammoth	2&3	54	1.298	NA	NA	NA	NA	NA	NA	NA
SC-264	25-Aug	Mammoth	4	36	0.371	NA	NA	NA	NA	NA	NA	NA
SC-265	25-Aug	Mammoth	4	40	0.564	NA	NA	NA	NA	NA	NA	NA
SC-267	25-Aug	Mammoth	4	53	1.213	NA	NA	NA	NA	NA	NA	NA
SC-268	25-Aug	Mammoth	4	52	1.638	NA	NA	NA	NA	NA	NA	NA
SC-269	25-Aug	Mammoth	4	36	0.355	NA	NA	NA	NA	NA	NA	NA
SC-270	25-Aug	Mammoth	4	42	0.529	NA	NA	NA	NA	NA	NA	NA
SC-272	25-Aug	Mammoth	4	50	1.013	NA	NA	NA	NA	NA	NA	NA
SC-273	25-Aug	Mammoth	4	41	0.559	NA	NA	NA	NA	NA	NA	NA
SC-274	25-Aug	Mammoth	4	41	0.499	NA	NA	NA	NA	NA	NA	NA
SC-275	25-Aug	Mammoth	4	56	1.44	NA	NA	NA	NA	NA	NA	NA
SC-276	25-Aug	Mammoth	4	63	2.19	NA	NA	NA	NA	NA	NA	NA
SC-277	25-Aug	Mammoth	4	60	1.748	NA	NA	NA	NA	NA	NA	NA
SC-278	25-Aug	Mammoth	4	64	2.202	NA	NA	NA	NA	NA	NA	NA
SC-97	22-Aug	Lake D1	1&2&3	48	0.877	0.0112	0.0021	U	I	2	0	0
SC-102	22-Aug	Lake D1	1&2&3	50	1.136	0.0196	0.0047	U	I	2	1	0.0628
SC-110	22-Aug	Lake D1	1&2&3	49	1.007	0.0159	0.0095	U	I	2	0	0
SC-112	22-Aug	Lake D1	1&2&3	52	1.102	0.0193	0.0109	U	I	2	0	0
SC-113	22-Aug	Lake D1	1&2&3	48	0.981	0.0151	0.0034	U	I	2	0	0
SC-117	22-Aug	Lake D1	1&2&3	49	0.929	0.0173	0.0174	F	M	2	0	0
SC-87	22-Aug	Lake D1	1&2&3	69	2.737	0.0478	0.0481	M	M	3	0	0
SC-90	22-Aug	Lake D1	1&2&3	61	2.165	0.0761	0.0387	F	M	3	0	0
SC-98	22-Aug	Lake D1	1&2&3	63	2.006	0.0311	0.0311	M	M	3	0	0
SC-100	22-Aug	Lake D1	1&2&3	51	1.259	0.0176	0.0036	U	I	3	1	0.2208
SC-107	22-Aug	Lake D1	1&2&3	54	1.363	0.0264	0.029	F	M	3	0	0

