EEM CYCLE 7 INTERPRETIVE REPORT FOR SKOOKUMCHUCK PULP INC.

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EEM CYCLE 7 INTERPRETIVE REPORT FOR SKOOKUMCHUCK PULP INC.

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EXECUTIVE SUMMARY

EcoMetrix Incorporated was retained by Skookumchuck Pulp Inc (SPI), to implement the seventh-cycle EEM program at the Skookumchuck mill near Cranbrook, British Columbia. SPI is owned by Paper Excellence. The program included water, sediment, benthic invertebrate, and fish collections in the mill's effluent receiving environment and corresponding reference area. This report documents the methods by which the field program was conducted, the results generated by the field program and the interpretation of these results. The results of previous EEM studies at the mill, as well as other relevant information, are also included to provide context to the results of this current study.

BACKGROUND INFORMATION

SPI is located north of Cranbrook on the Kootenay River in British Columbia. The facility produces approximately 740 metric tonnes per day of softwood pulp for the production of paper products. Pulp at the mill undergoes a five-stage bleaching process using oxygen, chlorine dioxide, sodium hydroxide, and hydrogen peroxide. Prior to discharge to the Kootenay River, effluent undergoes secondary treatment in aeration stabilization basins. Also, as required, effluent undergoes tertiary treatment to remove colour from effluent prior to discharge.

Mill Effluent Quality and Dispersion in the Receiving Environment

Effluent flow rates are generally on the order of 34,000 m^3/day. Effluent quality currently meets all applicable provincial and federal limits. A single TSS exceedance was measured in March 2014, but was short lived. Effluent dispersion in the Kootenay River is variable based on river flows. Previous dispersion modelling has predicted that under average flows an effluent concentration of 1% v/v extends 5 km downstream of the effluent discharge.

Field measurements taken during EEM field surveys have generally confirmed the results of the dispersion modelling.

Effluent Toxicity

Mill effluent is tested regularly for both acute and chronic toxicity. Mill effluent has not been acutely toxic to Rainbow Trout (*Oncorhynchus mykiss*), nor to *Daphnia magna* during routine testing since 2002.

Sublethal toxicity testing of mill effluent is conducted twice annually in accordance with the Pulp and Paper Effluent Regulations (PPER) (ss. 29(3)). Laboratory testing is conducted on a water flea (*Ceriodaphnia dubia*), and a green alga (*Pseudokirchneriella subcapitata*. In Cycle 7, no acute toxicity was measured during sublethal effluent toxicity testing. The results of *C. dubia* tests were within the range or improved compared to historical testing. IC25 values ranged from 18.3% to 56.7%. IC25 values for tests conducted with *P. subcapitata* ranged from 58.2% to >95.9%, though effects, when measured, were typically

only seen at relatively high effluent concentrations, similar to or improved relative to past testing.

Key Results of the Cycle 7 EEM Study

Supporting Environmental Data

- Habitat features of the sampling areas were similar to the extent that differences in fish and benthic community structure measured would not likely be related to habitat factors.
- The influence of mill effluent on water chemistry was conspicuous, with effluent-exposed areas having higher concentrations of several constituents.
- Periphyton growth was higher in the effluent-exposed areas, likely due to orthophosphate concentrations associated with the discharge of mill effluent into the Kootenay River.

Benthic Invertebrate Community

- A total of 33 unique benthic taxa were identified in the study area (31 families, plus one Phylum and one Class) of which 28, 30, and 24 were identified in the reference, near-field, and far-field areas, respectively.
- Invertebrate density ranged from approximately 4,500 to 10,600 organisms/m^2 across the study area. Generally the same taxa were most abundant in each of the sampling areas. These taxa included mayflies from the Families Ephemerellidae and Heptageniidae, caddisflies from the family Hydropsychidae and midge larvae from the Family Chironomidae. Worms from the Family Naididae were abundant in the far-field area.
- Significant statistical differences were detected between the reference and near-field and reference and far-field areas in terms of density, richness, evenness, and Bray-Curtis Index (NF>REF and FF>REF). In each case the magnitude of difference expressed relative to the standard deviation for the reference area for each endpoint was less than the two reference areas standard deviations suggesting the differences were not ecologically meaningful.
- The magnitude of differences detected between key benthic invertebrate community effect endpoints was less in Cycle 7 than in Cycle 4. In Cycle 4, where statistical differences in endpoints were measured the differences all exceeded the 3 reference standard deviations, whereas in Cycle 7 the differences were all less than 2 reference standard deviations.

Fish Health Survey

The key findings associated with the Cycle 7 fish health survey are:

- Generally, the rate at which any internal or external abnormalities were noted in Torrent Sculpin were low and such observations did not appear to differ across the study area.
- Male Torrent Sculpin
    - No differences were detected across the study area for male Torrent Sculpin in terms of age. Some statistical differences were detected in energy use and/or energy storage endpoints between near-field and reference fish but the differences were small in magnitude and were below the critical effects size defined by Environment Canada. No difference was seen in relative gonad size between the near-field and reference fish.
    - Many of the effect endpoints differed statistically between the male Torrent Sculpin populations of the reference areas and the far-field area. In most of these instances the magnitude of differences seen were greater than the critical effects size defined by Environment Canada. On average far-field area Torrent Sculpin populations were younger but had greater measures of energy use and energy storage than their reference area counterparts. No difference was seen in relative gonad size between the far-field and reference fish.
- Female Torrent Sculpin
    - Some differences were detected among the female Torrent Sculpin populations of the reference areas and the near-field area. In no instance was a statistical difference of a magnitude that exceeded the critical effects size defined by Environment Canada. Only one effect endpoint was statistically different between the near-field area and both reference areas: relative liver size.
    - As with the male Torrent Sculpin, more statistical differences were seen between reference area fish and the far-field area fish. Where statistical differences were measured, the magnitude of difference between the reference area and far-field area fish was generally above the critical effect size. On average far-field area Torrent Sculpin populations had greater measures of energy use and energy storage than their reference area counterparts.

- Immature Torrent Sculpin
    - No statistical differences were detected in the measured endpoints between the near-field and Canal Flats reference areas. Statistical differences were detected between two effect endpoints - age and relative liver size - when the Torrent reference area and near-field area Torrent Sculpin populations were compared. In each case the magnitude of the difference was below the critical effect size.
    - Far-field immature Torrent Sculpin populations were statistically different from the reference populations for three of the four effect endpoints measured. Age, relative liver size, and size at age were all statistically different at the far-field area in comparison to both reference areas. The magnitudes of the effects seen in the effect endpoints were all greater than critical effect sizes.
- Temporal Comparison
    - In general, the results of the Cycle 7 survey indicate a decreased magnitude of response in near-field area fish to mill effluent exposure, relative to Cycle 4.

Overall Cycle 7 EEM Program Conclusions

- Based Benthos - Overall, in consideration of the results of the Cycle 7 benthic invertebrate community survey, as well as the temporal comparison of benthic invertebrate community data generated from previous cycles, it is suggested that the efforts made by the mill to improve effluent quality and reduce nutrient loadings to the Kootenay River have most likely been effective. Statistical differences in the near-field benthic community were present for all endpoints but the magnitude of difference measured between the near-field and reference area were less than seen in the past and also were less than the critical effect size defined by EEM technical guidance (EC, 2010).
- Fish Health – Some statistical differences were detected between reference area and exposure area fish populations. For the near-field populations, these differences were less than the critical effects sizes defined by EEM technical guidance (EC, 2010) and less than those seen during the last EEM fish health survey conducted in Cycle 4.
- Far-field Exposure – Generally, differences detected between the reference and far-field areas in both the benthic invertebrate community and fish health surveys were greater in magnitude than those detected between reference and near-field areas. The far-field area is considerably downstream of the mill where the influence of mill effluent on water quality and presumably biological communities should be less in

magnitude than in the near-field area. It is suggested that the differences seen between the reference and far-field area are not likely mill related; rather, the differences are more likely attributable to natural broad-scale habitat differences between the areas. For instance, although it was possible to find sampling stations for the benthic survey that had similar substrate size, water depth, etc. this type of habitat is not the predominant type in the far-field area as it is in the near-field and reference areas. The Kootenay River is the vicinity of the far-field area is much more of a lower-gradient, broad meandering river channel than it is in more upstream areas.

Recommendations

As the mill has only completed one survey since the implementation of upgrades to the effluent treatment system, a second survey should be completed in three years time to confirm the findings of the Cycle 7 study

Consideration should be given to dropping the far-field area from the EEM program, as effects seen in the area are not representative the typical spatial pattern that could be attributed to mill effluent.

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1.0 INTRODUCTION

1.1 Environmental Effects Monitoring Framework

In May 1992, Environment Canada (EC) and the Department of Fisheries and Oceans (DFO) amended the *Pulp and Paper Effluent Regulations* (PPER) under the *Fisheries Act*. In addition to limiting the discharge of total suspended solids (TSS), biochemical oxygen demand (BOD), and the acute lethality of effluents, these amendments prescribed that all mills were required to conduct an Environmental Effects Monitoring (EEM) program.

The objective of the EEM program is to evaluate the effects of pulp mill effluents (PME) on fish, fish habitat and the use of fisheries resources by humans. The information generated by the EEM program is used to help assess the adequacy of the regulations to effectively protect these aquatic resources. As such, EEM goes beyond end-of-pipe measurement of chemicals in PME to examine the effectiveness of environmental protection measures directly in aquatic ecosystems. The program consists of:

- sublethal toxicity testing of PME;
- assessment of benthic invertebrate community (BIC) structure in the effluent receiving environment;
- assessment of fish population health in the effluent receiving environment; and,
- evaluation of effects on fisheries resource use (dioxins and furans in fish tissue) in the effluent receiving environment.

In 2010, EC made available an updated version of the “Pulp and Paper Environmental Effects Monitoring (EEM) Technical Guidance Document” (TGD; EC, 2010). The TGD provides information on the recommended methodologies for EEM studies.

EEM is an iterative series of three-year monitoring cycles, with the requirements of each cycle dependent on the results of the previous cycle. For mills across the country that have been in continuous operation, the first six EEM cycles have been completed and study results were reported to EC by 01 April 1996, 01 April 2000, 01 April 2004, 01 April 2007, 01 April 2010, 01 April 2013 respectively.

1.2 EEM Cycle 7 at the Skookumchuck Mill

Skookumchuck Pulp Inc. (SPI), a Paper Excellence facility, is located north of Cranbrook on the Kootenay River in British Columbia (**Figure 1.1**). The facility produces approximately 740 metric tonnes per day of softwood pulp for the production of paper products. Pulp at the mill undergoes a five-stage bleaching process using oxygen, chlorine dioxide, sodium hydroxide, and hydrogen peroxide. Prior to discharge to the Kootenay River, effluent undergoes secondary treatment in aeration stabilization basins. Also, as required, effluent undergoes tertiary treatment to remove colour from effluent prior to discharge.

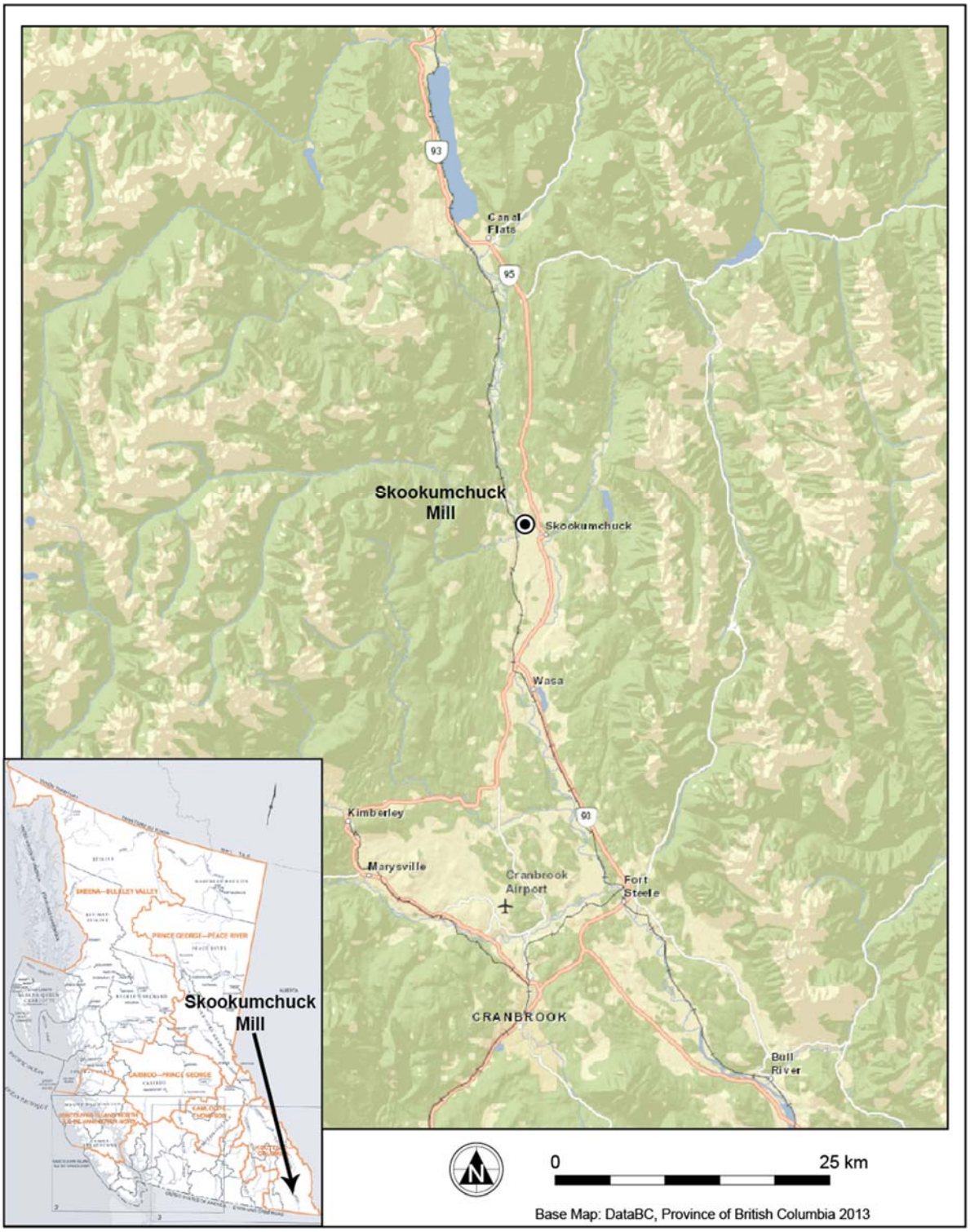

Figure 1.1:
Location of the Skookumchuck Pulp Inc. facility near Cranbrook, BC

The design of the EEM Cycle 7 program for the mill is detailed in Hatfield (2014) and included contingency for water, benthic invertebrate, and fish collections in the mill's effluent receiving environment and corresponding reference area. EcoMetrix was retained by the SPI to implement the seventh-cycle EEM field survey program and prepare the Cycle 7 Interpretive Report. This report documents the methods by which the field survey program was conducted, the results generated by the field survey program and the interpretation of those results.

1.3 Report Format

Following this introductory section, the remainder of the report is organized as follows:

- In Section 2.0 site characterization information is presented, including mill operations and effluent quality;
- In Section 3.0 the results of past EEM studies conducted at the mill are summarized;
- In Section 4.0 an overview of the Cycle 7 EEM program is presented;
- In Section 5.0 supporting habitat information and water quality data collected as part of the Cycle 7 field survey are provided;
- In Section 6.0 the benthic invertebrate community sampling program and its results are detailed;
- In Section 7.0 the fish health survey sampling program and its results are presented;
- In Section 8.0 the results of the different components of the program are integrated;
- In Section 9.0 the key study conclusions are provided;
- In Section 10.0 recommendations for future monitoring are suggested; and,
- In Section 11.0 the references consulted in the preparation of this report are given.

The following appendices, containing raw data and additional information related to the implementation of the Cycle 7 EEM study, are attached to this report including:

- Appendix A – QA/QC information;
- Appendix B – Supporting environment information;
- Appendix C – Benthic invertebrate community survey information; and,
- Appendix D – Fish health survey information.

2.0 BACKGROUND INFORMATION

2.1 Mill Operations

SPI originally opened in 1968. In 1999, the mill was acquired by Tembec Inc., from Crestbrook Forest Industries Ltd. In 2013, the pulp mill was purchased by its current owner, Paper Excellence.

When it first opened the mill had a production capacity of 345 ADMt/d of bleached Kraft pulp. Various modifications have been made to the mill since that time that have increased productivity to its current level, which, on average, exceeds 740 ADt of pulp per day.

Mill furnish is provided as wood chips sourced from sawmills in and around the East and West Kootenays, Alberta, Montana and Idaho. Whole log chipping is also done on adjacent land. The primary tree species that comprise the mill furnish include lodgepole pine, interior Douglas fir, western larch, Engelmann spruce, hemlock and subalpine/balsam fir.

The mill employs a five-step pulp bleaching process using oxygen, chlorine dioxide, sodium hydroxide, and hydrogen peroxide. Chlorine gas was replaced with 100% chlorine dioxide substitution in 1989. From 1992 to 1994, a large scale Asset Renewal Program was completed. Significant improvements were made to reduce air emissions and improve effluent quality.

2.2 Mill Effluent Treatment

Prior to discharge to the Kootenay River, effluent undergoes secondary treatment in aeration stabilization basins. Effluent can also, as required, be directed from the secondary treatment plant to tertiary treatment for colour removal.

Treated mill effluent is discharged into the Kootenay River through a submerged multi-port diffuser. The diffuser comprises 20 ports and extends approximately 65 m into the river from the west shore along the riverbed. Twelve ports are currently in use. Water depth at the diffuser ranges from 1.0 to 4.7 m, depending on seasonal flow and in-stream location.

A number of recommendations were implemented to reduce nutrient loading in effluent to the Kootenay River. These operational improvements, described in further detail by Hatfield (2014), included:

- Switching to a low-phosphorous fertilizer;
- Improving nutrient control strategy through installation of a new sampling dock at the end of Cell #1;

- Reducing phosphorous addition by re-use of orthophosphate through recycling treated effluent from Cell #3 back to Cell #1; and
- Reducing winter phosphorous additions by redirecting condensate back into the condensate steam stripper treatment process.

2.3 Effluent Flow

From 2005 to 2015, the average volume of effluent discharged from SPI ranged from 28,829 to 35,476 m^3/d **(Figure 2.1)**. In 2015, the effluent discharge rate was 34,267 m^3/d, on the order of the average discharge rate over the last number of years but well below the average rate of discharge between the time at which the mill opened and the early 1990s.

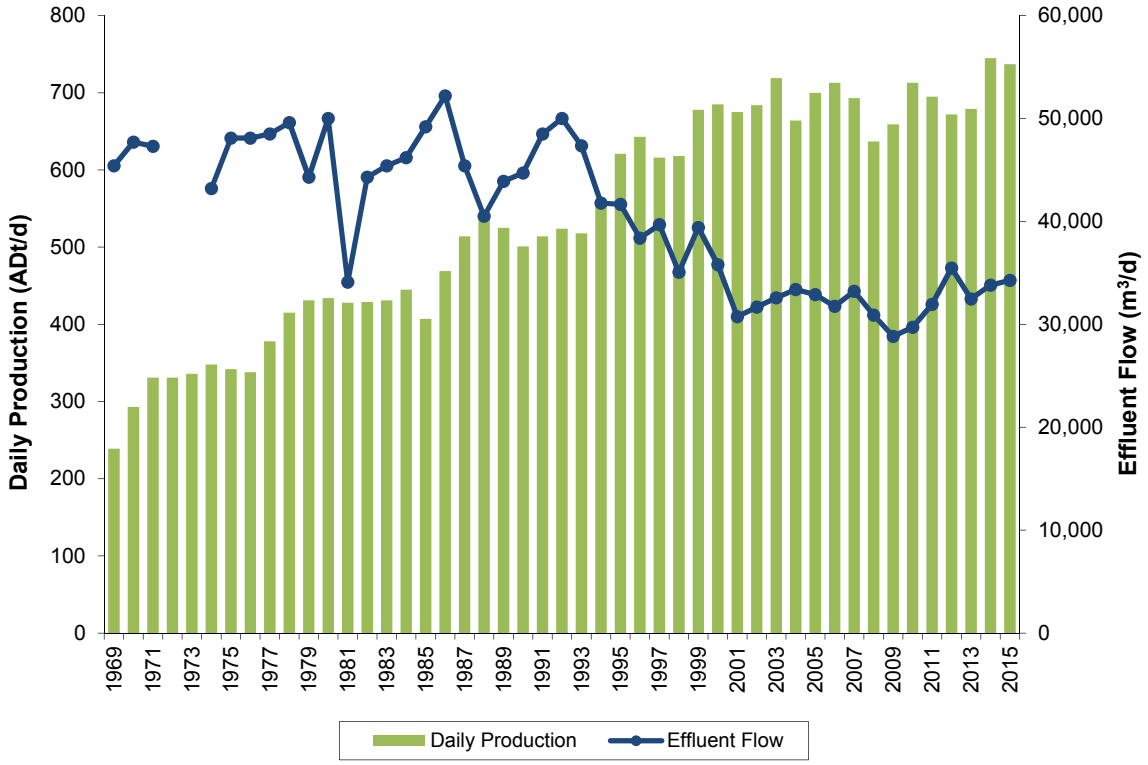

Figure 2.1:
Annual Averages of Daily Production and Effluent Flow at Skookumchuck Mill 1969 To 2015 (adapted from Hatfield, 2014)

2.4 Final Effluent Chemistry

Effluent quality data for the period 2005 through 2015 are summarized in **Table 2.1** and are discussed in the following subsections.

2.4.1 pH

Since 2005, effluent pH has been neutral to slightly alkaline, ranging from 7.2 to 7.8 (**Table 2.1**).

2.4.2 Conductivity

Effluent conductivity for the period 2005 through 2015 is shown in **Table 2.1**. The conductivity of mill effluent has ranged from 2,863 to 3,988 µS/cm.

2.4.3 Total Suspended Solids (TSS)

Average TSS loading in effluent ranged from 1,314 to 6,647 kg/d, since 2005 (**Table 2.1; Figure 2.2**). In 2015, TSS loadings averaged 1,590 kg/d, well below the provincial permit limit of 4500 kg/d.

During Cycle 7, there was a single TSS permit level exceedance (March 18, 2014). The mill determined the cause of the exceedance to be the occasional stripping off of solids that accumulate on the outfall pipe (Brian Stevenson personal communications, September 10, 2014). It is noted that TSS was in compliance on days that bracketed the March 18 exceedance, indicating that the event was short-lived.

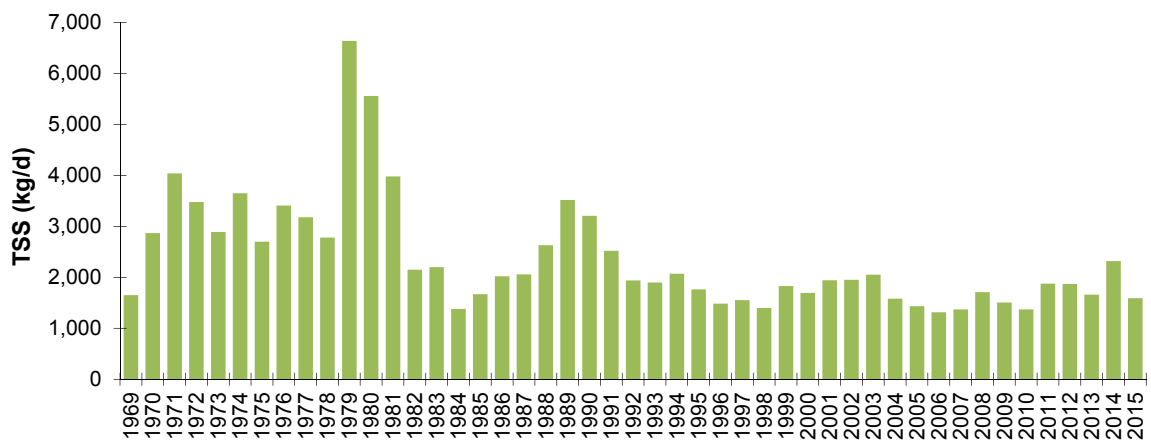

Figure 2.2:
Total Suspended Solids (TSS) in effluent from Skookumchuck Mill, 1969 to 2015 (adapted from Hatfield, 2014)

2.4.4 Five Day Biochemical Oxygen Demand

Effluent BOD_5 data for the period 1969 through 2015 are shown in **Figure 2.3**. Effluent BOD has been consistently lower since Asset Renewal Program was undertaken between

1992 and 1994. In 2015, on average the BOD loading rate was on the order of 1,350 kg/d. BOD levels are currently well below the provincial permit limit of 3,500 kg/d.

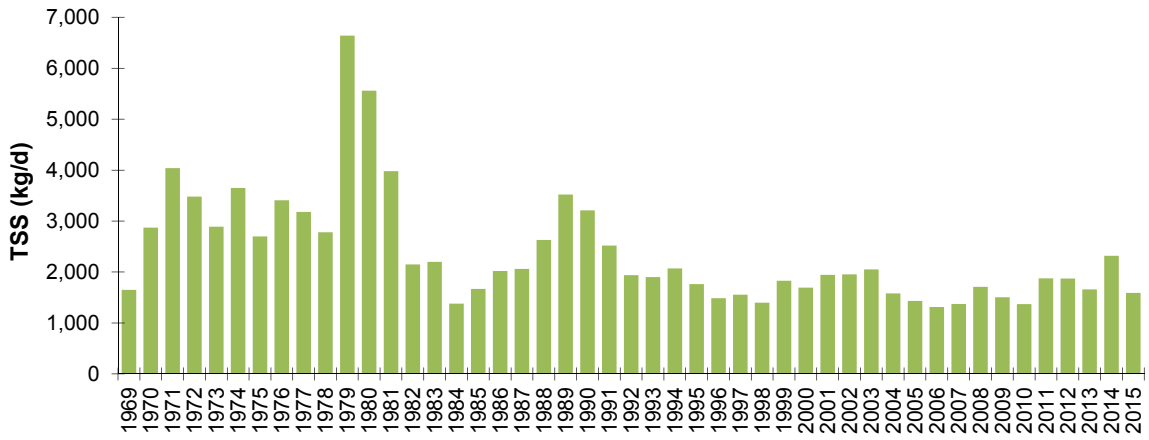

Figure 2.3:
Biochemical Oxygen Demand (BOD5) in effluent from Skookumchuck Mill, 1969 to 2015 (adapted from Hatfield 2014)

2.4.5 Adsorbable Organic Halides (AOX)

Adsorbable organic halide levels ranged from 0.11 to 0.18 kg/adt from2005 to 2015, well below provincial permit limit of 0.25 kg/adt. In 2015, AOX levels in mill effluent were averaged 0.16 kg/ADt (**Table 2.1**).

2.4.6 Dioxins and Furans

Since 2005, dioxins have not been at detectable levels in mill effluent. Over the period 2005 to 2015, concentrations of furans in mill effluent have ranged from 3 to 11 parts per quadrillion (ppq) **(Table 2.1)**. Test results are well below the Canadian Environmental Protection Act criteria.

Table 2.1:
Annual Average Values for Process Effluent Quality Variables

Variable	Unit	2005	2006	2007	2008[1]	2009[2]	2010	2011	2012	2013	2014	2015
Total Production	Admt/d	700	713	693	637	659	713	695	672	679	745	737
Effluent Flow	m^3/d	32,882	31,752	33,222	30,904	29,829	29,714	31,938	35,476	32,468	33,489	34,267
pH		7.8	7.6	7.6	7.6	7.3	7.3	7.2	7.3	7.6	7.6	7.4
Conductivity	µS/cm	3,847	3,988	3,710	3,650	2,886	3,105	3,032	2,914	3,194	3,471	3,207
TSS	Kg/d	1,434	1,314	1,372	1,709	1,505	1,370	1,876	1,872	1,659	2,024	1,590
BOD	Kg/d	728	822	983	1,016	1,030	793	899	932	845	1,014	1,357
AOX	Kg/ADt	0.18	0.14	0.16	0.15	0.12	0.11	0.12	0.13	0.14	0.15	0.16
2,3,7,8-TCDD (Dioxin)	ppq	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,3,7,8-TCDF (Furan)	ppq	11	7	3	7	4	7	5	6	4	7	5
Rainbow Trout 96-hr LC50	% effluent	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
***Daphnia magna* 48-hr LC50**	% effluent	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100

[1] Average calculated from 359 measurements representing all days when effluent was discharged, the mill was operational for 336 days.

[2] Due to a production curtailment, SPI was operational for 210 Days.

2.5 Effluent Toxicity

2.5.1 Acute Toxicity

The Skookumchuck mill routinely measures acute toxicity of effluent to Rainbow Trout (*Oncorhynchus mykiss*) and the cladoceran (waterflea) *Daphnia magna*. Mill effluent was not acutely toxic to Rainbow Trout, nor to *Daphnia magna* during routine testing over the period 2005 through 2015 **(Table 2.1)**.

2.5.2 Sublethal Toxicity

Sublethal toxicity testing of mill effluent is conducted twice annually in accordance with PPER (ss. 29(3)). Laboratory testing is conducted on a water flea (*Ceriodaphnia dubia*), and a green alga (*Pseudokirchneriella subcapitata (*formerly known as *Selenastrum capricornutum*). Reported endpoints include effluent concentrations that cause 50% mortality in the test species (i.e., the LC_{50}; *C. dubia* only) and effluent concentrations that cause a 25% reduction (inhibitory effect) in a test endpoint such as growth or reproduction relative to a control (i.e., the IC_{25}; both *C. dubia* and *P. subcapitata*).

A summary of the results of previous testing for EEM cycles 1 through 7 is provided below (**Figure 2.4**). Overall, the results of the sublethal effluent toxicity testing program indicate that mill effluent has generally elicited a smaller magnitude response in test species over time (i.e., reduced effluent toxicity).

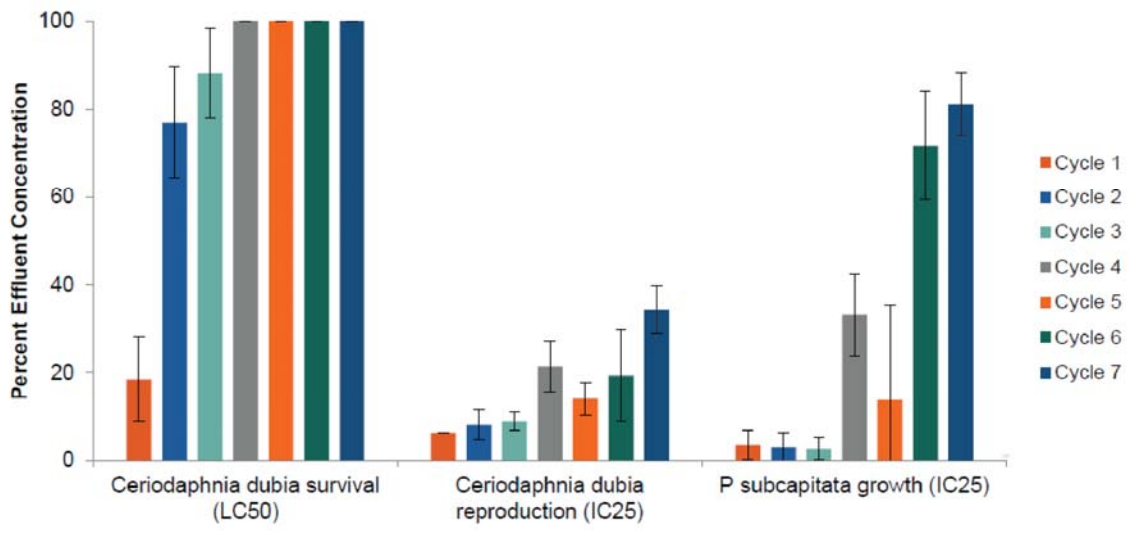

Figure 2.4:
Geometric Mean and Standard Error of Sublethal Toxicity Test Endpoints for Skookumchuck Mill Effluent, Cycles One through Seven (Adapted from Hatfield, 2014).

Results for laboratory tests completed during EEM Cycle 7 (April 2013 to present) are summarized in **Table 2.2**. As in previous testing, no acute toxicity was measured during sublethal effluent toxicity testing with *C. dubia*. The IC25 values for testing with *C. dubia* ranged from 18.3% to 56.7%, with a geometric mean IC25 value of 34.5%.

The IC25 values for tests conducted with *P. subcapitata* ranged from 58.2% to >95.2%, though effects, when measured, were typically only seen at relatively high effluent concentrations, similar to the results of Cycle 6 testing. The geometric mean IC25 value for Cycle 7 testing with *P. subcapitata* was 81.3%.

On average, effluent concentrations that induced effects in laboratory testing are higher than those seen in the Kootenay River. The potential effect zone, based on the IC25 values for tests completed in Cycle 7, can be predicted by expected patterns of effluent dispersion in the Kootenay River. It has been estimated that under average flow conditions, an effluent concentration of 1% v/v extends 5 km downstream of the effluent discharge (see Section 2.6.2; Hatfield, 1995). From this relationship, the maximum sublethal effects (based on the lowest IC25) would extend approximately 246 m downstream of the mill discharge.

Table 2.2:
EEM Cycle 7 Sublethal Effluent Toxicity Test Results for Skookumchuck Pulp Inc.

Date	*C. dubia*		*P. subcapitata*
	LC50	**IC25**	**IC25**
March and April 2013	> 100%	18.3%	63.3%[1]
September 2013	> 100%	56.7%[1,2]	> 95.2%
March 2014	> 100%	30.7%[1]	> 95.2%
September 2014	> 100%	42.9%[1]	> 95.2%
March 2015	> 100%	29.9%[1]	58.2%[1]
September 2015	> 100%	41.2%	> 90.9%
GM	**>100%**	**34.5%**	**81.3%**

Notes:

- 1 - IC25 was calculated by replacing means for treatment groups in which hormesis was observed with the control mean
- 2 - Repeat test, original test results were not bracketed by test concentrations and therefore not valid
- Results provided as effluent concentrations as % effluent (v/v).
- GM is geometric mean.

2.5.3 Unscheduled Effluent Releases

No unscheduled effluent releases to the Kootenay River have occurred during Cycle 7. Spills that have occurred to the ground have been appropriately managed as per mill standard procedures. Spills were reported to the BC Provincial Emergency Program when applicable.

2.6 Study Area

2.6.1 General Overview of the Kootenay River

A review of available historical data for and the classification of habitat in the receiving environment for SPI was completed as part of the Pre-Design Phase for EEM Cycle 1 and updated in the Cycle 1 Interpretative Report (Hatfield 1994b, 1996).

Overall, the Kootenay River in the vicinity of the mill consists of mostly erosional habitat. The river in this area is predominately made up of riffles with bottom substrates that are dominated by cobble with some gravel and finer sized material.

2.6.2 Effluent Dispersion

The 1% effluent concentration envelope in the Kootenay River downstream of the mill varies seasonally and is based on river flows. Hatfield (1994a) identified a zone of incomplete effluent mixing from the mill to the Skookumchuck highway bridge, 2.5 km downstream that constitutes the 1% zone of effluent concentration from May to October. It was also reported that under low-flow conditions, effluent concentrations of 1% or greater may extend as far as Fort Steele and Wardner, 35 and 60 km downstream, respectively (Hatfield, 1994a). For the purpose of EEM, Environment Canada delineated the 1% effluent concentration zone as 5 km downstream of the outfall. This representation of the effluent plume was used in the Cycle 7 Study Design for the calculation of the potential effluent effects zone. (Hatfield, 2014).

3.0 RESULTS OF PAST EEM CYCLES

3.1 EEM Context

The EEM program includes biological monitoring studies, which are conducted in three or six year cycles to investigate if there are any effects on the indicators that are mill related. Biological monitoring includes three components: a benthic invertebrate community (BIC) survey, a fish population survey and an assessment of fish usability of (dioxins and furans in fish tissues). The requirements for each study are dependent on the results of the previous cycle's results.

The studies for the BIC and fish population components are conducted in both exposure and reference areas. The exposure area is all fish habitat and waters frequented by fish that are exposed to effluent, and the reference area means is water frequented by fish that are not exposed to effluent and that has fish habitat that, as far as is practical, is the most similar to that of the exposure area (PPER Schedule IV.1, s. 1).

The PPER defines an effect for indicators in each of the three biological monitoring components (PPER Schedule IV.1, s. 1) and further prescribes the data assessment required for specific indicators (PPER Schedule IV.1, s. 1, and s. 9 to s. 11). Generally, an effect on the BIC or fish population means that there is a statistical difference between data collected in an exposure area and in a reference area for a key "effect endpoint" BIC data are evaluated based on the effect endpoints: total benthic invertebrate density; taxa richness; Simpson's evenness index; and, Bray-Curtis index).

Fish population survey (FS) data are evaluated based on endpoints representing growth, reproduction, condition and survival (PPER Schedule IV.1, par. 11(a)(i)). An effect on fish usability occurs when concentrations of chlorinated dioxins and furans, expressed as toxic equivalents of 2,3,7,8- tetrachlorodibenzo-para-dioxin, exceeding 15 picograms per gram (pg/g) wet weight in muscle, or 30 pg/g wet weight in liver or hepatopancreas are found in fish taken in the exposure area.

In order to confirm that observed effects are not artifacts and are mill-related, biological monitoring studies to assess effects are repeated in subsequent three-year cycles. If the same effect (same endpoint in same direction) on the BIC, fish population or fish tissue occurs in studies from consecutive cycles, the effect is considered confirmed (PPER Schedule IV.1, s. 4). Confirmation of an effect for fish endpoints need not be limited to the same sex or same species, unless site-specific conditions warrant a different approach.

If effects are confirmed in one or more components, a mill proceeds in subsequent cycles to investigate those effects. If no effects are confirmed in one or more components, a mill proceeds to a reduced biological monitoring schedule for that component (PPER s. 30). A mill confirming effects in one component and confirming no effects in another component would have different monitoring and reporting frequencies for the two components.

3.2 Summary of Past Results

Detailed summaries of results from past EEM Cycles is provided in **Appendix C** (benthic) and **Appendix D** (fish) as they were presented in the Cycle 7 Study Design (Hatfield 2014).

Overall, the results from the past benthic surveys have demonstrated an enrichment effect in the areas downstream from the mill. The effect downstream of the mill is typical of a mild eutrophication response pattern with no evidence of a contaminant (i.e. toxic) response. The results of the Cycle 4 survey confirmed the enrichment effect and therefore the mill proceeded to an investigation of solution for Cycle 5. After the solutions were identified in Cycle 5 the mill implemented corrective actions in in Cycle 6.

4.0 OVERVIEW OF THE EEM CYCLE 7 BENTHIC INVERTEBRATE COMMUNITY AND FISH HEALTH SURVEYS

The Cycle 7 EEM at SPI included assessments of benthic invertebrate community structure and fish health in the Kootenay River upstream and downstream of the mill effluent discharge. The benthic samples were collected between September 29th and October 1st 2015. Fish collections were completed in April 14th to the 27th.2015 (14th to 27th).

The benthic invertebrate community was surveyed in three areas including one reference area located upstream of the mill ("Torrent") and two exposure areas downstream of the mill (near-field and far-field). Benthic samples were collected with a Hess sampler at six replicate stations in each area (**Figure 4.1**). Benthic invertebrate community structure was assessed by calculating various endpoints including: density; taxonomic richness; Simpson's Diversity Index; Simpson's Evenness Index; and, Bray-Curtis Index. Statistical comparisons of these endpoints were completed to assess the extent to which there were differences between the reference and exposure areas. Temporal comparisons between the Cycle 7 and Cycle 4 data are also completed to evaluate changes in benthic community structure over time and in response to upgrades and changes to the mill's effluent treatment system.

The fish survey included the collection of Torrent Sculpin (*Cottus Rhotheus*) via electrofishing in two reference areas ("Canal Flats" and "Torrent") upstream of the mill and two exposure areas downstream of the mill (near-field and far-field) **(Figure 4.2)**. The far-field area was added to the Cycle 7 study to provide further information regarding the magnitude and extent of potential mill-related effects, if any. Captured Torrent Sculpin were retained for various morphological measurements. From these measurements various effect and support endpoints, representative of measures of survival, energy storage, growth and reproductive investment, were derived and compared statistically to assess potential differences in the reference and exposure area fish populations.

Supporting environmental data were measured coincident with the benthic invertebrate and fish survey programs, including measures of various habitat and sampling station/area related features, as well as water quality.

Details associated with the implementation of each of the field survey components are provided in the following report sections.

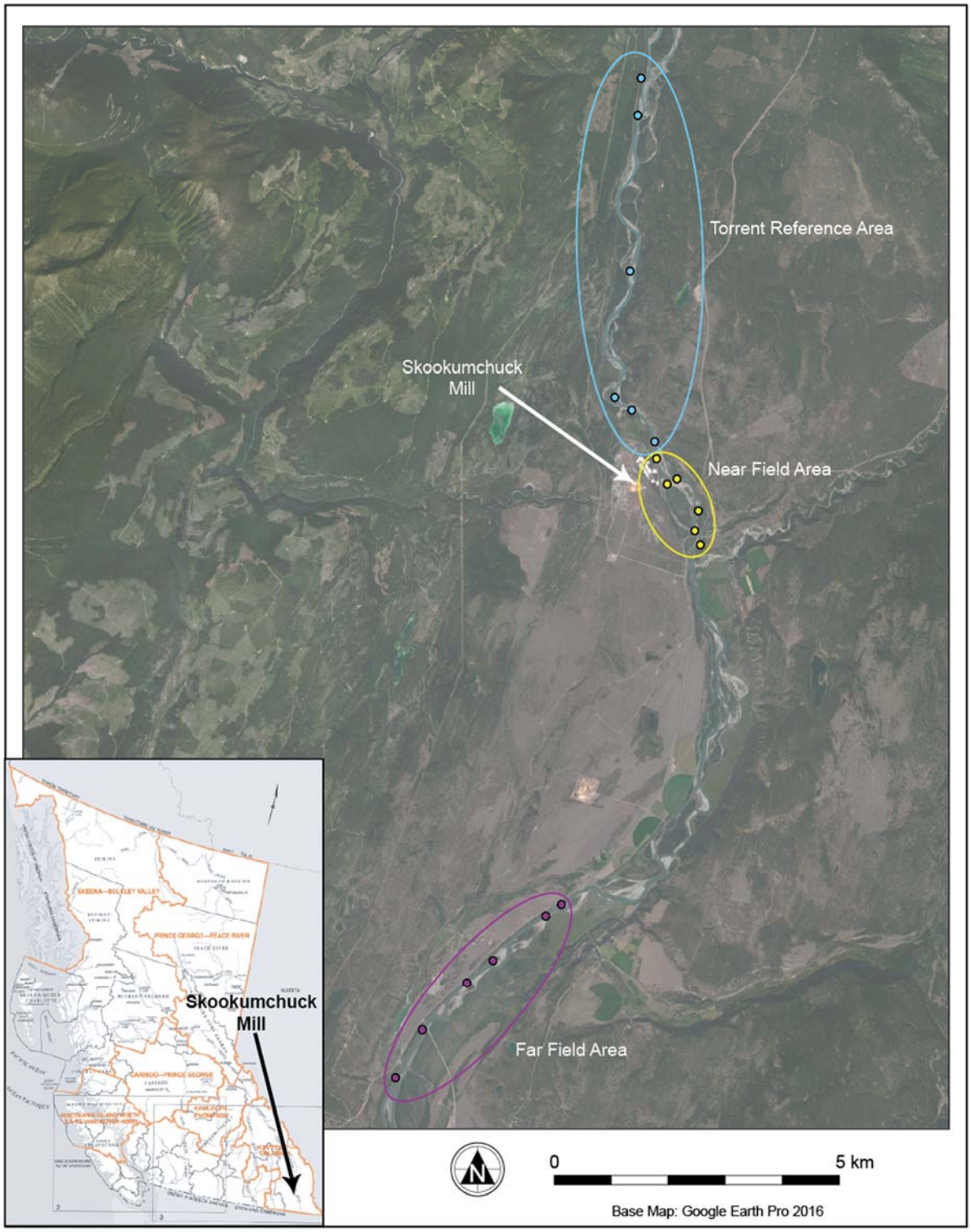

Figure 4.1:
Location of Benthic Invertebrate Sample Collection Sites, EEM Cycle 7

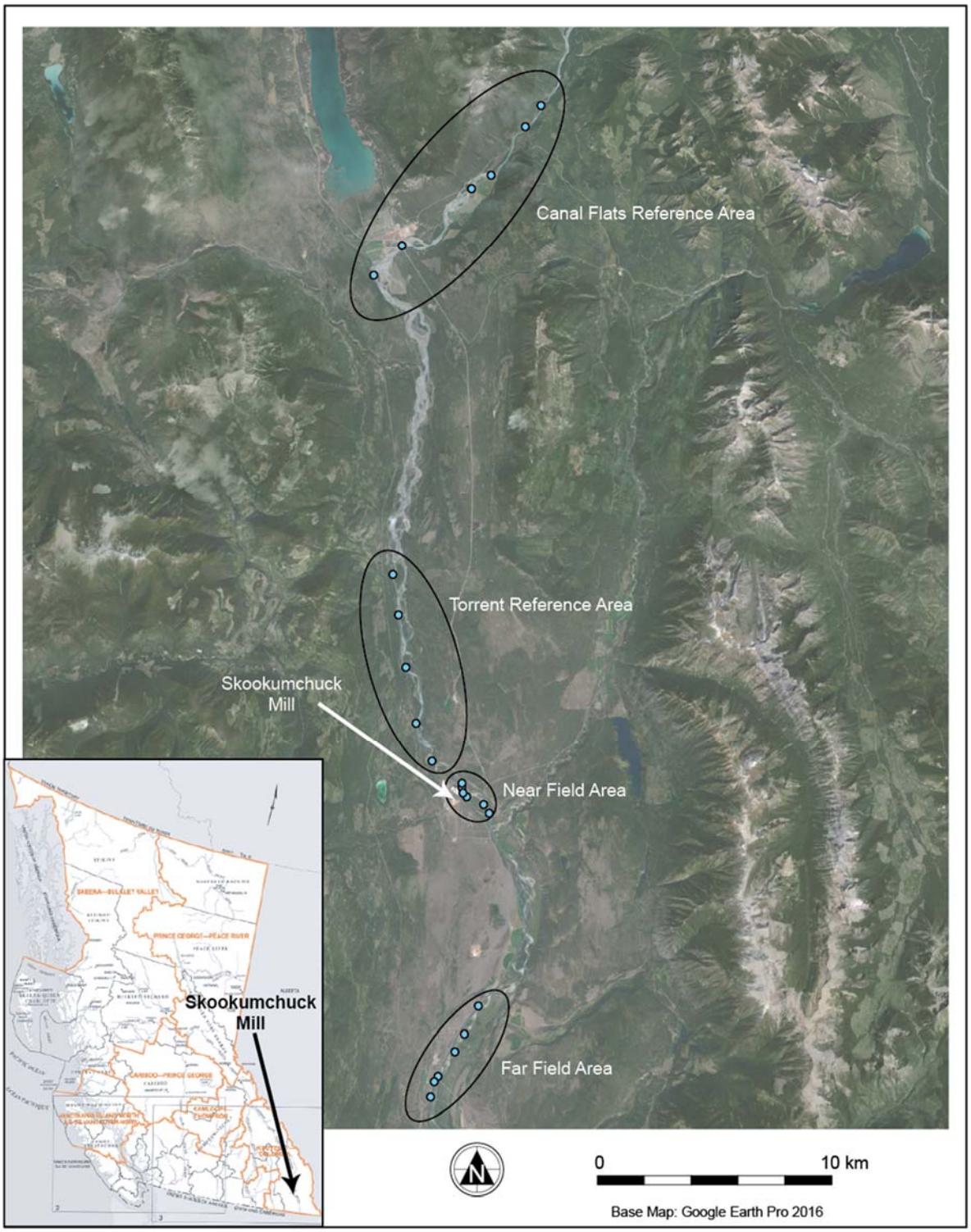

Figure 4.2:
Location of Torrent Sculpin Collection Areas, EEM Cycle 7

5.0 SUPPORTING ENVIRONMENTAL MEASUREMENTS

Following the guidance provided by Environment Canada (EC, 2010), as well as the results of past EEM studies at the mill, supporting environmental data were collected coincident with the benthic invertebrate and fish survey programs. The supporting environment variables included measures of various habitat and sampling station related features including water quality. Raw data are provided in **Appendix B**.

5.1 Habitat and Sampling Station Related Features

5.1.1 Data Collection

The following habitat and sampling site related features were recorded coincident with the field sampling programs:

- GPS coordinates – obtained at each sampling station/area with a Garmin Map 60CX handheld global positioning system (GPS);
- Water depth (m) – obtained (to the nearest 0.1 m) for each sampling station/area with a meter stick;
- Current velocity (m/s) – obtained at each station/area at 2/3 depth from water surface with a Marsh-McBirney Velocity Meter;
- Surrounding land use;
- Type of reach, canopy coverage, macrophyte coverage, and riparian vegetation;
- The 1st and 2nd most dominant substrate size; and
- Embeddedness and size of sampled substrate.