Fish ID	Date (2020)	Lake	E-fish Run	Length (mm)	Weight (g)	Liver Weight (g)	Gonad Weight (g)	Sex	Maturity	Age	Parasite Count	Parasite Weight
SC-108	22-Aug	Lake D1	1&2&3	64	1.878	0.0331	0.0255	M	M	3	0	0
SC-115	22-Aug	Lake D1	1&2&3	60	1.782	0.0421	0.021	M	M	3	0	0
SC-301	27-Aug	Lake D1	4&5&6	72	3.254	0.1024	0.0497	M	M	3	0	0
SC-302	27-Aug	Lake D1	4&5&6	71	3.032	0.0802	0.0658	M	M	3	0	0
SC-88	22-Aug	Lake D1	1&2&3	59	2.583	0.0364	0.0143	F	M	4	1	0.263
SC-92	22-Aug	Lake D1	1&2&3	57	1.987	0.0412	0.0181	M	M	4	0	0
SC-93	22-Aug	Lake D1	1&2&3	56	1.517	0.0358	0.0287	F	M	4	0	0
SC-95	22-Aug	Lake D1	1&2&3	56	2.127	0.0398	0.0248	M	M	4	0	0
SC-103	22-Aug	Lake D1	1&2&3	66	2.564	0.0441	0.0455	M	M	5	0	0
SC-105	22-Aug	Lake D1	1&2&3	67	2.552	0.0419	0.0392	M	M	5	0	0
SC-85	22-Aug	Lake D1	1&2&3	71	3.088	0.0854	0.0553	M	M	6	0	0
SC-304	22-Aug	Lake D1	1&2&3	78	4.6	NA	NA	NA	NA	NA	NA	NA
SC-84	22-Aug	Lake D1	1&2&3	74	4.808	NA	NA	NA	NA	NA	NA	NA
SC-86	22-Aug	Lake D1	1&2&3	61	2.217	NA	NA	NA	NA	NA	NA	NA
SC-89	22-Aug	Lake D1	1&2&3	60	2.214	NA	NA	NA	NA	NA	NA	NA
SC-91	22-Aug	Lake D1	1&2&3	53	1.435	NA	NA	NA	NA	NA	NA	NA
SC-94	22-Aug	Lake D1	1&2&3	52	1.877	NA	NA	NA	NA	NA	NA	NA
SC-96	22-Aug	Lake D1	1&2&3	49	1.183	NA	NA	NA	NA	NA	NA	NA
SC-99	22-Aug	Lake D1	1&2&3	58	1.634	NA	NA	NA	NA	NA	NA	NA
SC-101	22-Aug	Lake D1	1&2&3	50	1.026	NA	NA	NA	NA	NA	NA	NA
SC-104	22-Aug	Lake D1	1&2&3	71	2.892	NA	NA	NA	NA	NA	NA	NA
SC-106	22-Aug	Lake D1	1&2&3	59	1.664	NA	NA	NA	NA	NA	NA	NA
SC-109	22-Aug	Lake D1	1&2&3	57	1.32	NA	NA	NA	NA	NA	NA	NA
SC-111	22-Aug	Lake D1	1&2&3	51	1.15	NA	NA	NA	NA	NA	NA	NA
SC-114	22-Aug	Lake D1	1&2&3	51	1.041	NA	NA	NA	NA	NA	NA	NA
SC-116	22-Aug	Lake D1	1&2&3	47	0.814	NA	NA	NA	NA	NA	NA	NA
SC-118	22-Aug	Lake D1	1&2&3	49	1.236	NA	NA	NA	NA	NA	NA	NA
SC-119	22-Aug	Lake D1	1&2&3	45	0.998	NA	NA	NA	NA	NA	NA	NA
SC-120	22-Aug	Lake D1	1&2&3	39	0.696	NA	NA	NA	NA	NA	NA	NA
SC-121	22-Aug	Lake D1	1&2&3	44	0.923	NA	NA	NA	NA	NA	NA	NA
SC-122	22-Aug	Lake D1	1&2&3	39	0.684	NA	NA	NA	NA	NA	NA	NA
SC-123	22-Aug	Lake D1	1&2&3	44	1.003	NA	NA	NA	NA	NA	NA	NA
SC-124	22-Aug	Lake D1	1&2&3	45	0.737	NA	NA	NA	NA	NA	NA	NA
SC-125	22-Aug	Lake D1	1&2&3	35	0.414	NA	NA	NA	NA	NA	NA	NA
SC-126	22-Aug	Lake D1	1&2&3	34	0.509	NA	NA	NA	NA	NA	NA	NA
SC-127	22-Aug	Lake D1	1&2&3	43	0.757	NA	NA	NA	NA	NA	NA	NA
SC-128	22-Aug	Lake D1	1&2&3	48	0.859	NA	NA	NA	NA	NA	NA	NA
SC-129	22-Aug	Lake D1	1&2&3	46	0.986	NA	NA	NA	NA	NA	NA	NA
SC-130	22-Aug	Lake D1	1&2&3	41	0.848	NA	NA	NA	NA	NA	NA	NA
SC-131	22-Aug	Lake D1	1&2&3	34	0.337	NA	NA	NA	NA	NA	NA	NA
SC-132	22-Aug	Lake D1	1&2&3	35	0.559	NA	NA	NA	NA	NA	NA	NA
SC-133	22-Aug	Lake D1	1&2&3	35	0.454	NA	NA	NA	NA	NA	NA	NA
SC-134	22-Aug	Lake D1	1&2&3	35	0.453	NA	NA	NA	NA	NA	NA	NA
SC-135	22-Aug	Lake D1	1&2&3	34	0.405	NA	NA	NA	NA	NA	NA	NA
SC-136	22-Aug	Lake D1	1&2&3	46	0.805	NA	NA	NA	NA	NA	NA	NA
SC-137	22-Aug	Lake D1	1&2&3	47	0.823	NA	NA	NA	NA	NA	NA	NA
SC-138	22-Aug	Lake D1	1&2&3	42	0.598	NA	NA	NA	NA	NA	NA	NA
SC-139	22-Aug	Lake D1	1&2&3	47	0.794	NA	NA	NA	NA	NA	NA	NA
SC-140	22-Aug	Lake D1	1&2&3	45	0.816	NA	NA	NA	NA	NA	NA	NA
SC-141	22-Aug	Lake D1	1&2&3	37	0.419	NA	NA	NA	NA	NA	NA	NA
SC-142	22-Aug	Lake D1	1&2&3	36	0.399	NA	NA	NA	NA	NA	NA	NA
SC-143	22-Aug	Lake D1	1&2&3	45	0.734	NA	NA	NA	NA	NA	NA	NA
SC-144	22-Aug	Lake D1	1&2&3	46	0.747	NA	NA	NA	NA	NA	NA	NA
SC-145	22-Aug	Lake D1	1&2&3	46	0.834	NA	NA	NA	NA	NA	NA	NA
SC-146	22-Aug	Lake D1	1&2&3	35	0.369	NA	NA	NA	NA	NA	NA	NA
SC-147	22-Aug	Lake D1	1&2&3	44	0.706	NA	NA	NA	NA	NA	NA	NA
SC-148	22-Aug	Lake D1	1&2&3	48	0.763	NA	NA	NA	NA	NA	NA	NA