5.1.2 Results

Habitat and sampling sites related features that were recorded coincident with both the fish and benthic invertebrate field sampling programs. More in depth information was collected during the benthic survey to support the interpretation of the benthic invertebrate data. The habitat data collected at the benthic invertebrate stations are summarized in **Table 5.1**. More detailed information from both surveys are provided in **Appendix B**.

All benthic samples were collected from relatively shallow water areas with the far-field stations sampled deepest. The mean sample depth in the reference area was 35.9 cm, 28.1 cm for near-field stations, and 38.1 cm in the far-field stations.

Mean current velocity in the study areas was approximately 0.41 m/s, with the far-field stations slowest and the reference stations fastest. The range of velocities measured in the near-field and far-field areas was 0.29 m/s to 0.53 m/s and 0.25 m/s to 0.57 m/s, respectively. The reference stations ranged from 0.39 m/s to 0.54 m/s.

The Canal Flats reference area was surrounded by forests (except for the CanFor sawmill) and there was no other major activities evident. The Torrent reference area was surrounded by forests with minimal activity. The near-field area was surrounded by forest (except for the SPI mill) with no other major activities evident. The far-field area was mixed forest and plains with agricultural rangeland areas just upstream.

Canopy cover in all areas was 1-25% of the river, with 1-25% macrophyte cover. Ferns, shrubs, and coniferous trees were the dominant streamside vegetation with deciduous trees also present in the reference areas.

The substrate ranged from gravel to cobble across the study areas. The reference and near-field areas were comprised of slightly smaller substrate than in the far-field area. In all areas substrate was unembedded, except in one of the near-field stations was ¼ embedded.

Table 5.1:
Summary of Habitat Related Measures Collected Coincident with the EEM Cycle 7 Benthic Invertebrate Survey

Station	Latitude	Longitude	Depth (cm)	Current Velocity (m/sec)	Dominant Substrate Class	Dominant Substrate	2nd Dominant Substrate Class	2nd Dominant Substrate	Embeddedness
Torrent Reference									
TBBR-1	N50 00 00.2	W115 47 55.3	36.0	0.43	7	12.8-25.6	3	0.2-1.6	unembedded
TBBR-2	N49 59 33.1	W115 47 51.3	32.0	0.54	6	6.4-12.8	3	0.2-1.6	unembedded
TBBR-3	N49 56 14.2	W115 46 26.8	37.0	0.54	5	3.2-6.4	3	0.2-1.6	unembedded
TBBR-4	N49 56 03.8	W115 46 29.3	35.7	0.40	5	3.2-6.4	3	0.2-1.6	unembedded
TBBR-5	N49 55 52.4	W115 46 10.5	34.0	0.47	7	12.8-25.6	5	3.2-6.4	unembedded
TBBR-6	N49 57 37.2	W115 46 59.7	41.0	0.39	6	6.4-12.8	4	1.6-3.2	unembedded
Average			**35.9**	**0.46**	**6**		**4**		
Near-field									
NF-1	N49 55 24.7	W115 45 26.9	30.7	0.46	6	6.4-12.8	3	0.2-1.6	unembedded
NF-2	N49 55 11.8	W115 45 10.8	27.0	0.40	7	12.8-25.6	5	3.2-6.4	unembedded
NF-3	N49 55 13.5	W115 45 05.2	40.0	0.31	6	6.4-12.8	4	1.6-3.2	unembedded
NF-4	N49 54 48.4	W115 44 23.6	34.3	0.42	6	6.4-12.8	2	0.1-0.2	unembedded
NF-5	N49 54 33.5	W115 44 12.6	20.3	0.29	5	3.2-6.4	6	6.4-12.8	unembedded
NF-6	N49 54 40.9	W115 44 20.7	16.0	0.53	7	12.8-25.6	5	3.2-6.4	1/4 embedded
Average			**28.1**	**0.40**	**6**		**4**		
Far-field									
FF-1	N49 50 20.9	W115 44 27.6	35.0	0.19	7	12.8-25.6	4	1.6-3.2	unembedded
FF-2	N49 50 11.2	W115 44 39.4	35.0	0.41	7	12.8-25.6	5	3.2-6.4	unembedded
FF-3	N49 49 17.0	W115 45 32.1	34.3	0.25	5	3.2-6.4	6	6.4-12.8	unembedded
FF-4	N49 49 37.5	W115 45 15.8	42.7	0.49	7	12.8-25.6	6	6.4-12.8	unembedded
FF-5	N49 48 35.8	W115 46 04.6	38.2	0.23	7	12.8-25.6	6	6.4-12.8	unembedded
FF-6	N49 48 07.8	W115 46 13.7	43.7	0.57	6	6.4-12.8	5	3.2-6.4	unembedded
Average			**38.1**	**0.36**	**7**		**5**		

Fish collection was completed in the same general areas as the benthic invertebrates, as well as the Canal Flats reference area. Collections of fish were in the spring, whereas benthic invertebrates were sampled in the fall. Therefore, fish collection may have occurred

with slightly different water levels and flows but measurements at the Fort Steele discharge station (downstream) were similar between sampling events.

5.2 Water Quality

5.2.1 Sample Collection and Analysis

Conventional *in situ* water quality parameters (dissolved oxygen (DO), pH, conductivity, and water temperature) were measured with appropriately calibrated hand-held meters at mid-depth at each benthic invertebrate sampling station, and within each fish survey area using an YSI hand-held water quality meter and Sonde.

Water samples for laboratory analysis were collected 15 to 30 cm below the water surface by hand, directly into the sample bottles. Three water samples were collected from each area during the fish collection program and six samples were collected from each benthic invertebrate area during the benthic survey program. In addition, three water samples were collected from Skookumchuck Creek and the Lussier River and two final effluent samples were collected during both the benthic and fish surveys. Three quality assurance and quality control (QA/QC) samples (i.e., field blank, trip blank, and duplicate field sample) were collected during each sampling event. All sample containers were appropriately labeled with station number, sample date, and project reference number. Laboratory supplied chain of custody forms were appropriately filled out and were submitted to the laboratory with the samples. Samples were kept on ice following collection and for transport to the laboratory for analysis.

The following parameters were measured in the laboratory:

- hardness;
- ammonia (as nitrogen);
- nitrite (as nitrogen);
- nitrate (as nitrogen);
- total nitrogen (N);
- dissolved orthophosphate;
- total phosphorus;
- total dissolved phosphorus;
- total organic carbon (TOC);
- dissolved organic carbon (DOC); and
- sodium.

Laboratory analysis on all water samples was conducted by ALS Environmental (Burnaby, British Columbia).

5.2.2 Results

Conventional water quality measures are summarized in **Table 5.2** for the fish survey and in **Table 5.3** for the benthic invertebrate survey. Laboratory chemistry data associated with both the fish and benthic surveys are summarized in **Table 5.4**.

As expected, the influence of mill effluent on water quality in the Kootenay River was seen in at least some of the conventional water quality measures.

Specific conductance values from upstream to downstream (Canal Flats, Torrent, near-field, far-field) in the Kootenay River were 0.253, 0.215, 0.211, and 0.243 mS/cm during the fish survey. During the benthic invertebrate survey the specific conductance values in these same areas were 0.335, 0.291, 0.333, and 0.335 mS/cm. Due to the inputs of the Skookumchuck Creek (lower conductivity) just upstream and the Lussier River (higher conductivity) just downstream of the mill typical spatial patterns of conductivity due to mill effluent are not evident.

Water temperatures within the study area ranged between 6.8°C and 12.6°C in the spring and between 5.8°C and 8.4°C in the fall. Water temperatures in Skookumchuck Creek were similar between the surveys; whereas water temperature in the Lussier River was 6.8°C higher in spring than in the fall. Water temperatures in the exposure areas were slightly higher than Torrent reference area, in a fairly typical spatial pattern due to the influence of mill effluent. Water temperatures were higher at the Canal Flats reference than in the exposure areas during the benthic invertebrate survey.

Dissolved oxygen levels were relatively high across the study area during both the benthic invertebrate sampling and the fish survey.

The pH of water was similar across the study areas and ranged from 7.3 to 7.7 in the spring and from 8.3 to 8.5 in the fall.

Table 5.2:
Conventional Water Quality Measures Coincident with the Skookumchuck Mill EEM Cycle 7 Fish Survey

Area	Temperature	Specific Conductance	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	°C	mS/cm°C	mS/cm	%	mg/L	-
Canal Flats Reference	7.1	0.336	0.253	97.5	11.8	7.3
Torrent Reference	6.8	0.332	0.215	87.0	10.8	7.6
Skookumchuck Creek	6.9	0.132	0.086	98.6	12.4	7.5
Near-field	9.2	0.302	0.211	96.0	11.5	7.4
Lussier River	12.6	0.498	0.380	-	-	8.1
Far-field	9.2	0.347	0.243	79.9	9.5	7.7

Table 5.3:
Conventional Water Quality Measures Coincident with the Skookumchuck Mill EEM Cycle 7 Benthic Invertebrate Survey

Station	Temperature	Specific Conductance	Conductivity	Dissolved Oxygen	Dissolved Oxygen	pH
	°C	mS/cm°C	mS/cm	%	mg/L	-
Canal Flats Reference						
CF-1	8.3	0.335	0.228	92.8	10.9	8.4
CF-2	8.6	0.334	0.230	94.0	11.0	8.5
CF-3	8.4	0.335	0.228	93.4	10.9	8.4
Average	**8.4**	**0.335**	**0.229**	**93.4**	**10.9**	**8.4**
Torrent Reference						
TBBR-1	6.7	0.320	0.208	90.7	11.1	8.3
TBBR-2	7.0	0.320	0.210	90.9	11.0	8.3
TBBR-3	6.9	0.324	0.212	91.3	11.1	8.5
TBBR-4	7.2	0.323	0.213	91.7	11.1	8.5
TBBR-5	6.4	0.137	0.088	130.8	12.8	8.4
TBBR-6	9.8	0.319	0.226	98.7	11.2	8.4
Average	**7.3**	**0.291**	**0.193**	**99.0**	**11.4**	**8.4**
Skookumchuck Creek						
SK-1	6.9	0.133	0.087	95.0	11.5	8.4
SK-2	7.3	0.135	0.089	94.5	11.4	8.6
SK-3	6.3	0.121	0.078	101.2	12.6	8.5
Average	**6.8**	**0.130**	**0.085**	**96.9**	**11.8**	**8.5**
Final Effluent						
FE1	21.2	2.829	2.624	73.5	6.5	7.3
Near-field						
NF-1	7.3	0.340	0.225	74.7	9.3	8.4
NF-2	8.0	0.317	0.214	94.9	11.2	8.5
NF-3	7.6	0.341	0.228	91.1	10.9	8.5
NF-4	7.6	0.336	0.225	94.1	11.2	8.5
NF-5	8.3	0.346	0.236	95.7	11.3	7.9
NF-6	8.4	0.317	0.216	93.1	10.9	8.2
Average	**7.9**	**0.333**	**0.224**	**90.6**	**10.8**	**8.3**
Lussier River						
LR-1	5.4	0.552	0.345	86.3	10.9	8.4
LR-2	6.0	0.552	0.352	87.8	10.9	8.4
LR-3	5.9	0.553	0.351	87.0	10.8	8.4
Average	**5.8**	**0.552**	**0.349**	**87.0**	**10.8**	**8.4**
Far-field						
FF-1	8.8	0.320	0.221	97.1	11.3	8.5
FF-2	8.8	0.332	0.229	97.5	11.3	8.5
FF-3	8.7	0.326	0.225	96.8	11.2	8.5
FF-4	7.6	0.344	0.230	90.0	10.7	8.3
FF-5	7.9	0.344	0.231	87.7	10.4	8.3
FF-6	7.8	0.344	0.231	87.7	10.4	8.3
Average	**8.3**	**0.335**	**0.228**	**92.8**	**10.9**	**8.4**

The influence of the mill discharge on the concentrations of most constituents measured in the laboratory was conspicuous in both the near-field and far-field areas, although the chemistry data also suggests that inputs from the Lussier River below the mill also affect water quality in the far-field area (**Table 5.4**).

Higher concentrations of several constituents were higher in the near-field area than in the reference areas, presumably as the result of discharge of mill effluent. This included concentrations of ammonia, nitrogen, phosphorous (total, dissolved, orthophosphate), carbon (total, dissolved) and sodium in the spring and concentrations of all constituents, with the exception of nitrite, in the fall. A similar spatial pattern was evident in the far-field area, though concentrations of some constituents, TOC, DOC and sodium, were higher in the far-field area than in the near-field. The higher concentrations of these constituents most likely reflects the influence of the Lussier River.

Generally, concentrations of the constituents that were measured in the laboratory were higher in the spring than they were in the fall across the study area. The seasonal differences in concentrations may be due to variations of baseflow source inputs into the river (i.e., lower elevation vs higher elevation sources) during the different times of the year.

Table 5.4:
Mean General Water Chemistry for Skookumchuck Mill EEM Cycle 7

Area	Date	Hardness	Total Ammonia	Nitrate	Nitrite	Total Nitrogen	Dissolved Orthophosphate
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Canal Flats Reference	April	196	<0.0050	0.1733	<0.0010	0.195	<0.0010
Torrent Reference	April	182	<0.0050	0.1573	<0.0010	0.172	<0.0010
Skookumchuck Creek	April	72	<0.0050	0.0344	<0.0010	0.105	<0.0010
Final Effluent	April	408	1.19	<0.10	<0.020	11.2	0.676
Near-field	April	153	<0.0070	0.1287	<0.0010	0.207	0.0030
Lussier River	April	299	<0.0050	0.1060	<0.0010	0.119	<0.0010
Far-field	April	179	0.0109	0.1183	<0.0010	0.215	0.0053
Canal Flats Reference	September	-	-	-	-	-	-
Torrent Reference	September	142	<0.0068	0.1088	<0.0010	0.137	<0.0010
Skookumchuck Creek	September	61	<0.0050	<0.0050	<0.0010	0.055	<0.0010
Final Effluent	September	429	3.82	<0.10	<0.020	6.3	0.374
Near-field	September	170	0.0218	0.1283	<0.0010	0.189	0.0057
Lussier River	September	280	0.0077	0.0979	<0.0010	0.141	<0.0012
Far-field	September	160	0.0178	0.1165	<0.0010	0.174	0.0035

Area	Date	Total Phosphorus	Total Dissolved Phosphorus	Total Organic Carbon	Dissolved Organic Carbon	Sodium	Chlorophyll α
		mg/L	mg/L	mg/L	mg/L	mg/L	$\mu g/cm^2$
Canal Flats Reference	April	0.0026	<0.0020	0.63	0.62	7.6	-
Torrent Reference	April	0.0024	<0.0020	0.69	0.67	7.0	-
Skookumchuck Creek	April	0.0040	<0.0020	2.03	1.82	2.1	-
Final Effluent	April	2.96	0.970	169	147	547	-
Near-field	April	0.0135	0.0045	1.73	1.53	8.1	-
Lussier River	April	<0.0027	<0.0020	<0.52	<0.53	2.5	-
Far-field	April	0.0186	0.0078	2.47	1.77	10.5	-
Canal Flats Reference	September	-	-	-	-	-	0.17
Torrent Reference	September	<0.0020	<0.0020	<0.56	<0.56	3.4	0.57
Skookumchuck Creek	September	<0.0020	<0.0020	0.83	0.92	2.1	0.98
Final Effluent	September	1.90	0.946	118	84	438	-
Near-field	September	0.0086	0.0064	<0.78	0.87	6.0	4.69
Lussier River	September	<0.0020	<0.0020	<0.50	<0.54	2.5	0.56
Far-field	September	0.0080	0.0045	0.87	0.91	5.9	1.59

5.2.3 Sodium as a Tracer of Effluent Exposure

The average concentrations of sodium from the exposure area, mill effluent and the reference areas (ambient) were used to estimate effluent dilution in the Kootenay River downstream of the mill. The dilution of effluent was calculated by subtracting the ambient sodium concentration from the sodium concentration in the mill effluent and dividing that difference by the difference of the ambient sodium concentration and the sodium concentration in the exposure areas. Only data from the fall field survey were used for this purpose as results from the spring field survey indicated that sodium concentrations in the far-field area were higher than the near-field area, reflecting inputs from downstream of the mill.

During the fall field survey, it was estimated that the effluent concentrations in the exposure areas were 0.60% and 0.58% in the near-field and far-field areas, respectively (**Table 5.5**).

Table 5.5:
Sodium Concentrations and Estimated Percent Effluent in the Near-field and Far-Field Areas, Skookumchuck Mill EEM Cycle 4, September 2015

Area	Mean Sodium (mg/L)	Dilution	Percent Effluent
Torrent Reference	3.4	-	-
Effluent	438	-	-
Near-field	6.0	167	0.60%
Far-field	5.9	174	0.58%

5.3 Periphyton Sampling

5.3.1 Collection

Triplicate periphyton samples were collected from each sampling area coincident with the benthic community survey in the fall of 2015. The samples were collected following the BC MOE guidance (Cavanagh et al. 1994). A summary of these collection methods is as follows:

- Rocks that had a relatively flat surface of at least 4 x 4 cm were selected;
- A 16 cm^2 template was used and randomly placed on the flat surface;
- The 16 cm^2 surface area was scrapped with a scalpel on to a 0.45 µm filter paper;
- Three different rock scrapings were composited on one filter and vacuum pumped free of water; and
- The filter paper was folded, placed into an opaque container, and frozen until lab submission.

5.3.2 Results

Chlorophyll α was 4 to 27 times greater in the near-field area, and 1.5 to 9 times greater in the far-field area than in the reference areas and Kootenay River tributary sampling areas. These results are consistent with visual observations made during sampling. It was observed that the rocks in the near-field and far-field areas were more densely covered with periphyton than those in the reference areas and Kootenay River tributary sampling areas.

Periphyton growth is limited by dissolved nitrogen and dissolved orthophosphate phosphorous concentrations at 0.04 mg/L and 0.005 mg/L, respectively; although periphyton growth saturation has been observed at 0.001 mg/L orthophosphate (Hatfield, 2007). **Figure 5.1** and **Figure 5.2** present the chlorophyll α levels and dissolved orthophosphate and total nitrogen concentrations, respectively. Concentrations of orthophosphate followed a similar spatial (upstream to downstream) pattern as chlorophyll α levels; whereas total nitrogen concentrations did not. This suggests that nitrogen was not

limiting periphyton growth. Chlorophyll α levels were highest in the near-field area, the sampling area with the highest concentrations of orthophosphate. The data indicate that orthophosphate, presumably associated with mill effluent, contributes to enhanced periphyton growth downstream of the discharge.

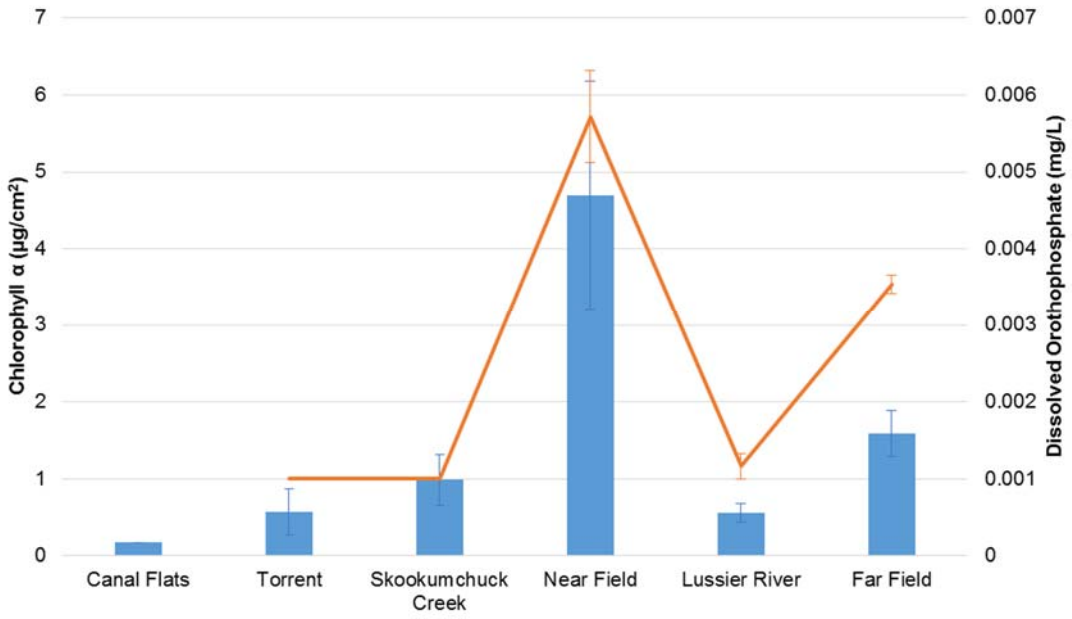

Figure 5.1:
Chlorophyll α Levels (blue bars) and Dissolved Orthophosphate Concentrations (orange line) in the Skookumchuck Mill EEM Cycle 7 Study Area

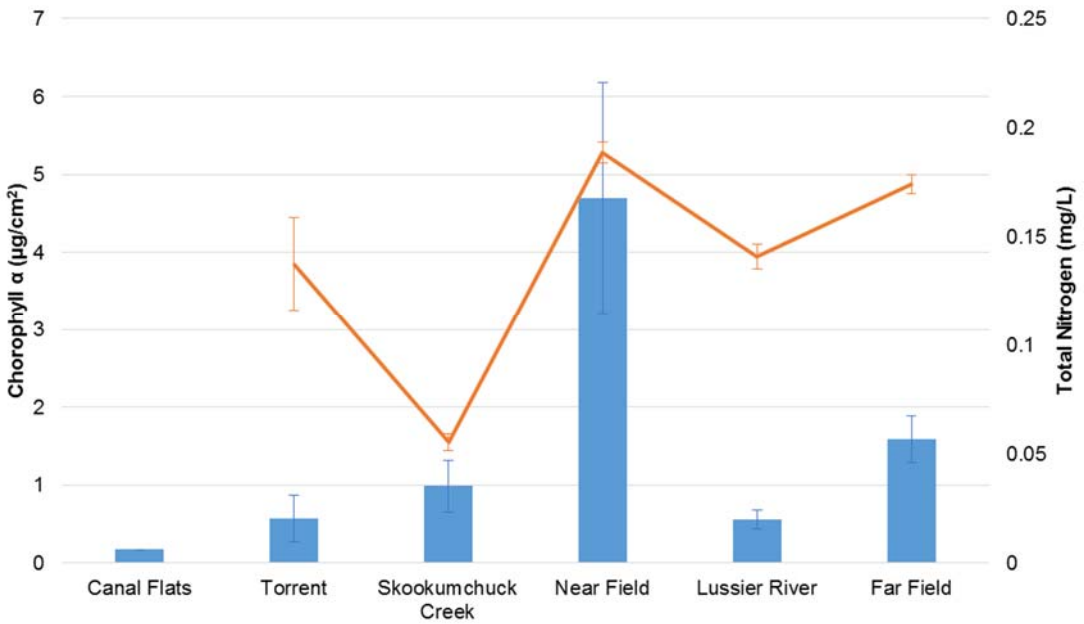

Figure 5.2:
Chlorophyll α Levels (blue bars) and Total Nitrogen Concentrations (orange line) in the Skookumchuck Mill EEM Cycle 7 Study Area

5.4 Sediment Quality

The receiving environment is erosional in nature and, therefore, sediments samples were not collected for chemical or physical characterization as part of this EEM study.

5.5 Summary of Key Findings

The following key observations or conclusions can be made with respect to the Cycle 7 supporting environmental data and its analysis:

- habitat features of the sampling areas were similar to the extent that differences in fish and benthic community structure measured would not likely be related to habitat factors,
- the influence of mill effluent on water chemistry was conspicuous, with effluent-exposed areas having higher concentrations of several constituents; and,
- periphyton growth was higher in the effluent-exposed areas, likely due to orthophosphate concentrations associated with the discharge of mill effluent into the Kootenay River.

6.0 BENTHIC INVERTEBRATE COMMUNITY SURVEY

6.1 Objective

An assessment of the benthic invertebrate community in the receiving environment serves as a basis to delineate the extent and magnitude of fish habitat degradation, if any, due to organic or nutrient enrichment, or other forms of physical and chemical contamination potentially associated with mill operations. It also provides a basis for an evaluation of the aquatic food resources available for fish communities in the receiving environment.

6.2 Study Design and Methods

6.2.1 Timing

The benthic invertebrate community survey was completed between September 29th and October 1st 2015, consistent with the timing of past surveys. This timing is appropriate because most benthic invertebrates are numerous and large enough for genus-level taxonomic identification at that time of year.

6.2.2 Habitat Selection

All sampling stations were located in erosional habitats which represent the dominant habitat type in the study area. To further limit the influence of habitat differences/variability among and between benthic invertebrate samples, replicate stations within each study reach were standardized in terms of sample depth, water velocity, and general habitat features to the extent practical.

6.2.3 Sampling Areas and Within Area Replication

Samples were collected in the same general areas as in past surveys, including the Torrent reference area on the Kootenay River upstream of the mill, the near-field area immediately downstream of the mill discharge and the far-field area approximately 10 km downstream from the mill discharge. Sampling area and station locations are presented in **Figure 4.1**.

Six replicate stations were sampled in each area. This level of replication is more than is required to detect a difference equal of ±2 Standard Deviations (SD) for α (i.e., the likelihood of a Type I error) = 0.1 and power (i.e., 1 – ß; where ß is the likelihood of a Type II error) = 0.9.

6.2.4 Benthic Sample Collection

Samples were collected following standard operating procedures (SOPs) (EcoMetrix, 2014) that are consistent with pulp and paper technical guidance (EC, 2010).

A Hess sampler (0.086 m^2 surface area) was used to collect benthic invertebrates. An individual benthic sample, which represented the benthos at a single sampling station, consisted of a composite of three subsamples. Following collection, each subsample was sieved through the 500 μm Nitex mesh bag attached to the Hess sampler and subsequently transferred to labeled (inside and out) 250 mL plastic containers. All samples were preserved to a level of 10% buffered formalin in the field.

As indicated above, in order to minimize the variability in the benthic community as the result of natural habitat differences within and among stations and areas, efforts, were made to standardize the physical habitat between stations.

6.2.5 Sample Processing and Analysis

When the invertebrate samples arrived at the EcoMetrix Incorporated office (Mississauga, Ontario) following the field program, each was logged and crosschecked with field data sheets to ensure that all of the samples were received and that all of the samples were labeled correctly. Samples were also checked to ensure that they had been properly preserved in the field.

Detailed taxonomic identifications were completed by Zaranko Environmental Assessment Services (ZEAS), Nobleton, Ontario. When the samples arrived at ZEAS, they were checked for proper labeling and preservation, and stained to ease removal of the invertebrates. Prior to further processing, the samples were washed free of formalin. Samples were sorted with the aid of a dissecting microscope at ten times magnification. All benthic fauna were identified to the lowest practical level.

Because of the large number of animals in individual samples, all samples were subsampled (see **Appendix A**). Subsampling error was estimated to determine the precision of the density estimates derived from the subsampling procedure.

Recovery checks (i.e., re-sorting of samples to determine initial sorting efficacy) were undertaken on 10% of the samples collected, as required.

A voucher collection, including representatives of identified taxa, was compiled and is catalogued at ZEAS.

6.2.6 Data Management, Data Summary and Statistical Analyses

6.2.6.1 Data Management

Data received from the taxonomist was imported directly into a data base format so as to minimize transcription errors. Non-benthic and unidentified taxa were removed. Data were queried from the database and random checks performed on 10% of the total number of entries to confirm validity and accuracy.

6.2.6.2 Data Summary

Data were summarized and several benthic invertebrate community metrics were calculated using embedded Microsoft® Excel™ spreadsheet functions. As a means to ensure the data were summarized in an accurate manner all spreadsheet calculations and formula were checked by an independent technician. In addition, one full set of benthic invertebrate community survey metrics for one sample was re-calculated.

These metrics included those defined as "EEM effect parameters" (Environment Canada, 2010), as well as several others that helped to better reveal patterns of invertebrate community structure:

- total invertebrate density[1] and density of major taxonomic groups;
- invertebrate (taxa) richness[1];
- Simpson's Evenness (E)[1];
- Bray-Curtis Dissimilarity Index (B-C)[1];
- EPT taxa number and abundance of individual groups;
- relative density of invertebrate taxa and major taxonomic groups;
- presence/absence of taxa at the Family level; and,
- Simpson's Diversity (D).

Total invertebrate density was determined as the total number of organisms found in a given sample expressed per unit surface area (no. of organisms/m^2). Densities of major taxonomic groups was determined as the sum of the density of individual taxa within the group, typically at a Family or Order level.

Taxa richness is the number of unique organisms identified in a given sample, in this case where the organisms have been identified to the lowest practical level. By simply enumerating the organisms at each station (i.e., total abundance) and by determining taxa richness, general statements can be made regarding the quality of the environment at a specific location. Typically, decreasing taxa richness is associated with decreasing water quality, whereas, organism abundance can increase or decrease in association with different types of environmental stress.

Evenness (E) is an expression of how equitably taxa are represented within a given sample. In some cases, disturbance or stress can create conditions whereby relatively few taxa are favored and those taxa become disproportionately abundant in that location. In this instance the effect is manifested as relatively low evenness. Evenness ranges from zero to

[1] Total invertebrate abundance, richness, E and B-C are "EEM effect parameters". According to EEM technical guidance, during the Initial, Periodic and Focused phases of the monitoring program, an effect on the benthic invertebrate community is said to occur if there are statistical differences between reference and exposure areas in any of the effect parameters.

one (one representing a sample in which all taxa have the same abundance) and is calculated as in Smith and Wilson (1996):

$$E = 1 / \sum_{i=1}^{s} (p_i)^2 / S$$

where: E = Evenness
p*i* = the proportion of the *i*th taxon (family) at the station
S = the total number of taxa (families) at the station

The B-C Index is a distance co-efficient that reaches a maximum value of 1 for two sites that are entirely different and a minimum value of 0 for two sites that possess identical descriptors. These distance coefficients measure the amount of association between sites and the B-C Index is a member of the class of distance coefficients known as semi-metric that some prefer to call dissimilarity coefficients. The B-C Index measures the percentage of difference between sites (Legendre and Legendre, 1983) where the distance statistic is calculated as below:

$$B - C = \frac{\sum_{i=1}^{n} \left| y_{i1} - y_{i2} \right|}{\sum_{i=1}^{n} (y_{i1} + y_{i2})}$$

where: B-C = Bray-Curtis distance between sites 1 and 2;
Y_{i1} = count for species (family) *i* at site 1;
Y_{i2} = count for species (family) *i* at site 2;
n = total number of species (families) present at the two sites.

In the present application, the B-C distances for each of the sampling stations, as well as mean B-C distances for each sampling area, are expressed as distances relative to a calculated reference median condition.

The EPT (Ephemeroptera, Plecoptera, and Trichoptera) index provides a measure of taxa (family) richness within three taxonomic insect orders (mayflies, stoneflies, caddisflies), which are generally sensitive to pollution, and therefore should increase with increasing water quality. The EPT index is equal to the total number of taxa represented within these three orders within a given sample. The abundance of EPT taxa is the sum of the densities of the individual taxa in a given sample.

Relative abundance quantifies the relative proportion (as a percent) of taxa and major taxonomic groups comprising the benthic invertebrate community.

Presence/absence is quantified through a presence/absence matrix at the Family taxonomic level for each sampling area.

Another measure of diversity within the benthic invertebrate community is described by the Simpson's Diversity Index (D). This index places relatively little weight on rare taxa and more weight on common species (Krebs, 1985). Its values range from 0, indicating a low level of diversity, to a maximum of 1-1/*s*. D was calculated as follows:

$$D = 1 - \sum_{i=1}^{s} (p_i)^2$$

where: s = the total number of taxa (family) at the station;
p_i = the proportion of the ith taxon (family) at the station.

6.2.6.3 Statistical Analyses

The benthic invertebrate data were analyzed in a manner consistent with the overall objective of identifying potential spatial differences (i.e., among sampling area differences) in benthic community structure (as represented by community endpoint data) within the study area. All statistical procedures were carried out using SYSTAT 13 (Systat Software, Inc.).

Outliers were checked and validity confirmed by using the least squares function in SYSTAT to examine residuals. Endpoints were compared among exposed and reference areas using statistical procedures consistent with Environment Canada guidance (Environment Canada, 2010).

Prior to testing, the Cycle 7 endpoint data were tested to determine whether they met the assumptions of normality (normal probability plot of residuals) and homoscedasticity (variance plot of residuals). In the case where these assumptions were met, among-area comparisons of the Cycle 7 macroinvertebrate data were made via single factor ANOVA. Where the assumptions were not met, the data were transformed (as appropriate) to meet the assumptions prior to ANOVA. Non-parametric analysis were also performed as an alternative to ANOVA when assumptions were not met, or could not be met via data transformation. The Kruskal-Wallis test, which is the non-parametric equivalent of a one-way ANOVA, was used on data for this purpose.

For any test that resulted in a statistical difference, the direction and magnitude of the difference was noted. Direction provides an indication of whether the exposure means were larger or smaller than the reference means. The magnitude of the difference was

calculated relative to the standard deviation for a given endpoint based on reference area area according to the following equation:

{(exposure area mean) – (reference area mean mean)}/reference area standard deviation

The magnitude of the difference was identified as being > or < 2 reference area standard deviations (RefSD), a value which has been suggested as being indicative of a meaningful ecological difference (Environment Canada, 2010).

Spearman correlation analysis was used to determine if there were relationships between the ICS endpoints (abundance, richness, E, B-C) and measured habitat and water quality variables. The analysis was carried out on the combined-areas Cycle 7 data set individually for each endpoint.

As the previous EEM benthic collections (Cycle 4) were made at the same areas as those used in Cycle 7, and by same methodology and with the same (or similar) sampling rigor as Cycle 7, it was also possible to analyze the Cycle 7 benthic data in a Before-After-Control-Impact (BACI) framework to evaluate changes in benthic community structure through space and time simultaneously. To this end, among EEM cycle endpoint data were compared with Two-Way ANOVA.

Differences among groups of data were considered statistically different at $\alpha < 0.10$ (i.e., a 10% probability of committing a Type I error or rejecting a true null hypothesis). Consistent with Environment Canada guidance, no correction of α (e.g., Bonferroni correction) was made, as might typically be done when multiple statistical tests are completed on the same data set, to compensate for the multiplicative nature of probability. In this application, fixing α at 0.10 rather than correcting for multiple tests errs on the side of being protective of the environment.

6.3 Results

6.3.1 EEM Cycle 7 Survey Data

Raw benthic invertebrate community data are provided in **Appendix C**. Invertebrate community data are summarized by sampling area in **Table 6.1** (absolute densities of major taxonomic families), **Table 6.2** (presence/absence) and **Table 6.3** (relative density of major taxonomic families). Summary statistics for benthic invertebrate community endpoint data are provided in **Table 6.4**. A summary of the results of the statistical comparisons of the Cycle 7 invertebrate community endpoint data are provided in **Table 6.5**. Graphical representations of the benthic community endpoint data are presented in **Figure 6.1** to **Figure 6.4**. Graphs showing temporal trends in the benthic community endpoint data are presented in **Figure 6.6** to **Figure 6.8.**

6.3.1.1 General Taxonomic Characteristics

A total of 33 unique benthic taxa were identified in the study area (31 families, plus one Phylum and one Class) of which 28, 30, and 24 were identified in the reference, near-field, and far-field areas, respectively (**Table 6.1**).

Invertebrate density ranged from approximately 4,500 to 10,600 organisms/m^2 across the study area. Generally the same taxa were most abundant in each of the sampling areas. These taxa included mayflies from the Families Ephemerellidae and Heptageniidae, caddisflies from the family Hydropsychidae and midge larvae from the Family Chironomidae. Worms from the Family Naididae were abundant in the far-field area.

Table 6.1:
Density of the Major Benthic invertebrate Taxonomic Families (no./m^2) in Skookumchuck Mill Study Area.

Taxa	Torrent Reference			Near-field			Far-field		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
P. Nemata	0	0	0	63	108	27	16	54	0
Cl. Turbellaria	2	13	0	0	0	0	0	0	0
F. Enchytraeidae	0	0	0	0	0	0	4	27	0
F. Naididae	49	215	0	18	108	0	1,037	2,721	0
F. Hygrobatidae	20	108	0	9	54	0	0	0	0
F. Lebertiidae	29	108	0	7	27	0	0	0	0
F. Sperchonidae	18	27	0	70	323	0	0	0	0
F. Elmidae	18	108	0	4	27	0	0	0	0
F. Ameletidae	31	81	0	13	81	0	7	40	0
F. Baetidae	30	108	0	49	215	0	111	269	27
F. Ephemerellidae	879	4,741	13	1,777	3,394	397	1,262	3,879	485
F. Heptageniidae	517	1,172	222	676	1,077	283	233	323	0
F. Leptophlebiidae	45	189	0	9	40	0	11	54	0
F. Capniidae	12	27	0	29	108	0	25	67	0
F. Chloroperlidae	6	13	0	29	108	0	0	0	0
F. Nemouridae	0	0	0	18	108	0	18	54	0
F. Perlidae	9	30	0	3	13	0	4	13	0
F. Perlodidae	20	54	0	52	108	27	45	108	0
F. Pteronarcyidae	6	27	0	44	111	0	1	3	0
F. Taeniopterygidae	127	539	7	339	646	148	254	620	27
F. Brachycentridae	20	108	0	88	458	0	121	232	0
F. Glossosomatidae	141	539	0	1,381	2,801	108	196	630	0
F. Hydropsychidae	746	3,556	40	3,207	6,205	232	1,251	2,758	54
F. Hydroptilidae	8	27	0	301	1,051	0	2,642	5,495	431
F. Lepidostomatidae	19	67	0	22	81	0	0	0	0
F. Psychomyiidae	0	0	0	9	54	0	276	862	54
F. Athericidae	33	81	0	68	162	3	25	77	0
F. Blephariceridae	18	108	0	9	54	0	0	0	0
F. Chironomidae	1,440	8,081	13	1,793	2,316	269	2,934	6,195	1,077
F. Empididae	249	1,401	0	105	215	54	45	111	0
F. Simuliidae	2	13	0	49	162	0	110	404	0
F. Tipulidae	6	17	0	11	54	0	0	0	0
F. Sphaeriidae	0	0	0	0	0	0	22	54	0

In general, benthic community composition was similar within each sampling areas. Twenty of the 33 taxonomic groups identified (Family or higher) were found across the study area (**Table 6.2**). One taxon was unique to the reference area (Class Turbellaria), no taxa were unique to the near-field area and two taxa were found only in the far-field area (Family Enchytraeidae, Famliy Sphaeriidae). Based solely on the presence and/or absence of benthic taxa it is apparent that the communities in the reference area and near-field area were more similar to each other than either was to the far-field area.

Table 6.2:
Presence/absence Matrix for the Major Benthic invertebrate Taxonomic Families in the Skookumchuck Mill Study Area.

Taxa	Torrent Reference	Near-field	Far-field
P. Nemata	A	P	P
Cl. Turbellaria	P	A	A
F. Enchytraeidae	A	A	P
F. Naididae	P	P	P
F. Hygrobatidae	P	P	A
F. Lebertiidae	P	P	A
F. Sperchonidae	P	P	A
F. Elmidae	P	P	A
F. Ameletidae	P	P	P
F. Baetidae	P	P	P
F. Ephemerellidae	P	P	P
F. Heptageniidae	P	P	P
F. Leptophlebiidae	P	P	P
F. Capniidae	P	P	P
F. Chloroperlidae	P	P	A
F. Nemouridae	A	P	P
F. Perlidae	P	P	P
F. Perlodidae	P	P	P
F. Pteronarcyidae	P	P	P
F. Taeniopterygidae	P	P	P
F. Brachycentridae	P	P	P
F. Glossosomatidae	P	P	P
F. Hydropsychidae	P	P	P
F. Hydroptilidae	P	P	P
F. Lepidostomatidae	P	P	A
F. Psychomyiidae	A	P	P
F. Athericidae	P	P	P
F. Blephariceridae	P	P	A
F. Chironomidae	P	P	P
F. Empididae	P	P	P
F. Simuliidae	P	P	P
F. Tipulidae	P	P	A
F. Sphaeriidae	A	A	P

6.3.1.2 Percent Composition

Several taxa comprised at least 1% of total invertebrate abundance, on average, across the study area, including mayflies from the Families Ephemerllidae and Heptageniidae, stoneflies from the family Taeniopterygidae, caddisflies from the Families Glossisomidae, Hydropsychidae and Hydroptilidae and midge larvae from the Family Chironomidae (**Table 6.3**).

In the reference area, heptageniid mayflies, hydropsychid caddisflies and midge larvae were the dominant families together comprising on average more than 60% of benthic invertebrate density. Ephemerellid mayflies, glossosomatid and hydropsychid caddisflies, and midge larvae were the dominate families in the near-field area where together they comprised on average greater than 75% of benthic invertebrate density. In the far-field area ephemerellid mayflies, hydropsychid and hydroptilid caddisflies, and midge larvae together comprised on average more than 70% of total invertebrate abundance

Table 6.3:
Relative Density of the Major Taxonomic Families in Skookumchuck Mill Study Area.

Taxa	Torrent Reference			Near-field			Far-field		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
P. Nemata	0%	0%	0%	1%	1%	0%	0%	0%	0%
Cl. Turbellaria	0%	1%	0%	0%	0%	0%	0%	0%	0%
F. Enchytraeidae	0%	0%	0%	0%	0%	0%	0%	0%	0%
F. Naididae	1%	3%	0%	0%	1%	0%	8%	24%	0%
F. Hygrobatidae	0%	1%	0%	0%	0%	0%	0%	0%	0%
F. Lebertiidae	1%	2%	0%	0%	0%	0%	0%	0%	0%
F. Sperchonidae	1%	3%	0%	1%	2%	0%	0%	0%	0%
F. Elmidae	0%	0%	0%	0%	0%	0%	0%	0%	0%
F. Ameletidae	2%	5%	0%	0%	1%	0%	0%	1%	0%
F. Baetidae	1%	5%	0%	1%	2%	0%	1%	2%	0%
F. Ephemerellidae	9%	22%	1%	16%	27%	7%	11%	22%	4%
F. Heptageniidae	30%	51%	1%	7%	15%	4%	3%	5%	0%
F. Leptophlebiidae	3%	11%	0%	0%	1%	0%	0%	1%	0%
F. Capniidae	1%	3%	0%	1%	2%	0%	0%	1%	0%
F. Chloroperlidae	0%	1%	0%	0%	2%	0%	0%	0%	0%
F. Nemouridae	0%	0%	0%	0%	1%	0%	0%	1%	0%
F. Perlidae	1%	2%	0%	0%	0%	0%	0%	0%	0%
F. Perlodidae	2%	4%	0%	1%	2%	0%	0%	1%	0%
F. Pteronarcyidae	0%	2%	0%	0%	2%	0%	0%	0%	0%
F. Taeniopterygidae	3%	5%	1%	3%	4%	2%	3%	7%	0%
F. Brachycentridae	0%	1%	0%	1%	4%	0%	1%	3%	0%
F. Glossosomatidae	4%	17%	0%	11%	20%	2%	2%	7%	0%
F. Hydropsychidae	19%	25%	9%	26%	41%	6%	13%	32%	1%
F. Hydroptilidae	1%	2%	0%	4%	17%	0%	24%	37%	5%
F. Lepidostomatidae	1%	4%	0%	0%	1%	0%	0%	0%	0%
F. Psychomyiidae	0%	0%	0%	0%	0%	0%	2%	5%	0%
F. Athericidae	2%	4%	0%	1%	1%	0%	0%	1%	0%
F. Blephariceridae	0%	0%	0%	0%	0%	0%	0%	0%	0%
F. Chironomidae	14%	43%	2%	25%	52%	3%	28%	44%	20%
F. Empididae	2%	6%	0%	1%	1%	1%	0%	1%	0%
F. Simuliidae	0%	1%	0%	1%	2%	0%	1%	5%	0%
F. Tipulidae	1%	2%	0%	0%	0%	0%	0%	0%	0%
F. Sphaeriidae	0%	0%	0%	0%	0%	0%	0%	0%	0%

6.3.1.3 Diversity at the Lowest Practical Level

The greatest number of taxa were identified within the Family Chironomidae, with 21 genera found in the study area. Twelve genera were in the near-field area, 17 genera were found in the far-field, and 10 genera were found in the reference area. The genus Cricotopus/Orthocladius were found in relative high abundance across the study areas.

Eleven mayfly taxa were identified across the study area, several of which were found in each sampling including *Baetis*, *Drunella*, *Ephemerella*, *Cynigmula* and *Rhithrogena*. *Ephemeralla* were relatively abundant across the study area.

Eleven stonefly taxa were found in the study area. Though stonefly abundance differed among the areas no stonefly taxa were unique to any one sampling area. *Isoperla* and immature specimens from the Family Taeniopterygidae were abundant in the study area.

Seven caddisfly genera were identified in the study area. *Hydropsyche* were relatively abundant in the near-field area but also found in the reference and far-field areas. *Hydroptila* were relatively abundant in the far-field area but also found in the reference and near-field areas. The genus Psychomyia was almost exclusively found in the far-field area.

6.3.1.4 Benthic Invertebrate Community Endpoint Data

Benthic invertebrate community endpoint data are summarized in **Table 6.4** and discussed by sampling area below.

Invertebrate density in the reference area ranged from 761 to 20,040 organisms/m^2 and was on average 4,503 organisms/m^2. Mean taxa richness was 21 with richness at individual sampling stations ranging from 16 to 27. EPT taxa richness ranged from 10 to 16 and was on average 13. On average the density of the EPT taxa was on the order of 2,700 organisms/m^2, comprising about half the total invertebrate density in the reference area. The mean D value was 0.84 with scores at individual sampling stations ranging from 0.79 to 0.91. Evenness (E) ranged from 0.25 to 0.50 and was on average 0.38. B-C distances ranged from 0.33 to 0.92 and the mean B-C distance value for the reference area samples was 0.47.

Invertebrate density in the near-field area ranged from 4,202 to 17,293 organisms/m^2 and was on average 10,262 organisms/m^2. Mean taxa richness was 26, with richness ranging from 21 to 30. EPT taxa richness ranged from 11 to 18 and averaged 15. On average the density of the EPT taxa was on the order of 8,000 organisms/m^2, comprising about 80% of the total invertebrate density in the near-field area. The mean D value was 0.81 with scores ranging from 0.78 to 0.84 for individual stations. Evenness (E) ranged from 0.17 to 0.29 and was on average 0.22. B-C distances ranged from 0.67 to 0.91 and the mean B-C distance value for the near-field area samples was 0.83.

Invertebrate density in the far-field area ranged from 5,670 to 17,195 organisms/m^2 and was on average 10,656 organisms/m^2. Mean taxa richness was 26, with richness ranging from 21 to 32. EPT taxa richness ranged from 9 to 17 and averaged 14. On average the density of the EPT taxa was on the order of 6,400 organisms/m^2, and comprised about 65% of the total invertebrate density in the far-field area. The mean D value was 0.83 with scores ranging from 0.78 to 0.88. Evenness (E) ranged from 0.19 to 0.31 and was on average 0.25. B-C distances ranged from 0.79 to 0.94 and the mean B-C value for the reference area samples was 0.87.

Table 6.4:
Summary Statistics of Benthic Invertebrate Effect Parameters

	Mean	Median	Min	Max	SD	SE
Torrent Reference						
Density (no/m^2)	4,503	1,444	761	20,040	7,626	3,113
Richness	21	22	16	27	4	2
EPT Richness	13	13	10	16	3	1
Mayfly Desnity (no/m^2)	1,503	727	519	5,172	1,822	744
Stonefly Density (no/m^2)	180	109	88	539	177	72
Caddisfly Density (no/m^2)	935	333	40	4,202	1,608	657
Simpson's D	0.84	0.81	0.79	0.91	0.06	0.02
Simpson's E	0.38	0.40	0.25	0.50	0.10	0.04
B-C	0.47	0.40	0.33	0.92	0.23	0.09
Near-field						
Density (no/m^2)	10,262	9,473	4,202	17,293	5,352	2,185
Richness	26	27	21	30	3	1
EPT Richness	15	16	11	18	3	1
Mayfly Desnity (no/m^2)	2,524	2,256	694	4,471	1,447	591
Stonefly Density (no/m^2)	514	497	242	875	241	98
Caddisfly Density (no/m^2)	5,007	4,636	842	9,158	3,705	1,512
Simpson's D	0.81	0.80	0.78	0.84	0.03	0.01
Simpson's E	0.22	0.23	0.17	0.29	0.04	0.02
B-C	0.83	0.86	0.67	0.91	0.09	0.04
Far-field						
Density (no/m^2)	10,656	9,815	5,670	17,195	4,541	1,854
Richness	26	25	21	32	4	2
EPT Richness	14	15	9	17	4	1
Mayfly Desnity (no/m^2)	1,625	1,136	512	4,418	1,430	584
Stonefly Density (no/m^2)	346	291	81	707	255	104
Caddisfly Density (no/m^2)	4,487	3,911	3,091	6,825	1,513	618
Simpson's D	0.83	0.84	0.78	0.88	0.04	0.01
Simpson's E	0.25	0.26	0.19	0.31	0.05	0.02
B-C	0.87	0.89	0.79	0.94	0.07	0.03

6.3.1.5 Statistical Comparisons of EEM Cycle 7 Effect Parameters

A summary of the results of the statistical comparisons of EEM effect endpoints is provided in **Table 6.5**.

Table 6.5:
Summary Statistics Comparisons of EEM Cycle 7 Effect Parameters.

Effect Endpoint	Comparison	p-value	p < 0.1?	Direction	Magnitude (RefSD)
Abundance (log)	REF vs NF	0.019	Yes	NF>REF	1.3
	REF vs FF	0.055[2]	Yes	FF>REF	1.3
Richness	REF vs NF	0.051	Yes	NF>REF	1.1
	REF vs FF	0.068	Yes	FF>REF	1.1
Simpson's Evenness	REF vs NF	0.012[1]	Yes	REF>NF	1.5
	REF vs FF	0.020	Yes	REF>FF	1.2
B-C Dissimilarity	REF vs NF	0.055[2]	Yes	NF>REF	1.6
	REF vs FF	0.025[2]	Yes	FF>REF	1.8

[1] Analyzed using T-test assuming unequal variance

[2] Analyzed using Non-parametric Mann-Whitney U-test due to non-normality

[3] RefSD is the magnitude of difference between the refernce and exposure area enpoint values (mean) expressed as a function of the reference standard deviation for the endpoint.

Pairwise between-sampling-area comparisons indicated that total invertebrate densities in the near-field and far-field areas were different (greater) than in the reference area. The differences between density in the near-field and reference areas and far-field and reference areas was in each case 1.3 reference standard deviations in magnitude (**Figure** 6.2).

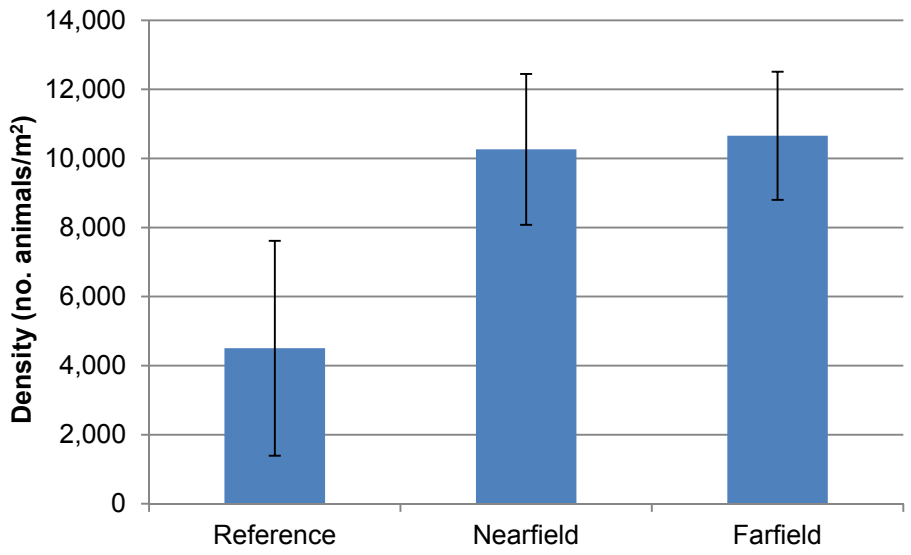

Figure 6.1:
Invertebrate Density in the Skookumchuck Mill Study Area in Cycle 7
(error bars are ± standard errors)

Pairwise between-sampling-area comparisons indicated that richness values in the near-field and far-field areas were different (greater) than in the reference area. The differences between the near-field and reference areas and far-field and reference areas were in each case equivalent to 1.1 reference standard deviations in magnitude (**Figure 6.2**).

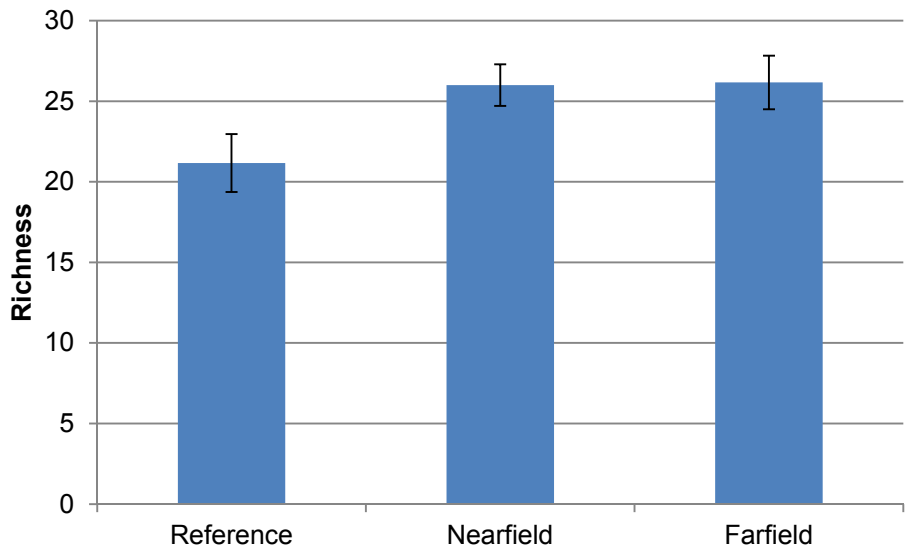

Figure 6.2:
Invertebrate Richness in the Skookumchuck Mill Study Area in Cycle 7
(error bars are ± standard errors)

Simpson's Evenness was higher than the reference in the near- and far-field, indicating that the density of taxa was more equitably distributed in reference area samples than in exposure area samples (**Figure 6.3**). The differences between the near-field and reference areas and far-field and reference areas were 1.5 and 1.2 reference standard deviations in magnitude, respectively.

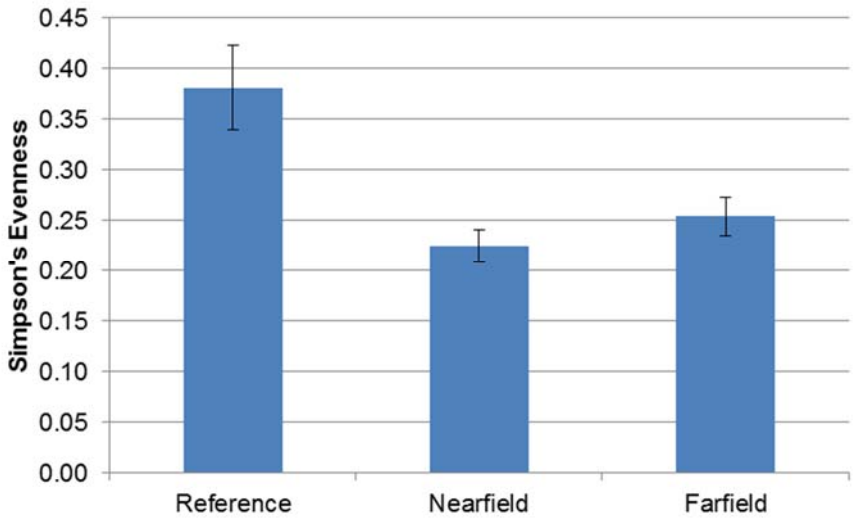

Figure 6.3:
Simpson's Evenness Values in the Skookumchuck Mill Study Area in Cycle 7
(error bars are ± standard errors)

Pairwise between-sampling-area comparisons indicated that Bray-Curtis scores in the near-field area and far-field areas were different (higher) than in the reference area, indicating that the near- and far-field benthic communities differed from the median reference condition more the reference area benthic community. The magnitude of the difference between Bray-Curtis scores in the near-field and reference areas was 1.6 reference standard deviations. The magnitude of the difference between Bray-Curtis scores in the mid-field and reference areas was 1.8 reference standard deviations (**Figure 6.3**).

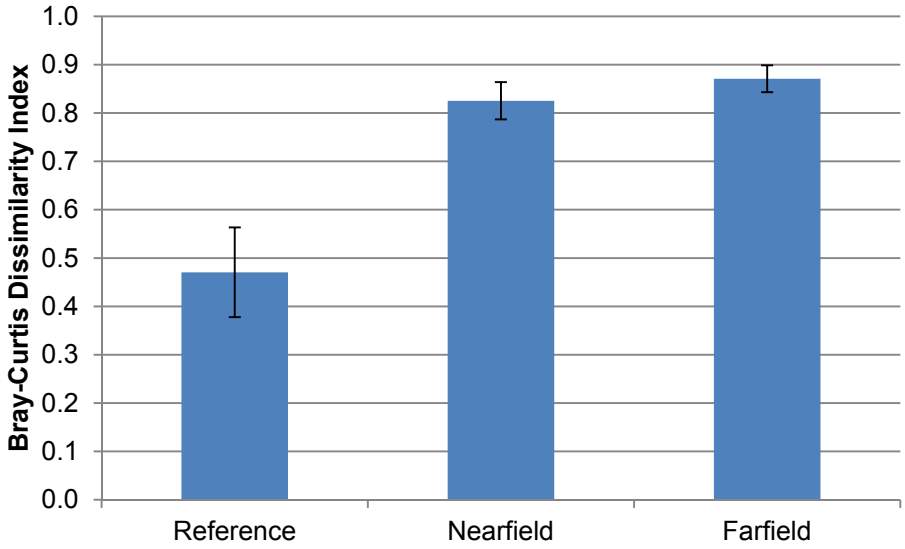

Figure 6.4:
Bray-Curtis Dissimilarity Index Values in the Skookumchuck Mill Study Area in Cycle 7 (error bars are ± standard errors)

6.3.2 Correlation of Endpoint Data and Supporting Environmental and Water Quality Data

Results of a correlation analysis of benthic invertebrate community endpoint data and supporting environment and water quality measures collected as part of the Cycle 7 EEM program are provided in **Appendix C**. For the purpose of the assessment, where a supporting environment or water quality measure was reasonably correlated with a benthic invertebrate community endpoint ($r > \sim 0.5$, or $< \sim -0.5$) the relationship between the two variables was further explored via plotting their regression relationship (see **Appendix C**).

Density correlated with the dominant substrate fraction classification (positively), nitrate levels (negatively) and DOC levels (positively). Further examination of the regression relationships between density and these variables indicated that none of the variables was helpful in explaining the variability in density across the study area.

Taxa richness correlated with the dominant and secondary substrate fraction classifications (positively), pH (negatively) and ammonia levels (positively). Further examination of the regression relationships between density and these variables indicated that none of the variables was helpful in explaining the variability in taxa richness across the study area.

Both E (negatively) and B-C scores (positively) correlated with the concentrations of each of the various fractions of nitrogen, phosphorus and carbon that were measured in water, as well as with sodium concentrations in water, all of which were also highly correlated with each other. Examination of the regression relationships of E and B-C scores with these water quality constituents indicated that in each case the relationships associated with two

groups of data points – one associated with the reference sampling stations and one with the exposure sampling stations. Generally, the higher scores of the reference area were associated with lower sodium and nutrient concentrations, whereas the higher B-C scores of the exposure areas were associated with higher sodium and nutrient concentrations. These results essentially confirm the results of the ANOVA comparisons of the these endpoints whereby statistically significant differences were identified between the reference area and each of the exposure areas and suggest that, at least in some part, the differences are correlated with the effluent discharge.

6.3.3 Temporal Trends in Invertebrate Community Structure

The Cycle 7 benthic assessment was implemented in part to determine whether changes made within the effluent treatment system at the mill to improve overall effluent quality and reduce nutrient loads to the Kootenay River have, to date, positively affected benthic community structure downstream of the mill. Below is a comparison of the Cycle 7 benthic invertebrate community survey results to the result of the Cycle 4 benthic community assessment. Statistical comparisons of Cycle 4 and 7 effect endpoints were made via Two-Way ANOVA to assess endpoint data in time (i.e., EEM Cycle) and space (i.e., reference vs exposure) simultaneously.

The results of the Cycle 4 survey provide the basis upon which changes in benthic community structure can be assessed, as that survey was completed prior to the implementation of changes to the mill's effluent treatment system. It was also the survey in which effects on the benthic community downstream of the mill were "confirmed" (Hatfield, 2007). It is noted that the Cycle 4 survey only included sampling in the reference and near-field areas and therefore temporal comparisons are limited to these areas.

Invertebrate density was higher in the near-field area in both cycles 4 and 7 than in the reference area, though the magnitude of difference in density between the areas was lower in Cycle 7 than in Cycle 4, both in absolute terms and expressed as a function of the magnitude of the reference area standard deviation (**Figure 6.5**). In Cycle 4 the difference in density between the near-field and reference area exceeded 2 RefSD in magnitude, the effect size that Environment Canada technical guidance suggests represents an ecologically meaningful difference, whereas in Cycle 7 the difference was less than 2 RefSD. No significant cycle*area interaction term ($p = 0.363$) was measured for density, indicating that density varied between EEM cycles 4 and 7 across the study area in a similar manner.

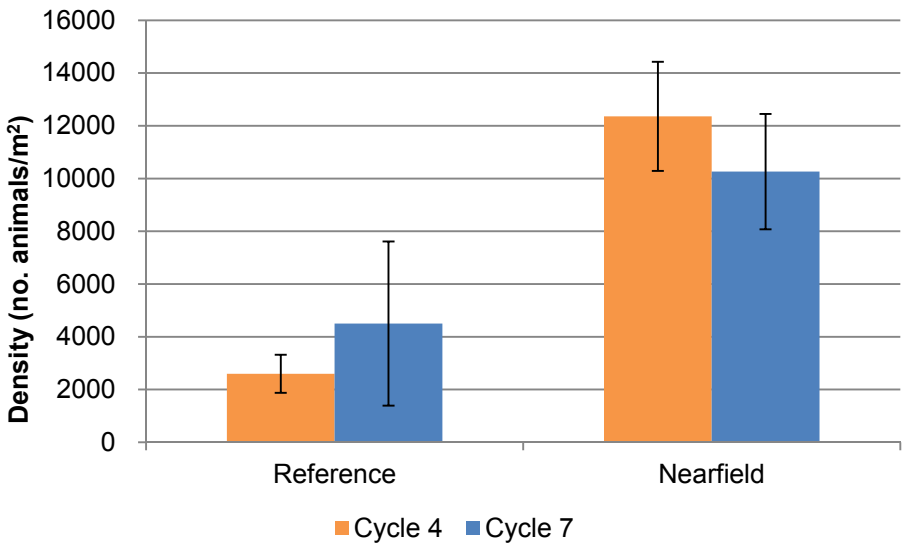

Figure 6.5:
Invertebrate Density in the Skookumchuck Mill Study Area, EEM Cycles 4 and (error bars are ± standard errors)

Taxa richness was also higher in the near-field area in both Cycles 4 and 7 than in the reference area, though as with invertebrate density, the magnitude of difference in richness between the areas was lower in Cycle 7 than in Cycle 4 (**Figure 6.6**). In Cycle 4 the difference in density between the near-field and reference area was greater 4 RefSD in magnitude, whereas in Cycle 7 the difference was less than 2 RefSD. No significant cycle*area interaction term ($p = 0.102$) was measured for richness, indicating that richness varied between EEM cycles 4 and 7 across the study area in a similar manner.

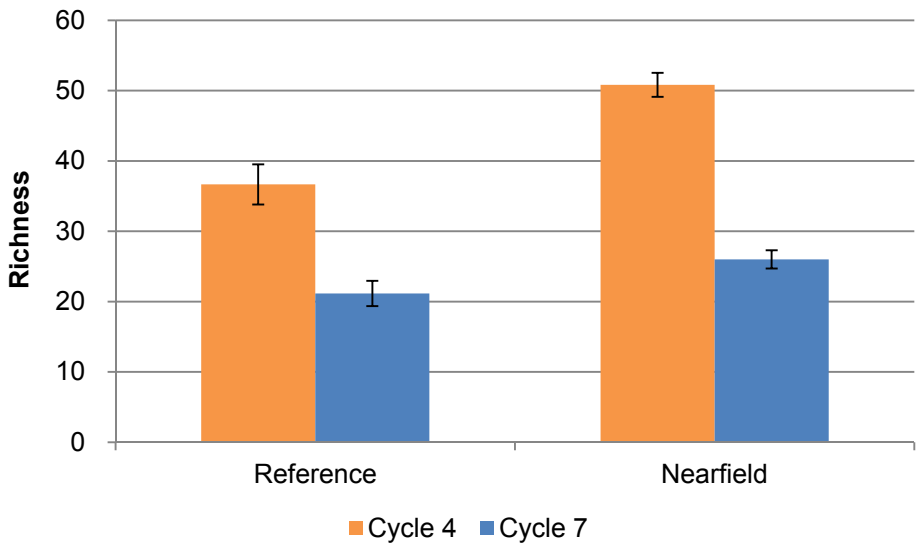

Figure 6.6:
Taxa Richness in the Skookumchuck Mill Study Area, EEM Cycles 4 and 7
(error bars are ± standard errors)

No difference was detected in between the reference area and near-field area in terms of E in Cycle 4, whereas E was less in the near-field area than in the reference area in Cycle 7 (**Figure 6.7**). Though a statistical difference was measured in Cycle 7 the magnitude of difference was relatively small (< 2 RefSD) and therefore not expected to represent an ecologically meaningful difference. No significant cycle*area interaction term ($p = 0.178$) was measured for E, indicating that E varied between EEM cycles 4 and 7 across the study area in a similar manner.

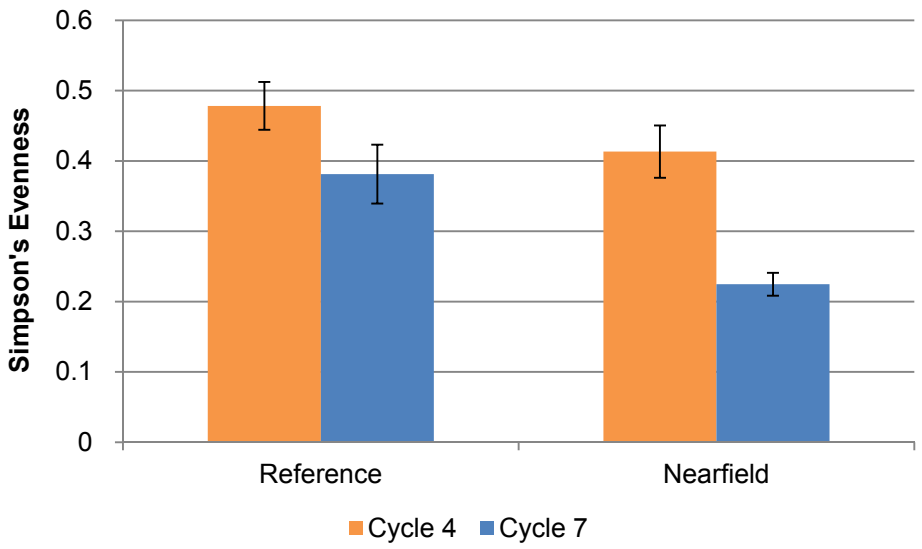

Figure 6.7:
Simpson's Evenness Index in the Skookumchuck Mill Study Area, EEM Cycles 4 and 7 (error bars are ± standard errors)

Similar to invertebrate density and taxa richness, B-C scores were higher in the near-field area in both cycles 4 and 7 than in the reference area, though the magnitude of difference in B-C scores between the areas was lower in Cycle 7 than in Cycle 4 (**Figure 6.8**). In Cycle 4 the difference in B-C scores between the near-field and reference area was greater than 4 RefSD in magnitude, whereas in Cycle 7 the difference was less than 2 RefSD. No significant cycle*area interaction term ($p = 0.363$) was measured for B-C scores, indicating that B-C scores varied between EEM cycles 4 and 7 across the study area in a similar manner.

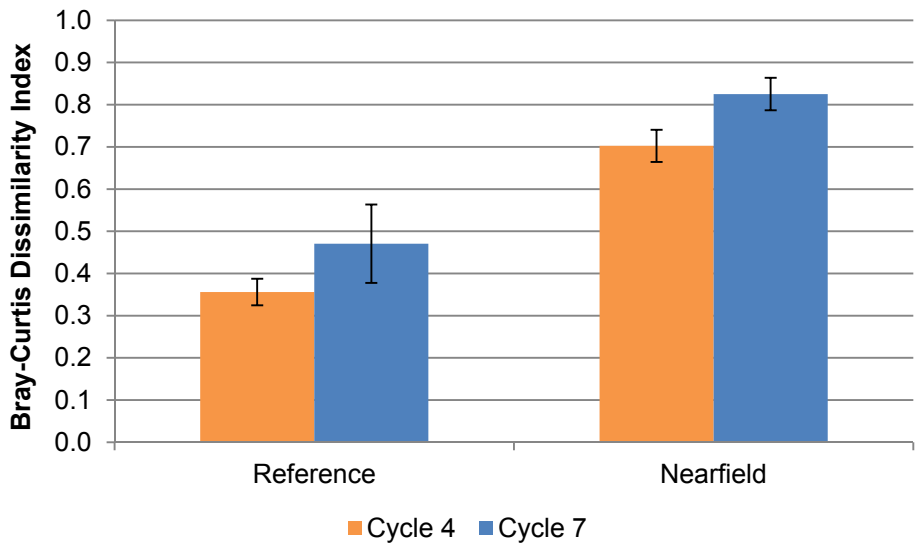

Figure 6.8:
Bray-Curtis Dissimilarity Index in the Skookumchuck Mill Study Area, EEM Cycles 4 and 7 (error bars are ± standard errors)

6.3.4 Confounding Influences

During the benthic survey water was collected from every benthic station as well as three stations within the Lussier River and Skookumchuck Creek. The results are presented in Section 5 of this report. Samples collected in the Lussier Liver and Skookumchuck Creek during the benthic and fish sampling program do not show levels of nutrients that would provide meaningful inputs to the Kootenay River.

It should be noted though that during the fish survey, in April, average concentrations of dissolved orthophosphate, total ammonia, nitrogen, total dissolved phosphorus, and total organic carbon were all higher in the Far-field samples than in the near-field. This would suggest that a source of nutrient input is located between the near-field and far-field areas.

6.4 Summary of Key Findings

The key findings associated with the Cycle 7 benthic invertebrate community survey are:

- A total of 33 unique benthic taxa were identified in the study area (31 families, plus one Phylum and one Class) of which 28, 30, and 24 were identified in the reference, near-field, and far-field areas, respectively.
- Invertebrate density ranged from approximately 4,500 to 10,600 organisms/m^2 across the study area. Generally the same taxa were most abundant in each of the sampling areas. These taxa included mayflies from the Families Ephemerellidae and Heptageniidae, caddisflies from the family Hydropsychidae and midge larvae

from the Family Chironomidae. Worms from the Family Naididae were abundant in the far-field area.

- Significant statistical differences were detected between the reference and near-field and reference and far-field areas in terms of density, richness, evenness, and Bray-Curtis Index (NF>REF and FF>REF). In each case the magnitude of difference expressed relative to the standard deviation for the reference area for each endpoint was less than the two reference areas standard deviations suggesting the differences were not ecologically meaningful.

- The magnitude of differences detected between key benthic invertebrate community effect endpoints was less in Cycle 7 than in Cycle 4. In Cycle 4, where statistical differences in endpoints were measured the differences all exceeded the 3 RefSD, whereas in Cycle 7 the differences were all less than 2 RefSD.

7.0 FISH HEALTH SURVEY

7.1 Objective

Field data generated by the fish survey provides the basis for an assessment of whether or not there are differences between exposed and reference populations of sentinel fish species in terms of growth, energy storage and reproduction. The status of the sentinel fish species with respect to these life history measures should reflect the overall condition of the aquatic environment in which the fish reside. The fish survey does not attempt to provide an absolute or direct assessment of the health of a fish population.

7.2 Study Design and Methods

7.2.1 Timing

The fish survey was completed between 14 and 27 April 2015. This timing is appropriate because the sentinel fish species (Torrent Sculpin; *Cottus rhotheus*) had reached an appropriate level of gonadal development at this time in advance of the spring spawning season.

7.2.2 Study Areas

As indicated above, fish were collected from two reference areas (Canal Flats and Torrent) and two exposure areas (near-field and far-field) **(Figure 4.2)**. The far-field area was added to the Cycle 7 study to provide further information consistent with a magnitude and extent survey. The far-field area was located between the confluence of the Lussier River and Wasa. The addition of the far-field area provides greater ability to discriminate potential differences in fish characteristics along the Kootenay River downstream of the mill.

7.2.3 Fish Collection

Adult and juvenile Torrent Sculpin were targeted for collection in each of the four sampling areas. Backpack electrofishing and baited minnow traps, that were weighted down to prevent movement, were utilized. For the minnow traps set location (GPS coordinates), set depth and deployment and collection times were noted for each set of traps. For the electrofishing the total time spent actively fishing a given area was recorded.

The total amount of fishing effort in each area during the field program is shown below in **Table 7.1**.

Table 7.1:
Total Fish Effort Expended in Each Sampling Areas During The EEM Cycle 7 Study

Sampling Area	Total Effort (Electrofishing Seconds)	Total Effort (Trap Hours)
Canal Flats Reference	18,490	487
Torrent Reference	11,437	198
Near-field	18,159	235
Far-Field	7,124	410
Total	**55,210**	**1,330**

7.2.4 Fish Processing – In Field and Laboratory Activities

All fish that were captured were identified and enumerated. Live non-sentinel species were released back into the area in which they were collected. Incidental mortalities were noted and dead fish were disposed of as per scientific fish collection license requirements.

Torrent Sculpin were retained for further in-field processing. Fish gender was noted and measurements of total length (standard measuring board), fork length (standard measuring board), total weight (electronic balance), gonad weight (electronic balance) and liver weight (electronic balance) were collected for each retained fish. These measurements were collected in a manner to satisfy precision and reporting requirements prescribed in EEM technical guidance given the small body size of the fish (EC, 2010). Ageing structures (otoliths) were collected from each retained specimen for subsequent laboratory age determination. Ovaries from female fish were collected for subsequent laboratory fecundity estimates.

An external examination of general fish condition was made on each fish and features that did not appear to be “normal”, such as wounds, tumours, parasites, fin fraying or erosion, gill parasites, and/or lesions, were noted). Fish were also examined internally for overall organ health, and the presence of parasites and tumours.

In the laboratory the otoliths were allowed to dry completely and then were then processed via the crack and burn method. The crack and burn method uses a scalpel to split the otolith transversely through the nucleus. After cracking, each section is held in forceps just above a flame to allow charring. The burned otolith sections are mounted, cracked surface up, in a small cap of plasticine, immersed in oil and growth rings are read using a dissecting scope, at a minimum of 10-times magnification. Fish age was estimated by counting the growth rings on the otoliths. A subsample (i.e., 10%) of the samples were re-aged by a second specialist for QA/QC checks.

Female fecundity was estimated as follows. Each ovarian sample was counted, in its entirety, with the aid of a dissecting microscope under eight-times magnification. Egg weight was determined by dividing the total weight of the unpreserved ovaries (measured in the field) by

the estimated fecundity (i.e., number of eggs per female). A subsample (i.e., 10% of the samples) of the fecundity count were recounted by a second technician for QA/QC checks.

7.2.5 Data Management

All field data were transcribed from field sheets into an electronic spreadsheet. Data were queried from the database and random checks performed on 10% of the total number of entries to confirm validity and accuracy.

Data Summary

Catch-per-unit-effort (CPUE) was determined for each species and summarized by area to document the effort expended in collecting fish. This calculation provides a measure of relative abundance among sampling areas by standardizing the catch data.

Fish measures, in addition to those collected in the field or derived in the laboratory, were calculated including condition factor (K), gonadosomatic index (GSI), and liversomatic index (LSI) as follows:

- K = [weight /(fork length*10^3)]*100;
- GSI = gonad weight / adjusted body weight; and,
- LSI – liver weight / adjusted body weight.

Summary statistics, including arithmetic mean, median, standard deviation, standard error, maximum and minimum, were calculated for each fish health endpoint.

Statistical Analyses

Statistical procedures used were consistent with Environment Canada guidance (Environment Canada, 2010). Specific effect endpoints used for the fish survey included those recommended by Environment Canada (2010), which may be broadly grouped into the following response categories: survival, energy use and energy storage.

The specific endpoints used to assess these response categories are summarized in **Table 7.2**. As some variability associated with individual physiological/morphological endpoints may be dependent upon other characteristics (covariates), it is necessary to compare exposure and reference fish according to the covariate combinations outlined in **Table 7.2**.

Outliers were identified by visual inspection of the covariate plots and by using the “explore” function in SPSS (SPSS Inc., 2007) to examine the residuals. In the “explore” function, significant (extreme) outliers have values greater than 3-times the interquartile distance (i.e.,

the distance between the 25th and 75th percentiles). When outliers were identified statistical comparisons were performed and reported with and without the outliers present.

Statistical analyses to quantify differences in the endpoint data were completed using appropriate statistical software (e.g., SPSS for Windows Version 17.0; SPSS Inc., 2007). Tests of normality (Anderson-Darling) and homogeneity of variance (Levene's) were applied to the residuals after the analysis to ensure that the assumptions of parametric statistics were met and any required transformations were applied, if necessary.

Table 7.2:
Fish Endpoint and Statistical Analyses Completed as Part of the Cycle 7 EEM Fish Survey at the Skookumchuck Mill

Response Variable	Endpoint	Effect or Support?	Appropriate Test
Survival	Age (mean)	Effect	Mann-Whitney U-test
Energy Use	Size (body weight) at age	Effect	ANCOVA
	Body weight (whole)	Support	ANOVA
	Length	Support	ANOVA
	Size (length) at age	Support	ANCOVA
	Relative gonad size (gonad weight at body weight)	Effect	ANCOVA
	Relative gonad size (gonad weight at length)	Support	ANCOVA
	Relative fecundity (# eggs at body weight)	Support	ANCOVA
	Relative fecundity (# eggs at length)	Support	ANCOVA
	Relative fecundity (# eggs at age)	Support	ANCOVA
Energy Storage	Body weight at length	Effect	ANCOVA
	Relative liver size (liver size at body weight)	Effect	ANCOVA
	Relative liver size (liver size at length)	Support	ANCOVA
	Relative egg size (egg weight at body weight)	Support	ANCOVA

ANCOVA, within the general linear model (GLM) framework, was used to assess covariate relationships. The GLM was used to test for homogeneity of the slopes between the dependent variable and the covariate term for each area.

Where there was a significant interaction between the dependent variable and the covariate term (i.e., the slopes of the covariate lines were not equal) the interaction resolution approaches, as defined by Environment Canada (2010; Section 7.0, Appendix 1), were followed. This entailed calculating the percentage difference between the predicted (regression line) covariate values for the exposure and reference areas for both the minimum and maximum values that defined the range of overlap in the covariate data in the areas. Thus in these cases, two percentage differences were calculated: one representing the difference between the predicted covariate values in the reference and exposure areas at the upper end of the range of overlap in actual covariate values, and the other representing the difference between the predicted covariate values in the reference and exposure areas at the lower end of the range of overlap in actual covariate values.

Where no significant interaction was identified (i.e., the slopes of the covariate lines were equal) ANCOVA could be performed. In this application, ANCOVA tests for an area effect on the dependent variable by comparing the intercepts of the covariate plots.

For each response variable, the degree of change between the reference and exposure means was calculated as a percentage of the reference mean. Differences were determined using transformed data or transformed covariate adjusted data as appropriate and are considered statistically significant at α <0.1. A threshold criterion equal to a 25% difference between sampling area measures for liver weight at adjusted-body-weight or conversely a 10% difference in condition factor, was used for comparative purposes consistent with Environment Canada's consideration of an "ecologically meaningful effect".

Power analyses were completed to identify the sample sizes required to detect differences of these magnitudes between reference and effluent-exposed immature White Sucker for subsequent surveys. *A priori* power analysis is based on the measurement of variability in the sample population and assumes that the variability measured in the sample population is representative of the entire population. For the purposes of the power analyses conducted here, sample sizes were determined such that it would be possible to detect a difference of 25% in relative gonad size, using a power level of 0.9 (1-β) and the following relationship:

$$n = 2\,(t_{\alpha}(2) + t_{\beta})^2\,(SD/\delta)^2$$

where: n is the number of samples
SD is the sample standard deviation (or MSE from ANOVA or ANCOVA model)
δ is the specified effect size (between reference and near-field area)
$t_{\alpha(2)}$ (two tailed test) and t_{β} (one tailed test) are critical values of the Student's t-test statistic (given Type I error probability α and Type II error probability β as taken from Student's tables with 2(n-1) degrees of freedom).

7.3 Results

Cycle 7 fish collections are summarized in **Section 7.3.1**. A discussion of general internal and external fish health based on observations made in the field is provided in **Section 7.3.2**. The results of the statistical comparisons of fish health endpoints are provided in **Section 7.3.3**. Raw data associated with the fish survey, as well as summary statistics, including arithmetic mean, median, standard deviation, standard error, maximum and minimum, were calculated for the various fish health survey endpoints are shown in **Appendix D**.

7.3.1 Fish Collections and Abundance

EEM Cycle 7 fish collections are summarized in **Table 7.3**. It is noted that the sampling program targeted small bodied Torrent Sculpin, so the survey data do not in all likelihood represent all fish species present in a given sampling area. The discussion of relative abundance of fish species in the study area focuses on the electrofishing data, as minnow trap collections were not overly effective.

A total of 7 fish species were collected in the study area including seven in the reference areas, six in the near-field area and five in the far-field area. Of the total of seven species collected, three were collected in each of the four sampling areas, one was collected from three of the sampling areas and two were collected in only one of the sampling areas. Fish that were ubiquitous across the study area included Torrent Sculpin, Sucker sp. (*Catostomus sp*.) and Redside Shiner (*Richardsonius balteatus*). Rainbow Trout (*Oncorhynchus mykis*s) and Longnose Dace (*Rhinichthys cataractae*) were found at three of the areas. One Brook Trout (*Salvelinus fontinalis*) was found at the Torrent reference area and one Bull Trout (*Salvelinus malma*) was found in the near-field Area

Table 7.3:
EEM Cycle 7 Fish Collections Summary

		Canal Flats Reference	Torrent Reference	Near-field	Far-Field
Common Name	**Scientific Name**				
Torrent Sculpin	*Cottus rhotheus*	47	75	90	80
Redside Shiner	*Richardsonius balteatus*	11	7	21	33
Sucker sp.	*Catostomus sp.*	1	1	1	1
Rainbow Trout	*Oncorhynchus mykiss*	1	0	1	1
Longnose Dace	*Rhinichthys cataractae*	1	0	2	1
Brook Trout	*Salvelinus fontinalis*	0	1	0	0
Bull Trout	*Salvelinus confluentus*	0	0	1	0
	Total Fish	**61**	**84**	**116**	**116**

The relative abundance of fish, expressed as the numbers of fish collected per minute of fishing effort (i.e., catch-per-unit-effort), is summarized in **Table 7.4**. Overall, fish were most abundant in the far-field area, moderately abundant in the near-field area and least abundant in the reference areas. In terms of the fish species that were ubiquitous across the study area, Torrent Sculpin were the most abundant in the sampled habitat. Other species were not captured at a sufficient rate within the sampling areas to be considered as a potential species to be utilized for the fish health assessment.

Table 7.4:
Catch-Per-Unit-Effort for EEM Cycle 7 Electrofishing Collections Summary (CPUE as Fish Per Minute)

		Canal Flats Reference	Torrent Reference	Near-Field	Far-Field
Common Name	**Scientific Name**				
Torrent Sculpin	*Cottus rhotheus*	0.153	0.393	0.297	0.674
Redside shiner	*Richardsonius balteatus*	0.036	0.037	0.069	0.278
Sucker sp.	*Catostomus sp.*	0.003	0.005	0.003	0.008
Rainbow Trout	*Oncorhynchus mykiss*	0.003	-	0.003	0.008
Longnose dace	*Rhinichthys cataractae*	0.003	-	0.007	0.008
Brook Trout	*Salvelinus fontinalis*	-	0.005	-	-
Bull trout	*Salvelinus malma*	-	-	0.003	-
	All Fish	**0.198**	**0.441**	**0.383**	**0.977**

7.3.2 General Indicators of External and Internal Fish Health

Based on internal and external visual examination of the Torrent Sculpin retained for the fish health assessment, there was no indication of differences in the incidence abnormalities, such as those in body form, body surface, fins, eyes, lesions, tumours, neoplasms, scars, eroded, frayed or hemorrhagic fins, internal lesions, abnormal growths, and/or parasites. Generally, the rate at which any abnormalities were noted in was low. Internal parasites were the most commonly reported observation but the number of observations of such were similar across the study area.

7.3.3 Statistical Comparisons of Fish Health Endpoints

Summaries of the statistical analyses of fish health endpoints for Torrent Sculpin are provided below. The tables include the statistical results of the comparisons of both effect and support endpoints as defined by Environment Canada (2010), though the discussion below generally focusses on the effect endpoints. Comparison of both adult and juvenile fish populations are provided.

Graphical representations of the measured meristics are provided in **Figures 7.1** (male), **7.2** (female) and **7.3** (immature). Graphical representations of covariate combinations identified in **Table 7.2**, are provided in **Appendix D**.

Summaries of the statistical analyses of fish health endpoints for male, female, and immature Torrent Sculpin compared to the Torrent reference area are provided in **Table 7.5 and 7.6.** The equivalent summaries of the statistical analyses of fish health endpoints compared to the Canal Flats reference area are provided in **Table 7.7 and 7.8.**

Torrent Reference Area Comparisons (Table 7.5, Table 7.6)

Survival

No statistical differences in age ($p > 0.10$) were detected between the Torrent reference and near-field area male Torrent sculpin populations. Age differed significantly ($p < 0.10$) between the Torrent Reference and far-field area male Torrent Sculpin populations. On average, the male Torrent Sculpin population in the reference area were older than the male Torrent Sculpin population in the far-field area by 23%. The difference in mean age among the male Torrent Sculpin populations in the Torrent reference area and far-field area was reflected in the age-frequency distribution in these fish. Generally, fish from older age classes were present in the Torrent reference area but were not represented in the far-field area population.

No statistical differences in age were detected among the female Torrent Sculpin populations of the exposure areas and the Torrent reference area ($p > 0.1$) and generally there was similar age class representation across the study area.

Age differed significantly ($p < 0.10$) among the study area immature Torrent Sculpin populations. On average, the immature Torrent Sculpin population in the Torrent reference area were older than the near-field and far-field immature Torrent Sculpin populations by 23% and 25%, respectively. The difference in mean age among the immature Torrent Sculpin populations was reflected in the age-frequency distribution in these fish.

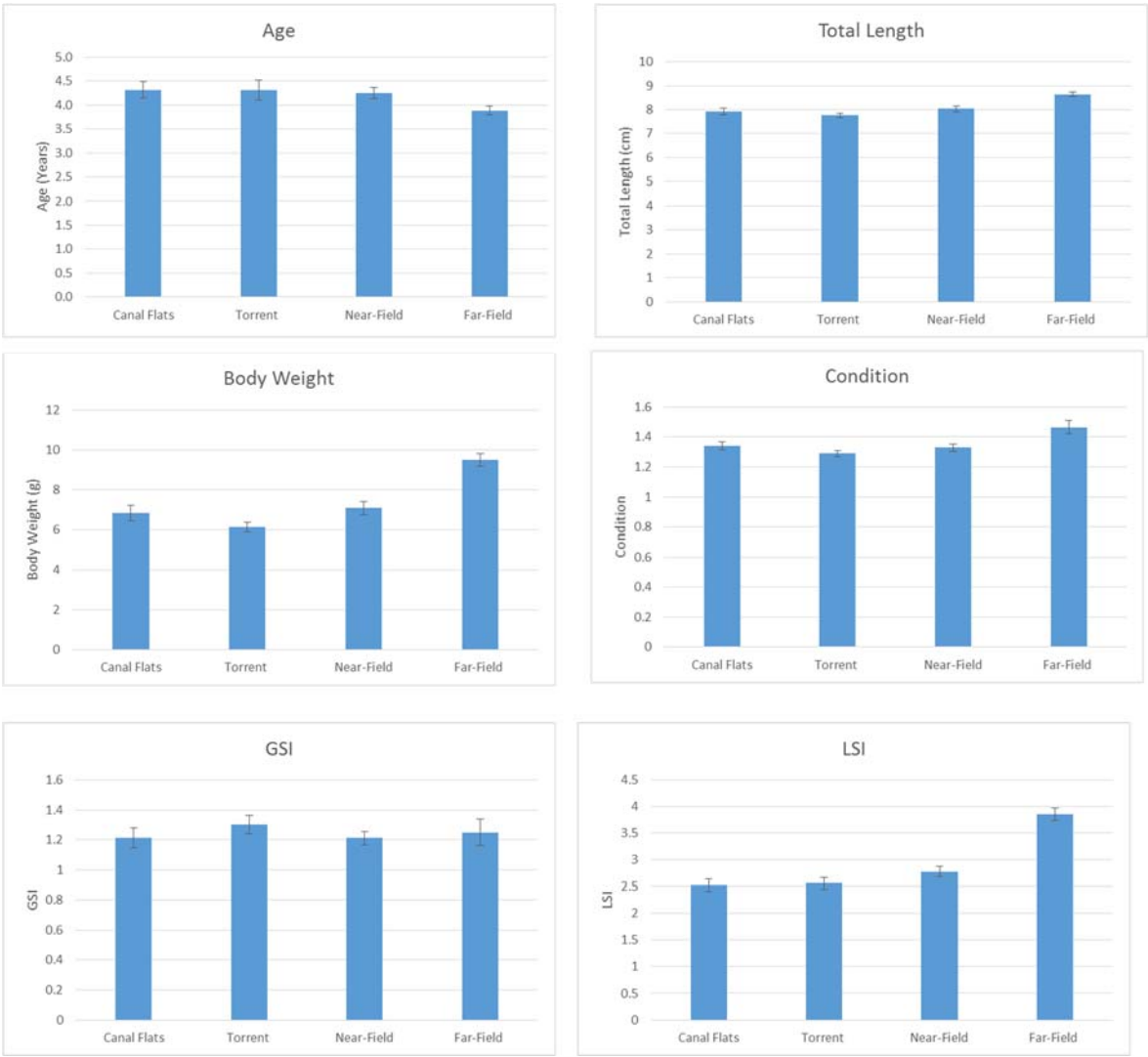

Figure 7.1:
Average Fish Meristic Measurements for Male Torrent Sculpin
(error bars are ± standard errors)

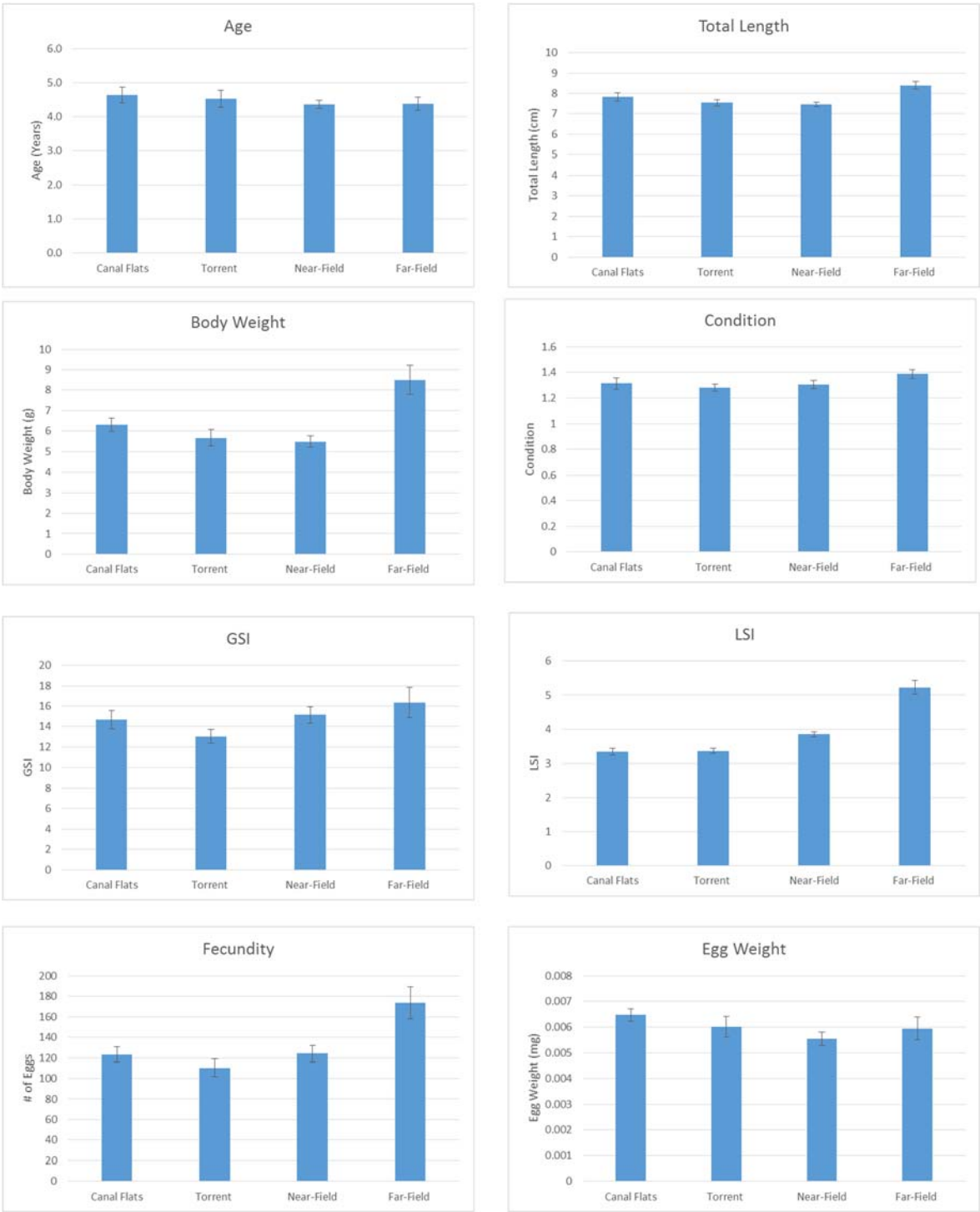

Figure 7.2:
Average Fish Meristic Measurements for Female Torrent Sculpin
(error bars are ± standard errors)

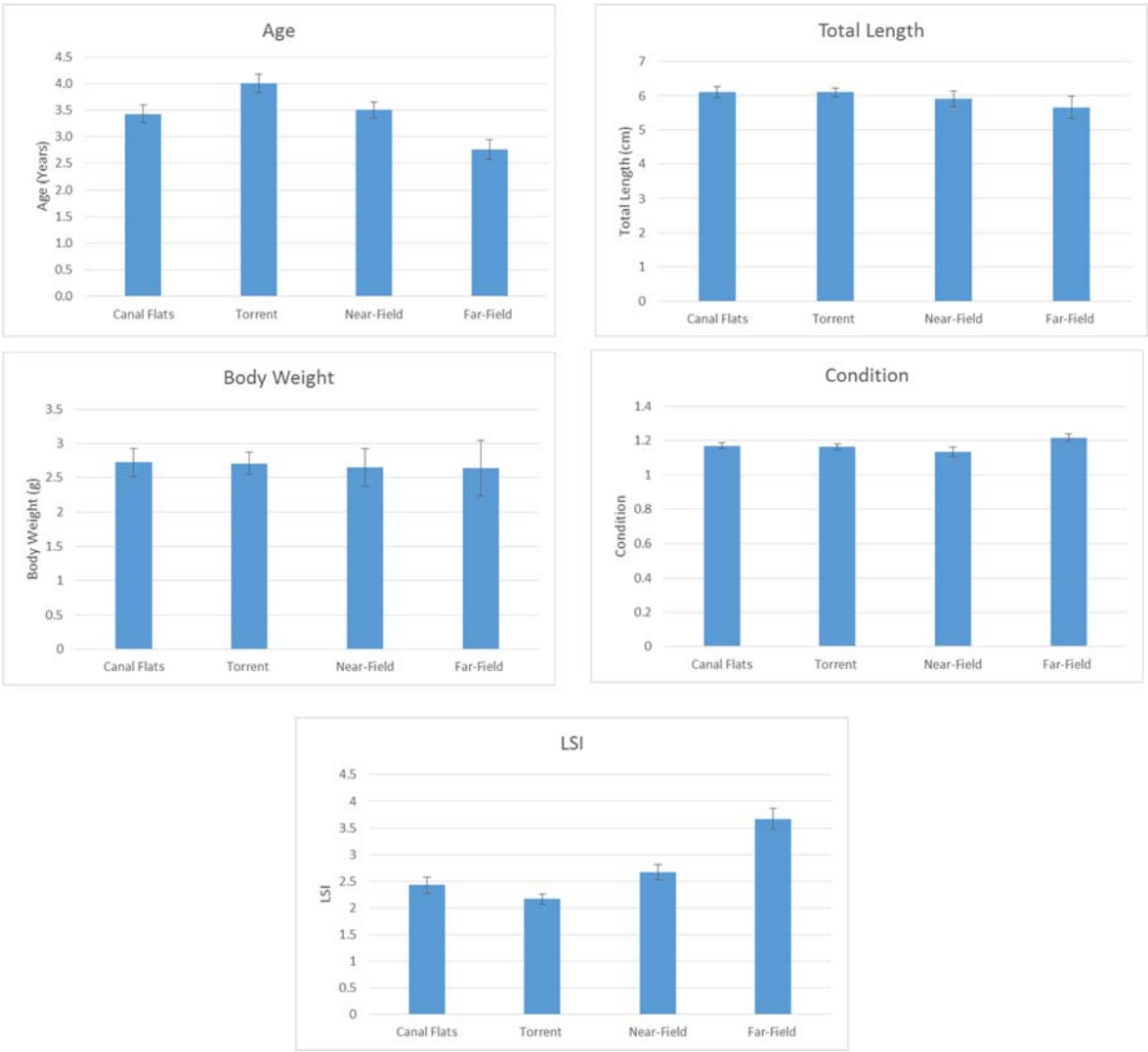

Figure 7.3:
Average Fish Meristic Measurements for Immature Torrent Sculpin
(error bars are ± standard errors)