Fish ID	Date (2020)	Lake	E-fish Run	Length (mm)	Weight (g)	Liver Weight (g)	Gonad Weight (g)	Sex	Maturity	Age	Parasite Count	Parasite Weight
SC-149	22-Aug	Lake D1	1&2&3	35	0.378	NA	NA	NA	NA	NA	NA	NA
SC-150	22-Aug	Lake D1	1&2&3	48	0.812	NA	NA	NA	NA	NA	NA	NA
SC-151	22-Aug	Lake D1	1&2&3	47	0.723	NA	NA	NA	NA	NA	NA	NA
SC-152	22-Aug	Lake D1	1&2&3	49	0.837	NA	NA	NA	NA	NA	NA	NA
SC-153	22-Aug	Lake D1	1&2&3	49	0.809	NA	NA	NA	NA	NA	NA	NA
SC-154	22-Aug	Lake D1	1&2&3	52	1.121	NA	NA	NA	NA	NA	NA	NA
SC-155	22-Aug	Lake D1	1&2&3	35	0.452	NA	NA	NA	NA	NA	NA	NA
SC-156	22-Aug	Lake D1	1&2&3	44	0.753	NA	NA	NA	NA	NA	NA	NA
SC-157	22-Aug	Lake D1	1&2&3	47	0.776	NA	NA	NA	NA	NA	NA	NA
SC-158	22-Aug	Lake D1	1&2&3	48	0.835	NA	NA	NA	NA	NA	NA	NA
SC-159	22-Aug	Lake D1	1&2&3	40	0.514	NA	NA	NA	NA	NA	NA	NA
SC-160	22-Aug	Lake D1	1&2&3	36	0.413	NA	NA	NA	NA	NA	NA	NA
SC-161	22-Aug	Lake D1	1&2&3	37	0.442	NA	NA	NA	NA	NA	NA	NA
SC-281	27-Aug	Lake D1	4&5&6	50	0.809	NA	NA	NA	NA	NA	NA	NA
SC-282	27-Aug	Lake D1	4&5&6	52	1.226	NA	NA	NA	NA	NA	NA	NA
SC-283	27-Aug	Lake D1	4&5&6	52	1.023	NA	NA	NA	NA	NA	NA	NA
SC-284	27-Aug	Lake D1	4&5&6	36	0.372	NA	NA	NA	NA	NA	NA	NA
SC-285	27-Aug	Lake D1	4&5&6	62	1.901	NA	NA	NA	NA	NA	NA	NA
SC-286	27-Aug	Lake D1	4&5&6	47	0.795	NA	NA	NA	NA	NA	NA	NA
SC-287	27-Aug	Lake D1	4&5&6	56	1.706	NA	NA	NA	NA	NA	NA	NA
SC-288	27-Aug	Lake D1	4&5&6	50	1.016	NA	NA	NA	NA	NA	NA	NA
SC-289	27-Aug	Lake D1	4&5&6	49	0.855	NA	NA	NA	NA	NA	NA	NA
SC-290	27-Aug	Lake D1	4&5&6	45	0.778	NA	NA	NA	NA	NA	NA	NA
SC-291	27-Aug	Lake D1	4&5&6	46	0.726	NA	NA	NA	NA	NA	NA	NA
SC-292	27-Aug	Lake D1	4&5&6	59	2.077	NA	NA	NA	NA	NA	NA	NA
SC-293	27-Aug	Lake D1	4&5&6	50	0.999	NA	NA	NA	NA	NA	NA	NA
SC-303	27-Aug	Lake D1	4&5&6	60	1.541	NA	NA	NA	NA	NA	NA	NA
SC-294	27-Aug	Lake D1	4&5&6	54	1.21	NA	NA	NA	NA	NA	NA	NA
SC-295	27-Aug	Lake D1	4&5&6	45	0.765	NA	NA	NA	NA	NA	NA	NA
SC-296	27-Aug	Lake D1	4&5&6	36	0.346	NA	NA	NA	NA	NA	NA	NA
SC-297	27-Aug	Lake D1	4&5&6	56	1.612	NA	NA	NA	NA	NA	NA	NA
SC-298	27-Aug	Lake D1	4&5&6	46	0.913	NA	NA	NA	NA	NA	NA	NA
SC-299	27-Aug	Lake D1	4&5&6	43	0.725	NA	NA	NA	NA	NA	NA	NA
SC-300	27-Aug	Lake D1	4&5&6	35	0.357	NA	NA	NA	NA	NA	NA	NA
SC-256	24-Aug	Lake 8	4	48	1.049	0.0162	0.0116	M	M	1	0	0
SC-258	24-Aug	Lake 8	4	47	0.93	0.0121	0.0075	F	M	1	1	0.1007
SC-216	23-Aug	Lake 8	1&2	51	1.035	0.0168	0.0143	M	M	2	0	0
SC-255	24-Aug	Lake 8	4	51	1.496	0.052	0.0193	M	M	2	0	0
SC-257	24-Aug	Lake 8	4	50	1.3	0.0194	0.0132	F	M	2	0	0
SC-259	24-Aug	Lake 8	4	50	1.31	0.0191	0.0094	F	M	2	1	0.1875
SC-260	24-Aug	Lake 8	4	48	0.983	0.02	0.0183	F	M	2	4	0.1638
SC-261	24-Aug	Lake 8	4	50	1.446	0.0167	0.0015	U	I	2	0	0
SC-215	23-Aug	Lake 8	1&2	57	1.478	0.0215	0.0183	M	M	3	0	0
SC-253	24-Aug	Lake 8	4	46	1.143	0.0117	0.0119	M	M	3	1	0.2584
SC-263	24-Aug	Lake 8	3	46	0.887	0.0155	0.0076	F	M	3	1	0.1179
SC-254	24-Aug	Lake 8	4	59	2.236	0.035	0.0036	U	I	4	1	0.4307
SC-262	24-Aug	Lake 8	3	65	2.629	0.0933	0.0443	M	M	4	0	0
SC-214	23-Aug	Lake 8	1&2	65	2.366	0.0513	0.0282	M	M	5	0	0
SC-222	24-Aug	Lake 8	4	42	0.715	NA	NA	NA	NA	NA	NA	NA
SC-223	24-Aug	Lake 8	4	31	0.35	NA	NA	NA	NA	NA	NA	NA
SC-224	24-Aug	Lake 8	4	40	0.71	NA	NA	NA	NA	NA	NA	NA
SC-225	24-Aug	Lake 8	4	43	0.763	NA	NA	NA	NA	NA	NA	NA
SC-226	24-Aug	Lake 8	4	30	0.303	NA	NA	NA	NA	NA	NA	NA
SC-227	24-Aug	Lake 8	4	37	0.677	NA	NA	NA	NA	NA	NA	NA
SC-228	24-Aug	Lake 8	4	28	0.266	NA	NA	NA	NA	NA	NA	NA
SC-162	23-Aug	Lake 8	1&2	46	0.735	NA	NA	NA	NA	NA	NA	NA
SC-163	23-Aug	Lake 8	1&2	50	1.172	NA	NA	NA	NA	NA	NA	NA

Fish ID	Date (2020)	Lake	E-fish Run	Length (mm)	Weight (g)	Liver Weight (g)	Gonad Weight (g)	Sex	Maturity	Age	Parasite Count	Parasite Weight
SC-164	23-Aug	Lake 8	1&2	35	0.389	NA	NA	NA	NA	NA	NA	NA
SC-165	23-Aug	Lake 8	1&2	30	0.289	NA	NA	NA	NA	NA	NA	NA
SC-166	23-Aug	Lake 8	1&2	37	0.557	NA	NA	NA	NA	NA	NA	NA
SC-167	23-Aug	Lake 8	1&2	46	1.053	NA	NA	NA	NA	NA	NA	NA
SC-168	23-Aug	Lake 8	1&2	45	0.598	NA	NA	NA	NA	NA	NA	NA
SC-169	23-Aug	Lake 8	1&2	51	1.138	NA	NA	NA	NA	NA	NA	NA
SC-170	23-Aug	Lake 8	1&2	34	0.287	NA	NA	NA	NA	NA	NA	NA
SC-171	23-Aug	Lake 8	1&2	45	0.63	NA	NA	NA	NA	NA	NA	NA
SC-172	23-Aug	Lake 8	1&2	40	0.533	NA	NA	NA	NA	NA	NA	NA
SC-173	23-Aug	Lake 8	1&2	40	0.514	NA	NA	NA	NA	NA	NA	NA
SC-174	23-Aug	Lake 8	1&2	60	1.774	NA	NA	NA	NA	NA	NA	NA
SC-175	23-Aug	Lake 8	1&2	44	0.675	NA	NA	NA	NA	NA	NA	NA
SC-176	23-Aug	Lake 8	1&2	31	0.271	NA	NA	NA	NA	NA	NA	NA
SC-177	23-Aug	Lake 8	1&2	41	0.567	NA	NA	NA	NA	NA	NA	NA
SC-178	23-Aug	Lake 8	1&2	38	0.44	NA	NA	NA	NA	NA	NA	NA
SC-179	23-Aug	Lake 8	1&2	27	0.215	NA	NA	NA	NA	NA	NA	NA
SC-180	23-Aug	Lake 8	1&2	44	0.675	NA	NA	NA	NA	NA	NA	NA
SC-181	23-Aug	Lake 8	1&2	41	0.579	NA	NA	NA	NA	NA	NA	NA
SC-182	23-Aug	Lake 8	1&2	53	1.159	NA	NA	NA	NA	NA	NA	NA
SC-183	23-Aug	Lake 8	1&2	51	1.01	NA	NA	NA	NA	NA	NA	NA
SC-184	23-Aug	Lake 8	1&2	52	1.017	NA	NA	NA	NA	NA	NA	NA
SC-185	23-Aug	Lake 8	1&2	39	0.506	NA	NA	NA	NA	NA	NA	NA
SC-186	23-Aug	Lake 8	1&2	44	0.731	NA	NA	NA	NA	NA	NA	NA
SC-187	23-Aug	Lake 8	1&2	45	0.726	NA	NA	NA	NA	NA	NA	NA
SC-188	23-Aug	Lake 8	1&2	41	0.598	NA	NA	NA	NA	NA	NA	NA
SC-189	23-Aug	Lake 8	1&2	30	0.266	NA	NA	NA	NA	NA	NA	NA
SC-190	23-Aug	Lake 8	1&2	45	0.732	NA	NA	NA	NA	NA	NA	NA
SC-191	23-Aug	Lake 8	1&2	35	0.341	NA	NA	NA	NA	NA	NA	NA
SC-192	23-Aug	Lake 8	1&2	43	0.541	NA	NA	NA	NA	NA	NA	NA
SC-193	23-Aug	Lake 8	1&2	31	0.262	NA	NA	NA	NA	NA	NA	NA
SC-194	23-Aug	Lake 8	1&2	45	0.689	NA	NA	NA	NA	NA	NA	NA
SC-195	23-Aug	Lake 8	1&2	37	0.567	NA	NA	NA	NA	NA	NA	NA
SC-196	23-Aug	Lake 8	1&2	41	0.546	NA	NA	NA	NA	NA	NA	NA
SC-197	23-Aug	Lake 8	1&2	32	0.272	NA	NA	NA	NA	NA	NA	NA
SC-198	23-Aug	Lake 8	1&2	37	0.518	NA	NA	NA	NA	NA	NA	NA
SC-199	23-Aug	Lake 8	1&2	43	0.546	NA	NA	NA	NA	NA	NA	NA
SC-200	23-Aug	Lake 8	1&2	38	0.379	NA	NA	NA	NA	NA	NA	NA
SC-201	23-Aug	Lake 8	1&2	45	0.673	NA	NA	NA	NA	NA	NA	NA
SC-202	23-Aug	Lake 8	1&2	38	0.422	NA	NA	NA	NA	NA	NA	NA
SC-203	23-Aug	Lake 8	1&2	42	0.515	NA	NA	NA	NA	NA	NA	NA
SC-204	23-Aug	Lake 8	1&2	44	0.686	NA	NA	NA	NA	NA	NA	NA
SC-205	23-Aug	Lake 8	1&2	34	0.28	NA	NA	NA	NA	NA	NA	NA
SC-206	23-Aug	Lake 8	1&2	38	0.564	NA	NA	NA	NA	NA	NA	NA
SC-207	23-Aug	Lake 8	1&2	32	0.29	NA	NA	NA	NA	NA	NA	NA
SC-208	23-Aug	Lake 8	1&2	32	0.255	NA	NA	NA	NA	NA	NA	NA
SC-209	23-Aug	Lake 8	1&2	33	0.284	NA	NA	NA	NA	NA	NA	NA
SC-210	23-Aug	Lake 8	1&2	33	0.254	NA	NA	NA	NA	NA	NA	NA
SC-211	23-Aug	Lake 8	1&2	34	0.293	NA	NA	NA	NA	NA	NA	NA
SC-212	23-Aug	Lake 8	1&2	30	0.21	NA	NA	NA	NA	NA	NA	NA
SC-213	23-Aug	Lake 8	1&2	30	0.238	NA	NA	NA	NA	NA	NA	NA
SC-217	24-Aug	Lake 8	4	42	0.869	NA	NA	NA	NA	NA	NA	NA
SC-218	24-Aug	Lake 8	4	38	0.574	NA	NA	NA	NA	NA	NA	NA
SC-219	24-Aug	Lake 8	4	40	0.649	NA	NA	NA	NA	NA	NA	NA
SC-220	24-Aug	Lake 8	4	31	0.363	NA	NA	NA	NA	NA	NA	NA
SC-221	24-Aug	Lake 8	4	37	0.601	NA	NA	NA	NA	NA	NA	NA
SC-229	24-Aug	Lake 8	4	36	0.492	NA	NA	NA	NA	NA	NA	NA
SC-230	24-Aug	Lake 8	4	40	0.695	NA	NA	NA	NA	NA	NA	NA