Table 7.5:
EEM Cycle 7 Fish Health Survey Statistical Comparisons of Torrent Sculpin Populations in the Near-field and Torrent Reference Areas

	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis				
				Interaction Statistic[1] (P)	Intercept Statistic[2] (P)	SSD[3]	Direction	Magnitude[4] (%)
Male	Survival	Age[6]	Effect	n/a	0.606	No	-	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	0.967	0.426	No	-	-
		Relative liver size (liver weight @ body weight)	Effect	0.121	**0.030**	Yes	NF > Ref	12
		Relative liver size (liver weight @ carcass weight)	Support	0.357	**0.060**	Yes	NF > Ref	11
		Relative liver size (liver weight @ total length)	Support	0.659	0.160	No	-	-
	Energy Use	Size (Body Weight) @ Age (Age = 4)	Effect	n/a	0.294	No	-	-
		Size (Body Weight) @ Age (Age = 5)	Effect	n/a	0.100	No	-	-
		Size (Total Length) @ Age (Age = 4)	Support	n/a	0.290	No	-	-
		Size (Total Length) @ Age (Age = 5)	Support	n/a	0.131	No	-	-
		Relative gonad size (gonad weight @ body weight)[7]	Effect	0.384	0.470	No	-	-
		Relative gonad size (gonad weight @ carcass weight)[7]	Support	0.656	0.450	No	-	-
		Relative gonad size (gonad weight @ total length)[7]	Support	0.622	0.599	No	-	-
		Body weight[7]	Support	n/a	**0.059**	Yes	NF > Ref	14
		Carcass weight[7]	Support	n/a	**0.062**	Yes	NF > Ref	13
		Total length[7]	Support	n/a	**0.087**	Yes	NF > Ref	3
Female	Survival	Age[6]	Effect	n/a	0.854	No	-	-
	Energy Storage	Condition (body weight @ total length)	Effect	0.198	0.934	No	-	-
		Relative liver size (liver weight @ body weight)[7]	Effect	0.155	**3.29E-04**	Yes	NF > Ref	13
		Relative liver size (liver weight @ carcass weight)	Support	0.518	**0.002**	Yes	NF > Ref	13
		Relative liver size (liver weight @ total length)	Support	0.782	**0.022**	Yes	NF > Ref	14
		Relative egg size (mean egg weight @ body weight)[7]	Support	0.876	0.524	No	-	-
		Relative egg size (mean egg weight @ carcass weight)[7,8]	Support	0.805	0.448	No	-	-
		Relative egg size (mean egg weight @ age) (Age = 4)[9]	Support	n/a	0.706	No	-	-
	Energy Use	Size (Body Weight) @ Age (Age = 4)[9]	Effect	n/a	0.942	No	-	-
		Size (Total Length) @ Age (Age = 4)[9]	Support	n/a	0.885	No	-	-
		Relative gonad size (gonad weight @ body weight)	Effect	0.229	**0.035**	Yes	NF > Ref	15
		Relative gonad size (gonad weight @ carcass weight)[7]	Support	0.732	**0.086**	Yes	NF > Ref	15
		Relative gonad size (gonad weight @ total length)	Support	0.578	0.172	No	-	-
		Relative fecundity (# of eggs/female @ body weight)	Support	0.290	**0.035**	Yes	NF > Ref	18
		Relative fecundity (# of eggs/female @ carcass weight)	Support	0.389	**0.037**	Yes	NF > Ref	19
		Relative fecundity (# of eggs/female @ total length)[10]	Support	0.855	0.210	No	-	-
		Relative fecundity (# of eggs/female @ age) (Age = 4)[9]	Support	n/a	0.626	No	-	-
		Body weight[7]	Support	n/a	0.846	No	-	-
		Carcass weight[7]	Support	n/a	0.850	No	-	-
		Total length	Support	n/a	0.644	No	-	-
Immature	Survival	Age[6]	Effect	n/a	**0.073**	Yes	NF < Ref	23
	Energy Storage	Condition (body weight @ total length)[7]	Effect	**0.071**	0.323	No	-	-
		Relative liver size (liver weight @ body weight)[7]	Effect	**0.012**	**0.002**	Yes	NF > Ref	23
		Relative liver size (liver weight @ carcass weight)[7]	Support	**0.007**	**0.007**	Yes	NF > Ref	21
		Relative liver size (liver weight @ total length) (Small = 4.8)	Support	**0.016**	-	No	-	2
		Relative liver size (liver weight @ total length) (Large = 7.2)	Support	**0.016**	-	Yes	NF > Ref	58
	Energy Use	Size (Body Weight) @ Age (Age = 4)	Effect	n/a	0.679	No	-	-
		Size (Total Length) @ Age (Age = 4)	Support	n/a	0.482	No	-	-
		Body weight[8]	Support	n/a	0.861	No	-	-
		Carcass weight[8]	Support	n/a	0.911	No	-	-
		Total length[8]	Support	n/a	0.482	No	-	-

Notes:
Shaded and bolded cells represent statistically significant difference
1. test for equal slopes
2. test for equality of test groups
3. statistically significant difference
4. difference between reference and exposure relative to reference mean
5. interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
6. calculated using Mann-Whitney non-parametric test due to non-normality
7. calculated using log10-transformed data
8. ANOVA conducted due to non-significant covariate
9. insufficient age classes for proper ANCOVA and only age class with sufficient data
10. used ranked data due to non-normality of data
11. used t-test assuming unequal variance due to non-homogeneity of variance

n/a - not applicable

Table 7.6:
EEM Cycle 7 Fish Health Survey Statistical Comparisons of Torrent Sculpin Populations in the Far-Field and Torrent Reference Areas

	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis				
				Interaction Statistic[1] (P)	Intercept Statistic[2] (P)	SSD[3]	Direction	Magnitude [4] (%)
Male	Survival	Age[6]	Effect	n/a	**0.022**	Yes	FF < Ref	25
	Energy Storage	Condition (body weight @ total length)[9]	Effect	0.373	**5.19E-04**	Yes	FF > Ref	31
		Condition (body weight @ total length)[7,10]	Effect	0.430	**8.32E-04**	Yes	FF > Ref	9
		Relative liver size (liver weight @ body weight)[7]	Effect	0.314	**1.43E-05**	Yes	FF > Ref	39
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.273	**2.30E-06**	Yes	FF > Ref	48
		Relative liver size (liver weight @ total length)[11]	Support	0.255	**6.67E-06**	Yes	FF > Ref	56
	Energy Use	Size (Body Weight) @ Age[7] (Age = 4)	Effect	n/a	**1.16E-05**	Yes	FF > Ref	48
		Size (Total Length) @ Age (Age = 4)	Support	n/a	**1.50E-04**	Yes	FF > Ref	11
		Relative gonad size (gonad weight @ body weight)[8,12]	Effect	0.959	0.988	No	-	-
		Relative gonad size (gonad weight @ carcass weight)[8,13]	Support	0.607	0.971	No	-	-
		Relative gonad size (gonad weight @ total length)[6,8,14]	Support	0.852	0.150	No	-	-
		Body weight[7]	Support	n/a	**3.91E-12**	Yes	FF > Ref	55
		Carcass weight[7]	Support	n/a	**2.38E-11**	Yes	FF > Ref	54
		Total length[7]	Support	n/a	**4.08E-09**	Yes	FF > Ref	11
Female	Survival	Age[6]	Effect	n/a	0.931	No	-	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	0.941	0.219	No	-	-
		Relative liver size (liver weight @ body weight)[7]	Effect	0.743	**1.46E-06**	Yes	FF > Ref	38
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.700	**1.52E-06**	Yes	FF > Ref	37
		Relative liver size (liver weight @ total length)[9]	Support	0.799	**1.40E-07**	Yes	FF > Ref	77
		Relative egg size (mean egg weight @ body weight)[9]	Support	0.430	0.205	No	-	-
		Relative egg size (mean egg weight @ body weight)[7,15]	Support	0.623	0.423	No	-	-
		Relative egg size (mean egg weight @ carcass weight)[9]	Support	0.476	0.301	No	-	-
		Relative egg size (mean egg weight @ carcass weight)[7,15]	Support	0.530	0.478	No	-	-
		Relative egg size (mean egg weight @ age)	Support	**Insufficient data at any age class**				-
	Energy Use	Size (Body Weight) @ Age (Age = 5)	Effect	n/a	**0.032**	Yes	FF > Ref	61
		Size (Total Length) @ Age (Age = 5)	Support	n/a	**0.028**	Yes	FF > Ref	13
		Relative gonad size (gonad weight @ body weight)[9,16]	Effect	0.683	0.735	No	-	-
		Relative gonad size (gonad weight @ body weight)[7,17]	Effect	0.418	**0.045**	Yes	FF > Ref	19
		Relative gonad size (gonad weight @ carcass weight)[9,16]	Support	0.997	0.416	No	-	-
		Relative gonad size (gonad weight @ carcass weight)[7,17]	Support	0.366	**0.025**	Yes	FF > Ref	21
		Relative gonad size (gonad weight @ total length)	Support	0.567	0.454	No	-	-
		Relative fecundity (# of eggs/female @ body weight)[18]	Support	0.279	0.247	No	-	-
		Relative fecundity (# of eggs/female @ carcass weight)[19]	Support	0.583	0.222	No	-	-
		Relative fecundity (# of eggs/female @ total length)[9]	Support	0.852	**0.030**	Yes	FF > Ref	46
		Relative fecundity (# of eggs/female @ age) (Age = 4)	Support	n/a	**0.026**	Yes	FF > Ref	65
		Body weight[7]	Support	n/a	**5.42E-04**	Yes	FF > Ref	49
		Carcass weight[7]	Support	n/a	**5.06E-04**	Yes	FF > Ref	50
		Total length	Support	n/a	**1.42E-03**	Yes	FF > Ref	11
Immature	Survival	Age[6]	Effect	n/a	**1.01E-04**	Yes	FF < Ref	49
	Energy Storage	Condition (body weight @ total length)[7]	Effect	**0.038**	0.136	No	-	-
		Relative liver size (liver weight @ body weight)[7]	Effect	0.230	**2.19E-09**	Yes	FF > Ref	62
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.257	**1.29E-08**	Yes	FF > Ref	63
		Relative liver size (liver weight @ total length)[7]	Support	0.113	**1.96E-08**	Yes	FF > Ref	67
	Energy Use	Size (Body Weight) @ Age[7,8] (Age = 3)	Effect	n/a	**0.002**	Yes	FF > Ref	87
		Size (Body Weight) @ Age[7,8,10] (Age = 3)	Effect	n/a	**0.003**	Yes	FF > Ref	67
		Size (Body Weight) @ Age[7,8,11] (Age = 4)	Effect	n/a	**0.021**	Yes	FF > Ref	40
		Size (Total Length) @ Age[7,8] (Age = 3)	Support	n/a	**0.002**	Yes	FF > Ref	24
		Size (Total Length) @ Age[7,8,11] (Age = 3)	Support	n/a	**0.004**	Yes	FF > Ref	20
		Body weight[6]	Support	n/a	0.732	No	-	-
		Carcass weight[6]	Support	n/a	0.640	No	-	-
		Total length[6]	Support	n/a	0.448	No	-	-

Notes:

Shaded and bolded cells represent statistically significant difference

1. test for equal slopes
2. test for equality of test groups
3. statistically significant difference
4. difference between reference and exposure relative to reference mean
5. Interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
6. calculated using Mann-Whitney non-parametric test due to non-normality
7. calculated using log10-transformed data
8. ANOVA conducted due to non-significant covariate
9. used ranked data due to non-normality of data
10. extreme outlier FF-73 removed
11. removed outliers TR (13, 34, 39, 44, 45, 56, 63) and FF (8, 9, 10, 16, 22, 30, 36, 38, 42, 43, 50, 53, 56, 71, 73, 76, 77, 78) due to overlap issues
12. removed outliers TR (13, 34, 39, 44, 45, 56, 63, 65) and FF (8, 9, 10, 16, 22, 30, 36, 38, 42, 43, 50, 53, 56, 71, 76, 77, 78 79) due to overlap issues
13. removed TR (13, 34, 39, 44, 45, 56, 63, 65, 67) and, FF (9, 10, 16, 22, 30, 36, 38, 42, 43, 50, 53, 56, 71, 76, 77, 78 79) due to overlap issues
14. removed TR (13, 34, 39, 44, 45, 56, 63) and FF (8, 9, 10, 16, 22, 30, 36, 38, 42, 43, 50, 53, 56, 71, 76, 77, 78) due to overlap issues
15. removed extreme outlier FF-19
16. removed TR (1, 2, 6, 33, 64, 14, 33, 55) due to overlap issues
17. removed extreme outliers FF (14, 19, 23, 33, 55) and TR (1, 2, 6, 33, 64,) due to overlap issues
18. removed TR (1, 2, 6, 14, 33, 64, 75) and FF (14, 33, 55) due to overlap issues
19. removed TR (2, 6, 14, 33, 64, 75), and FF (14, 33, 55) due to overlap issues
20. removed extreme outlier FF-63
21. removed extreme outlier FF-28

n/a - not applicable
nc - not calculable due to use of non-parametric test (non-normality)

Energy Storage

No statistical differences in condition ($p > 0.10$) were detected between the Torrent reference and near-field area male Torrent sculpin populations. Condition differed significantly ($p < 0.10$) between the Torrent reference and far-field area male populations. On average, body weight at fork length in the male Torrent Sculpin populations in the far-field area was greater than in the Torrent reference area male population by 31% when all data were considered. The magnitude of difference was only 9% after an outlier fish from the far-field area was removed from the analysis. No statistical differences were detected among the female Torrent Sculpin populations in the study area in terms of body weight at fork length.

Statistical differences ($p < 0.1$) were detected among the male and female Torrent Sculpin populations in the study area in terms of liver weight at body weight. On average, liver weight at body weight in male Torrent Sculpin populations in the near-field and far-field areas was greater than in the Torrent reference area male population by 12% and 39%, respectively. On average, liver weight at body weight in female Torrent Sculpin populations in the near-field and far-field areas was greater than in the Torrent reference area female population by 13% and 38%, respectively.

Based on the comparisons of immature Torrent Sculpin the following with respect to energy storage was noted. No statistical differences were detected among the immature Torrent Sculpin populations in the study area in terms of body weight at fork length. Statistical differences ($p < 0.1$) were detected among the immature Torrent Sculpin populations in the study area in terms of liver weight at body weight. On average, liver weight at body weight in immature Torrent Sculpin populations in the near-field and far-field areas was greater than in the immature population of Torrent Sculpin in the Torrent reference area by 23% and 62%, respectively.

Energy Use

No statistical differences in terms of size (body weight) at age ($p > 0.10$) were detected between the Torrent reference and near-field area male and female Torrent Sculpin populations. Size at age differed significantly ($p < 0.10$) between the Torrent reference area and far-field area for both the male and female Torrent Sculpin populations. On average, body weight at age in the male Torrent Sculpin population in the far-field area was greater than in the Torrent reference area male Torrent Sculpin population by 48%. For the female populations, far-field area sculpin were on average 61% larger than their reference area counterparts.

No statistical differences ($p > 0.1$) were detected among the male Torrent Sculpin populations in the exposure areas and Torrent reference in terms of gonad weight at body weight. Statistical differences ($p < 0.1$) were detected among female Torrent Sculpin populations in the exposure areas and Torrent reference areas in terms of gonad weight at

body weight. On average, gonad weight at body weight in female Torrent Sculpin populations in the near-field and far-field areas was greater than in the Torrent reference area female population by 15% and 19%, respectively.

No difference was detected between the immature Torrent Sculpin populations in the near-field and far-field areas in terms of size at age. Size at age in the immature Torrent Sculpin population in the far-field area was greater than the Torrent reference population for age class 3 and 4 fish. For age class 3 fish, the magnitude was 87%, or 67% in consideration of the removal of outlier fish. For age class 4 fish the magnitude of the difference was 40%.

Canal Flats Reference Area Comparisons

Survival

No statistical differences in age ($p > 0.10$) were detected between the Canal Flats reference area and near-field area for any of the Torrent Sculpin populations (i.e. male, female or immature).

No difference was detected in age ($p > 0.1$) between female Torrent Sculpin populations in the far-field area and the Canal Flats reference area, and generally there was similar age class representation across the study area. Age differed significantly ($p < 0.10$) between the male Torrent Sculpin populations in the Canal Flats reference area and far-field area populations. On average, the male Torrent Sculpin population in the reference area was older than the male Torrent Sculpin population in the far-field area by 25%. The difference in mean age among the male Torrent Sculpin populations was reflected in the age-frequency distribution in these fish. Generally, fish from older age classes were present in the Canal Flats reference area but were not represented in the far-field area population.

Age differed significantly ($p < 0.10$) between the Canal Flats Reference and far-field area immature Torrent Sculpin populations. On average, the immature Torrent Sculpin population in the Canal Flats reference area were older than the far-field immature Torrent Sculpin populations by 33%. The difference in mean age among the immature Torrent Sculpin populations was reflected in the age-frequency distribution in these fish. Generally, immature Torrent Sculpin were older in the torrent reference area than in the exposure areas.

Energy Storage

No statistical differences in condition (body weight at length) ($p > 0.10$) were detected between the Canal Flats reference area and near-field area Torrent sculpin populations (i.e. male, female or immature).

Condition differed significantly ($p < 0.10$) between the Canal Flats reference area and far-field area male populations. On average, body weight at total length in the male Torrent Sculpin populations in the far-field area was greater than in the Canal Flats reference area

male population by 24%, or by 7% when an extreme outlier was removed and the data was normalized with log transformation. No statistical differences were detected among the female Torrent Sculpin populations in the among the near-field, far-field and Canal Flats reference areas in terms of body weight at fork length.

Statistical differences ($p < 0.1$) were detected among the male and female populations in the study area in terms of liver weight at body weight. On average, liver weight at body weight in male Torrent Sculpin populations in the near-field and far-field areas was greater than in the Canal Flats reference area male population by 10% and 52%, respectively. On average, liver weight at body weight in female Torrent Sculpin populations in the near-field and far-field areas was greater than in the Canal Flats reference area female population by 18% and 39%, respectively.

No statistical differences were detected among the immature Torrent Sculpin populations among the near-field, far-field and Canal Flats reference areas in terms of body weight at fork length. No statistical differences in condition ($p > 0.10$) were detected between the Canal Flats reference and near-field areas in terms of liver weight at body weight, though differences ($p < 0.10$) were detected between liver weight at body weight between immature Torrent Sculpin in the Canal Flats reference and far-field areas. On average, liver weight at body weight in immature Torrent Sculpin populations in the far-field area was greater than in the Canal Flats reference area immature population by 45%.

Table 7.7:
EEM Cycle 7 Fish Health Survey Statistical Comparisons of Torrent Sculpin Populations in the Near-field and Canal Flats Reference Areas

	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis				
				Interaction Statistic[1] (P)	Intercept Statistic[2] (P)	SSD[3]	Direction	Magnitude[4] (%)
Male	Survival	Age[6]	Effect	n/a	0.742	No	-	-
	Energy Storage	Condition (body weight @ total length)[6]	Effect	0.406	0.713	No	-	-
		Relative liver size (liver weight @ body weight)	Effect	0.895	0.097	Yes	NF > Ref	10
		Relative liver size (liver weight @ carcass weight)[6]	Support	0.874	0.083	Yes	NF > Ref	11
		Relative liver size (liver weight @ total length)[6]	Support	0.983	0.157	No	-	-
	Energy Use	Size (Body Weight) @ Age (Age = 4 and Age = 5)	Effect	n/a	Insufficient data for analysis			
		Size (Total Length) @ Age (Age = 5)	Support	n/a	0.027	Yes	NF > Ref	6
		Relative gonad size (gonad weight @ body weight)[6]	Effect	0.419	0.959	No	-	-
		Relative gonad size (gonad weight @ carcass weight)[6]	Support	0.493	0.973	No	-	-
		Relative gonad size (gonad weight @ total length)[6]	Support	0.938	0.913	No	-	-
		Body weight[6]	Support	n/a	0.746	No	-	-
		Carcass weight	Support	n/a	0.648	No	-	-
		Total length	Support	n/a	0.578	No	-	-
Female	Survival	Age[6]	Effect	n/a	0.244	No	-	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	0.181	0.408	No	-	-
		Condition (body weight @ total length)[11]	Effect	0.835	0.330	No	-	-
		Relative liver size (liver weight @ body weight)	Effect	0.169	2.39E-04	Yes	NF > Ref	18
		Relative liver size (liver weight @ carcass weight)	Support	0.554	0.003	Yes	NF > Ref	17
		Relative liver size (liver weight @ total length)[7]	Support	0.456	0.282	No	-	-
		Relative liver size (liver weight @ total length)[11]	Support	0.120	0.155	No	-	-
		Relative egg size (mean egg weight @ body weight)[7,8]	Support	0.132	0.022	Yes	NF < Ref	15
		Relative egg size (mean egg weight @ carcass weight)[7,8]	Support	0.124	0.022	Yes	NF < Ref	15
		Relative egg size (mean egg weight @ age) (Age = 4)	Support	Insufficient data for analysis				-
		Relative egg size (mean egg weight @ age) (Age = 5)[7,9,12]	Support	n/a	0.017	Yes	NF < Ref	21
	Energy Use	Size (Body Weight) @ Age (Age = 4)[9]	Effect	Insufficient data for analysis				-
		Size (Body Weight) @ Age (Age = 5)[7,9]	Effect	n/a	0.061	Yes	NF < Ref	19
		Size (Total Length) @ Age (Age = 4)[9]	Support	Insufficient data for analysis				-
		Size (Total Length) @ Age (Age = 5)[9]	Support	Insufficient data for analysis				-
		Relative gonad size (gonad weight @ body weight)[7,12]	Effect	0.280	0.606	No	-	-
		Relative gonad size (gonad weight @ carcass weight)[7,12]	Support	0.384	0.679	No	-	-
		Relative gonad size (gonad weight @ total length)[7]	Support	0.231	0.379	No	-	-
		Relative fecundity (# of eggs/female @ body weight)	Support	0.182	0.116	No	-	-
		Relative fecundity (# of eggs/female @ carcass weight)	Support	0.163	0.147	No	-	-
		Relative fecundity (# of eggs/female @ total length)	Support	0.294	0.461	No	-	-
		Relative fecundity (# of eggs/female @ age) (Age = 4)[9]	Support	Insufficient data for analysis				-
		Relative fecundity (# of eggs/female @ age) (Age = 5)[9]	Support	Insufficient data for analysis				-
		Body weight	Support	n/a	0.063	Yes	NF < Ref	8
		Carcass weight[7]	Support	n/a	0.054	Yes	NF < Ref	15
		Total length	Support	n/a	0.093	Yes	NF < Ref	5
Immature	Survival	Age[6]	Effect	n/a	0.802	No	-	-
	Energy Storage	Condition (body weight @ total length)[14]	Effect	0.390	0.290	No	-	-
		Relative liver size (liver weight @ body weight)	Effect	0.843	0.147	No	-	-
		Relative liver size (liver weight @ carcass weight)	Support	0.583	0.121	No	-	-
		Relative liver size (liver weight @ total length)[7]	Support	0.918	0.497	No	-	-
	Energy Use	Size (Body Weight) @ Age (Ages 3 and 4)[9]	Effect	Insufficient data for analysis				-
		Size (Total Length) @ Age (Ages 3 and 4)[9]	Support	Insufficient data for analysis				-
		Body weight[7,13]	Support	n/a	0.209	No	-	-
		Carcass weight[7,13]	Support	n/a	0.196	No	-	-
		Total length[13]	Support	n/a	0.486	No	-	-

Notes:
Shaded and bolded cells represent statistically significant difference
1. test for equal slopes
2. test for equality of test groups
3. statistically significant difference
4. difference between reference and exposure relative to reference mean
5. interaction resolution approach applied according to Environment Canada TGD (2010) - section 7
6. calculated using Mann-Whitney non-parametric test due to non-normality
7. calculated using log10-transformed data
8. ANOVA conducted due to non-significant covariate
9. insufficient age classes for proper ANCOVA and only age class with sufficient data
10. used ranked data due to non-normality of data
11. removed extreme outlier CR-1
12. removed Cook's Distance extreme outlier CR-6 to resolve significant interaction
13. used t-test assuming unequal variance due to non-homogeneity of variance
14. used ranked data due to violations of assumptions (homogeneity of variance/normality)

n/a - not applicable
nc - not calculable due to use of non-parametric test (non-normality)

Table 7.8:
EEM Cycle 7 Fish Health Survey Statistical Comparisons of Torrent Sculpin Populations in the Far-Field and Canal Flats Reference Areas

	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis				
				Interaction Statistic[1] (P)	Intercept Statistic[2] (P)	SSD[3]	Direction	Magnitude[4] (%)
Male	Survival	Age[6]	Effect	n/a	**0.029**	Yes	FF < Ref	25
	Energy Storage	Condition (body weight @ total length)[9]	Effect	0.552	**1.76E-02**	Yes	FF > Ref	24
		Condition (body weight @ total length)[7]	Effect	0.935	**1.99E-02**	Yes	FF > Ref	7
		Relative liver size (liver weight @ body weight)[7]	Effect	0.421	**4.37E-08**	Yes	FF > Ref	52
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.446	**1.05E-08**	Yes	FF > Ref	57
		Relative liver size (liver weight @ total length)[7]	Support	0.763	**2.82E-09**	Yes	FF > Ref	77
	Energy Use	Size (Body Weight) @ Age[7,11] (Age = 4)	Effect	n/a	**2.89E-03**	Yes	FF > Ref	37
		Size (Body Weight) @ Age[11] (Age = 5)	Effect	n/a	**7.68E-04**	Yes	FF > Ref	53
		Size (Total Length) @ Age[11] (Age = 4)	Support	n/a	**0.031**	Yes	FF > Ref	7
		Size (Total Length) @ Age[11] (Age = 5)	Support	n/a	**9.33E-04**	Yes	FF > Ref	15
		Relative gonad size (gonad weight @ body weight)[6]	Effect	0.456	0.974	No	-	-
		Relative gonad size (gonad weight @ carcass weight)[9]	Support	0.391	0.931	No	-	-
		Relative gonad size (gonad weight @ carcass weight)[7,12]	Support	0.436	0.837	No	-	-
		Relative gonad size (gonad weight @ total length)[7]	Support	0.220	0.232	No	-	-
		Body weight[7]	Support	n/a	**9.40E-07**	Yes	FF > Ref	41
		Carcass weight[7]	Support	n/a	**3.35E-06**	Yes	FF > Ref	40
		Total length	Support	n/a	**5.54E-05**	Yes	FF > Ref	9
Female	Survival	Age[6]	Effect	n/a	0.459	No	-	-
	Energy Storage	Condition (body weight @ total length)[7,10]	Effect	0.116	0.663	No	-	-
		Relative liver size (liver weight @ body weight)[7]	Effect	0.851	**2.30E-05**	Yes	FF > Ref	39
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.723	**9.22E-06**	Yes	FF > Ref	41
		Relative liver size (liver weight @ total length)[9]	Support	0.150	**3.34E-06**	Yes	FF > Ref	112
		Relative liver size (liver weight @ total length)[9,13]	Support	0.861	**5.07E-06**	Yes	FF > Ref	-
		Relative egg size (mean egg weight @ body weight)	Support	0.213	0.106	No	-	-
		Relative egg size (mean egg weight @ carcass weight)[6,8]	Support	0.274	0.693	No	-	-
		Relative egg size (mean egg weight @ age)[11] (Age = 5)	Support	Insufficient data for analysis				-
	Energy Use	Size (Body Weight) @ Age[11] (Age = 5)	Effect	n/a	**0.042**	Yes	FF > Ref	40
		Size (Total Length) @ Age[11] (Age = 5)	Support	n/a	**0.055**	Yes	FF > Ref	9
		Relative gonad size (gonad weight @ body weight)[9,14]	Effect	0.118	0.932	No	-	-
		Relative gonad size (gonad weight @ carcass weight)[9,15]	Support	0.316	0.522	No	-	-
		Relative gonad size (gonad weight @ carcass weight)[14]	Support	0.588	0.952	No	-	-
		Relative gonad size (gonad weight @ total length)[9,16]	Support	0.276	0.413	No	-	-
		Relative fecundity (# of eggs/female @ body weight)[9]	Support	0.379	**0.038**	Yes	FF > Ref	53
		Relative fecundity (# of eggs/female @ body weight)[7,17]	Support	0.570	**0.003**	Yes	FF > Ref	35
		Relative fecundity (# of eggs/female @ carcass weight)	Support	0.796	0.173	No	-	-
		Relative fecundity (# of eggs/female @ total length)	Support	0.386	0.103	No	-	-
		Relative fecundity (# of eggs/female @ age)[11] (Age = 5)	Support	Insufficient data for analysis				-
		Body weight[7]	Support	n/a	**2.07E-02**	Yes	FF > Ref	30
		Carcass weight[7]	Support	n/a	**2.77E-02**	Yes	FF > Ref	29
		Total length	Support	n/a	**6.33E-02**	Yes	FF > Ref	7
Immature	Survival	Age[6]	Effect	n/a	**0.026**	Yes	FF < Ref	33
	Energy Storage	Condition (body weight @ total length)[7]	Effect	0.468	0.191	No	-	-
		Condition (body weight @ total length)[7,20]	Effect	0.275	0.211	No	-	-
		Relative liver size (liver weight @ body weight)	Effect	0.328	**3.93E-04**	Yes	FF > Ref	45
		Relative liver size (liver weight @ carcass weight)	Support	0.258	**4.67E-04**	Yes	FF > Ref	48
		Relative liver size (liver weight @ total length)[7]	Support	0.329	**2.14E-04**	Yes	FF > Ref	52
	Energy Use	Size (Body Weight) @ Age (Age = 3)[8]	Effect	n/a	Insufficient data for analysis			
		Size (Body Weight) @ Age (Age = 4)[8]	Effect	n/a	**0.015**	Yes	FF > Ref	50
		Size (Body Weight) @ Age (Age = 4)[8,21]	Effect	n/a	**3.40E-04**	Yes	FF > Ref	67
		Size (Total Length) @ Age (Age = 3)[8]	Support	n/a	Insufficient data for analysis			
		Size (Total Length) @ Age (Age = 4)[8]	Support	n/a	**0.060**	Yes	FF > Ref	20
		Body weight[6]	Support	n/a	0.788	No	-	-
		Carcass weight[6]	Support	n/a	0.711	No	-	-
		Total length	Support	n/a	0.749	No	-	-

Notes
Shaded and bolded cells represent statistically significant difference
1. test for equal slopes
2. test for equality of test groups
3. statistically significant difference
4. difference between reference and exposure relative to reference mean
5. interaction resolution approach applied according to Environment Canada TGD (2010) - section 7
6. calculated using Mann-Whitney non-parametric test due to non-normality
7. calculated using log10-transformed data
8. ANOVA conducted due to non-significant covariate
9. used ranked data due to non-normality of data
10. removed cook's distance extreme outlier CR-1
11. insufficient age classes for proper ANCOVA and only age class with sufficient data
12. removed extreme outlier FF-24
13. removed extreme outlier CR-1
14. removed cook's distance/extreme outliers CR-6 and FF-19
15. removed cook's distance extreme outlier CR-6
16. removed FF (14, 33, 55) due to overlap issues
17. removed extreme outliers FF-19 and FF-23
18. removed extreme outlier FF-63
19. removed extreme outlier FF-28
20. removed extreme outlier FF-3
21. removed extreme outlier FF-23

n/a - not applicable
nc - not calculable due to use of non-parametric test (non-normality)

Energy Use

Body weight at age differed significantly ($p < 0.1$) among the near-field, far-field and Canal Flats reference areas Torrent Sculpin populations, where sufficient numbers of fish were present within a given age class (e.g., age class 4 and 5 year fish) to permit statistical comparisons. On average, body weight at age in the male Torrent Sculpin populations in the far-field area was greater than in the reference area male Torrent Sculpin population by 37% and 53%, in age class 4 and 5 year fish, respectively. Body weight at age also differed significantly ($p < 0.1$) between female Torrent Sculpin in the exposure areas compared to the reference areas. The magnitude of difference was 19% in the near-field area and 40% in the far-field area for age class 5 fish, with body weight at age larger in exposure area fish.

No statistical differences ($p > 0.1$) were detected among the male or female Torrent Sculpin populations in the study area in terms of gonad weight at body weight.

Immature Torrent Sculpin in the year 4 age class in the far-field area were heavier than their age class counterparts in the Canal Flats reference area. The magnitude of the difference was 50%, or 67% with an outlier from the reference area removed.

7.3.4 Temporal Trends in Torrent Sculpin

The most recent fish health survey at the mill was conducted in EEM Cycle 4. The Cycle 4 fish survey combined fish collected in the Torrent and Canal Flats reference areas to form a single reference population for comparison to near-field exposure fish. Reference area fish data were kept separate in Cycle 7 to allow for a greater understanding of the reference area variability in the fish health endpoints.

In Cycle 4 it was concluded that the assessment was indicative of moderate enrichment in the near-field area based on increased energy storage and energy use in near-field fish, with the differences seen exceeding critical effect sizes defined by Environment Canada (EC, 2010). This general result of increased energy storage and use in exposure area fish was seen again in Cycle 7 but magnitude of difference measured between near-field and reference area fish was relatively small and below the critical effects size defined by Environment Canada.

7.4 Summary of Key Findings

The key findings associated with the Cycle 7 fish health survey are:

- Generally, the rate at which any internal or external abnormalities were noted in Torrent Sculpin were low and such observations did not appear to differ across the study area.
- Male Torrent Sculpin

- No differences were detected across the study area for male Torrent Sculpin in terms of age. Some statistical differences were detected in energy use and/or energy storage endpoints between near-field and reference fish but the differences were small in magnitude and were below the critical effects size defined by Environment Canada. No difference was seen in relative gonad size between the near-field and reference fish.

- Many of the effect endpoints differed statistically between the male Torrent Sculpin populations of the reference areas and the far-field area. In most of these instances the magnitude of differences seen were greater than the critical effects size defined by Environment Canada. On average far-field area Torrent Sculpin populations were younger but had greater measures of energy use and energy storage than their reference area counterparts. No difference was seen in relative gonad size between the far-field and reference fish.

- Female Torrent Sculpin

  - Some differences were detected among the female Torrent Sculpin populations of the reference areas and the near-field area. In no instance was a statistical difference of a magnitude that exceeded the critical effects size defined by Environment Canada. Only one effect endpoint was statistically different between the near-field area and both reference areas: relative liver size.

  - As with the male Torrent Sculpin, more statistical differences were seen between reference area fish and the far-field area fish. Where statistical differences were measured, the magnitude of difference between the reference area and far-field area fish was generally above the critical effect size. On average far-field area Torrent Sculpin populations had greater measures of energy use and energy storage than their reference area counterparts.

- Immature Torrent Sculpin

  - No statistical differences were detected in the measured endpoints between the near-field and Canal Flats reference areas. Statistical differences were detected between two effect endpoints - age and relative liver size - when the Torrent reference area and near-field area Torrent Sculpin populations were compared. In each case the magnitude of the difference was below the critical effect size.

  - Far-field immature Torrent Sculpin populations were statistically different from the reference populations for three of the four effect endpoints measured. Age, relative liver size, and size at age were all statistically

different at the far-field area in comparison to both reference areas. The magnitudes of the effects seen in the effect endpoints were all greater than critical effect sizes.

- Temporal Comparison
    - In general, the results of the Cycle 7 survey indicate a decreased magnitude of response in near-field area fish to mill effluent exposure, relative to Cycle 4.

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8.0 INTEGRATION OF STUDY COMPONENTS

Over the duration of EEM Cycle 7 mill effluent quality met all of its discharge quality limits, with the exception of one isolated event. No instances of acute lethality were measured during routine testing with Rainbow Trout (*Oncorhynchus mykiss*) and *Daphnia magna*.

On average, effluent concentrations that induced effects in test species in laboratory-based chronic effluent toxicity tests completed in Cycle 7 were similar or greater than (i.e., less toxic) than seen in previous testing. Effects on *P. subcapitata* growth, when seen, were observed at relatively high effluent concentrations. The Cycle 7 GMIC25 value for *P. subcapitata* growth was >81.3%. The GMIC25 value for *C. dubia* tests in Cycle 7 was 34.5%. Generally, effluent concentrations that induced effects in laboratory testing, when seen, were higher than those typically seen in the Kootenay River. The potential effluent effect zone in the Kootenay River based on the lowest IC25 would extend approximately 246 m downstream of the mill discharge under average flow conditions.

During the field survey component of the Cycle 7 program the influence of mill effluent on water chemistry was conspicuous, particularly in the near-field area, with effluent-exposed areas having higher, ammonia, nitrogen, phosphorous (total, dissolved, orthophosphate), carbon (total, dissolved) and sodium concentrations, though concentrations of some constituents were higher in the far-field area than in the near-field. Generally, the concentrations of the constituents that were measured in the laboratory were higher in the spring than they were in the fall across the study area.

Concentrations of orthophosphate followed a similar spatial (upstream to downstream) pattern as chlorophyll α levels. Periphyton growth was higher in the effluent-exposed areas, likely due to orthophosphate concentrations associated with the discharge of mill effluent into the Kootenay River.

A total of 33 unique benthic taxa were identified in the study area of which 28, 30, and 24 were identified in the reference, near-field, and far-field areas, respectively. Twenty of the 33 taxonomic groups identified (Family or higher) were found across the study area. One taxon was unique to the reference area (Class Turbellaria), no taxa were unique to the near-field area and two taxa were found only in the far-field area (Family Enchytraeidae, Famliy Sphaeriidae).

Significant statistical differences were detected between the reference and near-field and reference and far-field areas in terms of density, richness, evenness, and Bray-Curtis Index (NF>REF and FF>REF). In each case the magnitude of difference expressed relative to the standard deviation for the reference area for each endpoint was less than the two reference areas standard deviations suggesting the differences were not ecologically meaningful.

The Cycle 7 study results generally indicated that differences in benthic invertebrate community structure has improved from the previous EEM Cycle. Differences in effect endpoints were less in Cycle 7 than in Cycle 4. In Cycle 4, where statistical differences in endpoints were measured the differences all exceeded the 3 Reference Standard Deviations, whereas in Cycle 7 the differences were all less than 2 Reference Standard Deviations.

A total of 7 fish species were collected in the study area including seven in the reference areas, six in the near-field area and five in the far-field area. Fish that were ubiquitous across the study area included Torrent Sculpin, Sucker Sp (*Catostomus sp*.) and Redside Shiner (*Richardsonius balteatus*)

The targeted species for the fish health survey were the most abundant in the study area and captured in sufficient numbers to permit the assessment of fish health for most effect endpoints, as it concerns key EEM effect endpoints. Limited overlap in age class between the exposure and reference areas prevented the analysis of some size at age endpoint analysis.

Several statistical differences between Torrent Sculpin collected in the reference and exposure areas, with more and larger differences detected in the far-field area. In the near-field area the differences noted were relatively small in magnitude and less than the critical effects sizes defined in EEM technical guidance (EC, 2010). In the far-field the detected differences seen were for multiple effect endpoints. When these differences were detected among the Torrent Sculpin populations the magnitudes were almost consistently above critical effect sizes.

The Cycle 4 fish results had magnitudes above critical effect sizes for liver weight at body weight in female and immature populations of the near-field compared to reference. The Cycle 7 results show an increase in this endpoint for the near-field populations compared to both references but at magnitudes below critical effect sizes. This is suggestive that efforts taken in the Implementation of Solution (IOS) phase by the mill has reduced enrichment in the near-field area.

9.0 CONCLUSIONS

Based on the results of the Cycle 7 EEM program the following can be concluded:

- Benthos - Overall, in consideration of the results of the Cycle 7 benthic invertebrate community survey, as well as the temporal comparison of benthic invertebrate community data generated from previous cycles, it is suggested that the efforts made by the mill to improve effluent quality and reduce nutrient loadings to the Kootenay River have, most likely, been effective. Statistical differences in the near-field benthic community were present for all endpoints but the magnitude of difference measured between the near-field and reference area were less than seen in the past and also were less than the critical effect size defined by EEM technical guidance (EC, 2010).

- Fish Health – Some statistical differences were detected between reference area and exposure area fish populations. For the near- field populations, these differences were less than the critical effects sizes defined by EEM technical guidance (EC, 2010) and less than those seen during the last EEM fish health survey conducted in Cycle 4.

- Far-field Exposure – Generally, differences detected between the reference and far-field areas in both the benthic invertebrate community and fish health surveys were greater in magnitude than those detected between reference and near-field areas. The far-field area is considerably downstream of the mill where the influence of mill effluent on water quality and presumably biological communities should be less in magnitude than in the near-field area. It is suggested that the differences seen between the reference and far-field area are not likely mill related; rather, the differences are more likely attributable to natural broad-scale habitat differences between the areas. For instance, although it was possible to find sampling stations for the benthic survey that had similar substrate size, water depth, etc. this type of habitat is not the predominant type in the far-field area as it is in the near-field and reference areas. The Kootenay River in the vicinity of the far-field area is a lower-gradient, broad meandering river channel than it is in more upstream areas.

10.0 RECOMMENDATIONS

As the mill has only completed one survey since the implementation of upgrades to the effluent treatment system, a second survey should be completed in three years time to confirm the findings of the Cycle 7 study

Consideration should be given to dropping the far-field area from the EEM program, as effects seen in the area are not representative the typical spatial pattern that could be attributed to mill effluent.

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Appendix A **QA/QC Information**

General QA/QC Provisions

Specific quality assurance and quality control (QA/QC) measures were incorporated into each aspect of the study. These measures included the following:

- **Field Sampling**
  - personnel involved in the field sampling had appropriate training and experience with the field and sampling equipment used in the study and the field program was implemented with to standard operating procedures (SOPs);
  - water quality meters used to collect information pertaining to conventional water quality constituents were calibrated prior to use and the calibration was checked throughout the field program;
  - all samples collected were placed in appropriate containers;
  - suitable preservatives/fixatives were used;
  - all samples had appropriate labeling;
  - contamination during chemical sampling was evaluated via the use of field and trip blanks;
  - detailed field notes were maintained in bound notebooks and customized field data collections forms;
  - chain-of-custody (COC) forms and appropriate shipping and storage procedures were used; and
  - COC forms were crosschecked with field data sheets to ensure that all of the samples were received and that all of the samples were labeled correctly.

- **Benthic Sample Processing**
  - personnel involved in sample processing and analyses had appropriate training and experience;
  - the effects of subsampling on abundance estimates was examined on 20% of the samples and the effects of subsampling on the sample estimates has been documented;
  - re-sorting of randomly selected samples was done to determine the success of initial sorting and ensure 90% recovery;
  - appropriate taxonomic references were used given the type of habitat (erosional) and geographic location (northern Ontario);
  - a voucher collection was compiled and has been archived at ZEAS; and
  - detailed sample processing and laboratory notes were maintained and have been archived (at ZEAS).

- **Fish Sample Processing**
  - all morphometric measurements were taken using appropriate equipment of acceptable accuracy and precision;
  - instruments were calibrated and maintained in good working order; and

- chain-of-custody forms and appropriate shipping and storage procedures were used.

- **Analysis and Reporting**
  - screening exercises to identify transcription errors, outliers and other suspicious data points were conducted;
  - raw data were compiled in electronic database format and are provided as appendices to the report;
  - the methods (specific statistical tests) and software (as appropriate) used for analysis have been documented;
  - checks for editorial, grammatical and spelling errors and data entry errors have been completed;
  - checks for consistency of format and the completeness of each section have been made;
  - we have ensured that pertinent information has been reported in detail;
  - we have ensured that changes in protocol, study design, or other components of the study have been reported; and
  - we have ensured that all QA/QC documentation has been included in the report.

Analytical Laboratory QA/QC

The analytical laboratory engaged to complete the analyses was certified to conduct the requested analyses.

For those analytes that required laboratory analyses the quality assurance/quality control (QA/QC) program included checks on the integrity of both field sampling and laboratory analyses. One field blank and one trip blank sample were analyzed to assess potential issues with the field collections. Laboratory QA/QC comprised the analysis of method blanks, concentration standards and run duplicates. The QA/QC results for theses samples were as follows:

- all analytes were at or below detection levels in each of the sample blanks (trip and field) analyzed;
- all analytes were at or below detection levels in each of the method blanks analyzed;
- matrix spike recovery was within the acceptable range as reported by the lab; and
- the reproducibility of analysis results from run duplicates was high and met internal laboratory standards.

Overall, there were no apparent QA/QC issues noted with the laboratory chemistry data and therefore the data were deemed to be of acceptable quality.

Benthic Invertebrate Community Survey Sample Processing QA/QC

All of the benthic samples was subsampled prior to sorting. A list of the sample fractions that were sorted is provided below.

Station	Fraction Sorted	Station	Fraction Sorted	Station	Fraction Sorted
NF-1	1/8	FF-1	1/16	TBBR-1	1/2
NF-2	1/16	FF-2	1/8	TBBR-2	1/4
NF-3	1/4[a]	FF-3	1/8	TBBR-3	1/4
NF-4	1/16	FF-4	1/16	TBBR-4	1/4
NF-5	1/4	FF-5[a]	1/4	TBBR-5	1/32
NF-6	1/8	FF-6	1/8	TBBR-6	1/4

[a] two eighths sorted for subsampling error calculations.

Invertebrate recovery checks (i.e., the number of animals remaining in previously sorted sample fractions) were completed for two benthic samples. Recovery in these samples was 98.6% and 98.7%, as indicated below.

Station	Number of Organisms Recovered (initial sort)	Number of Organisms in Re-sort	Percent Recovery
NF-6	448	454	98.7%
FF-2	345	350	98.6%
		Average % Recovery	98.6%

Recovery standards as set for the EEM program by Environment Canada indicate that 90% recovery is acceptable (Environment Canada, 2010).

Subsampling precision estimates were calculated for two benthic samples that were subsampled, as presented below.

Station	Whole Organisms	Number of Organisms in Fraction 1	Number of Organisms in Fraction 2	Number of Organisms in Fraction 3	Number of Organisms in Fraction 4	Actual Density*	Precision % range		Accuracy min	max
NF-3	-	166	177	-	-	-	6.2	-	-	-
FF-5	-	257	261	-	-	-	1.5	-	-	-

Fish Survey Sample Processing QA/QC

Ageing checks were conducted by an independent technician. In each case the independent technician estimated the age of the fish ± one year of the original estimate.

Re-counts of the female Torrent Sculpin eggs indicated that the fecundity estimates generated by the re-counts were within ± 1% of the original estimate.

Appendix B Supporting Environment Information

ECOMETRIX INCORPORATED
ATTN: Karen Petersen
6800 Campobello Road
Mississauga ON L5N 2L8

Date Received: 23-APR-15
Report Date: 05-MAY-15 18:29 (MT)
Version: FINAL REV. 2

Client Phone: 416-459-2700

Certificate of Analysis

Lab Work Order #: L1602632

Project P.O. #: NOT SUBMITTED
Job Reference: 15-2168
C of C Numbers: 14-471235, 14-471236
Legal Site Desc:

Comments: 5-MAY-2015 This version of the report includes hardness data for all samples except for FIELD BLANK (ALSL1602632-24).

Dean Watt, B.Sc.
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1602632-1	L1602632-2	L1602632-3	L1602632-4	L1602632-5
	Description	SW	SW	SW	SW	SW
	Sampled Date	20-APR-15	20-APR-15	20-APR-15	20-APR-15	20-APR-15
	Sampled Time	10:00	10:15	10:30	14:40	14:10
	Client ID	CR-1	CR-2	CR-3	SK-1	SK-2
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	191	195	201	73.2	72.8
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Nitrate and Nitrite (as N) (mg/L)	0.173	0.174	0.173	0.0373	0.0345
	Nitrate (as N) (mg/L)	0.173	0.174	0.173	0.0373	0.0345
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Nitrogen (mg/L)	0.209	0.190	0.186	0.101	0.093
	Orthophosphate-Dissolved (as P) (mg/L)	<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
	Phosphorus (P)-Total (mg/L)	0.0032	0.0025	0.0020	0.0031	0.0038
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.55	0.73	0.57	1.73	1.85
	Total Organic Carbon (mg/L)	0.60	0.56	0.72	1.71	2.19
Total Metals	Sodium (Na)-Total (mg/L)	7.4	7.6	7.8	2.1	2.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1602632-6	L1602632-7	L1602632-8	L1602632-9	L1602632-10
	Description	SW	SW	SW	SW	SW
	Sampled Date	20-APR-15	20-APR-15	20-APR-15	20-APR-15	20-APR-15
	Sampled Time	15:00	15:10	15:20	12:00	11:30
	Client ID	LR-1	LR-2	LR-3	TR-1	TR-2
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	302	297	298	181	182
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Nitrate and Nitrite (as N) (mg/L)	0.106	0.106	0.106	0.158	0.157
	Nitrate (as N) (mg/L)	0.106	0.106	0.106	0.158	0.157
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Nitrogen (mg/L)	0.120	0.121	0.117	0.172	0.172
	Orthophosphate-Dissolved (as P) (mg/L)	<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
	Phosphorus (P)-Total (mg/L)	<0.0020	0.0040	<0.0020	0.0024	0.0021
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.52	0.56	<0.50	0.94	0.51
	Total Organic Carbon (mg/L)	0.56	<0.50	<0.50	0.77	0.61
Total Metals	Sodium (Na)-Total (mg/L)	2.5	2.5	2.5	7.0	7.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1602632-11	L1602632-12	L1602632-13	L1602632-14	L1602632-15
	Description	SW	SW	SW	SW	SW
	Sampled Date	20-APR-15	20-APR-15	20-APR-15	20-APR-15	
	Sampled Time	12:15	14:30	13:00	12:15	
	Client ID	TR-3	FE-1	FF-1	DUP-1	TRAVEL BLANK
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	182	408	183	181	<0.50
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	1.39	0.0128 RRV	<0.0050	<0.0050
	Nitrate and Nitrite (as N) (mg/L)	0.157	<0.10	0.121	0.156	<0.0051
	Nitrate (as N) (mg/L)	0.157	<0.10 DLM	0.121	0.156	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	<0.020 DLM	<0.0010	<0.0010	<0.0010
	Total Nitrogen (mg/L)	0.172	11.1	0.221	0.170	<0.030
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	0.706	0.0054	<0.0010	<0.0010
	Phosphorus (P)-Total Dissolved (mg/L)	<0.0020	1.02	0.0086	<0.0020	<0.0020
	Phosphorus (P)-Total (mg/L)	0.0028	2.98	0.0200	0.0020	<0.0020
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.57	129	1.68	0.68	
	Total Organic Carbon (mg/L)	0.68	166	2.50	0.84	<0.50
Total Metals	Sodium (Na)-Total (mg/L)	7.0	540	10.8	7.0	<2.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1602632-16	L1602632-17	L1602632-18	L1602632-19	L1602632-20
	Description	SW	SW	SW	SW	SW
	Sampled Date	21-APR-15	21-APR-15	21-APR-15	21-APR-15	21-APR-15
	Sampled Time	13:40	13:40	09:30	11:10	12:50
	Client ID	FF-2	FF-3	NF-1	NF-2	NF-3
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	175	179	149	154	157
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0103 RRV	0.0095 RRV	<0.0050	0.0078 RRV	0.0081 RRV
	Nitrate and Nitrite (as N) (mg/L)	0.117	0.117	0.123	0.129	0.134
	Nitrate (as N) (mg/L)	0.117	0.117	0.123	0.129	0.134
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Nitrogen (mg/L)	0.214	0.211	0.192	0.208	0.221
	Orthophosphate-Dissolved (as P) (mg/L)	0.0056	0.0050	0.0023	0.0031	0.0037
	Phosphorus (P)-Total Dissolved (mg/L)	0.0074	0.0075	0.0031	0.0049	0.0055
	Phosphorus (P)-Total (mg/L)	0.0189	0.0168	0.0099	0.0153	0.0153
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	1.85	1.78	1.35	1.65	1.59
	Total Organic Carbon (mg/L)	2.44	2.47	1.37	2.11	1.70
Total Metals	Sodium (Na)-Total (mg/L)	10.2	10.5	7.2	8.2	8.9

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1602632-21	L1602632-22	L1602632-23	L1602632-24	
	Description	SW	SW	SW	SW	
	Sampled Date	21-APR-15	21-APR-15	21-APR-15		
	Sampled Time	08:30	13:40	09:15		
	Client ID	SK-3	DUP-2	FE-2	FIELD BLANK	
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	68.5	183	408		
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	0.0098 RRV	0.993	<0.0050	
	Nitrate and Nitrite (as N) (mg/L)	0.0315	0.116	<0.10	<0.0051	
	Nitrate (as N) (mg/L)	0.0315	0.116	<0.10 DLM	<0.0050	
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.020 DLM	<0.0010	
	Total Nitrogen (mg/L)	0.120	0.218	11.2	<0.030	
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	0.0051	0.646	<0.0010	
	Phosphorus (P)-Total Dissolved (mg/L)	<0.0020	0.0076	0.920	<0.0020	
	Phosphorus (P)-Total (mg/L)	0.0052	0.0183	2.94	<0.0020	
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	1.88	1.78	164	<0.50	
	Total Organic Carbon (mg/L)	2.20	1.77	172	<0.50	
Total Metals	Sodium (Na)-Total (mg/L)	2.0	10.7	554		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Phosphorus (P)-Total Dissolved	MS-B	L1602632-1, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -2, -20, -21, -22, -23, -24, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Total Nitrogen	MS-B	L1602632-1, -10, -11, -12, -13, -14, -15, -16, -17, -18, -19, -2, -20, -21, -22, -23, -24, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Ammonia, Total (as N)	MS-B	L1602632-12, -23

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RRV	Reported Result Verified By Repeat Analysis

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-N+N-CALC-VA	Water	Nitrite & Nitrate in Water (Calculation)	EPA 300.0

Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

N-T-COL-VA	Water	Total Nitrogen in water by Colour	APHA Method 4500-P (J) / NEMI 5735

This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

P-TD-COL-VA	Water	Total Dissolved P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Reference Information

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

14-471235 14-471236

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1602632-COFC

COC Number: 14 - 471235

Page 1 of 2

Report To
Company: EcoMetrix
Contact: Karen Petersen
Address: 6800 Campobello Rd Mississauga
Phone: 416-459-2700

Report Format / Distribution
Select Report Format: [X] PDF [X] EXCEL [ ] EDD (DIGITAL)
Quality Control (QC) Report with Report [X] Yes [ ] No
[ ] Criteria on Report - provide details below if box checked
Select Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax: KPetersen@ecometrix.ca
Email 2

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
R [X] Regular (Standard TAT if received by 3pm)
P [ ] Priority (2-4 business days if received by 3pm)
E [ ] Emergency (1-2 business days if received by 3pm)
E2 [ ] Same day or weekend emergency if received by 10am - contact ALS for surcharge.
Specify Date Required for E2,E or P:

Invoice To Same as Report To [ ] Yes [X] No
Copy of Invoice with Report [X] Yes [ ] No
Company: Ecometrix
Contact: Barb Sproule

Invoice Distribution
Select Invoice Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax: BSproule@ecometrix.ca
Email 2

Project Information
ALS Quote #: Q50128
Job #: 15-2168
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)
Approver ID: Cost Center:
GL Account: Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only):
ALS Contact: Sampler:

Analysis Request
Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total Phosphorus (P)	Total Nitrogen (P)	TOC (P)	Na (P)	Ortho Phosphate (P)	Total dissolved Phosphorus (F/P)	Nitrate (P)	Nitrite (P)	Ammonia (P)	DOC (F/P)				Number of Containers
	CR-1	20-Apr-15	10:00	SW	X	X	X	X	X	X	X	X	X	X				4
	CR-2		10:15															
	CR-3		10:30															
	SK-1		14:40															
	SK-2		14:10															
	LR-1		15:10															
	LR-2		15:00															
	LR-3		15:20															
	TR-1		12:00															
	TR-2		11:30															
	TR-3		12:15															
	FE-1		14:30															

Rush Processing

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System? [ ] Yes [X] No
Are samples for human drinking water use? [ ] Yes [X] No

Special Instructions / Specify Criteria to add on report (client Use)
FE-1 + FE-2 DOC Bottle Not Field Filtered or Preser.

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen [ ] SIF Observations Yes [ ] No [ ]
Ice packs Yes [ ] No [ ] Custody seal intact Yes [ ] No [ ]
Cooling Initiated [ ]

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
			4.5	3.3	5.7

SHIPMENT RELEASE (client use)
Released by: Karen Petersen Date: 21-Apr-15 Time:

INITIAL SHIPMENT RECEPTION (lab use only)
Received by: Date: Time:

FINAL SHIPMENT RECEPTION (lab use only)
Received by: YL Date: Apr 23 Time: 10:45

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA-FM-03256 v09 FrontD4 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1602632-COFC

COC Number: 14 - 471236

Report To EcoMetrix
Company: Karen Petersen
Contact:
Address: 6800 Campobello Rd Mississauga
Phone:

Report Format / Distribution
Select Report Format: ☒ PDF ☒ EXCEL ☐ EDD (DIGITAL)
Quality Control (QC) Report with Report ☒ Yes ☐ No
☐ Criteria on Report - provide details below if box checked
Select Distribution: ☒ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax KPetersen@ecometrix.ca
Email 2

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
R ☒ Regular (Standard TAT if received by 3pm)
P ☐ Priority (2-4 business days if received by 3pm)
E ☐ Emergency (1-2 business days if received by 3pm)
E2 ☐ Same day or weekend emergency if received by 10am – contact ALS for surcharge.
Specify Date Required for E2,E or P:

Invoice To Same as Report To ☐ Yes ☒ No
Copy of Invoice with Report ☒ Yes ☐ No
Company: EcoMetrix
Contact: Barb Sproule

Invoice Distribution
Select Invoice Distribution: ☒ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax BSproule@ecometrix.ca
Email 2

Project Information
ALS Quote #: Q50128
Job #: 15-2168
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)
Approver ID: Cost Center:
GL Account: Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only)
ALS Contact: Sampler:

Analysis Request
Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	TP	TN	TOC	Na	Ortho P	Total Dis P	Nitrate	Nitrite	Ammonia	DOC				Number of Containers
					P	P	P	P		F/P	P	P	P	F/P				
	FE-1	20-Apr-15	13:00	SW	X	X	X	X	X	X	X	X	X	X				4
	DUP-1	↓	12:15	↓	X	X	X	X	X	X	X	X	X	X				4
	Travel Blank	—	—		X	X	X	X	X	X	X	X	X					3
	FF-2	21 Apr 15	13:40		X	X	X	X	X	X	X	X	X	X				4
	FF-3		13:40															
	NF-1		~~11:10~~ 9:30															
	NF-2		~~12:50~~ 11:10															
	NF-3		12:50															
	SK-3		8:30															
	DUP-2		13:40															
	FE-2		9:15															
	Field Blank		—															

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System? ☐ Yes ☒ No
Are samples for human drinking water use? ☐ Yes ☒ No

Special Instructions / Specify Criteria to add on report (client Use)
FE-1 + FE-2 DOC NOT Field Filtered or Preserved

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen ☐ SIF Observations Yes ☐ No ☐
Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
			4.5	2.1/3.3	5.7

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Karen Petersen	Date: 21 Apr-15	Time:	Received by:	Date:	Time:	Received by:	Date: Apr 23	Time: 12:45

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA-FM-0236e v08 Front04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

ECOMETRIX INCORPORATED
ATTN: Karen Petersen
6800 Campobello Road
Mississauga ON L5N 2L8

Date Received: 02-OCT-15
Report Date: 20-OCT-15 14:29 (MT)
Version: FINAL

Client Phone: 905-794-2325

Certificate of Analysis

Lab Work Order #: L1682301

Project P.O. #:	NOT SUBMITTED
Job Reference:	15-2168
C of C Numbers:	14-511556, 14-511557, 14-511558
Legal Site Desc:	

Dean Watt, B.Sc.
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID	L1682301-2	L1682301-3	L1682301-6	L1682301-7	L1682301-8
Description	SW	SW	SW	SW	SW
Sampled Date	29-SEP-15	30-SEP-15	29-SEP-15	29-SEP-15	29-SEP-15
Sampled Time	12:30	10:11	14:20	16:16	16:30
Client ID	TBBR-2	TBBR-3	TBBR-6	SK-1	SK-2
Grouping / **Analyte**					
FILTER					
Plant Pigments / Chlorophyll a (ug)	56.6	11.7	13.7	75.5	20.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID		L1682301-9	L1682301-10	L1682301-11	L1682301-12	L1682301-13
Description		SW	SW	SW	SW	SW
Sampled Date		30-SEP-15	29-SEP-15	29-SEP-15	29-SEP-15	30-SEP-15
Sampled Time		11:00	17:00	17:08	17:25	07:30
Client ID		SK-3	CF-1	CF-2	CF-3	LR-1
Grouping	**Analyte**					
FILTER						
Plant Pigments	Chlorophyll a (ug)	46.2	7.90	8.37	8.09	38.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1682301-14	L1682301-15	L1682301-16	L1682301-17	L1682301-18
	Description	SW	SW	SW	SW	SW
	Sampled Date	30-SEP-15	30-SEP-15	29-SEP-15	29-SEP-15	29-SEP-15
	Sampled Time	07:45	07:57	19:07	19:15	19:51
	Client ID	LR-2	LR-3	FF-1	FF-2	FF-3
Grouping	**Analyte**					
FILTER						
Plant Pigments	Chlorophyll a (ug)	23.1	19.3	47.7	89.6	92.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1682301-21				
	Description	SW				
	Sampled Date	30-SEP-15				
	Sampled Time	11:41				
	Client ID	NF-1				
Grouping	**Analyte**					
FILTER						
Plant Pigments	Chlorophyll a (ug)	119				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1682301-1	L1682301-2	L1682301-3	L1682301-4	L1682301-5
	Description	SW	SW	SW	SW	SW
	Sampled Date	29-SEP-15	29-SEP-15	30-SEP-15	30-SEP-15	30-SEP-15
	Sampled Time	11:50	12:30	10:11	10:30	11:11
	Client ID	TBBR-1	TBBR-2	TBBR-3	TBBR-4	TBBR-5
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	157	157	161	160	60.5
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	0.0155	<0.0050	<0.0050	<0.0050
	Nitrate (as N) (mg/L)	0.130	0.130	0.132	0.129	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Nitrogen (mg/L)	0.146	0.156	0.152	0.182	0.034
	Orthophosphate-Dissolved (as P) (mg/L)	<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
	Phosphorus (P)-Total (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	<0.50	<0.50	<0.50	<0.50	0.88
	Total Organic Carbon (mg/L)	<0.50	<0.50	<0.50	<0.50	0.86
Total Metals	Sodium (Na)-Total (mg/L)	3.5	3.5	3.7	3.7	2.1

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1682301-6	L1682301-7	L1682301-8	L1682301-9	L1682301-13
	Description	SW	SW	SW	SW	SW
	Sampled Date	29-SEP-15	29-SEP-15	29-SEP-15	30-SEP-15	30-SEP-15
	Sampled Time	14:20	16:16	16:30	11:00	07:30
	Client ID	TBBR-6	SK-1	SK-2	SK-3	LR-1
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	158	60.8	60.5	61.5	279
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	0.0099
	Nitrate (as N) (mg/L)	0.127	<0.0050	<0.0050	<0.0050	0.0926
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Nitrogen (mg/L)	0.154	0.063	0.052	0.051	0.144
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	0.0015
	Phosphorus (P)-Total Dissolved (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
	Phosphorus (P)-Total (mg/L)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	<0.50	0.98	1.00	0.79	0.61
	Total Organic Carbon (mg/L)	<0.50	0.80	0.96	0.74	0.51
Total Metals	Sodium (Na)-Total (mg/L)	3.6	2.1	2.1	2.2	2.5

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1682301-14	L1682301-15	L1682301-16	L1682301-17	L1682301-18
	Description	SW	SW	SW	SW	SW
	Sampled Date	30-SEP-15	30-SEP-15	29-SEP-15	29-SEP-15	29-SEP-15
	Sampled Time	07:45	07:57	19:07	19:15	19:51
	Client ID	LR-2	LR-3	FF-1	FF-2	FF-3
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	280	280	161	158	161
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0079	0.0052	0.0163	0.0177	0.0145
	Nitrate (as N) (mg/L)	0.100	0.101	0.116	0.115	0.112
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Nitrogen (mg/L)	0.149	0.130	0.175	0.175	0.161
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	0.0036	0.0032	0.0034
	Phosphorus (P)-Total Dissolved (mg/L)	<0.0020	<0.0020	0.0040	0.0036	0.0048
	Phosphorus (P)-Total (mg/L)	<0.0020	<0.0020	0.0073	0.0077	0.0085
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	<0.50	<0.50	0.98	1.15	0.84
	Total Organic Carbon (mg/L)	<0.50	<0.50	0.96	0.91	0.86
Total Metals	Sodium (Na)-Total (mg/L)	2.5	2.5	6.0	5.8	5.9

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1682301-19	L1682301-20	L1682301-21	L1682301-22	L1682301-23
	Description	SW	SW	SW	SW	SW
	Sampled Date	30-SEP-15	30-SEP-15	30-SEP-15	30-SEP-15	30-SEP-15
	Sampled Time	06:49	06:29	11:41	12:00	12:10
	Client ID	FF-4	FF-5	NF-1	NF-2	NF-3
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	163	160	156	151	162
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0179	0.0248	0.0268	0.0127	0.0284
	Nitrate (as N) (mg/L)	0.119	0.119	0.130	0.113	0.128
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Nitrogen (mg/L)	0.165	0.178	0.196	0.168	0.195
	Orthophosphate-Dissolved (as P) (mg/L)	0.0040	0.0033	0.0066	0.0035	0.0072
	Phosphorus (P)-Total Dissolved (mg/L)	0.0051	0.0048	0.0085	0.0042	0.0082
	Phosphorus (P)-Total (mg/L)	0.0080	0.0084	0.0114	0.0056	0.0103
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.85	0.89	0.94	0.70	0.98
	Total Organic Carbon (mg/L)	0.92	0.80	0.81	0.66	1.12
Total Metals	Sodium (Na)-Total (mg/L)	6.1	5.9	6.3	5.2	7.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1682301-24	L1682301-25	L1682301-26	L1682301-27	L1682301-28
	Description	SW	SW	SW	SW	SW
	Sampled Date	30-SEP-15	30-SEP-15	29-SEP-15	30-SEP-15	
	Sampled Time	12:20	12:40	16:00	08:30	
	Client ID	NF-4	NF-5	FE-1	FE-2	FB
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	156	230	429	429	<0.50
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0244	0.0230	3.76	3.87	<0.0050
	Nitrate (as N) (mg/L)	0.125	0.125	<0.10 DLDS	<0.10 DLDS	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.020 DLDS	<0.020 DLDS	<0.0010
	Total Nitrogen (mg/L)	0.184	0.188	6.41	6.26	<0.030
	Orthophosphate-Dissolved (as P) (mg/L)	0.0065	0.0062	0.306	0.442	<0.0010
	Phosphorus (P)-Total Dissolved (mg/L)	0.0071	0.0060	0.852	1.04	<0.0020
	Phosphorus (P)-Total (mg/L)	0.0092	0.0089	1.94	1.86	<0.0020
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.89	0.82 M	80	88	<0.50
	Total Organic Carbon (mg/L)	0.70 M	0.86	145	90	<0.50
Total Metals	Sodium (Na)-Total (mg/L)	6.5	4.7	434	441	<2.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1682301-29	L1682301-30	L1682301-31	L1682301-32	
	Description	SW	SW	SW	SW	
	Sampled Date	29-SEP-15		30-SEP-15	30-SEP-15	
	Sampled Time			12:40	06:13	
	Client ID	DUP-1	TRAVEL BLANK	NF 6	FF 6	
Grouping	**Analyte**					
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	61.7	<0.50	162	155	
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	0.0156	0.0154	
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	0.149	0.118	
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	0.0011	
	Total Nitrogen (mg/L)	<0.030	<0.030	0.201	0.190	
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	0.0043	0.0037	
	Phosphorus (P)-Total Dissolved (mg/L)	<0.0020	<0.0020	0.0045	0.0046	
	Phosphorus (P)-Total (mg/L)	<0.0020	<0.0020	0.0060	0.0081	
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.97	<0.50	0.87	0.73	
	Total Organic Carbon (mg/L)	0.88	<0.50	<0.50	0.74	
Total Metals	Sodium (Na)-Total (mg/L)	2.2	<2.0	6.2	5.8	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Total Organic Carbon	M	L1682301-17, -29
Duplicate	Total Organic Carbon	M	L1682301-17, -29
Duplicate	Dissolved Organic Carbon	M	L1682301-31
Duplicate	Dissolved Organic Carbon	M	L1682301-31
Matrix Spike	Sodium (Na)-Total	MS-B	L1682301-16, -17, -18, -19, -20, -21, -22, -23, -24, -25, -26, -27, -28, -29, -30, -31, -32
Matrix Spike	Total Organic Carbon	MS-B	L1682301-1, -13, -14, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Total Organic Carbon	MS-B	L1682301-1, -13, -14, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Ammonia, Total (as N)	MS-B	L1682301-26, -27
Matrix Spike	Ammonia, Total (as N)	MS-B	L1682301-26, -27

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
M	A peak has been manually integrated.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CHLOROA-F-VA	Filter	Chlorophyll a by Fluorometer (Filter)	EPA 445.0

This analysis is done using procedures modified from EPA Method 445.0. Chlorophyll-a is determined by a routine acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

N-T-COL-VA	Water	Total Nitrogen in water by Colour	APHA Method 4500-P (J) / NEMI 5735

This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

Reference Information

P-TD-COL-VA	Water	Total Dissolved P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorus is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location

Chain of Custody Numbers:

14-511556 14-511557 14-511558

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Short Holding Time

Rush Processing

in of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1682301-COFC

COC Number: 14 - 511558

Page 1 of 3

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)	
Company:	EcoMatrix	Select Report Format:	☒ PDF ☒ EXCEL ☐ EDD (DIGITAL)	R ☒	Regular (Standard TAT if received by 3pm)
Contact:	Karen Petersen	Quality Control (QC) Report with Report	☒ Yes ☐ No	P ☐	Priority (2-4 business days if received by 3pm)
Address:	6800 Campobello Rd	☐ Criteria on Report - provide details below if box checked		E ☐	Emergency (1-2 business days if received by 3pm)
		Select Distribution:	☒ EMAIL ☐ MAIL ☐ FAX	E2 ☐	Same day or weekend emergency if received by 10am – contact ALS for surcharge.
Phone:	416-459-2700	Email 1 or Fax	KPetersen@ecomatrix.ca	Specify Date Required for E2,E or P:	
		Email 2			

Invoice To		Invoice Distribution	
Same as Report To	☒ Yes ☐ No	Select Invoice Distribution:	☒ EMAIL ☐ MAIL ☐ FAX
Copy of Invoice with Report	☒ Yes ☐ No		
Company:		Email 1 or Fax	
Contact:		Email 2	

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:	Q50128	Approver ID:	Cost Center:
Job #:	15-2168	GL Account:	Routing Code:
PO / AFE:		Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)	L1682301	ALS Contact:	Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Chlorophyll a	Hardness	Total Phosphorus	Total N	TOC	Na	Total dissolved P	Nitrate/Nitrite	Ammonia	DOC	Ortho P			Number of Containers
						P	P	P	P	P	F/P	P	P	F/P				
	TBBR-1	29-Sept-15	11:56	SW		X	X	X	X	X	X	X	X	X	X			4
	TBBR-2	29-Sept-15	12:36		X													5
	TBBR-3	30-Sept-15	~~11:50~~	10:11	X													5
	TBBR-4	30-Sept-15	~~12:30~~	10:30														4
	TBBR-5	30-Sept-15	~~14:20~~	11:11														4
	TBBR-6	29-Sept-15	14:20		X													5
	SK-1	29-Sept-15	16:16		X													5
	SK-2	29-Sept-15	16:30		X													5
	SK-3	30-Sept-15	11:00		X													5
	CF-1	29-Sept-15	17:00		X													1
	CF-2	29-Sept-15	17:08		X													1
	CF-3	29-Sept-15	17:25		X													1

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client Use)
Are samples taken from a Regulated DW System? ☐ Yes ☒ No	Both FE Samples (DOC Bottle) Not Filtered or Preserved
Are samples for human drinking water use? ☐ Yes ☒ No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen	☐		SIF Observations	Yes ☐	No ☐
Ice packs	Yes ☐	No ☐	Custody seal intact	Yes ☐	No ☐
Cooling Initiated	☐				

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
			1.0	0.3	1.7	1.3	0.7

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Karen Petersen	Date: Sept 30/15	Time:	Received by:	Date:	Time:	Received by: lady	Date: Oct. 2	Time: 8AM

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA-FM-0326a v09 Front04 January 2014

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1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Short Holding Time

Rush Processing

1 of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1682301-COFC

COC Number: 14 - 511557

Report To

Company: EcoMetrix
Contact: Karen Petersen
Address: 6800 Campo Bello Rd
Phone: 416-459-2700

Report Format / Distribution

Select Report Format: [X] PDF [X] EXCEL [ ] EDD (DIGITAL)
Quality Control (QC) Report with Report [X] Yes [ ] No
[ ] Criteria on Report - provide details below if box checked
Select Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax: KPetersen@ecometrix.ca
Email 2

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R [X] Regular (Standard TAT if received by 3pm)
- P [ ] Priority (2-4 business days if received by 3pm)
- E [ ] Emergency (1-2 business days if received by 3pm)
- E2 [ ] Same day or weekend emergency if received by 10am – contact ALS for surcharge.

Specify Date Required for E2,E or P:

Invoice To Same as Report To [X] Yes [ ] No
Copy of Invoice with Report [X] Yes [ ] No
Company:
Contact:

Invoice Distribution

Select Invoice Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax
Email 2

Project Information

ALS Quote #: Q50128
Job #: 15-2168
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)

Approver ID: Cost Center:
GL Account: Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only): L1682301
ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Chlorophyll a (P)	Hardness (P)	Total P (P)	Total N (P)	TOC (P)	Hg (P)	Total Dissolved P (F/P)	Nitrate/Nitrite (P)	Ammonia (P)	DOC (F/P)	Ortho P (F/P)			Number of Containers
	LR-1	30-Sept-15	7:30	SW	X	X	X	X	X	X	X	X	X	X	X			5
	LR-2	30 Sept 15	7:45		X													5
	LR-3	30 Sept 15	07:57		X													5
	FF-1	29 Sept/15	19:07		X													5
	FF-2	29 Sept/15	19:15		X													5
	FF-3	29 Sept 15	19:51		X													5
	FF-4	30 Sept-15	06:49															4
	FF-5	30 Sept-15	06:89															4
	NF-1	30 Sept 15	11:41		X													~~4~~ 5
	NF-2	30 Sept 15	12:00															4
	NF-3	30 Sept 15	12:10															4
	NF-4	30 Sept 15	12:20															4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? [ ] Yes [X] No
Are samples for human drinking water use? [ ] Yes [X] No

Special Instructions / Specify Criteria to add on report (client Use)

Both FE Samples (Doc Bottle) Not Filtered or Preserved

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen [ ] SIF Observations Yes [ ] No [ ]
Ice packs Yes [ ] No [ ] Custody seal intact Yes [ ] No [ ]
Cooling Initiated [ ]

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C				
			1.0	0.3	1.7	1.3	0.7

SHIPMENT RELEASE (client use)

Released by: Date: Time:

INITIAL SHIPMENT RECEPTION (lab use only)

Received by: Date: Time:

FINAL SHIPMENT RECEPTION (lab use only)

Received by: lady Date: Oct. 2 Time: 8AM

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

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NA-FM-0326e v08 Final04 January 2014

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1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Short Holding Time

● Rush Processing

Custody (COC) / Analytic Request Form

ida Toll Free: 1 800 668 9878

L1682301-COFC

re

COC Number: 14 - 511556

Report To

Company: ECOMetrix
Contact: Karen Petersen
Address: 6800 Campobello Rd
Phone: 416-459-2700

Report Distribution

Select Report Format: [X] PDF [X] EXCEL [ ] EDD (DIGITAL)
Quality Control (QC) Report with Report [X] Yes [ ] No
[ ] Criteria on Report - provide details below if box checked
Select Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax: KPetersen@ecometrix.ca
Email 2

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R [X] Regular (Standard TAT if received by 3pm)
- P [ ] Priority (2-4 business days if received by 3pm)
- E [ ] Emergency (1-2 business days if received by 3pm)
- E2 [ ] Same day or weekend emergency if received by 10am – contact ALS for surcharge.

Specify Date Required for E2,E or P:

Invoice To Same as Report To [X] Yes [ ] No
Copy of Invoice with Report [X] Yes [ ] No
Company:
Contact:

Invoice Distribution

Select Invoice Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax
Email 2

Project Information

ALS Quote #: Q50128
Job #: 15-2168
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)

Approver ID: Cost Center:
GL Account: Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only) L1682301
ALS Contact: Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Chlorophyll a (P)	Hardness (P)	Total P (P)	Total N (P)	TOC (P)	Na (P)	Total dissolved P (F/P)	Nitrate/Nitrite (P)	Ammonia (P)	DOC (F/P)	ortho P (F/P)			Number of Containers
	NF-5	30-Sept-15	12:40	SW		X	X	X	X	X	X	X	X	X	X			4
	FF-1 (Not Filtered or Preserved)	29-Sept-15	16:00															4
	FF-2 (Not Filtered or Presirved)	30-Sept-15	08:30															4
	FB																	4
	DUP-1	29-Sept-15	—	—														4
	~~DUP-2~~	~~30-Sept-15~~	—	—														4
	Travel Blank		—	—														4
	~~DUP-3~~	~~30-Sept-15~~	—	—														4
	NF6	30-Sept-15	12:40	SW		X	X	X	X	X	X	X	X	X	X			4
	FF 6	30-Sept-15	06:13	SW		X	X	X	X	X	X	X	X	X	X			4

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? [ ] Yes [X] No
Are samples for human drinking water use? [ ] Yes [X] No

Special Instructions / Specify Criteria to add on report (client Use)

Both FE Samples Not (DOC Bottle) Filtered or Preserved

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen [ ] SIF Observations Yes [ ] No [ ]
Ice packs Yes [ ] No [ ] Custody seal intact Yes [ ] No [ ]
Cooling Initiated [ ]

INITIAL COOLER TEMPERATURES °C		FINAL COOLER TEMPERATURES °C			
		1.0/0.3	1.7	1.3	0.7

SHIPMENT RELEASE (client use)

Released by: Karen Petersen Date: Sept 30/15 Time:

INITIAL SHIPMENT RECEPTION (lab use only)

Received by: Date: Time:

FINAL SHIPMENT RECEPTION (lab use only)

Received by: lady Date: Oct. 2 Time: 8AM

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

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NA FM 03206 v09 Front/04 January 2014

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1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

ECOMETRIX INCORPORATED
ATTN: Karen Petersen
6800 Campobello Road
Mississauga ON L5N 2L8

Date Received: 08-OCT-15
Report Date: 21-OCT-15 15:13 (MT)
Version: FINAL

Client Phone: 905-794-2325

Certificate of Analysis

Lab Work Order #: L1685714

Project P.O. #: NOT SUBMITTED
Job Reference: 15-2168
C of C Numbers: 14-492096
Legal Site Desc:

Dean Watt, B.Sc.
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1685714-1	L1685714-2			
	Description	Periphyton	Periphyton			
	Sampled Date	30-SEP-15	30-SEP-15			
	Sampled Time					
	Client ID	NF-3	NF-6			
Grouping	**Analyte**					
FILTER						
Plant Pigments	Chlorophyll a (ug)	361	196			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
CHLOROA-F-VA	Filter	Chlorophyll a by Fluorometer (Filter)	EPA 445.0

This analysis is done using procedures modified from EPA Method 445.0. Chlorophyll-a is determined by a routine acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location

Chain of Custody Numbers:

14-492096

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental
www.alsglobal.com

Canada Toll Free: 1 800 6[illegible] 9878

L1685714-COFC

COC Number: 14 - 492096

Page 1 of 1

Report To:	Ecomatrix Karen Petersen Erin Clyde
Company:	
Contact:	
Address:	6800 Campobello Rd
Phone:	416-459-2700
Invoice To	Same as Report To: [X] Yes [ ] No
	Copy of Invoice with Report: [X] Yes [ ] No
Company:	
Contact:	

Report Format / Distribution

Select Report Format: [X] PDF [X] EXCEL [ ] EDD (DIGITAL)
Quality Control (QC) Report with Report [X] Yes [ ] No
[ ] Criteria on Report - provide details below if box checked
Select Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax: KPetersen@ecomatrix.ca
Email 2: EClyde@ecomatrix.ca

Invoice Distribution

Select Invoice Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax
Email 2

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R [X] Regular (Standard TAT if received by 3pm)
- P [ ] Priority (2-4 business days if received by 3pm)
- E [ ] Emergency (1-2 business days if received by 3pm)
- E2 [ ] Same day or weekend emergency if received by 10am – contact ALS for surcharge.

Specify Date Required for E2,E or P:

Project Information

ALS Quote #: Q50128 > #1
Job #: 15-2168
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)

Approver ID: Cost Center:
GL Account: Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only):
ALS Contact: Sampler:

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Chlorophyll	Dissolved Metals	Acidity	Sulphate	Hardness	Short Holding Time / Rush Processing	Number of Containers
	NF-3 > #1	30-Sept-15		Periphyton	X						1
	NF-6	↓		↓	X						1
	SEEP A > #2	4-Oct-15		SW							2
	LGS > #3	4-Oct-15		SW		X	X	X	X		2
	D1-SA	4-Oct-15		SW		X	X	X	X		2
	Please Separate Invoice + Report.										

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? [ ] Yes [X] No
Are samples for human drinking water use? [ ] Yes [X] No

Special Instructions / Specify Criteria to add on report (client Use)

NF-3 + NF-6 to Karen Petersen #1 Invoice
Seep A to Erin Clyde #2 Invoice
LGS + D1-SB to Erin Clyde #3 Invoice

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen [ ]
Ice packs Yes [ ] No [ ]
Cooling Initiated [ ]
SIF Observations Yes [ ] No [ ]
Custody seal intact Yes [ ] No [ ]

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
			2°C		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Karen Petersen	Date: 06-Oct-15	Time:	Received by:	Date:	Time:	Received by: lady	Date: Oct. 8	Time: 9AM

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

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NA ITM-0/026e v09 Front/09 January 2014

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1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Appendix C Benthic Invertebrate Community Survey Information

Summary of Previous Benthic Community Results as Presented in Hatfield 2014

Cycle One

Benthic invertebrate assemblages were surveyed in both erosional and depositional habitats during Cycle One (Hatfield Consultants Ltd. 1996). Benthic invertebrates from depositional areas were collected with an Ekman grab in October 1994. Artificial substrate trays were set in the Kootenay River at erosional sites from September 15 to October 23, 1994. Four replicates (grabs or trays) were analyzed from four stations for each survey: two reference, one near-field and one far-field (Wasa). Samples were sieved using a 180-µm screen and identified to lowest practicable level. For the erosional survey, the average density in the near and far-field zones was more than twice that of the reference site (i.e., 142,000 compared to 61,200 organisms/m2), while total richness was slightly less in the near-field and far-field zones (i.e., 42 compared to 54 taxa). Similar results were reported for depositional communities.

Chironomid larvae dominated all communities, while more sensitive taxa (e.g., Ephemeroptera) were found in lower proportions at Skookumchuck relative to other stations. Principal component analysis conducted on erosional benthic invertebrate data separated the near-field station from other stations, primarily due to higher densities of Ephemerella sp. and other chironomid larvae. Other statistical differences related to density and richness indicated enrichment in the near-field area.

Cycle Two

A benthic invertebrate survey was conducted September 1999 in three areas of the Kootenay River, five stations per area: reference area upstream of the mill, near-field area between the diffuser and Skookumchuck Bridge, and far-field area upstream of Wasa to Fort Steele. Four subsamples per station were collected with a Hess sampler (area 0.1 m2, 243-µm mesh screen) at each station. Three subsamples were analyzed in their entirety at 500 µm; the fourth subsample was archived.

Benthic invertebrate density and taxa richness increased significantly downstream of the pulpmill. The upper-most near-field station (CBBN1) appeared to not be exposed by effluent, based on water quality variables; the community at this station resembled those found at reference stations. The remaining four near-field stations exhibited moderate densities and a good diversity of taxa. Far-field stations exhibited highest densities and the same number of taxa as in the near-field.

Cycle Three

A benthic invertebrate survey similar to that in Cycle Two was conducted in August 2002. It included three areas, five stations per area, with three Hess samples collected per station, for a total of 45 samples. Samples were sieved using a 500 µm screen and taxa were identified generally to genus or species.

Results were consistent with those observed in Cycle Two. Density was significantly higher in the near-field and far-field areas relative to the reference area; mean area densities exceeded two standard deviations in the near-field and far-field areas relative to the reference area. Taxa richness was significantly different among areas; however, no difference was observed between the reference area and the near-field area. Richness was higher in the far-field area relative to reference and near-field areas; richness was greater than two standard deviations in the far-field area relative to the reference area.

Evenness did not differ significantly among areas. The Bray-Curtis index differed significantly among areas, although no difference was observed between the reference area and the near-field area. These results suggest slight enrichment of benthic communities in the near-field area (density in particular), with increasing enrichment effects observed in the far-field. No toxic effects were observed, as indicated by the high number of taxa in all areas, which increased with increasing distance downstream.

Cycle Four

The Cycle Four benthic invertebrate survey was conducted in September 2006, and included sampling of six stations in both near-field and reference areas, using a Hess sampler. Samples were sieved at 500 µm and taxa were identified generally to genus or species.

Results were consistent with those observed in previous cycles. Total density of invertebrate communities was higher in the near-field area relative to the reference area; mean station densities were greater than two standard deviations above the reference mean. Taxonomic richness also was significantly higher at near-field stations, although within the EEM effects criterion of ±2 standard deviation from the reference mean. Bray-Curtis index, a measure of community dissimilarity, also was significantly different between sampling areas in the near-field and reference areas.

Benthic invertebrate survey results generally indicate that pulp mill effluent contributes nutrients and organic carbon into the Kootenay River and these result in an enrichment of benthic invertebrate communities. No toxic effect was observed at invertebrate stations located in the near-field area. Rather, increased density and number of taxa indicated enhanced communities in near-field and far-field areas relative to reference area communities. Additional nutrient enrichment

Cycle 7 Benthic Data (per square meter) Collected for the Skookumchuck Mill, 2015

Station	NF						FF						TBBR					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
ROUNDWORMS																		
P. Nemata	53.872	107.74	26.936	107.74	53.872	26.936	53.872	0	0	0	13.468	26.936	0	0	0	0	0	0
FLATWORMS																		
P. Platyhelminthes																		
Cl. Turbellaria																		
Polycelis	0	0	0	0	0	0	0	0	0	0	0	0	13.468	0	0	0	0	0
ANNELIDS																		
P. Annelida																		
WORMS																		
Cl. Oligochaeta																		
F. Enchytraeidae	0	0	0	0	0	0	0	0	0	0	0	26.936	0	0	0	0	0	0
F. Naididae																		
S.F. Naidinae																		
Nais bretscheri	0	0	0	0	0	80.808	1235.7	0	1629.6	1292.9	188.55	134.68	40.404	13.468	0	0	215.49	0
Nais	0	0	0	0	0	26.936	0	0	545.45	0	0	0	0	0	0	0	0	0
Specaria josinae	0	0	0	0	0	0	272.73	0	0	0	0	0	0	0	0	0	0	0
S.F. Tubificinae																		
Limnodrilus hoffmeisteri	0	0	0	0	0	0	0	0	107.74	0	0	26.936	0	0	0	0	0	0
immatures with hair chaetae	0	0	0	0	0	0	0	0	107.74	0	13.468	0	0	0	0	0	0	26.936
immatures without hair chaet	0	0	0	0	0	0	0	0	329.97	269.36	40.404	26.936	0	0	0	0	0	0
ARTHROPODS																		
P. Arthropoda																		
MITES																		
Cl. Arachnida																		
O. Acarina																		
F. Hygrobatidae																		
Hygrobates	0	0	0	53.872	0	0	0	0	0	0	0	0	13.468	0	0	0	107.74	0
F. Lebertiidae																		
Lebertia	0	0	13.468	0	26.936	0	0	0	0	0	0	0	26.936	40.404	0	0	107.74	0
F. Sperchonidae																		
Sperchon	0	0	67.34	323.23	0	26.936	0	0	0	0	0	0	26.936	13.468	26.936	26.936	0	13.468
INSECTS																		
Cl. Insecta																		
BEETLES																		
O. Coleoptera																		
F. Elmidae																		
Heterlimnius	0	0	0	0	0	26.936	0	0	0	0	0	0	0	0	0	0	107.74	0
MAYFLIES																		
O. Ephemeroptera																		
F. Ameletidae																		
Ameletus	0	0	0	0	80.808	0	0	0	0	0	40.404	0	67.34	80.808	0	40.404	0	0
F. Baetidae																		
Acentrella insignificans	0	53.872	0	0	13.468	0	0	0	0	53.872	13.468	0	0	0	0	26.936	0	0
Baetis tricaudatus	0	0	0	0	13.468	0	0	0	0	0	0	0	0	0	0	0	0	0
Baetis	26.936	161.62	0	0	**107.74**	26.936	53.872	195.29	26.936	215.49	80.808	26.936	6.734	0	26.936	13.468	107.74	0
F. Ephemerellidae																		
Caudatella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	107.74	0
Drunella doddsi	0	0	0	0	13.468	53.872	0	53.872	0	0	0	0	0	0	0	0	107.74	13.468
Drunella	0	53.872	6.734	107.74	94.276	53.872	0	26.936	53.872	215.49	13.468	53.872	53.872	94.276	0	13.468	0	0
Ephemerella	511.78	1831.6	390.57	3286.2	1158.2	3097.6	592.59	757.58	430.98	3663.3	1198.7	511.78	114.48	94.276	13.468	26.936	4525.3	107.74

Cycle 7 Benthic Data (per square meter) Collected for the Skookumchuck Mill, 2015

Station	NF						FF						TBBR					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
F. Heptageniidae																		
Cinygmula	26.936	107.74	107.74	161.62	215.49	26.936	53.872	0	0	53.872	67.34	53.872	195.29	336.7	175.08	269.36	107.74	404.04
Rhithrogena	1050.5	592.59	175.08	915.82	80.808	592.59	161.62	296.3	0	215.49	255.89	242.42	26.936	40.404	404.04	161.62	215.49	767.68
F. Leptophlebiidae																		
Paraleptophlebia	0	0	13.468	0	40.404	0	0	53.872	0	0	13.468	0	53.872	188.55	0	0	0	26.936
STONEFLIES																		
O. Plecoptera																		
F. Capniidae																		
immature	26.936	0	107.74	0	40.404	0	0	0	53.872	0	67.34	26.936	20.202	13.468	0	26.936	0	13.468
F. Chloroperlidae																		
Sweltsa	0	0	40.404	0	0	0	0	0	0	0	0	0	6.734	0	13.468	0	0	0
immature	107.74	0	0	0	0	26.936	0	0	0	0	0	0	0	0	0	0	0	13.468
F. Nemouridae																		
Zapada cinctipes	0	107.74	0	0	0	0	0	53.872	0	53.872	0	0	0	0	0	0	0	0
F. Perlidae																		
Claassenia	0	0	0	0	0	0	0	3.367	0	0	13.468	0	0	3.367	0	0	0	10.101
Hesperoperla	0	3.367	0	0	0	0	0	3.367	0	0	0	3.367	0	0	0	0	0	13.468
immature	0	**53.872**	0	0	13.468	0	0	0	0	0	**13.468**	0	0	26.936	0	0	0	**13.468**
F. Perlodidae																		
Cultus	0	0	16.835	53.872	13.468	0	53.872	0	0	53.872	0	0	13.468	0	0	0	0	0
Isogenoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.468	0	0
Isoperla	107.74	53.872	13.468	0	26.936	26.936	0	0	0	53.872	26.936	0	40.404	26.936	0	13.468	0	13.468
immature	0	0	**40.404**	**53.872**	**13.468**	0	0	26.936	0	**53.872**	0	53.872	0	0	0	0	0	0
F. Pteronarcyidae																		
Pteronarcella	107.74	53.872	3.367	0	0	26.936	0	0	0	0	0	0	0	0	26.936	0	0	0
Pteronarcys	3.367	10.101	0	0	0	57.239	0	0	0	3.367	0	0	0	0	0	0	0	10.101
F. Taeniopterygidae																		
immature	269.36	646.46	188.55	592.59	148.15	188.55	53.872	619.53	26.936	430.98	175.08	215.49	6.734	53.872	53.872	40.404	538.72	67.34
CADDISFLIES																		
O. Trichoptera																		
F. Brachycentridae																		
Brachycentrus	0	0	13.468	53.872	0	457.91	0	215.49	53.872	232.32	53.872	171.72	13.468	0	0	0	107.74	0
F. Glossosomatidae																		
Glossosoma	107.74	2370.4	542.09	2801.3	121.21	2343.4	0	629.63	0	333.33	134.68	80.808	0	0	242.42	0	538.72	67.34
pupae	0	0	0	**107.74**	0	**26.936**	0	0	0	0	0	0	0	0	0	0	0	0
F. Hydropsychidae																		
Arctopsyche	0	10.101	0	0	0	114.48	0	0	0	0	0	0	0	0	0	0	0	0
Hydropsyche	2181.8	6195.3	232.32	5872.1	835.02	3798	53.872	2747.5	107.74	2757.6	646.46	1195.3	195.29	121.21	161.62	40.404	3555.6	404.04
immature	**80.808**	**430.98**	**53.872**	**269.36**	**13.468**	**53.872**	**53.872**	**53.872**	0	**53.872**	0	0	**67.34**	**40.404**	**202.02**	**80.808**	**538.72**	**134.68**
F. Hydroptilidae																		
Hydroptila	0	161.62	26.936	377.1	1050.5	188.55	5494.9	430.98	3501.7	2639.7	2356.9	1427.6	6.734	26.936	13.468	0	0	0
F. Lepidostomatidae																		
Lepidostoma	0	0	26.936	0	26.936	80.808	0	0	0	0	0	0	33.67	67.34	0	0	0	13.468
F. Psychomyiidae																		
Psychomyia	0	0	0	53.872	0	0	323.23	80.808	53.872	861.95	121.21	215.49	0	0	0	0	0	0
TRUE FLIES																		
O. Diptera																		
indeterminate	0	53.872	0	0	0	0	0	26.936	0	0	0	0	0	0	0	0	0	0
F. Athericidae																		
Atherix	80.808	161.62	33.67	53.872	3.367	77.441	0	0	16.835	77.441	13.468	43.771	13.468	70.707	13.468	16.835	0	80.808
F. Blephariceridae																		
Bibiocephala	0	53.872	0	0	0	0	0	0	0	0	0	0	0	0	0	0	107.74	0
MIDGES																		
F. Chironomidae																		
chironomid pupae	538.72	**592.59**	**363.64**	**484.85**	**175.08**	**53.872**	**377.1**	**377.1**	**161.62**	**269.36**	**134.68**	**134.68**	0	**40.404**	0	**26.936**	**1185.2**	0
S.F. Chironominae																		
Micropsectra	0	0	0	53.872	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microtendipes	0	0	26.936	53.872	107.74	0	2909.1	26.936	1885.5	1131.3	579.12	242.42	0	13.468	13.468	0	0	0
Paracladopelma	0	0	0	0	0	0	53.872	0	0	0	0	0	0	0	0	0	0	0
Polypedilum scalaenum	0	0	0	0	0	0	0	0	26.936	53.872	26.936	0	0	0	0	0	0	0
Polypedilum	0	0	0	0	0	0	0	0	0	0	0	0	0	13.468	0	0	0	0
Rheotanytarsus	0	0	0	0	0	0	0	0	0	53.872	0	0	0	0	0	0	0	0
Stempellinella	0	0	0	0	0	0	53.872	0	0	0	0	0	0	0	0	0	0	0
Tanytarsus	0	0	0	53.872	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Cycle 7 Benthic Data (per square meter) Collected for the Skookumchuck Mill, 2015