Fish ID	Date (2020)	Lake	E-fish Run	Length (mm)	Weight (g)	Liver Weight (g)	Gonad Weight (g)	Sex	Maturity	Age	Parasite Count	Parasite Weight
SC-231	24-Aug	Lake 8	4	42	0.75	NA	NA	NA	NA	NA	NA	NA
SC-232	24-Aug	Lake 8	4	45	0.976	NA	NA	NA	NA	NA	NA	NA
SC-233	24-Aug	Lake 8	4	42	0.694	NA	NA	NA	NA	NA	NA	NA
SC-234	24-Aug	Lake 8	4	30	0.374	NA	NA	NA	NA	NA	NA	NA
SC-235	24-Aug	Lake 8	4	32	0.515	NA	NA	NA	NA	NA	NA	NA
SC-236	24-Aug	Lake 8	4	31	0.312	NA	NA	NA	NA	NA	NA	NA
SC-237	24-Aug	Lake 8	4	42	0.855	NA	NA	NA	NA	NA	NA	NA
SC-238	24-Aug	Lake 8	4	31	0.314	NA	NA	NA	NA	NA	NA	NA
SC-239	24-Aug	Lake 8	4	30	0.351	NA	NA	NA	NA	NA	NA	NA
SC-240	24-Aug	Lake 8	4	43	0.765	NA	NA	NA	NA	NA	NA	NA
SC-241	24-Aug	Lake 8	4	31	0.366	NA	NA	NA	NA	NA	NA	NA
SC-242	24-Aug	Lake 8	4	40	0.588	NA	NA	NA	NA	NA	NA	NA
SC-243	24-Aug	Lake 8	4	30	0.327	NA	NA	NA	NA	NA	NA	NA
SC-244	24-Aug	Lake 8	4	37	0.641	NA	NA	NA	NA	NA	NA	NA
SC-245	24-Aug	Lake 8	4	32	0.351	NA	NA	NA	NA	NA	NA	NA
SC-246	24-Aug	Lake 8	4	32	0.374	NA	NA	NA	NA	NA	NA	NA
SC-247	24-Aug	Lake 8	4	28	0.245	NA	NA	NA	NA	NA	NA	NA
SC-248	24-Aug	Lake 8	4	31	0.313	NA	NA	NA	NA	NA	NA	NA
SC-249	24-Aug	Lake 8	4	30	0.308	NA	NA	NA	NA	NA	NA	NA
SC-250	24-Aug	Lake 8	4	31	0.342	NA	NA	NA	NA	NA	NA	NA
SC-251	24-Aug	Lake 8	4	33	0.389	NA	NA	NA	NA	NA	NA	NA
SC-252	24-Aug	Lake 8	4	32	0.347	NA	NA	NA	NA	NA	NA	NA