Station	NF						FF						TBBR					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
S.F. Diamesinae																		
Pagastia	0	0	53.872	107.74	13.468	0	53.872	80.808	53.872	0	40.404	0	87.542	67.34	0	0	107.74	0
S.F. Orthocladiinae																		
Brillia	0	0	0	0	0	0	0	0	26.936	0	0	0	0	0	0	0	0	0
Cardiocladius	26.936	0	0	0	0	0	0	26.936	0	0	0	0	0	0	0	0	0	0
Chaetocladius	26.936	0	0	0	0	0	0	0	0	0	0	0	13.468	0	0	0	0	13.468
Cricotopus/Orthocladius	1373.7	1831.6	1670	1885.5	1427.6	242.42	2585.9	1158.2	1939.4	1885.5	484.85	484.85	67.34	188.55	13.468	0	6356.9	26.936
Eukiefferiella claripennis gro	0	53.872	0	53.872	0	0	0	0	0	53.872	13.468	0	0	13.468	0	0	430.98	0
Eukiefferiella	0	0	26.936	0	13.468	0	0	26.936	0	0	0	0	0	0	0	0	969.7	0
Orthocladius (Euorthocladius	215.49	215.49	296.3	0	121.21	26.936	161.62	350.17	0	0	67.34	323.23	0	0	0	0	0	13.468
Parakiefferiella	0	0	0	0	0	0	269.36	0	0	0	0	0	0	0	0	0	0	0
Synorthocladius	0	53.872	0	0	13.468	0	53.872	0	80.808	0	0	0	0	0	0	13.468	0	0
Tvetenia	0	0	0	0	0	0	0	0	0	53.872	0	26.936	0	0	0	0	0	0
S.F. Prodiamesinae																		
Monodiamesa	0	0	0	0	0	0	0	0	0	53.872	13.468	0	0	0	0	0	0	0
S.F. Tanypodinae																		
Thienemannimyia complex	26.936	0	0	107.74	40.404	0	53.872	0	0	107.74	26.936	0	0	0	0	0	215.49	0
F. Empididae																		
Neoplasta	53.872	215.49	67.34	107.74	26.936	107.74	0	111.11	107.74	53.872	0	0	26.936	53.872	13.468	0	1185.2	0
Wiedemannia	0	0	0	0	26.936	26.936	0	0	0	0	0	0	0	0	0	0	215.49	0
F. Simuliidae	161.62	107.74	0	0	0	26.936	0	404.04	26.936	215.49	13.468	0	0	0	0	0	0	13.468
F. Tipulidae																		
Hexatoma	0	0	13.468	53.872	0	0	0	0	0	0	0	0	6.734	0	13.468	16.835	0	0
MOLLUSCS																		
P. Mollusca																		
CLAMS																		
Cl. Bivalvia																		
F. Sphaeriidae																		
Cyclocalyx	0	0	0	0	0	0	0	0	26.936	53.872	26.936	26.936	0	0	0	0	0	0
TOTAL NUMBER OF ORGANISMS	7168.4	16347	4659.9	18209	6171.7	11993	15030	8838.4	11384	17572	6989.9	5804.7	1259.3	1744.1	1427.6	868.69	21764	2282.8
TOTAL NUMBER OF TAXA [a]	21	26	27	24	30	28	21	25	24	30	32	25	27	24	16	16	22	22
EPT TAXA	12	16	16	11	18	17	9	16	9	16	17	14	16	14	10	12	10	15
MAYFLY DENSITY	1616.2	2801.3	693.6	4471.4	1818.2	3851.9	861.95	1383.8	511.78	4417.5	1683.5	888.89	518.52	835.02	619.53	552.19	5171.7	1319.9
STONEFLY DENSITY	622.9	929.29	410.77	700.34	255.89	326.6	107.74	707.07	80.808	649.83	296.3	299.66	87.542	124.58	94.276	94.276	538.72	154.88
CADDISFLY DENSITY	2370.4	9168.4	895.62	9535.4	2047.1	7064	5925.9	4158.2	3717.2	6878.8	3313.1	3090.9	316.5	255.89	619.53	121.21	4740.7	619.53
CLAM DENSITY	0	0	0	0	0	0	0	0	26.936	53.872	26.936	26.936	0	0	0	0	0	0
SIMPSON DIVERSITY	0.83	0.80	0.83	0.82	0.86	0.79	0.79	0.86	0.82	0.88	0.83	0.87	0.92	0.92	0.84	0.85	0.83	0.81
SIMPSON EVENNESS	0.2873	0.1967	0.222	0.2359	0.2366	0.1697	0.2255	0.2822	0.2355	0.2861	0.1863	0.3086	0.4681	0.5007	0.3906	0.4094	0.2738	0.2453
BRAY-CURTIS DISSIMILARITY	0.8087	0.8971	0.681	0.8979	0.7611	0.8784	0.9268	0.8484	0.9353	0.9146	0.7991	0.7915	0.3226	0.4324	0.372	0.3101	0.9201	0.4195

[a] Bold entries excluded from taxa count

CORRELATION OF TOTAL INVERTEBRATE DENSITY AND SUPPORTING ENVIRONMENT INFORMATION COLLECTED AT IN THE KOOTENAY RIVER IN EEM CYCLE 7

	Density	Depth	Velocity	Dom Sub	Sec Sub	Temp	Cond	DO	pH	Ammonia, Total (as N)	Nitrate (as N)	Total Nitrogen	Orthophosphate-Dissolved	Phosphorus (P)-Total	Phosphorus (P)-Total	Dissolved Organic Carbon	Total Organic Carbon	Sodium (Na)-Total
Density	1.0000																	
Depth	-0.1594	1.0000																
Velocity	-0.0947	0.0012	1.0000															
Dom Sub	**0.4884**	0.0032	0.0342	1.0000														
Sec Sub	0.3344	-0.1132	-0.2961	0.2079	1.0000													
Temp	0.0569	-0.0732	-0.4452	0.0189	0.3765	1.0000												
Cond	-0.4214	0.0615	-0.1603	-0.2578	-0.0477	0.3732	1.0000											
DO	0.4697	-0.0468	-0.0462	0.2037	0.2246	-0.0824	-0.8870	1.0000										
pH	0.2295	0.4247	-0.1064	0.0671	-0.3087	-0.0050	-0.1647	0.1348	1.0000									
Ammonia, Total (as N)	0.1817	-0.1282	-0.3194	0.0521	0.1607	0.1526	0.4715	-0.4521	-0.1793	1.0000								
Nitrate (as N)	**-0.5310**	-0.1305	0.0056	-0.2551	-0.2457	0.3110	0.9109	-0.8583	-0.2090	0.2762	1.0000							
Total Nitrogen	-0.3138	-0.1552	-0.1489	-0.2121	-0.0596	0.3998	0.9205	-0.8465	-0.1813	0.5728	0.8857	1.0000						
Orthophosphate-Dissolved (as P)	0.2869	-0.2401	-0.2659	-0.0464	0.1155	0.1865	0.4137	-0.3732	-0.1492	0.8918	0.2582	0.5747	1.0000					
Phosphorus (P)-Total Dissolved	0.2510	-0.1222	-0.2556	-0.0615	0.0817	0.1177	0.4099	-0.4389	-0.0652	0.9001	0.2384	0.5457	0.9740	1.0000				
Phosphorus (P)-Total	0.3080	-0.0581	-0.3641	0.0185	0.3051	0.2835	0.4655	-0.4209	-0.0460	0.9035	0.2130	0.5691	0.9166	0.9301	1.0000			
Dissolved Organic Carbon	**0.5774**	-0.1223	-0.3684	0.3756	0.3935	0.2696	-0.0118	0.0887	0.1472	0.6806	-0.2074	0.1523	0.6650	0.6347	0.7689	1.0000		
Total Organic Carbon	0.4386	0.1978	-0.5079	0.1688	0.4518	0.1559	-0.0136	0.1251	0.1559	0.6229	-0.3112	0.0305	0.6084	0.6117	0.7199	0.8178	1.0000	
Sodium (Na)-Total	0.2644	-0.0211	-0.2882	0.1293	0.2015	0.3911	0.6215	-0.5434	0.0945	0.8057	0.4580	0.7359	0.8161	0.8176	0.8916	0.6726	0.5403	1.0000

CORRELATION OF TAXA RICHNESS AND SUPPORTING ENVIRONMENT INFORMATION COLLECTED AT IN THE KOOTENAY RIVER IN EEM CYCLE 7

	Taxa	Depth	Velocity	Dom Sub	Sec Sub	Temp	Cond	DO	pH	Ammonia, Total (as N)	Nitrate (as N)	Total Nitrogen	Orthophosphate-Dissolved	Phosphorus (P)-Total	Phosphorus (P)-Total	Dissolved Organic Carbon	Total Organic Carbon	Sodium (Na)-Total
Taxa	1.0000																	
Depth	-0.1746	1.0000																
Velocity	-0.2089	0.0012	1.0000															
Dom Sub	**0.4520**	0.0032	0.0342	1.0000														
Sec Sub	**0.6206**	-0.1132	-0.2961	0.2079	1.0000													
Temp	0.1808	-0.0732	-0.4452	0.0189	0.3765	1.0000												
Cond	0.2380	0.0615	-0.1603	-0.2578	-0.0477	0.3732	1.0000											
DO	-0.1047	-0.0468	-0.0462	0.2037	0.2246	-0.0824	-0.8870	1.0000										
pH	**-0.5489**	0.4247	-0.1064	0.0671	-0.3087	-0.0050	-0.1647	0.1348	1.0000									
Ammonia, Total (as N)	**0.5238**	-0.1282	-0.3194	0.0521	0.1607	0.1526	0.4715	-0.4521	-0.1793	1.0000								
Nitrate (as N)	0.0963	-0.1305	0.0056	-0.2551	-0.2457	0.3110	0.9109	-0.8583	-0.2090	0.2762	1.0000							
Total Nitrogen	0.2092	-0.1552	-0.1489	-0.2121	-0.0596	0.3998	0.9205	-0.8465	-0.1813	0.5728	0.8857	1.0000						
Orthophosphate-Dissolved (as P)	0.4095	-0.2401	-0.2659	-0.0464	0.1155	0.1865	0.4137	-0.3732	-0.1492	0.8918	0.2582	0.5747	1.0000					
Phosphorus (P)-Total Dissolved	0.3673	-0.1222	-0.2556	-0.0615	0.0817	0.1177	0.4099	-0.4389	-0.0652	0.9001	0.2384	0.5457	0.9740	1.0000				
Phosphorus (P)-Total	0.4490	-0.0581	-0.3641	0.0185	0.3051	0.2835	0.4655	-0.4209	-0.0460	0.9035	0.2130	0.5691	0.9166	0.9301	1.0000			
Dissolved Organic Carbon	0.3708	-0.1223	-0.3684	0.3756	0.3935	0.2696	-0.0118	0.0887	0.1472	0.6806	-0.2074	0.1523	0.6650	0.6347	0.7689	1.0000		
Total Organic Carbon	0.3419	0.1978	-0.5079	0.1688	0.4518	0.1559	-0.0136	0.1251	0.1559	0.6229	-0.3112	0.0305	0.6084	0.6117	0.7199	0.8178	1.0000	
Sodium (Na)-Total	0.4075	-0.0211	-0.2882	0.1293	0.2015	0.3911	0.6215	-0.5434	0.0945	0.8057	0.4580	0.7359	0.8161	0.8176	0.8916	0.6726	0.5403	1.0000

CORRELATION OF TOTAL EVENNESS AND SUPPORTING ENVIRONMENT INFORMATION COLLECTED AT IN THE KOOTENAY RIVER IN EEM CYCLE 7

	Evenness	Depth	Velocity	Dom Sub	Sec Sub	Temp	Cond	DO	pH	Ammonia, Total (as N)	Nitrate (as N)	Total Nitrogen	Orthophosphate-Dissolved	Phosphorus (P)-Total	Phosphorus (P)-Total	Dissolved Organic Carbon	Total Organic Carbon	Sodium (Na)-Total
Evenness	1.0000																	
Depth	0.2494	1.0000																
Velocity	**0.4696**	0.0012	1.0000															
Dom Sub	-0.2523	0.0032	0.0342	1.0000														
Sec Sub	**-0.5425**	-0.1132	-0.2961	0.2079	1.0000													
Temp	**-0.5846**	-0.0732	-0.4452	0.0189	0.3765	1.0000												
Cond	-0.0253	0.0615	-0.1603	-0.2578	-0.0477	0.3732	1.0000											
DO	-0.1298	-0.0468	-0.0462	0.2037	0.2246	-0.0824	-0.8870	1.0000										
pH	-0.0061	0.4247	-0.1064	0.0671	-0.3087	-0.0050	-0.1647	0.1348	1.0000									
Ammonia, Total (as N)	**-0.4688**	-0.1282	-0.3194	0.0521	0.1607	0.1526	0.4715	-0.4521	-0.1793	1.0000								
Nitrate (as N)	0.0930	-0.1305	0.0056	-0.2551	-0.2457	0.3110	0.9109	-0.8583	-0.2090	0.2762	1.0000							
Total Nitrogen	-0.2042	-0.1552	-0.1489	-0.2121	-0.0596	0.3998	0.9205	-0.8465	-0.1813	0.5728	0.8857	1.0000						
Orthophosphate-Dissolved (as P)	**-0.5800**	-0.2401	-0.2659	-0.0464	0.1155	0.1865	0.4137	-0.3732	-0.1492	0.8918	0.2582	0.5747	1.0000					
Phosphorus (P)-Total Dissolved	**-0.5346**	-0.1222	-0.2556	-0.0615	0.0817	0.1177	0.4099	-0.4389	-0.0652	0.9001	0.2384	0.5457	0.9740	1.0000				
Phosphorus (P)-Total	**-0.6012**	-0.0581	-0.3641	0.0185	0.3051	0.2835	0.4655	-0.4209	-0.0460	0.9035	0.2130	0.5691	0.9166	0.9301	1.0000			
Dissolved Organic Carbon	**-0.6613**	-0.1223	-0.3684	0.3756	0.3935	0.2696	-0.0118	0.0887	0.1472	0.6806	-0.2074	0.1523	0.6650	0.6347	0.7689	1.0000		
Total Organic Carbon	**-0.5037**	0.1978	-0.5079	0.1688	0.4518	0.1559	-0.0136	0.1251	0.1559	0.6229	-0.3112	0.0305	0.6084	0.6117	0.7199	0.8178	1.0000	
Sodium (Na)-Total	**-0.5891**	-0.0211	-0.2882	0.1293	0.2015	0.3911	0.6215	-0.5434	0.0945	0.8057	0.4580	0.7359	0.8161	0.8176	0.8916	0.6726	0.5403	1.0000

CORRELATION OF TOTAL B-C SCORES AND SUPPORTING ENVIRONMENT INFORMATION COLLECTED AT IN THE KOETENAY RIVER IN EEM CYCLE 7

	B-C	Depth	Velocity	Dom Sub	Sec Sub	Temp	Cond	DO	pH	Ammonia, Total (as N)	Nitrate (as N)	Total Nitrogen	Orthophosphate-Dissolved	Phosphorus (P)-Total	Phosphorus (P)-Total	Dissolved Organic Carbon	Total Organic Carbon	Sodium (Na)-Total
B-C	1.0000																	
Depth	-0.2192	1.0000																
Velocity	-0.2438	0.0012	1.0000															
Dom Sub	0.3966	0.0032	0.0342	1.0000														
Sec Sub	**0.5450**	-0.1132	-0.2961	0.2079	1.0000													
Temp	0.2881	-0.0732	-0.4452	0.0189	0.3765	1.0000												
Cond	-0.1339	0.0615	-0.1603	-0.2578	-0.0477	0.3732	1.0000											
DO	0.2024	-0.0468	-0.0462	0.2037	0.2246	-0.0824	-0.8870	1.0000										
pH	0.1004	0.4247	-0.1064	0.0671	-0.3087	-0.0050	-0.1647	0.1348	1.0000									
Ammonia, Total (as N)	**0.5140**	-0.1282	-0.3194	0.0521	0.1607	0.1526	0.4715	-0.4521	-0.1793	1.0000								
Nitrate (as N)	-0.3302	-0.1305	0.0056	-0.2551	-0.2457	0.3110	0.9109	-0.8583	-0.2090	0.2762	1.0000							
Total Nitrogen	0.0149	-0.1552	-0.1489	-0.2121	-0.0596	0.3998	0.9205	-0.8465	-0.1813	0.5728	0.8857	1.0000						
Orthophosphate-Dissolved (as P)	**0.5650**	-0.2401	-0.2659	-0.0464	0.1155	0.1865	0.4137	-0.3732	-0.1492	0.8918	0.2582	0.5747	1.0000					
Phosphorus (P)-Total Dissolved	**0.5351**	-0.1222	-0.2556	-0.0615	0.0817	0.1177	0.4099	-0.4389	-0.0652	0.9001	0.2384	0.5457	0.9740	1.0000				
Phosphorus (P)-Total	**0.6729**	-0.0581	-0.3641	0.0185	0.3051	0.2835	0.4655	-0.4209	-0.0460	0.9035	0.2130	0.5691	0.9166	0.9301	1.0000			
Dissolved Organic Carbon	**0.8203**	-0.1223	-0.3684	0.3756	0.3935	0.2696	-0.0118	0.0887	0.1472	0.6806	-0.2074	0.1523	0.6650	0.6347	0.7689	1.0000		
Total Organic Carbon	**0.6488**	0.1978	-0.5079	0.1688	0.4518	0.1559	-0.0136	0.1251	0.1559	0.6229	-0.3112	0.0305	0.6084	0.6117	0.7199	0.8178	1.0000	
Sodium (Na)-Total	**0.5850**	-0.0211	-0.2882	0.1293	0.2015	0.3911	0.6215	-0.5434	0.0945	0.8057	0.4580	0.7359	0.8161	0.8176	0.8916	0.6726	0.5403	1.0000

NF vs REF	Significant	Anderson	Levene's	Test
Density		< 0.01*	0.782	mann-U try logging

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
LOCATIONS	99,507,201.64	1	99,507,201.64	2.293	0.161
Error	4.34E+08	10	43,400,909.39		

Log Density	Yes	0.089	0.421	ANOVA

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
LOCATIONS	1.229	1	1.229	7.767	0.019
Error	1.582	10	0.158		

Taxa	Yes	> 0.15*	0.375	ANOVA

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
LOCATIONS	70.083	1	70.083	4.773	0.054
Error	146.833	10	14.683		

Simpson's Evenness	Yes	> 0.15*	0.048	T-test

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
LOCATIONS	0.074	1	0.074	12.124	0.006
Error	0.061	10	0.006		

Separate Variance

Variable	LOCATION$	Mean Difference	95.00% Confidence Interval		t	df	p-Value	
			Lower Limit	Upper Limit				
EVENNESS	NF	-0.157	-0.265	-0.049	-3.482	6.484	0.012	Yes
	REF							

Bray-Curtis

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value	
LOCATIONS	0.378	1	0.378	12.431	0.005	Yes
Error	0.304	10	0.03			

			0.024	0.273	Mann-U

Mann-Whitn	:	30	
p-Value	:	0.055	Yes
Chi-Square	:	3.692	
df	:	1	

Kruskal-Wallis Test Statistic: 3.692

The p-value is 0.055 assuming chi-square distribution with 1 df.

FF vs REF

	Significant	Anderson	Levene's	Test
Density				
Analysis of Variance		< 0.01*	0.521	mann-U
				try log

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value	Significant
LOCATIONS	1.14E+08	1	1.14E+08	2.884	0.12	No
Error	3.94E+08	10	39,388,865.28			

Log Density	0.032	0.256	mann-U

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value	Significant
LOCATIONS	1.377	1	1.377	9.447	0.012	Yes
Error	1.458	10	0.146			

Mann-Whitn	: 30	
p-Value	: 0.055	Yes
Chi-Square	: 3.692	
df	: 1	

Kruskal-Wallis Test Statistic: 3.692

The p-value is 0.055 assuming chi-square distribution with 1 df.

Taxa			
Analysis of Variance	> 0.15*	0.861	ANOVA

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value	Significant
LOCATIONS	75	1	75	4.174	0.068	Yes
Error	179.667	10	17.967			

Evenness			
Analysis of Variance	> 0.15*	0.083	ANOVA

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value	Significant
LOCATIONS	0.049	1	0.049	7.684	0.02	Yes
Error	0.063	10	0.006			

Bray-Curtis

Analysis of Variance

< 0.01* 0.18 Mann-U

Source	Type III SS	df	Mean Squares	F-Ratio	p-Value	
LOCATIONS	0.481	1	0.481	17.034	0.002	Yes
Error	0.282	10	0.028			

Mann-Whitn	:	32
p-Value	:	0.025
Chi-Square	:	5.026
df	:	1

Yes

Kruskal-Wallis Test Statistic: 5.026

The p-value is 0.025 assuming chi-square distribution with 1 df.

Appendix D **Fish Survey Information**

Summary of Previous Fish Health Results as Presented in Hatfield 2014

Cycle One

In the EEM Cycle One fish survey (October 1994), mountain whitefish and largescale sucker were selected as sentinel species, based on their biology, ecology, distribution and abundance. Both sentinel species were collected from the Kootenay River from reference (Canal Flats) and near-field (Mill) areas. Mountain whitefish were captured in sufficient numbers from reference and near-field areas; however, largescale sucker were not (27 at Canal Flats, 20 in the near-field), partly because sampling was curtailed to avoid incidental impacts on spawning kokanee.

Significant age differences were observed between female mountain whitefish collected in Canal Flats and the near-field. Female mountain whitefish from Canal Flats were, on average, two years older than their counterparts from the near-field. Similarly, male whitefish from Canal Flats were, on average, four years older than male mountain whitefish from the near-field. Mountain whitefish gonads were larger in fish collected from Canal Flats relative to fish from the near-field. However, mountain whitefish condition indices (condition factor, liver somatic index, and general health) did not indicate any significant differences. Historical dioxin/furan monitoring data (Dwernychuk 1996) suggest that whitefish may travel along the Kootenay River between Canal Flats and Wasa, thus confounding interpretation of differences between sampling areas.

In contrast to whitefish, largescale sucker collected from Canal Flats (both male and female) were younger than those collected from the near-field. Canal Flats sucker were also smaller in length and weight; however, the condition factor was similar between areas. Also in contrast to white fish, largescale gonads were generally larger in near-field fish, and the gonadosomatic index for near-field fish was twice that of the reference fish (both male and female).

Cycle Two

The fish survey for Cycle Two (August 1999) focused on largescale sucker, with additional attempts made to collect redside shiner or peamouth chub as a second sentinel species. Mountain whitefish was dropped as the sentinel species, since they have a larger migration range than largescale sucker. If was felt that migration of whitefish between reference and near-field locations may have confounded Cycle One results. Sampling was conducted in August to avoid spawning kokanee in the river. Sufficient largescale sucker were collected in the near-field area (30 males and 29 females); however, only three males and 10 females were collected at Canal Flats during four days of effort.

Only eight adult redside shiner were caught and no peamouth chub. No other species were observed in sufficient numbers, except mountain whitefish (not counted). Turbid waters due to a recent landslide upstream of Canal Flats may have hampered fishing effort.

In Cycle Two, and consistent with Cycle One, female largescale suckers in the near-field area were older, heavier and grew faster (i.e., were larger-at-age) than fish from the reference area. Female largescale suckers in the near-field also exhibited larger relative liver sizes. Relative gonad size was smaller in suckers of both sexes from the near-field area than in reference area fish. Of the female sucker captured, 14 near-field fish and six reference fish exhibited differentiated ova; ova were smaller for gravid females in the near-field zone.

Few observed differences between areas were statistically significant, given statistical power was often limited by high variances and/or small sample sizes. However, the observed differences suggest a trade-off between reproduction and growth, with the near-field fish, particularly females, devoting more energy to somatic or body growth and less energy to reproduction than reference fish. No clear evidence existed that pulpmill effluent was having a negative effect on largescale sucker; rather, an enhancement effect through increased prey density may have influenced fish development in the near-field area.

Cycle Three

Study areas for the Cycle Three adult fish survey included the near-field area (Skookumchuck mill) and reference area (Canal Flats). An alternate reference area was sampled 10 to 14 km upstream of the mill at Torrent. Fish were collected by boat and backpack electrofishing during the day and after dark between April 9 and 17, 2003.

Insufficient numbers of largescale sucker were collected in the reference area; however, torrent sculpin were collected in sufficient numbers (females, males and immatures) for a small-bodied fish survey. Conclusions from the analysis of torrent sculpin variables are as follows:

- Torrent sculpin were the same age in the near-field area relative to the reference area;
- Weight-at-age and length-at-age did not differ between areas;
- Relative gonad weight was similar between sampling areas for male and female sculpin. For females, fecundity was not significantly different between areas; egg weight versus age was significantly greater in the near-field, however, egg weight versus body weight was not different;
- Condition was significantly lower for males and immatures in the near-field area relative to the reference area; differences between areas ranged from –4.9 to –

7.3%, although these differences are within the 10% critical effect size stipulated as constituting an “effect” in EEM guidance (Environment Canada 2002); and

- Relative liver weight was significantly lower in the near-field for all fish categories, with differences (based on body weight) ranging from –16.4 to –23.4%, within the 25% critical effect size for relative liver size stipulated by EEM (Environment Canada 2002).

The biological response pattern indicated lower energy storage by sculpin in the near-field area; however, energy use was not lower relative to reference fish.

Resin acids were measured in sculpin bile, as an indicator (tracer) of fish exposure to pulpmill effluent. Resin acids were not detected in sculpin bile in Cycle Three, limiting ability to confirm exposure of near-field sculpin to effluent.

Cycle Four

Torrent sculpin were again selected as a sentinel fish species in EEM Cycle Four, were collected from four areas, including two reference areas (Canal Flats and Torrent, located approximately 27 and 12 km upstream of the mill, respectively), the near-field area (Skookumchuck, immediately downstream of the mill discharge) and the far-field area (Wasa, approximately 15 km downstream). Fish were collected using backpack electrofishing in April 2006. Males, females, and immature fish were analyzed separately.

Male and female sculpin exhibited similar mean age, growth (i.e., size-at-age) and condition (i.e., weight-for-length) in reference and exposed areas. Female sculpin had larger relative liver size and greater fecundity downstream of the mill; increases in liver size were considered biologically and statistically significant. Relative liver size was also larger in immature sculpin and the increase was considered biologically, as well as statistically, significant. Differences in these variables in male sculpin generally were not significant. This biological response pattern generally indicated higher energy storage by sculpin in near-field and far-field areas, consistent with enrichment effects observed in benthos downstream of the pulpmill. Observed effects in sculpins were extended to the far-field sampling area at Wasa, approximately 15 km downstream of the pulpmill.

Table D1: Fish Survey - Detailed Data Record Male Torrent Sculpin- Canal Flats Reference

Location: Canal Flats
Species: Torrent Sculpin
Sex: Male

Fish ID	Sex	Total Length cm	Age (Yrs)	Body Weight (g)	Caracass Weight(g)	Liver Weight (g)	Gonad Weight (g)	Condition Factor	Gonad Somatic Index	Liver Somatic Index
CR-3	M	8.5	5	8.478	7.051	0.210	0.107	1.4	1.3	2.6
CR-4	M	8.3	5	6.585	5.468	0.127	0.122	1.2	1.9	2.0
CR-5	M	8.8	4	8.968	7.146	0.294	0.075	1.3	0.9	3.4
CR-8	M	9.0	4	9.510	8.131	0.214	0.097	1.3	1.1	2.3
CR-10	M	9.1	3	10.017	8.416	0.217	0.119	1.3	1.2	2.2
CR-11	M	8.1	5	7.518	6.262	0.122	0.086	1.4	1.2	1.7
CR-13	M	7.8	3	6.652	5.560	0.167	0.082	1.4	1.3	2.6
CR-19	M	7.5	5	5.806	4.971	0.143	0.055	1.4	1.0	2.5
CR-20	M	7.0	5	4.869	3.926	0.176	0.069	1.4	1.5	3.8
CR-26	M	6.8	4	3.937	3.272	0.086	0.025	1.3	0.7	2.2
CR-29	M	7.6	3	4.501	3.674	0.111	0.059	1.0	1.4	2.6
CR-31	M	7.4	5	5.327	4.497	0.143	0.043	1.3	0.8	2.8
CR-32	M	7.1	3	4.508	3.738	0.097	0.058	1.3	1.3	2.2
CR-35	M	8.7	6	9.777	8.408	0.216	0.117	1.5	1.2	2.3
CR-36	M	7.6	5	6.148	5.096	0.162	0.066	1.4	1.1	2.7
CR-37	M	8.7	4	9.162	7.886	0.189	0.106	1.4	1.2	2.1
CR-40	M	8.4	4	6.799	5.726	0.104	0.060	1.1	0.9	1.6
CR-41	M	8.1	5	7.403	6.161	0.171	0.095	1.4	1.3	2.4
CR-42	M	7.7	5	7.473	6.334	0.235	0.095	1.6	1.3	3.3
CR-43	M	7.4	4	5.633	4.879	0.100	0.107	1.4	2.0	1.8
CR-45	M	7.9	4	6.100	5.044	0.192	0.052	1.2	0.9	3.3
CR-47	M	6.9	4	4.755	3.889	0.134	0.055	1.4	1.2	2.9
Sample Size		22	22	22	22	22	22	22	22	22
Mean		7.9	4.3	6.815	5.706	0.164	0.080	1.3	1.2	2.5
Median		7.9	4.0	6.619	5.514	0.165	0.079	1.4	1.2	2.5
Minimum		6.8	3.0	3.937	3.272	0.086	0.025	1.0	0.7	1.6
Maximum		9.1	6.0	10.017	8.416	0.294	0.122	1.6	2.0	3.8
Standard Deviation		0.68	0.82	1.823	1.567	0.052	0.027	0.13	0.31	0.56
Standard Error		0.14	0.17	0.389	0.334	0.011	0.006	0.03	0.07	0.12

Table D2: Fish Survey - Detailed Data Record Male Torrent Sculpin- Torrent Reference

Location: Torrent Sculpin
Species: Torrent Reference
Sex: Male

Fish ID	Sex	Total Length cm	Age (Yrs)	Body Weight (g)	Caracass Weight(g)	Liver Weight (g)	Gonad Weight (g)	Condition Factor	Gonad Somatic Index	Liver Somatic Index
TR-3	M	7.4	4	5.500	4.700	0.146	0.065	1.4	1.2	2.8
TR-4	M	7.5	4	6.200	5.200	0.144	0.077	1.5	1.3	2.4
TR-5	M	7.8	3	6.300	5.300	0.155	0.041	1.3	0.7	2.5
TR-7	M	8.2	4	7.000	6.100	0.181	0.110	1.3	1.6	2.7
TR-8	M	8.5	4	8.400	6.600	0.355	0.092	1.4	1.2	4.5
TR-9	M	8.1	5	6.500	5.500	0.112	0.100	1.2	1.6	1.8
TR-13	M	7.2	2	5.040	4.168	0.145	0.054	1.4	1.1	3.0
TR-15	M	8.6	4	7.760	6.390	0.151	0.090	1.2	1.2	2.0
TR-23	M	8.0	5	6.872	5.674	0.209	0.082	1.3	1.2	3.2
TR-24	M	8.3	5	7.986	6.781	0.142	0.080	1.4	1.0	1.8
TR-29	M	8.1	5	6.614	5.613	0.177	0.112	1.2	1.8	2.8
TR-30	M	7.6	4	5.190	4.323	0.104	0.080	1.2	1.6	2.1
TR-31	M	8.1	6	7.362	6.027	0.233	0.071	1.4	1.0	3.3
TR-32	M	8.2	6	7.263	6.096	0.183	0.122	1.3	1.8	2.6
TR-34	M	7.1	6	3.934	3.302	0.066	0.034	1.1	0.9	1.7
TR-39	M	7.1	5	4.654	3.880	0.116	0.042	1.3	0.9	2.6
TR-44	M	7.2	4	4.617	3.885	0.082	0.068	1.2	1.5	1.8
TR-45	M	7.2	4	5.106	4.214	0.114	0.066	1.4	1.3	2.3
TR-47	M	7.4	3	4.972	4.124	0.115	0.064	1.2	1.3	2.4
TR-56	M	7.2	4	4.419	3.666	0.129	0.055	1.2	1.3	3.0
TR-58	M	7.4	2	5.329	4.568	0.105	0.083	1.3	1.6	2.0
TR-62	M	7.4	4	5.828	5.026	0.112	0.109	1.4	1.9	2.0
TR-63	M	7.3	6	4.461	3.731	0.106	0.064	1.1	1.5	2.5
TR-65	M	7.4	5	4.743	3.972	0.135	0.074	1.2	1.6	3.0
TR-67	M	7.8	2	5.572	4.601	0.107	0.094	1.2	1.8	2.0
TR-71	M	8.6	5	7.378	6.072	0.169	0.065	1.2	0.9	2.4
TR-72	M	8.2	5	8.172	6.862	0.229	0.079	1.5	1.0	2.9
TR-73	M	8.2	4	8.046	6.942	0.229	0.066	1.5	0.9	3.0
TR-74	M	7.9	5	5.786	4.879	0.176	0.053	1.2	1.0	3.2
Sample Size		29	29	29	29	29	29	29	29	29
Mean		7.8	4.3	6.104	5.110	0.153	0.076	1.3	1.3	2.6
Median		7.8	4.0	5.828	5.026	0.144	0.074	1.3	1.3	2.5
Minimum		7.1	2.0	3.934	3.302	0.066	0.034	1.1	0.7	1.7
Maximum		8.6	6.0	8.400	6.942	0.355	0.122	1.5	1.9	4.5
Standard Deviation		0.47	1.12	1.288	1.070	0.057	0.022	0.11	0.33	0.58
Standard Error		0.09	0.21	0.239	0.199	0.011	0.004	0.02	0.06	0.11

Table D3: Fish Survey - Detailed Data Record Male Torrent Sculpin- Near-Field

Location: Near Field
Species: Torrent Sculpin
Sex: Male

Fish ID	Sex	Total Length cm	Age (Yrs)	Body Weight (g)	Caracass Weight(g)	Liver Weight (g)	Gonad Weight (g)	Condition Factor	Gonad Somatic Index	Liver Somatic Index
NF-1	M	8.8	5	8.678	7.167	0.162	0.147	1.3	1.8	1.9
NF-4	M	7.5	4	4.626	3.834	0.100	0.058	1.1	1.3	2.2
NF-9	M	8.1	4	6.821	5.459	0.230	0.057	1.3	0.9	3.5
NF-10	M	7.6	4	4.482	3.627	0.114	0.069	1.0	1.6	2.7
NF-11	M	7.1	3	4.303	3.648	0.112	0.065	1.2	1.6	2.7
NF-14	M	8.2	5	6.190	5.327	0.166	0.081	1.1	1.4	2.8
NF-15	M	7.8	4	6.030	4.760	0.220	0.047	1.3	0.8	3.8
NF-21	IM	7.1	4	5.035	4.112	0.132	0.033	1.4	0.7	2.7
NF-22	M	8.0	5	6.519	5.454	0.145	0.069	1.3	1.1	2.3
NF-23	M	7.6	5	5.580	4.668	0.133	0.044	1.3	0.8	2.5
NF-29	M	8.5	4	9.604	7.947	0.299	0.080	1.6	0.9	3.2
NF-30	M	7.6	5	5.206	4.392	0.107	0.076	1.2	1.5	2.1
NF-37	M	6.8	3	4.524	3.562	0.170	0.039	1.4	0.9	3.9
NF-45	M	9.4	4	13.696	10.627	0.356	0.162	1.6	1.2	2.7
NF-47	M	8.7	4	9.140	7.778	0.219	0.114	1.4	1.3	2.5
NF-48	M	8.7	4	9.198	7.875	0.216	0.124	1.4	1.4	2.4
NF-49	M	7.4	4	5.987	4.982	0.203	0.053	1.5	0.9	3.5
NF-51	M	7.3	3	5.643	4.855	0.166	0.091	1.5	1.7	3.1
NF-52	M	7.7	5	7.631	6.434	0.221	0.108	1.7	1.5	3.0
NF-53	M	8.5	5	9.087	7.956	0.204	0.103	1.5	1.2	2.3
NF-58	M	7.3	4	4.423	3.714	0.094	0.061	1.1	1.4	2.2
NF-59	M	8.4	5	8.110	6.998	0.162	0.084	1.4	1.1	2.1
NF-62	M	8.9	3	9.140	7.476	0.272	0.099	1.3	1.1	3.1
NF-64	M	7.2	3	5.491	4.714	0.171	0.084	1.5	1.6	3.3
NF-65	M	8.2	5	8.096	6.998	0.223	0.074	1.5	0.9	2.9
NF-66	M	6.7	4	3.558	2.977	0.118	0.052	1.2	1.5	3.5
NF-67	M	8.6	4	8.358	6.910	0.160	0.105	1.3	1.3	2.0
NF-69	M	8.7	5	8.696	7.583	0.166	0.086	1.3	1.0	2.0
NF-71	M	8.4	5	7.661	6.250	0.252	0.079	1.3	1.1	3.4
NF-73	M	8.4	4	8.390	7.133	0.213	0.105	1.4	1.3	2.6
NF-74	M	8.7	4	9.055	7.602	0.251	0.088	1.4	1.0	2.9
NF-75	M	8.7	5	7.543	6.329	0.208	0.066	1.1	0.9	2.9
NF-77	M	9.0	5	9.232	7.873	0.179	0.104	1.3	1.2	2.0
NF-80	M	7.7	4	6.155	5.320	0.179	0.074	1.3	1.3	3.0
NF-81	M	7.8	4	6.185	5.317	0.227	0.073	1.3	1.2	3.9
NF-85	M	8.0	5	6.353	5.271	0.148	0.080	1.2	1.3	2.4
Sample Size		36	36	36	36	36	36	36	36	36
Mean		8.0	4.3	7.067	5.915	0.186	0.082	1.3	1.2	2.8
Median		8.1	4.0	6.670	5.457	0.175	0.080	1.3	1.2	2.7
Minimum		6.7	3.0	3.558	2.977	0.094	0.033	1.0	0.7	1.9
Maximum		9.4	5.0	13.696	10.627	0.356	0.162	1.7	1.8	3.9
Standard Deviation		0.67	0.68	2.067	1.701	0.057	0.028	0.15	0.27	0.57
Standard Error		0.11	0.11	0.344	0.283	0.010	0.005	0.02	0.05	0.09

Table D4: Fish Survey - Detailed Data Record MaleTorrent Sculpin- Far-Field

Location: Far-Field
Species: Torrent Sculpin
Sex: Male

Fish ID	Sex	Total Length cm	Age (Yrs)	Body Weight (g)	Caracass Weight(g)	Liver Weight (g)	Gonad Weight (g)	Condition Factor	Gonad Somatic Index	Liver Somatic Index
FF-1	M	8.2	4	7.200	5.600	0.234	0.101	1.3	1.5	3.4
FF-8	M	9.0	3	10.245	8.478	0.425	0.084	1.4	0.9	4.4
FF-9	M	9.2	3	11.196	9.346	0.407	0.146	1.4	1.4	3.8
FF-10	M	9.5	3	13.377	11.509	0.658	0.104	1.6	0.8	5.2
FF-16	M	9.4	5	11.099	9.019	0.492	0.099	1.3	0.9	4.7
FF-18	M	8.5	4	9.493	7.518	0.380	0.079	1.5	0.9	4.2
FF-20	M	8.0	4	7.016	5.624	0.323	0.050	1.4	0.8	4.9
FF-22	M	9.2	4	10.950	9.343	0.347	0.119	1.4	1.1	3.3
FF-24	M	8.5	4	8.911	7.274	0.280	0.362	1.5	4.4	3.4
FF-25	M	8.4	4	8.256	6.872	0.325	0.067	1.4	0.9	4.1
FF-30	M	9.7	5	13.368	10.692	0.614	0.116	1.5	0.9	4.9
FF-34	M	8.3	3	8.322	6.744	0.305	0.062	1.5	0.8	3.8
FF-36	M	9.1	5	10.025	8.432	0.471	0.109	1.3	1.2	5.0
FF-38	M	9.7	4	12.473	10.534	0.383	0.159	1.4	1.3	3.2
FF-39	M	8.4	5	8.787	7.211	0.464	0.080	1.5	1.0	5.6
FF-40	M	8.1	4	7.689	6.226	0.396	0.099	1.4	1.4	5.5
FF-42	M	9.5	3	11.895	9.529	0.307	0.094	1.4	0.8	2.7
FF-43	M	8.9	4	11.092	9.189	0.367	0.100	1.6	0.9	3.5
FF-44	M	8.2	4	7.774	6.593	0.221	0.120	1.4	1.6	3.0
FF-46	M	8.5	4	7.689	6.003	0.205	0.128	1.3	1.7	2.8
FF-48	M	8.3	4	9.087	7.498	0.342	0.114	1.6	1.3	4.0
FF-49	M	8.7	4	7.648	6.367	0.255	0.063	1.2	0.9	3.5
FF-50	M	9.2	4	12.187	10.357	0.485	0.148	1.6	1.3	4.2
FF-52	M	8.7	4	10.710	8.664	0.379	0.098	1.6	1.0	3.7
FF-53	M	8.8	3	10.464	8.860	0.489	0.208	1.5	2.1	5.0
FF-56	M	9.4	4	12.755	10.789	0.328	0.244	1.5	2.0	2.7
FF-57	M	7.8	4	7.113	5.732	0.242	0.082	1.5	1.2	3.6
FF-58	M	8.7	4	9.121	7.756	0.210	0.113	1.4	1.3	2.4
FF-59	M	7.5	4	6.120	5.113	0.257	0.083	1.5	1.4	4.4
FF-60	M	7.7	3	6.039	5.224	0.214	0.083	1.3	1.4	3.7
FF-61	M	8.2	5	7.758	6.425	0.203	0.077	1.4	1.0	2.7
FF-67	M	8.1	3	7.665	6.108	0.301	0.081	1.4	1.1	4.1
FF-68	M	8.6	4	7.868	6.719	0.219	0.105	1.2	1.4	2.9
FF-70	M	8.0	4	7.393	5.846	0.281	0.078	1.4	1.1	4.0
FF-71	M	9.1	3	8.980	7.733	0.355	0.079	1.2	0.9	4.2
FF-73	M	7.5	3	13.746	11.715	0.645	0.155	3.3	1.2	5.0
FF-74	M	8.7	4	9.971	8.443	0.324	0.108	1.5	1.1	3.4
FF-75	M	8.3	3	7.255	5.994	0.257	0.059	1.3	0.9	3.7
FF-76	M	9.0	5	9.744	8.315	0.305	0.106	1.3	1.1	3.3
FF-77	M	9.0	4	11.182	9.314	0.381	0.135	1.5	1.3	3.6
FF-78	M	9.6	4	12.244	10.402	0.424	0.082	1.4	0.7	3.6
FF-79	M	8.7	4	9.061	7.624	0.261	0.143	1.4	1.7	3.0
FF-80	M	7.8	4	7.329	5.977	0.277	0.084	1.5	1.2	4.0
Sample Size		43	43	43	43	43	43	43	43	43
Mean		8.6	3.9	9.495	7.877	0.350	0.112	1.5	1.2	3.9

Table D4: Fish Survey - Detailed Data Record MaleTorrent Sculpin- Far-Field

Location: Far-Field
Species: Torrent Sculpin
Sex: Male

Fish ID	Sex	Total Length cm	Age (Yrs)	Body Weight (g)	Caracass Weight(g)	Liver Weight (g)	Gonad Weight (g)	Condition Factor	Gonad Somatic Index	Liver Somatic Index
Median		8.7	4.0	9.087	7.624	0.325	0.100	1.4	1.1	3.7
Minimum		7.5	3.0	6.039	5.113	0.203	0.050	1.2	0.7	2.4
Maximum		9.7	5.0	13.746	11.715	0.658	0.362	3.3	4.4	5.6
Standard Deviation		0.59	0.62	2.078	1.803	0.114	0.054	0.30	0.58	0.80
Standard Error		0.09	0.09	0.317	0.275	0.017	0.008	0.05	0.09	0.12

Table D5: Fish Survey - Detailed Data Record FemaleTorrent Sculpin- Canal Flats Reference

Location: Canal Flats
Species: Torrent Sculpin
Sex: Female

Fish ID	Sex	Total Length (cm)	Age	Body Weight (g)	Caracass Weight (g)	Liver Weight (g)	Gonad Weight (g)	Fecundity	Egg Weight (g)	Condition Factor	Gonad Somatic Index	Liver Somatic Index
CR-1	F	9.0	6	6.837	5.039	0.144	0.869	131	0.007	0.9	14.9	2.5
CR-6	F	8.7	5	7.933	6.088	0.261	0.535	109	0.005	1.2	7.5	3.7
CR-17	F	8.6	5	8.181	6.115	0.216	0.895	128	0.007	1.3	12.7	3.1
CR-18	F	7.6	3	6.100	4.376	0.181	0.910	128	0.007	1.4	18.2	3.6
CR-22	F	8.0	5	6.798	5.015	0.190	0.961	135	0.007	1.3	17.0	3.4
CR-24	F	7.2	4	5.037	3.774	0.155	0.582	84	0.007	1.3	13.5	3.6
CR-30	F	7.2	5	5.226	3.750	0.162	0.713	109	0.007	1.4	16.4	3.7
CR-38	F	7.8	5	6.397	4.873	0.181	0.773	141	0.005	1.3	14.2	3.3
CR-39	F	7.3	4	5.908	4.278	0.155	0.920	173	0.005	1.5	19.0	3.2
CR-44	F	7.0	4	4.508	3.310	0.126	0.613	83	0.007	1.3	16.3	3.3
CR-46	F	7.8	5	6.508	4.768	0.177	0.931	137	0.007	1.4	17.2	3.3
Sample Size		11	11	11	11	11	11	11	11	11	11	11
Mean		7.8	4.6	6.312	4.671	0.177	0.791	123.5	0.006	1.3	14.7	3.3
Median		7.8	5.0	6.397	4.768	0.177	0.869	128.0	0.007	1.3	15.7	3.3
Minimum		7.0	3.0	4.508	3.310	0.126	0.535	83.0	0.005	0.9	7.2	2.5
Maximum		9.0	6.0	8.181	6.115	0.261	0.961	173.0	0.007	1.5	18.4	3.7
Standard Deviation		0.64	0.77	1.085	0.860	0.035	0.149	24.8	0.001	0.14	2.96	0.34
Standard Error		0.19	0.23	0.327	0.259	0.011	0.045	7.5	0.0002	0.04	0.89	0.10

Table D6: Fish Survey - Detailed Data Record FemaleTorrent Sculpin- Torrent Reference

Location: Reference Torrent
Species: Torrent Sculpin
Sex: Female

Fish ID	Sex	Total Length (cm)	Age	Body Weight (g)	Caracass Weight (g)	Liver Weight (g)	Gonad Weight (g)	Fecundity	Egg Weight (g)	Condition Factor	Gonad Somatic Index	Liver Somatic Index
TR-1	F	7.1	4	4.900	3.300	0.150	0.618	134	0.005	1.4	15.0	3.6
TR-2	F	7.1	4	3.700	2.800	0.106	0.337	56	0.006	1.0	10.3	3.3
TR-6	F	6.4	4	3.100	2.200	0.093	0.313	75	0.004	1.2	11.6	3.5
TR-14	F	7.1	6	4.466	3.246	0.155	0.292	26	0.011	1.2	7.3	3.9
TR-18	F	8.2	5	6.748	4.880	0.199	0.593	73	0.008	1.2	10.0	3.3
TR-20	F	7.1	4	4.905	3.520	0.158	0.690	107	0.006	1.4	17.0	3.9
TR-21	F	8.0	4	7.516	5.433	0.228	0.869	147	0.006	1.5	13.5	3.6
TR-33	F	7.1	6	4.082	2.955	0.123	0.476	78	0.006	1.1	13.7	3.5
TR-36	F	7.7	3	5.759	4.425	0.186	0.489	132	0.004	1.3	9.6	3.7
TR-37	F	7.5	6	5.224	3.731	0.135	0.692	104	0.007	1.2	15.7	3.1
TR-46	F	8.2	7	5.850	4.501	0.148	0.527	88	0.006	1.1	10.2	2.9
TR-49	F	7.3	3	4.933	3.538	0.151	0.622	125	0.005	1.3	15.0	3.6
TR-50	F	8.0	5	6.577	5.002	0.186	0.660	134	0.005	1.3	11.5	3.2
TR-54	F	7.8	5	6.144	4.592	0.145	0.887	141	0.006	1.3	17.4	2.8
TR-55	F	7.3	4	5.090	3.981	0.150	0.412	132	0.003	1.3	9.1	3.3
TR-60	F	8.8	3	9.667	6.326	0.220	1.224	171	0.007	1.4	14.9	2.7
TR-64	F	6.9	5	4.321	3.066	0.125	0.617	110	0.006	1.3	17.2	3.5
TR-70	F	8.9	4	9.972	7.458	0.304	1.262	167	0.008	1.4	15.0	3.6
TR-75	F	6.9	4	4.734	3.418	0.121	0.543	98	0.006	1.4	13.3	3.0
Sample Size		19	19	19	19	19	19	19	19	19	19	19
Mean		7.5	4.5	5.668	4.125	0.162	0.638	110.4	0.006	1.3	13.0	3.4
Median		7.3	4.0	5.090	3.731	0.150	0.617	110.0	0.006	1.3	13.5	3.5
Minimum		6.4	3.0	3.100	2.200	0.093	0.292	26.0	0.003	1.0	7.3	2.7
Maximum		8.9	7.0	9.972	7.458	0.304	1.262	171.0	0.011	1.5	17.4	3.9
Standard Deviation		0.65	1.09	1.770	1.262	0.048	0.261	36.9	0.002	0.12	2.94	0.34
Standard Error		0.15	0.25	0.406	0.289	0.011	0.060	8.5	0.0004	0.03	0.67	0.08