Appendix 5. Water Chemistry Quality Assurance

Table 5-1. Equipment blanks and travel blanks for the 2020 CREMP water quality program.

Parameter	Blanks	
	Travel Blank	Equipment Blank
Physical Tests		
Conductivity (µS/cm)	<2.0	<2.0
Hardness (as $CaCO_3$), Dissolved (mg/L)	<0.60	<0.60
Hardness (as $CaCO_3$), from total Ca/Mg (mg/L)	<0.60	<0.60
pH (lab)	5.72	5.45
Total Dissolved Solids (mg/L)	<3.0	<3.0
Total Dissolved Solids (mg/L), calculated	<1.0	1
Total Suspended Solids (mg/L)	<1.0	<1.0
Turbidity (NTU)	<0.10	<0.10
Anions and Nutrients (mg/L)		
Alkalinity, Hydroxide (as $CaCO_3$)	<1.0	<1.0
Alkalinity, Carbonate (as $CaC0_3$)	<1.0	<1.0
Alkalinity, Bicarbonate (as $CaCO_3$)	<1.0	<1.0
Alkalinity, Total (as $CaCO_3$)	<1.0	<1.0
Total Kjeldahl Nitrogen	<0.050	<0.050
Ammonia, Total (as N)	<0.0050	0.0204
Bromide	<0.050	<0.050
Chloride	<0.10	<0.10
Fluoride	<0.020	<0.020
Nitrate (as N)	<0.0050	<0.0050
Nitrite (as N)	<0.0010	<0.0010
Phosphate, ortho-, dissolved (as P)	<0.0010	<0.0010
Phosphorus, Total	<0.0020	<0.0020
Phosphorus, Total Dissolved	<0.0020	<0.0020
Silicate (as SIO_2)	<0.50	<0.50
Sulfate (as SO_4)	<0.30	<0.30
Organic/Inorganic Carbon (mg/L)		
Dissolved Organic Carbon	<0.50	0.65
Total Organic Carbon	0.54	<0.50
Total Metals (mg/L)		
Aluminum	<0.0030	<0.0030
Antimony	<0.00010	<0.00010
Arsenic	<0.00010	<0.00010
Barium	<0.00010	<0.00010
Beryllium	<0.000100	<0.000100
Bismuth	<0.000050	<0.000050
Boron	<0.010	<0.010

Parameter	Blanks	
	Travel Blank	Equipment Blank
Cadmium	<0.0000050	<0.0000050
Calcium	<0.050	<0.050
Cesium	<0.000010	<0.000010
Chromium	<0.00010	<0.00010
Cobalt	<0.00010	<0.00010
Copper	<0.00050	<0.00050
Iron	<0.010	<0.010
Lead	<0.000050	0.000069
Lithium	<0.0010	<0.0010
Magnesium	<0.0050	<0.0050
Manganese	<0.00010	<0.00010
Mercury	<0.0000050	<0.0000050
Molybdenum	<0.000050	<0.000050
Nickel	<0.00050	<0.00050
Phosphorus	<0.050	<0.050
Potassium	<0.050	<0.050
Rubidium	<0.00020	<0.00020
Selenium	<0.000050	<0.000050
Silicon	<0.10	<0.10
Silver	<0.000010	<0.000010
Sodium	<0.050	<0.050
Strontium	<0.00020	<0.00020
Sulfur	<0.50	<0.50
Tellurium	<0.00020	<0.00020
Thallium	<0.000010	<0.000010
Thorium	<0.00010	<0.00010
Tin	<0.00010	<0.00010
Titanium	<0.00030	<0.00030
Tungsten	<0.00010	<0.00010
Uranium	<0.000010	<0.000010
Vanadium	<0.00050	<0.00050
Zinc	<0.0030	<0.0030
Zirconium	<0.00020	<0.00020

Appendix 6. Benthic Community Data

Appendix 6-1. Count data for benthic invertebrate samples collected on August 15 (Mammoth Lake), August 19 (Lake D1), and August 28 (Lake 8), 2020.

Taxonomy	**Lake D1**					**Lake 8**					**Mammoth Lake†**					
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5.1**	**5.2**
ROUNDWORMS																
P. Nemata	5	4	1	3	3	14	6	7	12	10	2	1	3	14	2	2
FLATWORMS																
P. Platyhelminthes																
Cl. Turbellaria																
indeterminate	-	-	-	-	2	-	-	-	-	-	-	-	-	4	2	-
<u>ANNELIDS</u>																
P. Annelida																
WORMS																
S.F. Tubificinae																
immatures with hair chaetae	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S.F. Rhyacodrilinae																
Rhyacodrilus coccineus	-	1	-	-	-	-	-	-	2	3	2	1	2	4	2	2
F. Lumbriculidae																
Lumbriculus	6	1	2	1	-	3	1	2	1	2	5	1	3	2	-	2
<u>ARTHROPODS</u>																
P. Arthropoda																
MITES																
Cl. Arachnida																
O. Acarina																
F. Acalyptonotidae																
Acalyptonotus	-	-	-	-	-	-	-	1	2	-	2	-	2	-	-	2
F. Hygrobatidae																
Hygrobates	-	1	-	-	1	-	-	-	-	-	-	-	1	-	-	-
F. Lebertiidae																
Lebertia	1	-	1	1	1	1	-	1	4	9	1	-	1	-	-	-
F. Oxidae																
Oxus	2	1	-	-	2	-	5	6	5	1	2	3	-	3	1	-
HARPACTICOIDS																
O. Harpacticoida	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
SEED SHRIMPS																
Cl. Ostracoda	3	10	2	3	4	17	22	39	70	30	19	28	19	13	12	17
<u>INSECTS</u>																