Table D7: Fish Survey - Detailed Data Record FemaleTorrent Sculpin- Near-Field

Location: Near Field
Species: Torrent Sculpin
Sex: Female

Fish ID	Sex	Total Length (cm)	Age	Body Weight (g)	Caracass Weight (g)	Liver Weight (g)	Gonad Weight (g)	Fecundity	Egg Weight (g)	Condition Factor	Gonad Somatic Index	Liver Somatic Index
NF-2	F	8.1	5	6.420	4.581	0.227	0.677	184	0.004	1.2	12.3	4.1
NF-3	F	6.8	4	3.804	2.672	0.122	0.576	102	0.006	1.2	18.5	3.9
NF-5	F	7.7	4	5.347	3.892	0.192	0.585	151	0.004	1.2	12.8	4.2
NF-6	F	7.5	5	4.559	3.471	0.141	0.396	73	0.005	1.1	9.8	3.5
NF-24	F	6.5	4	3.870	2.750	0.138	0.464	90	0.005	1.4	14.2	4.2
NF-25	F	7.0	5	4.483	3.112	0.142	0.673	146	0.005	1.3	18.3	3.9
NF-26	F	7.0	5	4.933	3.555	0.153	0.651	136	0.005	1.4	15.8	3.7
NF-31	F	8.0	5	4.880	3.757	0.136	0.403	72	0.006	1.0	9.3	3.1
NF-33	F	7.2	4	4.328	3.293	0.144	0.399	95	0.004	1.2	10.5	3.8
NF-46	F	8.1	4	8.708	5.744	0.302	1.200	176	0.007	1.6	16.7	4.2
NF-50	F	8.8	5	8.729	7.566	0.283	-	-	-	1.3		3.4
NF-54	F	7.2	5	6.001	4.093	0.208	0.871	162	0.005	1.6	17.7	4.2
NF-55	F	6.9	3	4.905	3.527	0.145	0.646	130	0.005	1.5	15.7	3.5
NF-57	F	7.5	5	5.361	3.858	0.174	0.668	73	0.009	1.3	14.8	3.9
NF-63	F	6.9	4	4.295	3.297	0.127	0.395	80	0.005	1.3	10.5	3.4
NF-70	F	7.4	5	5.100	3.611	0.181	0.885	163	0.005	1.3	21.9	4.5
NF-72	F	7.6	4	6.056	4.254	0.197	0.912	139	0.007	1.4	18.4	4.0
NF-76	F	7.9	4	6.824	4.768	0.201	1.213	176	0.007	1.4	22.4	3.7
NF-78	F	8.1	4	6.792	5.211	0.205	0.880	144	0.006	1.3	15.4	3.6
NF-79	F	7.3	4	5.223	3.749	0.181	0.712	125	0.006	1.3	16.4	4.2
NF-82	F	7.4	4	5.445	4.099	0.201	0.543	94	0.006	1.3	11.6	4.3
NF-83	F	7.2	4	4.454	3.215	0.128	0.570	98	0.006	1.2	15.2	3.4
Sample Size		22	22	22	22	22	21	21	21	22	21	22
Mean		7.5	4.4	5.478	4.003	0.179	0.682	124.2	0.006	1.3	15.2	3.8
Median		7.4	4.0	5.162	3.753	0.178	0.651	130.0	0.005	1.3	15.4	3.9
Minimum		6.5	3.0	3.804	2.672	0.122	0.395	72.0	0.004	1.0	9.3	3.1
Maximum		8.8	5.0	8.729	7.566	0.302	1.213	184.0	0.009	1.6	22.4	4.5
Standard Deviation		0.53	0.57	1.319	1.065	0.047	0.233	36.4	0.001	0.16	3.63	0.36
Standard Error		0.11	0.12	0.281	0.227	0.010	0.051	8.0	0.0003	0.03	0.79	0.08

Table D8: Fish Survey - Detailed Data Record FemaleTorrent Sculpin- Far-Field

Location: Far Field
Species: Torrent Sculpin
Sex: Female

Fish ID	Sex	Total Length (cm)	Age	Body Weight (g)	Caracass Weight (g)	Liver Weight (g)	Gonad Weight (g)	Fecundity	Egg Weight (g)	Condition Factor	Gonad Somatic Index	Liver Somatic Index
FF-11	F	8.5	5	8.886	6.384	0.394	1.004	147	0.007	1.4	13.4	5.3
FF-12	F	7.6	3	6.022	4.487	0.207	0.759	169	0.004	1.4	16.9	4.6
FF-14	F	10.0	5	13.901	10.494	0.506	1.430	179	0.008	1.4	13.6	4.8
FF-19	F	8.9	5	7.372	5.992	0.314	0.133	83	0.002	1.0	2.2	5.2
FF-23	F	7.7	5	5.875	4.465	0.336	0.114	13	0.009	1.3	2.6	7.5
FF-27	F	7.7	3	5.855	4.271	0.230	0.766	188	0.004	1.3	17.9	5.4
FF-31	F	7.8	3	6.041	4.318	0.245	0.644	137	0.005	1.3	14.9	5.7
FF-33	F	9.5	4	13.105	9.570	0.439	1.691	237	0.007	1.5	17.7	4.6
FF-37	F	7.7	4	5.818	4.072	0.232	0.772	158	0.005	1.3	19.0	5.7
FF-41	F	8.7	5	9.704	6.944	0.329	1.476	242	0.006	1.5	21.3	4.7
FF-45	F	7.4	4	5.999	4.328	0.201	0.863	116	0.007	1.5	19.9	4.6
FF-47	F	8.1	5	8.066	5.919	0.256	1.177	207	0.006	1.5	19.9	4.3
FF-51	F	8.4	5	9.135	6.224	0.343	1.539	196	0.008	1.5	24.7	5.5
FF-55	F	9.5	5	14.188	10.191	0.655	1.868	249	0.008	1.7	18.3	6.4
FF-66	F	8.8	5	8.845	6.450	0.293	1.223	213	0.006	1.3	19.0	4.5
FF-69	F	8.1	4	7.136	5.217	0.240	1.064	245	0.004	1.3	20.4	4.6
Sample Size		16	16	16	16	16	16	16	16	16	16	16
Mean		8.4	4.4	8.497	6.208	0.326	1.033	173.7	0.006	1.4	16.4	5.2
Median		8.3	5.0	7.719	5.956	0.304	1.034	183.5	0.006	1.4	18.1	5.0
Minimum		7.4	3.0	5.818	4.072	0.201	0.114	13.0	0.002	1.0	2.2	4.3
Maximum		10.0	5.0	14.188	10.494	0.655	1.868	249.0	0.009	1.7	24.7	7.5
Standard Deviation		0.76	0.78	2.825	2.072	0.119	0.490	62.5	0.002	0.14	5.95	0.81
Standard Error		0.19	0.20	0.706	0.518	0.030	0.123	15.6	0.0005	0.04	1.49	0.20

Table D9: Fish Survey - Detailed Data Record Immature Torrent Sculpin- Canal Flats Reference

Location: Canal Flats
Species: Torrent Sculpin
Sex: Immature

Fish ID	Sex	Total Length (cm)	Age (Yrs)	Body Weight (g)	Caracass Weight (g)	Liver Weight (g)	Condition Factor	Liver Somatic Index
CR-2	I	5.9	3	2.523	2.006	0.064	1.2	2.6
CR-7	I	5.5	2	1.879	1.551	0.051	1.1	2.8
CR-9	I	6.2	3	2.838	2.364	0.069	1.2	2.5
CR-12	I	5.6	4	2.217	1.865	0.040	1.3	1.8
CR-14	I	6.2	3	3.018	2.455	0.093	1.3	3.2
CR-16	I	5.5	4	1.806	1.462	0.034	1.1	1.9
CR-21	I	5.7	4	2.231	1.843	0.028	1.2	1.3
CR-23	I	6.4	3	3.069	2.607	0.070	1.2	2.3
CR-25	I	5.5	3	1.992	1.637	0.042	1.2	2.2
CR-27	I	6.6	4	3.121	2.624	0.069	1.1	2.3
CR-28	I	6.2	4	2.816	2.328	0.088	1.2	3.2
CR-33	I	6.5	4	3.028	2.604	0.055	1.1	1.8
CR-34	I	6.0	4	2.542	2.085	0.083	1.2	3.4
CR-15	I	7.7	3	5.019	4.292	0.131	1.1	2.7
Sample Size		14	14	14	14	14	14	14
Mean		6.1	3.4	2.7	2.3	0.1	1.2	2.4
Median		6.1	3.5	2.7	2.2	0.1	1.2	2.4
Minimum		5.5	2.0	1.8	1.5	0.0	1.1	1.3
Maximum		7.7	4.0	5.0	4.3	0.1	1.3	3.4
Standard Deviation		0.6	0.6	0.8	0.7	0.0	0.1	0.6
Standard Error		0.2	0.2	0.2	0.2	0.0	0.0	0.2

Table D10: Fish Survey - Detailed Data Record Immature Torrent Sculpin- Torrent Reference

Location: Torrent Reference
Species: Torrent Sculpin
Sex: Immature

Fish ID	Sex	Total Length (cm)	Age (Yrs)	Body Weight (g)	Caracass Weight (g)	Liver Weight (g)	Condition Factor	Liver Somatic Index
TR-28	I	5.2	3	1.783	1.516	0.049	1.3	2.8
TR-35	I	5.0	3	1.584	1.282	0.034	1.3	2.2
TR-38	I	4.9	3	1.431	1.119	0.029	1.2	2.1
TR-40	I	6.8	4	3.635	3.059	0.078	1.2	2.2
TR-41	I	5.3	5	1.669	1.366	0.031	1.1	1.9
TR-42	I	6.6	4	3.561	2.894	0.069	1.2	2.0
TR-43	I	5.9	4	2.399	1.910	0.065	1.2	2.8
TR-48	I	6.9	3	3.295	2.728	0.067	1.0	2.1
TR-51	I	7.1	5	4.069	3.322	0.072	1.1	1.8
TR-52	I	6.1	3	2.814	2.308	0.043	1.2	1.6
TR-53	I	6.4	6	2.653	2.166	0.049	1.0	1.9
TR-57	I	6.9	4	3.581	3.038	0.055	1.1	1.6
TR-59	I	5.3	3	1.895	1.500	0.040	1.3	2.2
TR-61	I	6.8	5	3.312	2.797	0.060	1.1	1.8
TR-66	I	6.0	4	2.496	2.034	0.068	1.2	2.8
TR-68	I	6.2	3	2.826	2.314	0.045	1.2	1.6
TR-26	I	5.5	6	1.853	1.438	0.040	1.1	2.2
TR-10	I	5.7	3	2.063	1.746	0.036	1.1	1.8
TR-11	I	6.2	4	2.676	2.135	0.060	1.1	2.3
TR-12	I	6.4	4	3.042	2.505	0.067	1.2	2.3
TR-16	I	5.0	3	1.590	1.223	0.061	1.3	4.0
TR-17	I	7.1	5	3.308	2.621	0.077	0.9	2.4
TR-19	I	5.7	4	2.435	1.941	0.060	1.3	2.5
TR-22	I	5.7	4	2.175	1.732	0.034	1.2	1.6
TR-25	I	6.3	5	2.858	2.340	0.061	1.1	2.2
TR-27	I	6.5	4	3.167	2.595	0.068	1.2	2.2
TR-69	I	7.2	4	4.880	4.059	0.086	1.3	1.8
Sample Size		27	27	27	27	27	27	27
Mean		6.1	4.0	2.7	2.2	0.1	1.2	2.2
Median		6.2	4.0	2.7	2.2	0.1	1.2	2.2
Minimum		4.9	3.0	1.4	1.1	0.0	0.9	1.6
Maximum		7.2	6.0	4.9	4.1	0.1	1.3	4.0
Standard Deviation		0.7	0.9	0.8	0.7	0.0	0.1	0.5
Standard Error		0.1	0.2	0.2	0.1	0.0	0.0	0.1

Table D11: Fish Survey - Detailed Data Record Immature Torrent Sculpin- Near-Field

Location: Near Field
Species: Torrent Sculpin
Sex: Immature

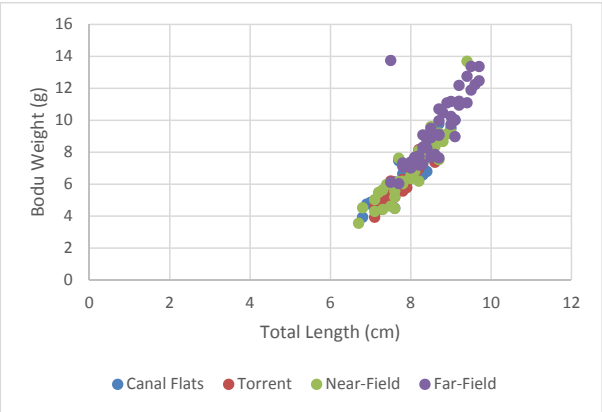
Fish ID	Sex	Total Length (cm)	Age (Yrs)	Body Weight (g)	Caracass Weight (g)	Liver Weight (g)	Condition Factor	Liver Somatic Index
NF-12	I	5.4	4	1.825	1.482	0.046	1.2	2.6
NF-13	I	7.0	4	3.603	3.077	0.075	1.1	2.1
NF-16	I	6.9	4	3.472	2.897	0.119	1.1	3.5
NF-17	I	3.3	2	0.410	0.311	0.010	1.1	2.5
NF-18	I	5.8	4	1.889	1.521	0.037	1.0	2.0
NF-19	I	5.1	4	1.380	1.145	0.030	1.0	2.2
NF-20	I	6.8	4	3.908	3.138	0.133	1.2	3.5
NF-27	I	7.3	4	4.260	3.647	0.096	1.1	2.3
NF-28	I	6.5	3	3.300	2.772	0.066	1.2	2.0
NF-32	I	4.0	3	0.928	0.739	0.029	1.5	3.2
NF-34	I	6.2	4	2.249	1.940	0.042	0.9	1.9
NF-36	I	3.9	2	0.654	0.549	0.011	1.1	1.7
NF-38	I	6.7	3	3.595	2.764	0.074	1.2	2.1
NF-39	I	6.4	4	3.200	2.459	0.078	1.2	2.5
NF-40	I	6.1	3	2.768	2.251	0.111	1.2	4.2
NF-41	I	4.8	3	1.253	1.039	0.024	1.1	2.0
NF-42	I	5.1	4	1.161	0.961	0.028	0.9	2.5
NF-43	I	7.2	3	4.796	4.041	0.162	1.3	3.5
NF-44	I	3.9	3	0.596	0.502	0.014	1.0	2.4
NF-56	I	5.7	3	2.173	1.791	0.044	1.2	2.1
NF-60	I	5.8	3	2.515	2.037	0.098	1.3	4.1
NF-61	I	5.6	4	2.183	1.818	0.056	1.2	2.6
NF-68	I	7.1	3	4.204	3.484	0.187	1.2	4.7
NF-7	I	6.4	5	2.282	1.924	0.046	0.9	2.1
NF-8	I	4.5	2	0.804	0.685	0.014	0.9	1.8
NF-84	I	6.9	4	3.755	3.137	0.125	1.1	3.4
NF-35	I	8.0	5	5.958	4.826	0.155	1.2	2.7
NF-21	I	7.1	4	5.035	4.112	0.132	1.4	2.7
Sample Size		28	28	28	28	28	28	28
Mean		5.9	3.5	2.6	2.2	0.1	1.1	2.7
Median		6.2	4.0	2.4	2.0	0.1	1.2	2.5
Minimum		3.3	2.0	0.4	0.3	0.0	0.9	1.7
Maximum		8.0	5.0	6.0	4.8	0.2	1.5	4.7
Standard Deviation		1.2	0.8	1.5	1.2	0.1	0.1	0.8
Standard Error		0.2	0.1	0.3	0.2	0.0	0.0	0.1

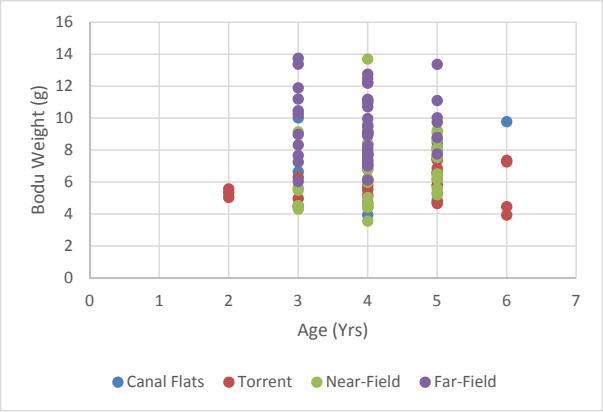
Table D12: Fish Survey - Detailed Data Record Immature Torrent Sculpin- Torrent Reference

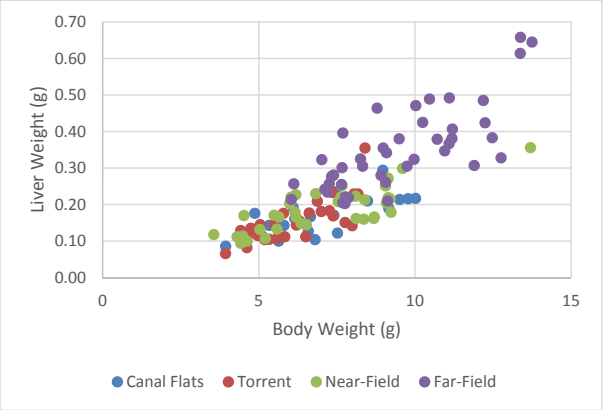
Location: Far Field
Species: Torrent Sculpin
Sex: Immature

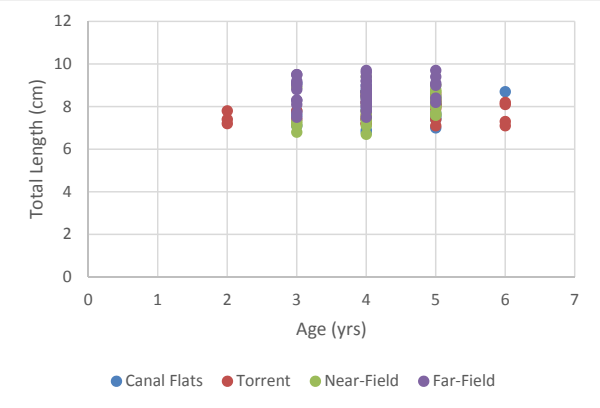
Fish ID	Sex	Total Length (cm)	Age (Yrs)	Body Weight (g)	Caracass Weight (g)	Liver Weight (g)	Condition Factor	Liver Somatic Index
FF-2	I	4.1	2	0.816	0.595	0.042	1.2	5.4
FF-3	I	3.9	2	0.881	0.623	0.037	1.5	4.4
FF-4	I	4.2	2	0.901	0.631	0.031	1.2	3.6
FF-5	I	4.0	2	0.808	0.606	0.034	1.3	4.4
FF-6	I	4.4	2	1.013	0.761	0.039	1.2	4.0
FF-7	I	3.8	1	0.651	0.503	0.030	1.2	4.8
FF-13	I	6.1	3	2.337	1.901	0.051	1.0	2.2
FF-15	I	6.4	3	3.157	2.591	0.127	1.2	4.2
FF-17	I	7.0	4	4.140	3.249	0.142	1.2	3.6
FF-21	I	6.5	4	3.720	2.918	0.189	1.4	5.4
FF-26	I	7.0	3	3.727	3.186	0.092	1.1	2.5
FF-28	I	5.6	4	2.150	1.676	0.065	1.2	3.1
FF-29	I	7.0	3	4.111	3.377	0.118	1.2	3.0
FF-32	I	7.5	4	4.894	4.058	0.190	1.2	4.0
FF-35	I	6.8	3	3.641	3.039	0.091	1.2	2.6
FF-54	I	4.1	2	0.879	0.745	0.030	1.3	3.5
FF-62	I	4.1	2	0.793	0.711	0.023	1.2	3.0
FF-64	I	7.0	4	4.166	3.576	0.121	1.2	3.0
FF-65	I	4.2	2	0.919	0.751	0.025	1.2	2.8
FF-72	I	6.8	3	3.918	3.257	0.128	1.2	3.4
FF-63	I	8.4	3	7.732	6.520	0.318	1.3	4.3
Sample Size		21	21	21	21	21	21	21
Mean		5.7	2.8	2.6	2.2	0.1	1.2	3.7
Median		6.1	3.0	2.3	1.9	0.1	1.2	3.6
Minimum		3.8	1.0	0.7	0.5	0.0	1.0	2.2
Maximum		8.4	4.0	7.7	6.5	0.3	1.5	5.4
Standard Deviation		1.5	0.9	1.9	1.6	0.1	0.1	0.9
Standard Error		0.3	0.2	0.4	0.3	0.0	0.0	0.2

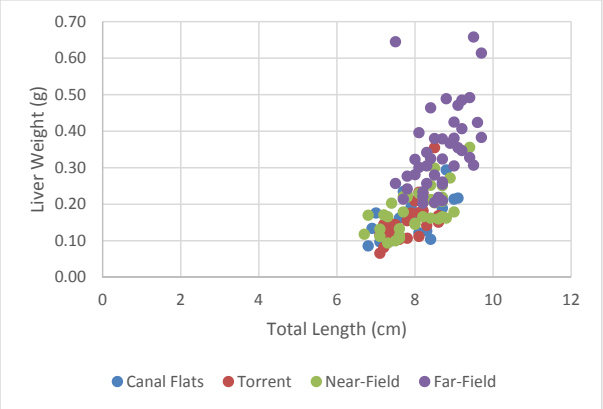
Figure D1: Male Torrent Sculpin Plots











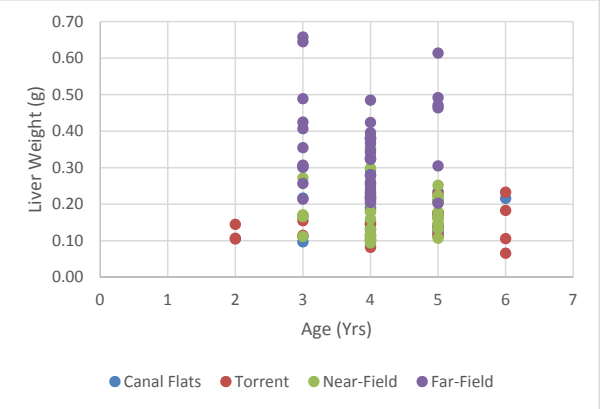
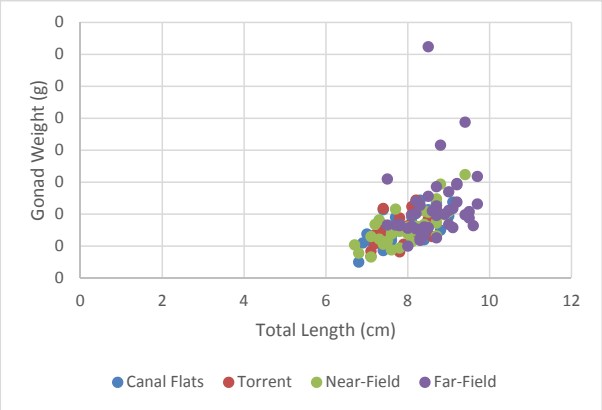
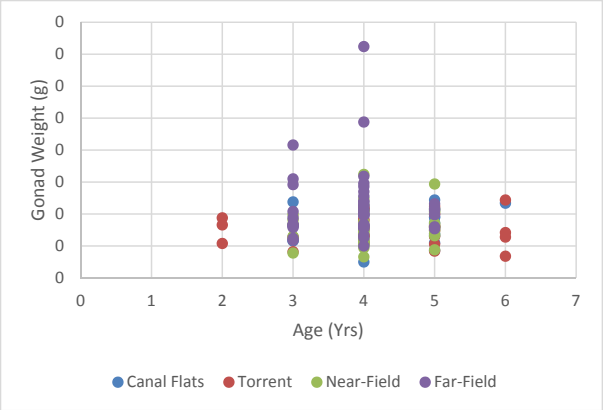


Figure D2: Male Torrent Sculpin Plots





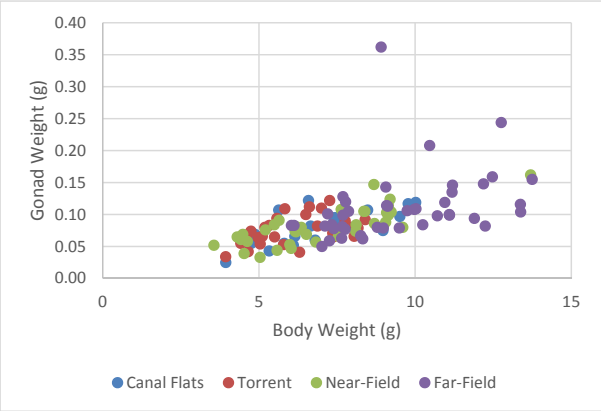
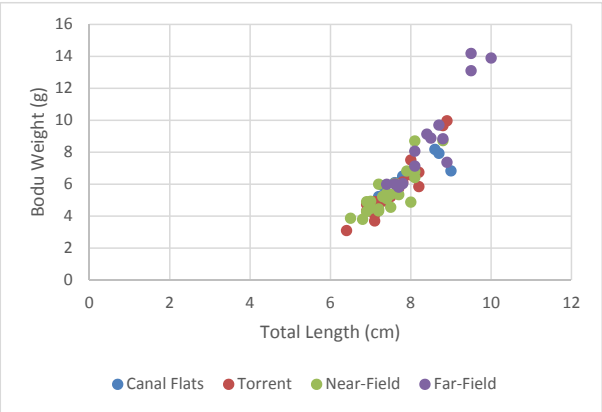
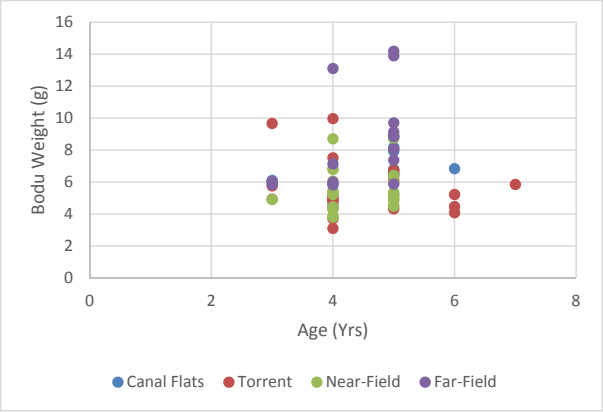
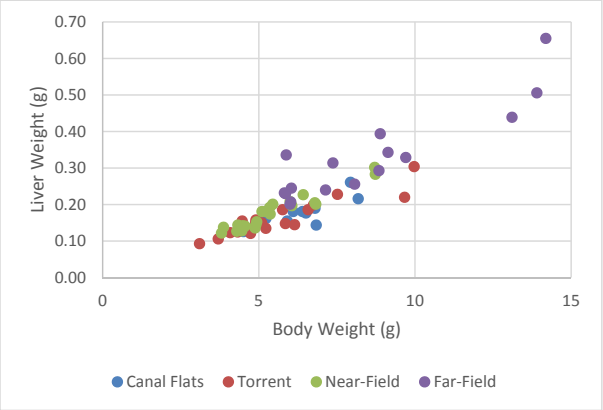
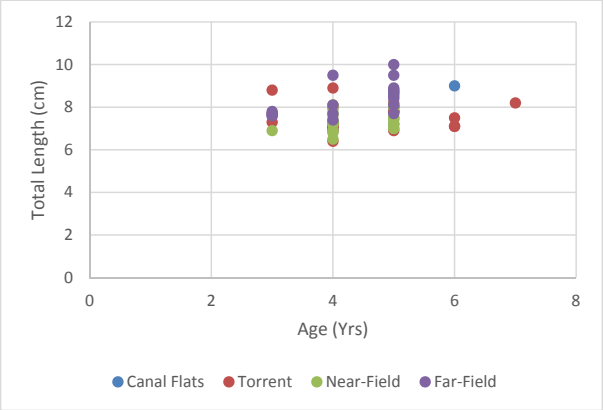


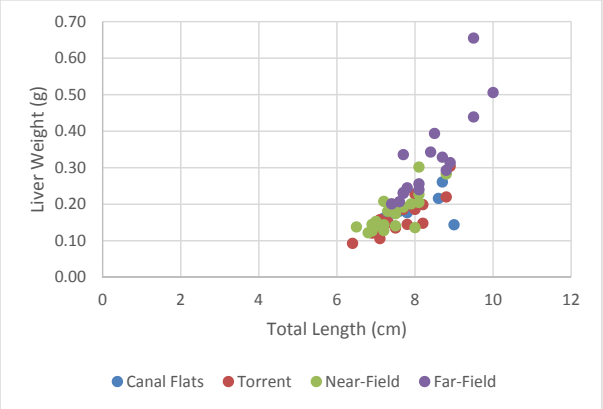
Figure D3: Female Torrent Sculpin Plots











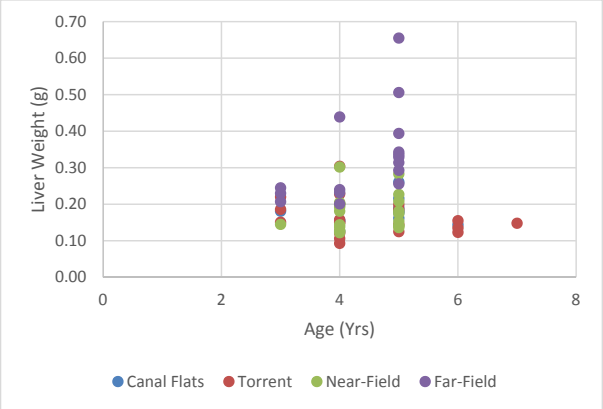
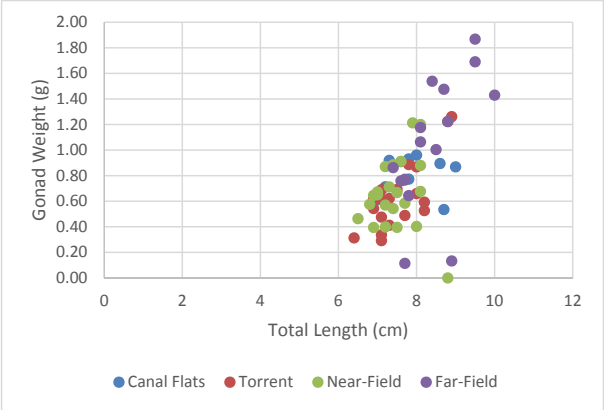
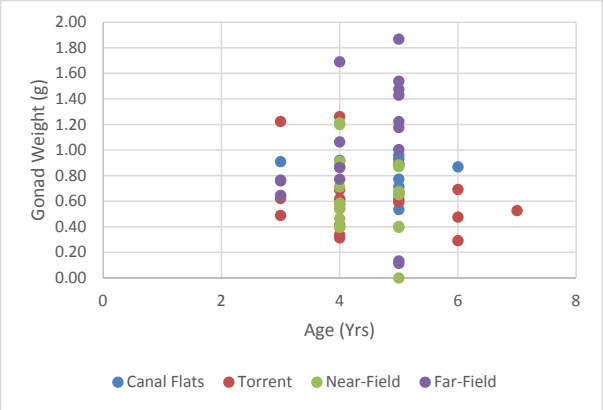
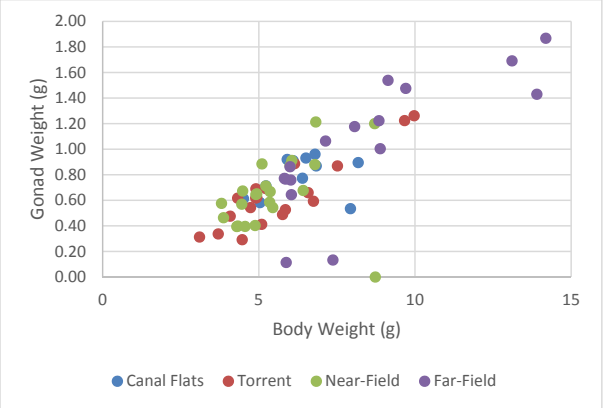
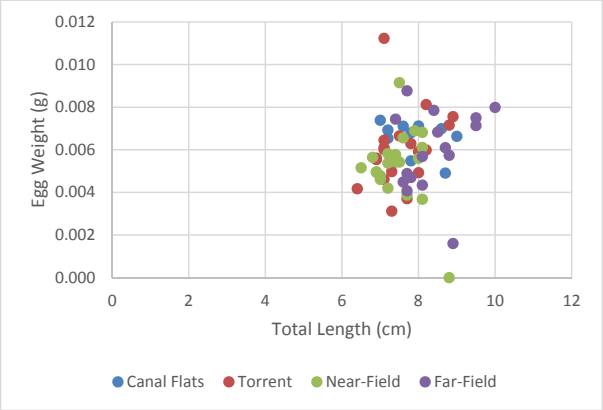


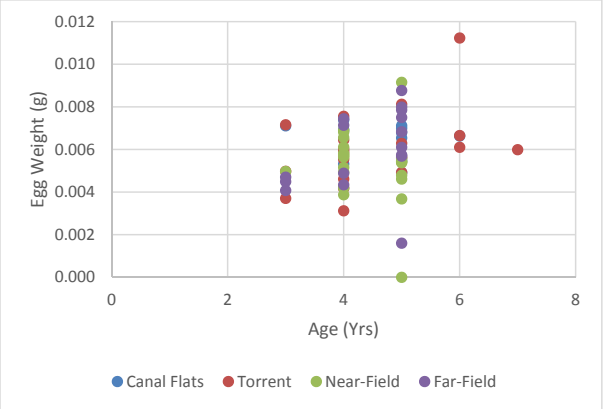
Figure D4: Female Torrent Sculpin Plots











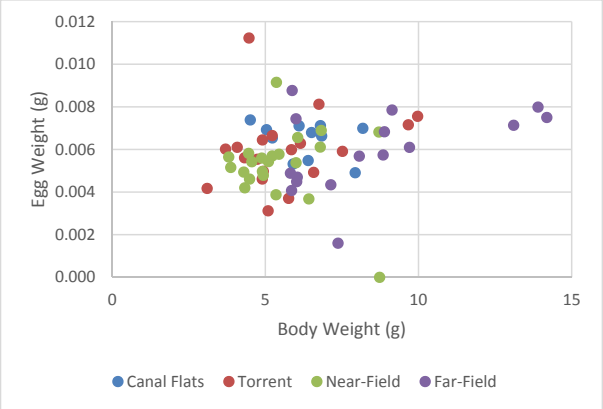
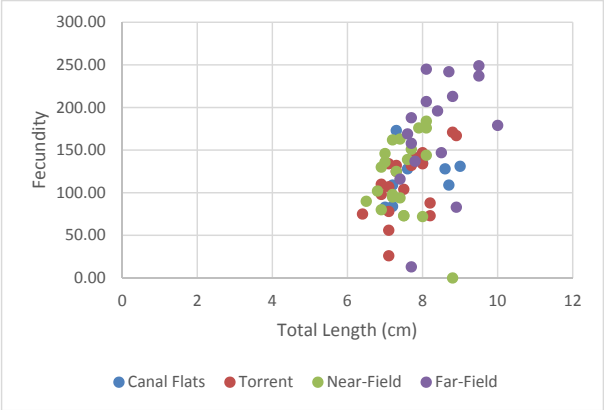
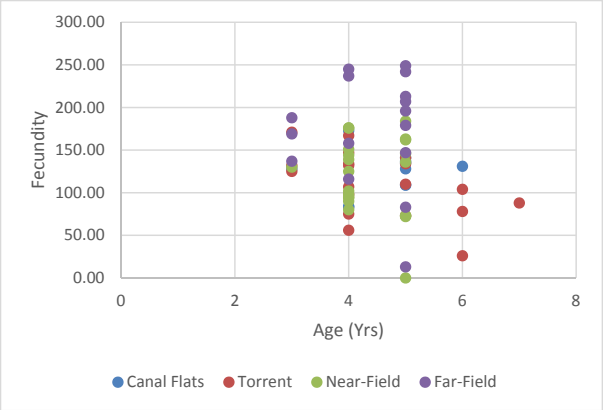


Figure D5: Female Torrent Sculpin Plots





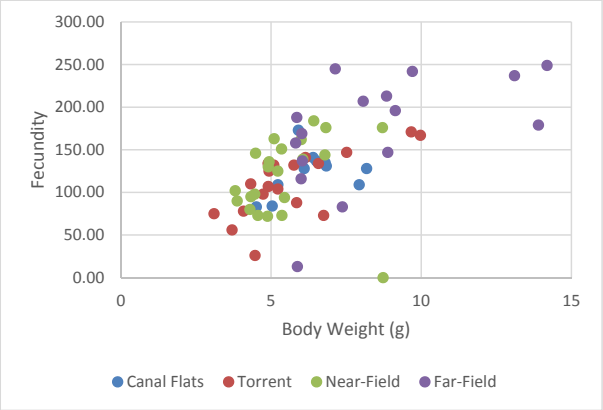
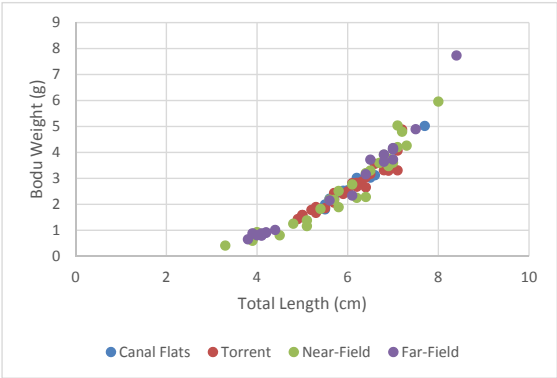
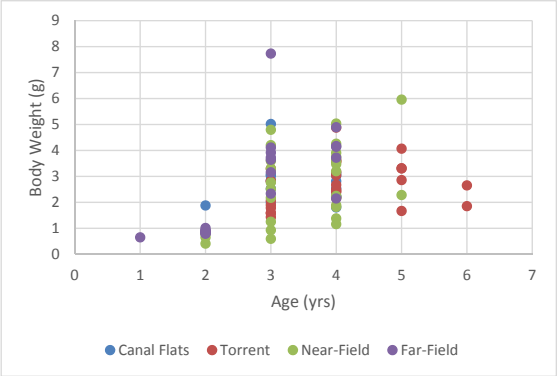
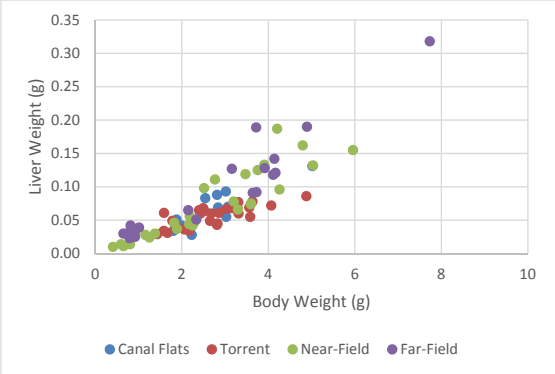
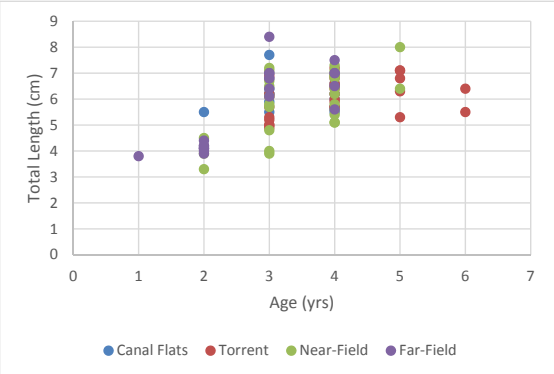


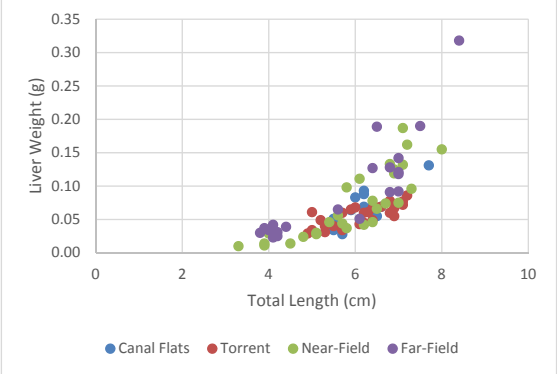
Figure D6: Immature Torrent Sculpin Plots

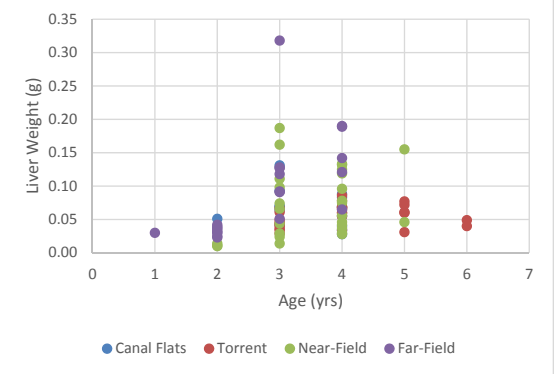












Statistical Analyses of Cycle 7 EEM Skookumchuck Sculpin Data

Torrent Reference
Reference vs Near-Field

Gender	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis					Power Analysis Effect Size = 25% except Condition = 10%	Post Hoc Power Analysis	Interaction Resolution Method[5]
				Interaction Statistic[1] (P)	Intercept Statistic[2] (P)	SSD[3]	Direction	Magnitude[4] (%)			
Male	Survival	Age[6]	Effect	n/a	0.606	No	-	-	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	0.967	0.426	No	-	-	20	0.971	-
		Relative liver size (liver weight @ body weight)	Effect	0.121	**0.030**	Yes	NF > Ref	12	16	-	2
		Relative liver size (liver weight @ carcass weight)	Support	0.357	**0.060**	Yes	NF > Ref	11	-	-	2
		Relative liver size (liver weight @ total length)	Support	0.659	0.160	No	-	-	-	-	-
	Energy Use	Size (Body Weight) @ Age (Age = 4)	Effect	n/a	0.294	No	-	-	nc	nc	-
		Size (Body Weight) @ Age (Age = 5)	Effect	n/a	0.100	No	-	-	nc	nc	-
		Size (Total Length) @ Age (Age = 4)	Support	n/a	0.290	No	-	-	-	-	-
		Size (Total Length) @ Age (Age = 5)	Support	n/a	0.131	No	-	-	-	-	-
		Relative gonad size (gonad weight @ body weight)[7]	Effect	0.384	0.470	No	-	-	23	0.951	-
		Relative gonad size (gonad weight @ carcass weight)[7]	Support	0.656	0.450	No	-	-	-	-	-
		Relative gonad size (gonad weight @ total length)[7]	Support	0.622	0.599	No	-	-	-	-	-
		Body weight[7]	Support	n/a	**0.059**	Yes	NF > Ref	14	-	-	-
		Carcass weight[7]	Support	n/a	**0.062**	Yes	NF > Ref	13	-	-	-
		Total length[7]	Support	n/a	**0.087**	Yes	NF > Ref	3	-	-	-
Female	Survival	Age[6]	Effect	n/a	0.854	No	-	-	nc	nc	-
	Energy Storage	Condition (body weight @ total length)	Effect	0.198	0.934	No	-	-	29	0.757	-
		Relative liver size (liver weight @ body weight)[7]	Effect	0.155	**3.29E-04**	Yes	NF > Ref	13	5	-	-
		Relative liver size (liver weight @ carcass weight)	Support	0.518	**0.002**	Yes	NF > Ref	13	-	-	-
		Relative liver size (liver weight @ total length)	Support	0.782	**0.022**	Yes	NF > Ref	14	-	-	-
		Relative egg size (mean egg weight @ body weight)[7]	Support	0.876	0.524	No	-	-	-	-	-
		Relative egg size (mean egg weight @ carcass weight)[7,8]	Support	0.805	0.448	No	-	-	-	-	-
		Relative egg size (mean egg weight @ age) (Age = 4)[9]	Support	n/a	0.706	No	-	-	-	-	-
	Energy Use	Size (Body Weight) @ Age (Age = 4)[9]	Effect	n/a	0.942	No	-	-	nc	nc	-
		Size (Total Length) @ Age (Age = 4)[9]	Support	n/a	0.885	No	-	-	-	-	-
		Relative gonad size (gonad weight @ body weight)	Effect	0.229	**0.035**	Yes	NF > Ref	15	15	-	-
		Relative gonad size (gonad weight @ carcass weight)[7]	Support	0.732	**0.086**	Yes	NF > Ref	15	-	-	-
		Relative gonad size (gonad weight @ total length)	Support	0.578	0.172	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ body weight)	Support	0.290	**0.035**	Yes	NF > Ref	18	-	-	-
		Relative fecundity (# of eggs/female @ carcass weight)	Support	0.389	**0.037**	Yes	NF > Ref	19	-	-	-
		Relative fecundity (# of eggs/female @ total length)[10]	Support	0.855	0.210	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ age) (Age = 4)[9]	Support	n/a	0.626	No	-	-	-	-	-
		Body weight[7]	Support	n/a	0.846	No	-	-	-	-	-
		Carcass weight[7]	Support	n/a	0.850	No	-	-	-	-	-
		Total length	Support	n/a	0.644	No	-	-	-	-	-

[1] test for equal slopes
[2] test for equality of test groups
[3] statistically significant difference
[4] difference between reference and exposure relative to reference mean
[5] Interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
[6] calculated using Mann-Whitney non-parametric test due to non-normality
[7] calculated using log_{10}-transformed data
[8] ANOVA conducted due to non-signficant covariate
[9] Insufficient age classes for proper ANCOVA and only age class with sufficient data
[10] Used ranked data due to non-normality of data
n/a - not applicable

Torrent Reference
Reference vs Far-Field

Gender	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis: Interaction Statistic[1] (P)	Primary Analysis: Intercept Statistic[2] (P)	Primary Analysis: SSD[3]	Primary Analysis: Direction	Primary Analysis: Magnitude[4] (%)	Power Analysis Effect Size = 25% except Condition = 10%	Post Hoc Power Analysis	Interaction Resolution Method[5]
Male	Survival	Age[6]	Effect	n/a	**0.022**	Yes	FF < Ref	25	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[9]	Effect	0.373	**5.19E-04**	Yes	FF > Ref	31	nc	nc	-
		Condition (body weight @ total length)[7,10]	Effect	0.430	**8.32E-04**	Yes	FF > Ref	9	17	-	
		Relative liver size (liver weight @ body weight)[7]	Effect	0.314	**1.43E-05**	Yes	FF > Ref	39	5	-	-
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.273	**2.30E-06**	Yes	FF > Ref	48	-	-	-
		Relative liver size (liver weight @ total length)[11]	Support	0.255	**6.67E-06**	Yes	FF > Ref	56	-	-	-
	Energy Use	Size (Body Weight) @ Age[7] (Age = 4)	Effect	n/a	**1.16E-05**	Yes	FF > Ref	48	nc	nc	-
		Size (Total Length) @ Age (Age = 4)	Support	n/a	**1.50E-04**	Yes	FF > Ref	11	-	-	-
		Relative gonad size (gonad weight @ body weight)[8,12]	Effect	0.959	0.988	No	-	-	nc	nc	-
		Relative gonad size (gonad weight @ carcass weight)[8,13]	Support	0.607	0.971	No	-	-	-	-	-
		Relative gonad size (gonad weight @ total length)[6,8,14]	Support	0.852	0.150	No	-	-	-	-	-
		Body weight[7]	Support	n/a	**3.91E-12**	Yes	FF > Ref	55	-	-	-
		Carcass weight[7]	Support	n/a	**2.38E-11**	Yes	FF > Ref	54	-	-	-
		Total length[7]	Support	n/a	**4.08E-09**	Yes	FF > Ref	11	-	-	-
Female	Survival	Age[6]	Effect	n/a	0.931	No	-	-	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	0.941	0.219	No	-	-	22	0.868	-
		Relative liver size (liver weight @ body weight)[7]	Effect	0.743	**1.46E-06**	Yes	FF > Ref	38	8	-	-
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.700	**1.52E-06**	Yes	FF > Ref	37	-	-	-
		Relative liver size (liver weight @ total length)[9]	Support	0.799	**1.40E-07**	Yes	FF > Ref	77	-	-	-
		Relative egg size (mean egg weight @ body weight)[9]	Support	0.430	0.205	No	-	-	-	-	-
		Relative egg size (mean egg weight @ body weight)[7,15]	Support	0.623	0.423	No	-	-	-	-	-
		Relative egg size (mean egg weight @ carcass weight)[9]	Support	0.476	0.301	No	-	-	-	-	-
		Relative egg size (mean egg weight @ carcass weight)[7,15]	Support	0.530	0.478	No	-	-	-	-	-
		Relative egg size (mean egg weight @ age)	Support	**Insufficient data at any age class**				-	-	-	-
	Energy Use	Size (Body Weight) @ Age (Age = 5)	Effect	n/a	**0.032**	Yes	FF > Ref	61	nc	nc	-
		Size (Total Length) @ Age (Age = 5)	Support	n/a	**0.028**	Yes	FF > Ref	13	-	-	-
		Relative gonad size (gonad weight @ body weight)[9,16]	Effect	0.683	0.735	No	-	-	nc	nc	-
		Relative gonad size (gonad weight @ body weight)[7,17]	Effect	0.418	**0.045**	Yes	FF > Ref	19	15	-	-
		Relative gonad size (gonad weight @ carcass weight)[9,16]	Support	0.997	0.416	No	-	-	-	-	-
		Relative gonad size (gonad weight @ carcass weight)[7,17]	Support	0.366	**0.025**	Yes	FF > Ref	21	-	-	-
		Relative gonad size (gonad weight @ total length)	Support	0.567	0.454	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ body weight)[18]	Support	0.279	0.247	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ carcass weight)[19]	Support	0.583	0.222	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ total length)[9]	Support	0.852	**0.030**	Yes	FF > Ref	46	-	-	-
		Relative fecundity (# of eggs/female @ age) (Age = 4)	Support	n/a	**0.026**	Yes	FF > Ref	65	-	-	-
		Body weight[7]	Support	n/a	**5.42E-04**	Yes	FF > Ref	49	-	-	-
		Carcass weight[7]	Support	n/a	**5.06E-04**	Yes	FF > Ref	50	-	-	-
		Total length	Support	n/a	**1.42E-03**	Yes	FF > Ref	11	-	-	-