Taxonomy	Lake D1						Lake 8						Mammoth Lake†					
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5.1	5.2
Cl. Insecta																		
CADDISFLIES																		
O. Trichoptera																		
F. Apataniidae																		
Apatania	-	1	-	-	-		-	-	-	-	-		-	-	-	-	-	-
F. Limnephilidae																		
Grensia praeterita	-	-	-	-	-		1	-	-	-	1		-	-	-	-	-	-
TRUE FLIES																		
O. Diptera																		
MIDGES																		
F. Chironomidae																		
chironomid pupae	-	**1**	**1**	-	**1**		-	-	-	-	-		**1**	**6**	**1**	**3**	-	**1**
S.F. Chironominae																		
Cladotanytarsus	1	-	-	-	2		-	-	-	-	-		-	-	-	-	-	4
Corynocera ambigua	42	29	13	24	63		-	-	-	-	-		84	83	94	77	54	106
Dicrotendipes	-	-	-	-	-		-	-	-	-	-		1	-	-	1	1	-
Micropsectra	-	12	21	25	-		13	30	16	26	28		14	12	5	19	34	45
Microtendipes	1	5	2	7	1		-	-	-	-	-		1	2	3	1	1	-
Paratanytarsus	17	14	10	9	20		10	28	33	27	30		4	9	5	9	32	6
Polypedilum	7	-	-	-	-		-	-	-	-	-		-	-	-	-	-	-
Stictochironomus	-	2	16	8	5		1	7	-	-	-		34	20	36	3	1	1
Tanytarsus	118	8	3	7	83		3	4	1	5	1		35	33	15	25	21	21
S.F. Diamesinae																		
Protanypus	-	1	2	1	-		2	-	-	1	2		-	-	-	-	-	-
S.F. Orthocladiinae																		
Abiskomyia	-	-	-	1	-		15	47	10	25	33		-	-	-	-	-	-
Heterotrissocladius	1	-	-	1	-		2	-	4	3	8		-	-	-	-	-	-
Paracladius	-	-	-	-	-		1	-	-	-	1		-	1	1	2	-	-
Psectrocladius	-	-	-	-	-		-	1	1	-	-		-	-	-	-	-	-
Zalutschia	-	-	-	1	-		-	-	-	-	-		-	-	-	-	-	-
S.F. Prodiamesinae																		
Monodiamesa	-	5	1	3	2		1	2	-	-	1		9	10	8	7	7	3
S.F. Tanypodinae																		
Ablabesmyia	-	-	1	-	-		-	-	-	-	-		-	1	-	-	-	-
Procladius	3	1	2	2	6		9	4	14	8	8		23	17	19	17	12	7
Thienemannimyia complex	-	-	-	-	-		2	3	3	3	2		3	1	-	3	-	1
MOLLUSCS																		

Taxonomy	Lake D1						Lake 8						Mammoth Lake†					
	1	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5.1**	**5.2**
P. Mollusca																		
CLAMS																		
Cl. Bivalvia																		
F. Sphaeriidae																		
Pisidium/Cyclocalyx	13	2	-	4	-		-	-	-	-	-		42	28	56	52	15	16
Pisidium (Cyclocalyx/Neopisidium)	17	27	16	6	20		39	45	48	52	52		14	7	4	11	7	4
Sphaerium nitidum	4	4	4	-	4		-	-	-	-	-		7	2	11	8	-	-
TOTAL NUMBER OF ORGANISMS	247	130	98	107	221		134	205	186	246	222		305	266	289	278	204	240
TOTAL NUMBER OF TAXA ǂ	17	19	16	18	17		17	14	15	16	18		20	19	19	20	16	16

† Grabs for MAM-5 were processed separately as 5.1 and 5.2

ǂ Bold entries excluded from taxa count

Appendix 7. Benthic Community Data Quality Assurance

Table 7-1. Percent recovery of benthic macroinvertebrates from benthic samples (2020).

Station	Number of Organisms Recovered (initial sort)	Number of Organisms in Re-sort	Percent Recovery
MAM-3	276	289	95.5%
LK1-4	106	107	99.1%
LK8-4	239	246	97.2%
		Average % Recovery	97.2%

<u>QA/QC notes</u>

Pupae were not counted toward total number of taxa unless they were the sole representative of their taxa group.

Immatures were not counted toward total number of taxa unless they were the sole representative of their taxa group. The exceptions to this rule are immature tubificidae with and without hairs. Immature oligochaetes are counted as taxa as the probability of the immature being a unique taxa is high.

Indeterminates are unique taxa that could not be identified further for whatever reason, e.g., (small, damaged).