[1] test for equal slopes
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[3] statistically significant difference
[4] difference between reference and exposure relative to reference mean
[5] Interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
[6] calculated using Mann-Whitney non-parametric test due to non-normality
[7] calculated using $\log_{10}$-transformed data
[8] ANOVA conducted due to non-signficant covariate
[9] Used ranked data due to non-normality of data
[10] Extreme outlier FF-73 removed
[11] Removed extreme outlier FF-73 and TR-13,TR-34,TR-39,TR-44,TR-45,TR-56,TR-63,FF-8,FF-9,FF-10,FF-16,FF-22,FF-30,FF-36,FF-38,FF-42,FF-43, FF-50,FF-53,FF-56,FF-71,FF-76,FF-77, and FF-78 due to overlap issues
[12] Removed TR-13,TR-34,TR-39,TR-44,TR-45,TR-56,TR-63,TR-65, FF-8,FF-9,FF-10,FF-16,FF-22,FF-30,FF-36,FF-38,FF-42,FF-43, FF-50,FF-53,FF-56,FF-71,FF-76,FF-77,FF-78 and FF-79 due to overlap issues
[13] Removed TR-13,TR-34,TR-39,TR-44,TR-45,TR-56,TR-63,TR-65, TR-67,FF-8,FF-9,FF-10,FF-16,FF-22,FF-30,FF-36,FF-38,FF-42,FF-43, FF-50,FF-53,FF-56,FF-71,FF-76,FF-77,FF-78 and FF-79 due to overlap issues
[14] Removed TR-13,TR-34,TR-39,TR-44,TR-45,TR-56,TR-63,FF-8,FF-9,FF-10,FF-16,FF-22,FF-30,FF-36,FF-38,FF-42,FF-43, FF-50,FF-53,FF-56,FF-71,FF-76,FF-77,FF-78 due to overlap issues
[15] Removed extreme outlier FF-19
[16] Removed TR-1,TR-2,TR-6,TR-33,TR-64,FF-14,FF-33,FF-55 due to overlap issues
[17] Removed extreme outliers FF-19,FF-23 and TR-1,TR-2,TR-6,TR-33,TR-64,FF-14,FF-33,FF-55 due to overlap issues
[18] Removed TR-1,TR-2,TR-6,TR-14,TR-33,TR-64,TR-75,FF-14,FF-33,FF-55 due to overlap issues
[19] Removed TR-2,TR-6,TR-14,TR-33,TR-64,TR-75,FF-14,FF-33,FF-55 due to overlap issues
n/a - not applicable
nc - not calculable due to use of non-parametric test (non-normality)

Statistical Outputs of Cycle 7 Skookumchuck Sculpin Data - Near-Field

MALE

Torrent Reference

	Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
Age	**0.021**	**0.002**	**<0.0005**	6.6
Body Weight @ Total Length	0.260	0.134	0.546	2.1
Liver Weight @ Body Weight	0.972	0.267	0.391	12.5
Liver Weight @ Carcass Weight	0.065	0.432	0.327	11.4
Liver Weight @ Total Length	0.202	**0.021**	0.082	10.5
Body Weight @ Age	0.060	0.381	0.197	14.8
Body Weight @ Age	0.760	0.638	0.114	14.5

Age

Test Statistics

	Age
Mann-Whitney U	485.500
Wilcoxon W	1151.500
Z	-0.515
Asymp. Sig. (2-tailed)	0.606

Between-Subjects Factors

		N	Mean
Area	Reference	29	34.259
	Near-Field	36	31.986

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.001	1	1.18E-03	0.643	0.426
Total Length	0.717	1	0.717	390.675	**1.86E-28**
Error	0.114	62	0.002		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	29	0.801	0.008
	Exposure	36	0.810	0.007

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Adjusted Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.037	1	0.037	4.966	**0.030**
Body Weight	0.694	1	0.694	93.203	**6.73E-14**
Error	0.454	61	0.007		

Removed outlier TR-8 due to extreme Cook's Distance from interaction analysis

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	28	-0.826	0.017
	Exposure	36	-0.775	0.015

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Carcass Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.004	1	0.004	3.685	**0.060**
Carcass Weight	0.099	1	0.099	82.443	**6.26E-13**
Error	0.073	61	0.001		

Removed outlier TR-8 due to extreme Cook's Distance from interaction analysis

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	28	0.158	0.007
	Exposure	36	0.176	0.006

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.004	1	0.004	2.022	0.160
Total Length	.087	1	0.087	42.648	**1.39E-08**
Error	0.127	62	0.002		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	29	0.162	0.009
	Exposure	36	0.179	0.008

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	5.588	1	5.588	1.149	0.294
Error	126.395	26	4.861		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	6.188	1.409
	Exposure	17	7.103	2.581

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Age = 5)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	4.917	1	4.917	2.953	0.100
Error	34.965	21	1.665		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	9	6.523	1.271
	Exposure	14	7.470	1.302

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.497	1	0.497	1.168	0.290
Error	11.062	26	0.425		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	7.727	0.541
	Exposure	17	8.000	0.713

0.293	**0.040**	0.547	3.5

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 5)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.509	1	0.509	2.469	0.131
Error	4.329	21	0.206		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	9	7.967	0.458
	Exposure	14	8.271	0.451

0.733	0.247	0.690	3.8

Gonad Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.006	1	0.006	.528	0.470
Body Weight	0.595	1	0.595	50.949	**1.24E-09**
Error	0.724	62	0.012		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	29	-1.115	0.020
	Exposure	36	-1.135	0.018

0.558	0.732	0.076	4.5

Gonad Weight @ Carcass Weight

Dependent Variable:Gonad Weight (Log) @ Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.006	1	0.006	.579	0.450
Carcass Weight	0.623	1	0.623	55.561	**3.51E-10**
Error	0.695	62	0.011		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	29	-1.114	0.020
	Exposure	36	-1.135	0.018

0.499	0.456	0.196	4.7

Gonad Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.003	1	0.003	.279	0.599
Total Length	.570	1	0.570	47.168	**3.64E-09**
Error	0.749	62	0.012		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	29	-1.118	0.021
	Exposure	36	-1.133	0.019

0.593	0.524	0.528	3.4

Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.049	1	0.049	3.689	**0.059**
Error	0.831	63	0.013		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	29	0.776	0.094
	Exposure	36	0.831	0.129

0.069	0.351	0.109	13.5

Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.048	1	0.048	3.599	**0.062**
Error	0.841	63	0.013		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	29	0.699	0.094
	Exposure	36	0.753	0.130

0.050	0.275	0.091	13.4

Total Length

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.003	1	0.003	3.021	**0.087**
Error	0.068	63	0.001		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	29	0.889	0.027
	Exposure	36	0.903	0.037

0.074	**0.028**	0.166	3.3

FEMALE

Age

Test Statistics

	Age
Mann-Whitney U	202.500
Wilcoxon W	455.500
Z	-0.184
Asymp. Sig. (2-tailed)	0.854

Between-Subjects Factors

		N	Mean Rank
Area	Reference	19	21.342
	Near-Field	22	20.705

0.014	**0.028**	**<0.0005**	3.0

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.003	1	0.003	0.007	0.934
Total Length	79.157	1.000	79.157	161.333	**3.00E-15**
Error	18.644	38	0.491		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	5.556	0.161
	Near-Field	22	5.574	0.150

0.642	0.680	0.452	0.3

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.027	1	0.027	15.590	**3.29E-04**
Body Weight	0.461	1	0.461	264.658	**1.03E-18**
Error	0.066	38	0.002		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	-0.811	0.010
	Near-Field	22	-0.759	0.009

0.480	0.143	0.241	12.7

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.004	1	0.004	10.738	**2.25E-03**
Carcass Weight	0.078	1	0.078	189.788	**2.34E-16**
Error	0.016	38	0.000		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	0.160	0.005
	Near-Field	22	0.181	0.004

0.391	0.154	0.131	13.1

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.005	1	0.005	5.708	**0.022**
Total Length	.061	1	.061	70.552	**3.43E-10**
Error	0.033	38	0.001		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	0.159	0.007
	Near-Field	22	0.181	0.006

0.792	0.764	0.115	13.8

Egg Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight (Log) @ Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.005	1	0.005	0.413	0.524
Body Weight	0.036	1	0.036	3.259	**0.079**
Error	0.406	37	0.011		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	-2.241	0.024
	Near-Field	21	-2.262	0.023

0.274	0.093	**0.034**	4.7

Egg Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.007	1	0.007	0.588	0.448
Error	0.442	38	0.012		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	19	-2.239	0.126
	Near-Field	21	-2.265	0.089

Covariate not significant

0.241	0.551	0.449	5.8

Egg Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	1.94E-07	1	1.94E-07	0.147	0.706
Error	2.37E-05	18	1.32E-06		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	8	0.00542	0.00140
	Near-Field	12	0.00562	0.00095

0.240	0.892	0.595	3.7

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.018	1	0.018	.006	0.942
Error	58.049	18	3.225		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	8	5.490	2.221
	Near-Field	12	5.429	1.462

0.322	0.071	0.288	-1.1

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 4)

Source	Squares	df	Mean Square	F	Sig.
Area	0.008	1	0.008	0.021	0.885
Error	6.989	18	0.388		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	8	7.350	0.767
	Near-Field	12	7.392	0.511

0.422	0.699	0.595	0.6

Gonad Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight @ Body Weight

Source	Squares	df	Mean Square	F	Sig.
Area	0.085	1	0.085	4.773	**0.035**
Body Weight	1.777	1	1.777	99.404	**4.98E-12**
Error	0.662	37	0.018		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	0.612	0.031
	Near-Field	21	0.705	0.029

0.840	0.303	0.394	15.2

Gonad Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Carcass Weight (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.037	1	0.037	3.108	**0.086**
Carcass Weight	.545	1	.545	45.369	**6.40E-08**
Error	0.445	37	0.012		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	-0.241	0.025
	Near-Field	21	-0.180	0.024

0.933	0.120	0.424	15.1

Gonad Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.075	1	0.075	1.939	0.172
Total Length	1.014	1	1.014	26.312	**9.45E-06**
Error	1.43E+00	37	3.85E-02		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	19	0.615	0.045
	Near-Field	21	0.703	0.043

0.535	0.184	0.973	14.3

Fecundity @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Fecundity @ Body Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	3790.444	1	3790.444	4.813	**0.035**
Body Weight	24652.764	1	24652.764	31.301	**2.22E-06**
Error	29141.677	37	787.613		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	107.371	6.461
	Near-Field	21	126.997	6.144

0.681	0.145	0.706	18.3

Fecundity @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Fecundity @ Carcass Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	4071.960	1	4071.960	4.663	**0.037**
Carcass Weight	21483.483	1	21483.483	24.601	**1.60E-05**
Error	32310.958	37	873.269		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	106.961	6.815
	Near-Field	21	127.368	6.479

0.437	0.064	0.549	19.1

Fecundity @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Fecundity (Rank) @ Total Length (Rank)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	189.466	1	189.466	1.630	0.210
Total Length	899.194	1	899.194	7.737	**8.46E-03**
Error	4299.965	37	116.215		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	19	18.204	2.478
	Near-Field	21	22.578	2.357

0.503	**0.003**	0.229	24.0

Fecundity @ Age

Tests of Between-Subjects Effects

Dependent Variable:Fecundity (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	307	1	307	.245	0.626
Error	22539	18	1252		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	20	44202	2441
	Near-Field	22	54611	2327

0.877	0.892	0.150	23.5

Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	4.99E-04	1	4.99E-04	0.038	0.846
Error	0.507	39	0.013		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	19	0.734	0.130
	Near-Field	22	0.727	0.099

0.281	0.503	0.292	1.6

Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	4.95E-04	1	4.95E-04	0.036	0.850
Error	0.531	39	0.014		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	19	0.597	0.130
	Near-Field	22	0.590	0.104

0.211	0.896	0.206	1.6

Total Length

Dependent Variable:Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.079	1	0.079	0.217	0.644
Error	14.261	39	0.366		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	19	7.547	0.668
	Near-Field	22	7.459	0.545

0.260	0.152	0.559	1.2

Statistically significant at $\alpha = 0.1$

Statistical Outputs of Cycle 7 Skookumchuck Sculpin Data - Far-Field

MALE

Torrent Reference

Age

Test Statistics

	Age
Mann-Whitney U	440.000
Wilcoxon W	1386.000
Z	-2.286
Asymp. Sig. (2-tailed)	**0.022**

Between-Subjects Factors

		N	Mean Rank
Area	Reference	29	42.828
	Far-Field	43	32.233

Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
0.014	**0.048**	**0.011**	24.7

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Rank) @ Total Length (Rank)

Source	Squares	df	Mean Square	F	Sig.
Area	962	1	962	13.263	**5.19E-04**
Total Length	10690	1	10690	147.384	**8.64E-19**
Error	5005	69	73		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	29	30.762	1.868
	Far-Field	43	40.370	1.462

Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
0.052	**0.303**	**<0.0005**	31.2

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.015	1	0.015	12.233	**8.32E-04**
Total Length	0.521	1	0.521	421.421	**7.44E-31**
Error	0.084	68	0.001		

Removed FF-73 as extreme outlier

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	29	0.864	0.008
	Far-Field	42	0.903	0.006

Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
0.391	0.146	0.123	9.4

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.179	1	0.179	21.823	**1.43E-05**
Body Weight	0.852	1	0.852	103.823	**2.14E-15**
Error	0.566	69	0.008		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	29	-0.711	0.021
	Far-Field	43	-0.567	0.016

Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
0.920	0.326	0.913	39.3

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.235	1	0.235	26.584	**2.30E-06**
Carcass Weight	0.810	1	0.810	91.724	**2.68E-14**
Error	0.609	69	0.009		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	29	-0.721	0.022
	Far-Field	43	-0.550	0.017

Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
0.915	0.323	0.926	48.3

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.096	1	0.096	26.124	**6.67E-06**
Total Length	0.022	1	0.022	6.123	**1.73E-02**
Error	0.161	44	0.004		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	0.177	0.014
	Far-Field	25	0.277	0.013

Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
0.064	0.051	0.545	56.5

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) (Age =4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.227	1	0.227	26.092	**1.16E-05**
Error	0.305	35	0.009		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	0.781	0.028
	Far-Field	26	0.953	0.018

Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
0.782	0.560	0.094	48.4

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 4)

Source	Squares	df	Mean Square	F	Sig.
Area	5.530	1	5.530	18.066	**1.50E-04**
Error	10.713	35	.306		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	7.727	0.167
	Far-Field	26	8.573	0.109

0.746 **0.040** 0.787 10.9

Gonad Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight @ Body Weight

Source	Squares	df	Mean Square	F	Sig.
Area	1.06E-07	1	1.06E-07	2.47E-04	0.988
Error	0.015	36	4.28E-04		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	20	0.084	0.021
	Far-Field	18	0.083	0.021

0.831 0.464 0.066 0.1

Removed TR-13,TR-34,TR-39,TR-44,TR-45,TR-56,TR-63,TR-65, FF-8,FF-9,FF-10,FF-16,FF-22,FF-30,FF-36,FF-38,FF-42,FF-43, FF-50,FF-53,FF-56,FF-71,FF-76,FF-77,FF-78 and FF-79 due to overlap issues

Gonad Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight @ Carcass Weight

Source	Squares	df	Mean Square	F	Sig.
Area	6.28E-07	1	6.28E-07	1.36E-03	0.971
Error	0.015	33	4.63E-04		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	17	0.083	0.022
	Far-Field	18	0.083	0.021

0.528 0.572 0.066 0.3

Removed TR-13,TR-34,TR-39,TR-44,TR-45,TR-56,TR-63,TR-65, TR-67,FF-8,FF-9,FF-10,FF-16,FF-22,FF-30,FF-36,FF-38,FF-42,FF-43, FF-50,FF-53,FF-56,FF-71,FF-76,FF-77,FF-78 and FF-79 due to overlap issues

Gonad Weight @ Total Length

Test Statistics

	Age
Mann-Whitney U	216.500
Wilcoxon W	469.500
Z	-1.439
Asymp. Sig. (2-tailed)	0.150

Between-Subjects Factors

		N	Mean Rank
Area	Reference	19	21.341
	Far-Field	25	27.173

0.204 0.667 **0.045** 27.3

Removed TR-13,TR-34,TR-39,TR-44,TR-45,TR-56,TR-63,FF-8,FF-9,FF-10,FF-16,FF-22,FF-30,FF-36,FF-38,FF-42,FF-43, FF-50,FF-53,FF-56,FF-71,FF-76,FF-77,FF-78 due to overlap issues

Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.634	1	0.634	69.951	**3.91E-12**
Error	0.635	70	0.009		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	29	0.776	0.094
	Far-Field	43	0.967	0.096

0.976 0.351 0.189 55.4

Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.601	1	0.601	63.009	**2.38E-11**
Error	0.668	70	0.010		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	29	0.699	0.094
	Far-Field	43	0.885	0.100

0.710 0.275 0.261 53.6

Total Length

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.038	1	0.038	45.120	**4.08E-09**
Error	0.059	70	0.001		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	29	0.889	0.027
	Far-Field	43	0.936	0.030

0.807 **0.028** 0.274 11.4

FEMALE

Age

Test Statistics[b]

	Age
Mann-Whitney U	149.500
Wilcoxon W	285.500
Z	-.087
Asymp. Sig. (2-tailed)	0.931
Exact Sig. [2*(1-tailed Sig.)]	.935a

Between-Subjects Factors

		N	Mean Rank
Area	Reference	19	18.132
	Near-Field	16	17.844

0.456	**0.028**	**<0.0005**	1.6

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	.003	1	.003	1.569	0.219
Total Length	5.245E-01	1	5.245E-01	268.993	**3.93E-17**
Error	.062	32	.002		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	0.804	0.011
	Far-Field	16	0.826	0.012

0.593	0.204	0.096	2.7

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Body Weight (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.115	1	0.115	34.793	**1.46E-06**
Body Weight	0.484	1	0.484	145.962	**1.83E-13**
Error	0.106	32	0.003		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	20	-0.735	0.014
	Far-Field	22	-0.596	0.016

0.230	0.204	0.268	37.7

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Carcass Weight (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.113	1	0.113	34.609	**1.52E-06**
Carcass Weight	0.486	1	0.486	149.222	**1.37E-13**
Error	0.104	32	0.003		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	-0.734	0.014
	Far-Field	16	-0.597	0.016

0.183	0.574	0.097	37.1

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Rank) @ Total Length (Rank)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	676.276	1	676.276	45.072	**1.40E-07**
Total Length	832.278	1	832.278	55.469	**1.78E-08**
Error	480.143	32	15.004		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	19	13.302	0.958
	Far-Field	16	23.578	1.058

0.759	0.538	**0.004**	77.3

Egg Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight (Rank) @ Body Weight (Rank)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	155.379	1	155.379	1.673	0.205
Body Weight	595.796	1	595.796	6.416	**0.016**
Error	2971.326	32	92.854		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	19	20.349	2.439
	Far-Field	16	15.211	2.702

0.693	0.106	**0.004**	25.2

Egg Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight (Log) @ Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.008	1	0.008	0.658	0.423
Body Weight	.065	1	.065	5.185	**0.030**
Error	0.386	31	0.012		

Removed extreme outlier FF-19

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	-2.213	0.028
	Far-Field	15	-2.250	0.032

0.655	0.120	0.628	8.2

Egg Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight (Rank) @ Carcass Weight (Rank)

Between-Subjects Factors

Source	Type III Sum of Squares	df	Mean Square	F	Sig.			N	Mean Rank	Std. Error				
Area	106.360	1	106.360	1.104	0.301	Area	Reference	19	19.892	2.448	0.608	0.062	**0.007**	20.8
Carcass Weight	484.309	1	484.309	5.027	**0.032**		Far-Field	16	15.754	2.706				
Error	3082.812	32	96.338											

Egg Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight (Log) @ Carcass Weight (Log)

Between-Subjects Factors

Source	Type III Sum of Squares	df	Mean Square	F	Sig.			N	Mean	Std. Error				
Area	0.007	1	0.007	0.516	0.478	Area	Reference	19	-2.215	0.028	0.662	0.062	0.674	7.3
Carcass Weight	.057	1	.057	4.508	**0.042**		Far-Field	15	-2.248	0.032				
Error	0.394	31	0.013											

Removed extreme outlier FF-19

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Age = 5)

Between-Subjects Factors

Source	Type III Sum of Squares	df	Mean Square	F	Sig.			N	Mean	Std. Dev.				
Area	35.988	1	35.988	6.021	**0.032**	Area	Reference	4	5.9	1.114	0.215	0.113	0.089	60.6
Error	65.749	11	5.977				Far-Field	9	9.6	2.785				

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 5)

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean	Std. Dev.				
Area	2.816	1	2.816	6.389	**0.028**	Area	Reference	4	7.725	0.574	0.721	0.210	0.799	13.1
Error	4.848	11	0.441				Far-Field	9	8.733	0.695				

Gonad Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Rank) @ Body Weight (Rank)

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean Rank	Std. Error				
Area	3.385	1	3.385	.118	0.735	Area	Reference	12	12.600	1.583	0.106	**0.017**	**0.002**	6.1
Body Weight	583.917	1	583.917	20.349	**1.73E-04**		Far-Field	13	13.369	1.518				
Error	3092.386	38	81.379											

Removed TR-1,TR-2,TR-6,TR-33,TR-64,FF-14,FF-33,FF-55 due to overlap issues

Gonad Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Body Weight (Log)

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean	Std. Error				
Area	.031	1	.031	4.357	**0.045**	Area	Reference	19	-0.146	0.021	**0.040**	0.250	0.531	19.1
Body Weight	.623	1	.623	87.362	**2.15E-10**		Far-Field	14	-0.070	0.026				
Error	.214	30	.007											

Removed extreme outliers FF-19,FF-23

Gonad Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Rank) @ Carcass Weight (Rank)

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean Rank	Std. Error				
Area	21.059	1	21.059	.688	0.416	Area	Reference	12	11.995	1.641	0.060	0.093	**<0.0005**	16.1
Carcass Weight	482.035	1	482.035	15.740	**6.53E-04**		Far-Field	13	13.928	1.574				
Error	673.734	22	30.624											

Removed TR-1,TR-2,TR-6,TR-33,TR-64,FF-14,FF-33,FF-55 due to overlap issues

Gonad Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight @ Carcass Weight

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean	Std. Error				
Area	0.149	1	0.149	5.877	**0.025**	Area	Reference	12	0.799	0.047	0.262	**0.023**	0.571	20.9
Carcass Weight	1.206	1	1.206	47.620	**1.06E-06**		Far-Field	11	0.966	0.049				
Error	0.507	20	0.025											

Removed extreme outliers FF-19,FF-23 and TR-1,TR-2,TR-6,TR-33,TR-64,FF-14,FF-33,FF-55 due to overlap issues

Gonad Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.053	1	0.053	.574	0.454
Total Length	2.168	1	2.168	23.321	**3.26E-05**
Error	2.97E+00	32	9.30E-02		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	19	0.777	0.076
	Far-Field	16	0.868	0.083

0.082	0.070	**0.035**	11.7

Fecundity @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Fecundity @ Body Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	2855.946	1	2855.946	1.412	0.247
Body Weight	14334.029	1	14334.029	7.085	**1.39E-02**
Error	46529.817	23	2023.036		

Removed TR-1,TR-2,TR-6,TR-14,TR-33,TR-64,TR-75,FF-14,FF-33,FF-55 due to overlap issues

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	20	134.057	12.730
	Far-Field	22	155.867	12.730

0.025	0.245	0.266	16.3

Fecundity @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Fecundity @ Carcass Weight

Source	Squares	df	Mean Square	F	Sig.
Area	3680.413	1	3680.413	1.582	0.222
Carcass Weight	11521.118	1	11521.118	4.951	**0.037**
Error	48868.687	21	2327.080		

Removed TR-2,TR-6,TR-14,TR-33,TR-64,TR-75,FF-14,FF-33,FF-55 due to overlap issues

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	133.275	14.699
	Far-Field	13	158.614	13.500

0.035	0.088	0.092	19.0

Fecundity @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Fecundity (Rank) @ Total Length (Rank)

Source	Squares	df	Mean Square	F	Sig.
Area	301.920	1	301.920	5.178	**0.030**
Total Length	539.682	1	539.682	9.255	**4.66E-03**
Error	1865.960	32	58.311		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	20	14.861	1.889
	Far-Field	22	21.727	2.085

0.032	**0.003**	0.067	46.2

Fecundity @ Age

Tests of Between-Subjects Effects

Dependent Variable:Fecundity (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	14801	1	14801	6.871	**0.026**
Error	21540	10	2154		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	8	115	37
	Far-Field	4	189	63

0.081	0.418	0.180	65.1

Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.261	1	0.261	14.675	**0.001**
Error	0.587	33	0.018		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	19	0.734	0.130
	Far-Field	16	0.908	0.138

0.624	0.503	**0.037**	49.1

Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.265	1	0.265	14.867	**0.001**
Error	0.589	33	0.018		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	19	0.597	0.130
	Far-Field	16	0.771	0.138

0.864	0.896	0.064	49.5

Total Length

Dependent Variable:Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	6.314	1	6.314	12.138	**0.001**
Error	17.167	33	0.520		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	20	7.547	0.668
	Far-Field	22	8.400	0.781

0.507	0.152	0.215	11.3

Statistically significant at $\alpha = 0.1$

Statistical Analyses of Cycle 7 EEM Skookumchuck Sculpin Data - Immatures

Torrent Reference
Reference vs Near-Field

Gender	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis					Power Analysis Effect Size = 25% except Condition = 10%	Post Hoc Power Analysis	Interaction Resolution Method[5]
				Interaction Statistic[1] (P)	Intercept Statistic[2] (P)	SSD[3]	Direction	Magnitude[4] (%)			
Immature	Survival	Age[6]	Effect	n/a	**0.073**	Yes	NF < Ref	23	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	**0.071**	0.323	No	-	-	26	0.916	1
		Relative liver size (liver weight @ body weight)[7]	Effect	**0.012**	**0.002**	Yes	NF > Ref	23	21	-	1
		Relative liver size (liver weight @ carcass weight)[7]	Support	**0.007**	**0.007**	Yes	NF > Ref	21	-	-	1
		Relative liver size (liver weight @ total length) (Small = 4.8)	Support	**0.016**	-	No	-	2	-	-	3
		Relative liver size (liver weight @ total length) (Large = 7.2)	Support	**0.016**	-	Yes	NF > Ref	58	-	-	3
	Energy Use	Size (Body Weight) @ Age[9] (Age = 4)	Effect	n/a	0.679	No	-	-	nc	nc	-
		Size (Total Length) @ Age[9] Age = 4)	Support	n/a	0.482	No	-	-	-	-	-
		Body weight[8]	Support	n/a	0.861	No	-	-	-	-	-
		Carcass weight[8]	Support	n/a	0.911	No	-	-	-	-	-
		Total length[8]	Support	n/a	0.482	No	-	-	-	-	-

[1] test for equal slopes
[2] test for equality of test groups
[3] statistically significant difference
[4] difference between reference and exposure relative to reference mean
[5] Interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
[6] calculated using Mann-Whitney non-parametric test due to non-normality
[7] calculated using $\log_{10}$-transformed data
[8] Used t-test assuming unequal variance due to non-homogeneity of variance
[9] Insufficient age classes for proper ANCOVA and only age class with sufficient data
[10] Used ranked data due to non-normality of data
n/a - not applicable

Torrent Reference
Reference vs Far-Field

Gender	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis: Interaction Statistic[1] (P)	Primary Analysis: Intercept Statistic[2] (P)	Primary Analysis: SSD[3]	Primary Analysis: Direction	Primary Analysis: Magnitude[4] (%)	Power Analysis Effect Size = 25% except Condition = 10%	Post Hoc Power Analysis	Interaction Resolution Method[5]
Immature	Survival	Age[6]	Effect	n/a	**1.01E-04**	Yes	FF < Ref	49	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	**0.038**	0.136	No	-	-	13	0.995	1
		Relative liver size (liver weight @ body weight)[7]	Effect	0.230	**2.19E-09**	Yes	FF > Ref	62	18	-	-
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.257	**1.29E-08**	Yes	FF > Ref	63	-	-	-
		Relative liver size (liver weight @ total length)[7]	Support	0.113	**1.96E-08**	Yes	FF > Ref	67	-	-	-
	Energy Use	Size (Body Weight) @ Age[7,8] (Age = 3)	Effect	n/a	**0.002**	Yes	FF > Ref	87	nc	nc	-
		Size (Body Weight) @ Age[7,8,10] (Age = 3)	Effect	n/a	**0.003**	Yes	FF > Ref	67	nc	nc	-
		Size (Body Weight) @ Age[7,8,11] (Age = 4)	Effect	n/a	**0.021**	Yes	FF > Ref	40	nc	nc	-
		Size (Total Length) @ Age[7,8] (Age = 3)	Support	n/a	**0.002**	Yes	FF > Ref	24	-	-	-
		Size (Total Length) @ Age[7,8,11] (Age = 3)	Support	n/a	**0.004**	Yes	FF > Ref	20	-	-	-
		Body weight[6]	Support	n/a	0.732	No	-	-	-	-	-
		Carcass weight[6]	Support	n/a	0.640	No	-	-	-	-	-
		Total length[9]	Support	n/a	0.448	No	-	-	-	-	-

[1] test for equal slopes
[2] test for equality of test groups
[3] statistically significant difference
[4] difference between reference and exposure relative to reference mean
[5] Interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
[6] calculated using Mann-Whitney non-parametric test due to non-normality
[7] calculated using log_{10}-transformed data
[8] ANOVA conducted due to limited covariate range
[9] Used ranked data due to non-normality of data
[10] Removed extreme outlier FF-63
[11] Removed extreme outlier FF-28
n/a - not applicable
nc - not calculable due to use of non-parametric test (non-normality)

Statistical Outputs of Cycle 7 Skookumchuck Sculpin Data - Near-Field

IMMATURES

Torrent Reference

	Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
Age	0.932	**<0.0005**	**<0.0005**	22.8
Body Weight @ Total Length	**0.035**	0.165	0.176	3.2
Liver Weight @ Body Weight	0.244	0.188	**0.023**	23.0
Liver Weight @ Carcass Weight	0.337	0.477	0.077	21.1
Liver Weight @ Total Length	-	-	-	-

Age

Test Statistics

	Age
Mann-Whitney U	278.5
Wilcoxon W	684.5
Z	-1.792
Asymp. Sig. (2-tailed)	**0.073**

Between-Subjects Factors

		N	Mean Rank
Area	Reference	27	31.685
	Near-Field	28	24.446

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.002	1	2.36E-03	0.998	0.323
Total Length	2.941	1	2.941	1241.741	**5.73E-38**
Error	0.123	52	0.002		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	27	0.380	0.009
	Exposure	28	0.366	0.009

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Adjusted Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.108	1	0.108	10.101	**0.002**
Body Weight	3.598	1	3.598	337.590	**2.15E-24**
Error	0.554	52	0.011		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	27	-1.315	0.020
	Exposure	28	-1.225	0.020

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.093	1	0.093	7.877	**0.007**
Carcass Weight	3.539	1	3.539	299.805	**3.07E-23**
Error	0.614	52	0.012		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	27	-1.311	0.021
	Exposure	28	-1.228	0.021

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.001	1	0.001	3.765	**0.058**
Total Length	.024	1	0.024	63.270	**1.96E-10**
Area * Total Length	0.002	1	0.002	6.1613168	**0.016**
Error	0.019	50	0.000		

Removed Cook's Distance outlier NF-68

Between-Subjects Factors

		N	Mean - Reference	Mean - Near Field
Area	Reference	26	0.034	0.075
	Exposure	28	0.034	0.118

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.189	1	0.189	0.175	0.679
Error	23.753	22	1.080		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	3.095	0.790
	Exposure	13	2.917	1.208

0.041	0.252	0.472	5.8

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.036	1	0.036	0.079	0.782
Error	10.050	22	0.457		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	7.727	0.541
	Exposure	13	8.000	0.713

0.040	0.869	0.158	3.5

Body Weight

Independent Samples Test - Body Weight

t-test for Equality of Means - Equal variances not assumed						
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
0.176	43.227	0.861	0.057	0.325	-0.598	0.712

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	27	2.706	0.849
	Exposure	28	2.648	1.486

0.002	0.682	0.591	2.1

Carcass Weight

Independent Samples Test - Carcass Weight

t-test for Equality of Means - Equal variances not assumed						
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
0.112	44.036	0.911	0.030	0.270	-0.514	0.574

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	27	2.211	0.722
	Exposure	28	2.180	1.224

0.004	0.831	0.659	1.4

Total Length

Independent Samples Test - Total Length

t-test for Equality of Means - Equal variances not assumed						
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
0.710	43.677	0.482	0.189	0.267	-0.348	0.727

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	27	6.100	0.706
	Exposure	28	5.911	1.214

0.008	0.463	0.167	3.1

Statistical Outputs of Cycle 7 Skookumchuck Sculpin Data - Far-Field

IMMATURES

Torrent Reference

	Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
Age	0.614	**<0.0005**	**0.002**	48.8
Body Weight @ Total Length	0.799	**0.050**	0.152	3.8
Liver Weight @ Body Weight	0.231	0.490	0.865	61.8
Liver Weight @ Carcass Weight	0.118	0.502	0.844	62.6
Liver Weight @ Total Length	0.207	0.095	0.854	66.7
Body Weight @ Age	0.836	0.242	0.169	87.1

Age

Test Statistics

	Age
Mann-Whitney U	104
Wilcoxon W	335
Z	-3.888
Asymp. Sig. (2-tailed)	**1.01E-04**

Between-Subjects Factors

		N	Mean Rank
Area	Reference	27	31.148
	Near-Field	21	15.952

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.003	1	2.63E-03	2.304	0.136
Total Length	2.871	1	2.871	2519.713	**3.72E-41**
Error	0.051	45	0.001		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	27	0.355	0.007
	Exposure	21	0.371	0.008

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.494	1	0.494	55.519	**2.19E-09**
Body Weight	2.375	1	2.375	266.702	**1.56E-20**
Error	0.401	45	0.009		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	27	-1.317	0.018
	Exposure	21	-1.108	0.021

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Carcass Weight (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.498	1	0.498	48.024	**1.29E-08**
Carcass Weight	2.310	1	2.310	222.866	**4.79E-19**
Error	0.466	45	0.010		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	27	-1.318	0.020
	Exposure	21	-1.107	0.023

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Total Length (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.543	1	0.543	46.357	**1.96E-08**
Total Length	2.249	1	2.249	191.939	**7.66E-18**
Error	0.527	45	0.012		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	27	-1.323	0.021
	Exposure	21	-1.101	0.024

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) (Age = 3)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.291	1	0.291	14.430	**0.002**
Error	0.283	14	0.020		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	9	0.313	0.130
	Exposure	7	0.585	0.157

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) (Age = 3)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.177	1	0.177	13.088	**0.003**
Error	0.175	13	0.013		

Removed Extreme outlier FF-63

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	9	0.313	0.130
	Exposure	6	0.535	0.090

0.227	0.242	0.117	66.5

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.062	1	0.062	6.901	**0.021**
Error	0.117	13	0.009		

Removed Extreme outlier FF-28

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	0.479	0.105
	Exposure	4	0.624	0.049

0.105	0.536	0.485	39.8

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Log) (Age = 3)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.035	1	0.035	14.953	**0.002**
Error	0.033	14	0.002		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	9	0.745	0.052
	Exposure	7	0.839	0.044

0.291	0.217	0.172	24.2

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Log) (Age = 3)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.023	1	0.023	12.373	**0.004**
Error	0.024	13	0.002		

Removed Extreme outlier FF-63

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	9	0.745	0.052
	Exposure	6	0.824	0.024

0.040	0.217	0.098	20.2

Body Weight

Test Statistics

	Age
Mann-Whitney U	267
Wilcoxon W	498
Z	-0.343
Asymp. Sig. (2-tailed)	0.732

Between-Subjects Factors

		N	Mean Rank
Area	Reference	27	25.111
	Exposure	21	23.714

7.21E-05	0.682	**0.004**	5.6

Carcass Weight

Test Statistics

	Age
Mann-Whitney U	261
Wilcoxon W	492
Z	-0.468
Asymp. Sig. (2-tailed)	0.640

Between-Subjects Factors

		N	Mean Rank
Area	Reference	27	25.333
	Exposure	21	23.429

9.33E-05	0.831	**0.005**	7.5

Total Length

Test Statistics

	Age
Mann-Whitney U	247
Wilcoxon W	478
Z	-0.759
Asymp. Sig. (2-tailed)	0.448

Between-Subjects Factors

		N	Mean Rank
Area	Reference	27	25.852
	Exposure	21	22.762

7.03E-07	0.463	**0.002**	12.0

Statistical Analyses of Cycle 7 EEM Skookumchuck Sculpin Data

Canal Flats Reference
Reference vs Near-Field

Gender	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis: Interaction Statistic[1] (P)	Primary Analysis: Intercept Statistic[2] (P)	Primary Analysis: SSD[3]	Primary Analysis: Direction	Primary Analysis: Magnitude[4] (%)	Power Analysis Effect Size = 25% except Condition = 10%	Post Hoc Power Analysis	Interaction Resolution Method[5]
Male	Survival	Age[6]	Effect	n/a	0.742	No	-	-	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	0.406	0.713	No	-	-	24	0.884	-
		Relative liver size (liver weight @ body weight)	Effect	0.895	**0.097**	Yes	NF > Ref	10	4	-	-
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.874	**0.083**	Yes	NF > Ref	11	-	-	-
		Relative liver size (liver weight @ total length)7	Support	0.983	0.157	No	-	-	-	-	-
	Energy Use	Size (Body Weight) @ Age (Age = 4 and Age = 5)	Effect	n/a	Insufficient data for analysis				nc	nc	-
		Size (Total Length) @ Age (Age = 5)	Support	n/a	**0.027**	Yes	NF > Ref	6	-	-	-
		Relative gonad size (gonad weight @ body weight)[7,12]	Effect	0.419	0.959	No	-	-	23	0.895	-
		Relative gonad size (gonad weight @ carcass weight)[7,12]	Support	0.493	0.973	No	-	-	-	-	-
		Relative gonad size (gonad weight @ total length)[6]	Support	0.938	0.913	No	-	-	-	-	-
		Body weight[7]	Support	n/a	0.746	No	-	-	-	-	-
		Carcass weight	Support	n/a	0.648	No	-	-	-	-	-
		Total length	Support	n/a	0.578	No	-	-	-	-	-
Female	Survival	Age[6]	Effect	n/a	0.244	No	-	-	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	0.181	0.408	No	-	-	27	0.548	-
		Condition (body weight @ total length)[11]	Effect	0.835	0.330	No	-	-	23	0.591	-
		Relative liver size (liver weight @ body weight)	Effect	0.169	**2.39E-04**	Yes	NF > Ref	18	6	-	-
		Relative liver size (liver weight @ carcass weight)	Support	0.554	**0.003**	Yes	NF > Ref	17	-	-	-
		Relative liver size (liver weight @ total length)[7]	Support	0.456	0.282	No	-	-	-	-	-
		Relative liver size (liver weight @ total length)[11]	Support	0.120	0.155	No	-	-	-	-	-
		Relative egg size (mean egg weight @ body weight)[7,8]	Support	0.132	**0.022**	Yes	NF < Ref	15	-	-	-
		Relative egg size (mean egg weight @ carcass weight)[7,8]	Support	0.124	**0.022**	Yes	NF < Ref	15	-	-	-
		Relative egg size (mean egg weight @ age) (Age = 4)	Support	Insufficient data for analysis				-	-	-	-
		Relative egg size (mean egg weight @ age) (Age = 5)[7,9,12]	Support	n/a	**0.017**	Yes	NF < Ref	21	-	-	-
	Energy Use	Size (Body Weight) @ Age (Age = 4)[9]	Effect	Insufficient data for analysis				-	nc	nc	-
		Size (Body Weight) @ Age (Age = 5)[7,9]	Effect	n/a	**0.061**	Yes	NF < Ref	19	nc	nc	-
		Size (Total Length) @ Age (Age = 4)[9]	Support	Insufficient data for analysis				-	-	-	-
		Size (Total Length) @ Age (Age = 5)[9]	Support	Insufficient data for analysis				-	-	-	-
		Relative gonad size (gonad weight @ body weight)[7,12]	Effect	0.280	0.606	No	-	-	15	0.762	2
		Relative gonad size (gonad weight @ carcass weight)[7,12]	Support	0.384	0.679	No	-	-	-	-	2
		Relative gonad size (gonad weight @ total length)[7]	Support	0.231	0.379	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ body weight)	Support	0.182	0.116	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ carcass weight)	Support	0.163	0.147	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ total length)	Support	0.294	0.461	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ age) (Age = 4)[9]	Support	Insufficient data for analysis				-	-	-	-
		Relative fecundity (# of eggs/female @ age) (Age = 5)[9]	Support	Insufficient data for analysis				-	-	-	-
		Body weight	Support	n/a	**0.063**	Yes	NF < Ref	8	-	-	-
		Carcass weight[7]	Support	n/a	**0.054**	Yes	NF < Ref	15	-	-	-
		Total length	Support	n/a	**0.093**	Yes	NF < Ref	5	-	-	-

[1] test for equal slopes
[2] test for equality of test groups
[3] statistically significant difference
[4] difference between reference and exposure relative to reference mean
[5] Interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
[6] calculated using Mann-Whitney non-parametric test due to non-normality
[7] calculated using log_{10}-transformed data
[8] ANOVA conducted due to non-signficant covariate
[9] Insufficient age classes for proper ANCOVA and only age class with sufficient data
[10] Used ranked data due to non-normality of data
[11] Removed extreme outlier CR-1
[12] Removed Cook's Distance extreme outlier CR-6 to resolve significant interaction
n/a - not applicable

Canal Flats Reference
Reference vs Far-Field

Gender	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis: Interaction Statistic[1] (P)	Primary Analysis: Intercept Statistic[2] (P)	Primary Analysis: SSD[3]	Primary Analysis: Direction	Primary Analysis: Magnitude[4] (%)	Power Analysis Effect Size = 25% except Condition = 10%	Post Hoc Power Analysis	Interaction Resolution Method[5]
Male	Survival	Age[6]	Effect	n/a	**0.029**	Yes	FF < Ref	25	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[9]	Effect	0.552	**1.76E-02**	Yes	FF > Ref	24	nc	nc	-
		Condition (body weight @ total length)[7]	Effect	0.935	**1.99E-02**	Yes	FF > Ref	7	5	-	
		Relative liver size (liver weight @ body weight)[7]	Effect	0.421	**4.37E-08**	Yes	FF > Ref	52	17	-	-
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.446	**1.05E-08**	Yes	FF > Ref	57	-	-	-
		Relative liver size (liver weight @ total length)[7]	Support	0.763	**2.82E-09**	Yes	FF > Ref	77	-	-	-
	Energy Use	Size (Body Weight) @ Age[7,11] (Age = 4)	Effect	n/a	**2.89E-03**	Yes	FF > Ref	37	nc	nc	-
		Size (Body Weight) @ Age[11] (Age = 5)	Effect	n/a	**7.68E-04**	Yes	FF > Ref	53	nc	nc	-
		Size (Total Length) @ Age[11] (Age = 4)	Support	n/a	**0.031**	Yes	FF > Ref	7	nc	nc	-
		Size (Total Length) @ Age[11] (Age = 5)	Support	n/a	**9.33E-04**	Yes	FF > Ref	15	nc	nc	-
		Relative gonad size (gonad weight @ body weight)[7]	Effect	0.456	0.974	No	-	-	35	0.742	-
		Relative gonad size (gonad weight @ carcass weight)[9]	Support	0.391	0.931	No	-	-	-	-	-
		Relative gonad size (gonad weight @ carcass weight)[7,12]	Support	0.436	0.837	No	-	-	-	-	-
		Relative gonad size (gonad weight @ total length)[7]	Support	0.220	0.232	No	-	-	-	-	-
		Body weight[7]	Support	n/a	**9.40E-07**	Yes	FF > Ref	41	-	-	-
		Carcass weight[7]	Support	n/a	**3.35E-06**	Yes	FF > Ref	40	-	-	-
		Total length	Support	n/a	**5.54E-05**	Yes	FF > Ref	9	-	-	-
Female	Survival	Age[6]	Effect	n/a	0.459	No	-	-	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[7,10]	Effect	0.116	0.663	No	-	-	20	0.644	2
		Relative liver size (liver weight @ body weight)[7]	Effect	0.851	**2.30E-05**	Yes	FF > Ref	39	9	-	-
		Relative liver size (liver weight @ carcass weight)[7]	Support	0.723	**9.22E-06**	Yes	FF > Ref	41	-	-	-
		Relative liver size (liver weight @ total length)[9]	Support	0.150	**3.34E-06**	Yes	FF > Ref	112	-	-	-
		Relative liver size (liver weight @ total length)[9,13]	Support	0.861	**5.07E-06**	Yes	FF > Ref	-	-	-	-
		Relative egg size (mean egg weight @ body weight)	Support	0.213	0.106	No	-	-	-	-	-
		Relative egg size (mean egg weight @ carcass weight)[6,8]	Support	0.274	0.693	No	-	-	-	-	-
		Relative egg size (mean egg weight @ age)[11] (Age = 5)	Support	Insufficient data for analysis				-	-	-	-
	Energy Use	Size (Body Weight) @ Age[11] (Age = 5)	Effect	n/a	**0.042**	Yes	FF > Ref	40	nc	nc	-
		Size (Total Length) @ Age[11] (Age = 5)	Support	n/a	**0.055**	Yes	FF > Ref	9	-	-	-
		Relative gonad size (gonad weight @ body weight)[9,14]	Effect	0.118	0.932	No	-	-	nc	nc	-
		Relative gonad size (gonad weight @ carcass weight)[9,15]	Support	0.316	0.522	No	-	-	-	-	2
		Relative gonad size (gonad weight @ carcass weight)[14]	Support	0.588	0.952	No	-	-	-	-	-
		Relative gonad size (gonad weight @ total length)[9,16]	Support	0.276	0.413	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ body weight)[9]	Support	0.379	**0.038**	Yes	FF > Ref	53	-	-	-
		Relative fecundity (# of eggs/female @ body weight)[7,17]	Support	0.570	**0.003**	Yes	FF > Ref	35	-	-	-
		Relative fecundity (# of eggs/female @ carcass weight)	Support	0.796	0.173	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ total length)	Support	0.386	0.103	No	-	-	-	-	-
		Relative fecundity (# of eggs/female @ age)[11] (Age = 5)	Support	Insufficient data for analysis				-	-	-	-
		Body weight[7]	Support	n/a	**2.07E-02**	Yes	FF > Ref	30	-	-	-
		Carcass weight[7]	Support	n/a	**2.77E-02**	Yes	FF > Ref	29	-	-	-
		Total length	Support	n/a	**6.33E-02**	Yes	FF > Ref	7	-	-	-

[1] test for equal slopes
[2] test for equality of test groups
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[4] difference between reference and exposure relative to reference mean
[5] Interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
[6] calculated using Mann-Whitney non-parametric test due to non-normality
[7] calculated using log_{10}-transformed data
[8] ANOVA conducted due to non-signficant covariate
[9] Used ranked data due to non-normality of data
[10] Removed Cook's Distance extreme outlier CR-1
[11] Insufficient age classes for proper ANCOVA and only age class with sufficient data
[12] Removed extreme outlier FF-24
[13] Removed extreme outlier CR-1
[14] Removed Cook's Distance/extreme outliers CR-6 and FF-19
[15] Removed Cook's Distance extreme outlier CR-6
[16] Removed FF-14,FF-33,FF-55 due to overlap issues
[17] Removed extreme outliers FF-19 and FF-23
n/a - not applicable
nc - not calculable due to use of non-parametric test (non-normality)

Statistical Outputs of Cycle 7 Skookumchuck Sculpin Data - Near-Field

MALE

Canal Flats Reference

	Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
Age	0.291	**<0.0005**	**<0.0005**	4.6
Body Weight @ Total Length	0.501	**0.044**	0.681	0.6
Liver Weight @ Body Weight	0.505	0.264	0.357	10.2
Liver Weight @ Carcass Weight	0.849	0.511	0.221	10.9
Liver Weight @ Total Length	0.843	0.224	0.118	10.4

Age

Test Statistics

	Age
Mann-Whitney U	377
Wilcoxon W	1043
Z	-0.329
Asymp. Sig. (2-tailed)	0.742

Between-Subjects Factors

		N	Mean Rank
Area	Reference	22	30.364
	Near-Field	36	28.972

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.000	1	2.96E-04	0.137	0.713
Total Length	0.771	1	0.771	356.517	**1.06E-25**
Error	0.119	55	0.002		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	0.829	0.010
	Near-Field	36	0.824	0.008

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Body Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.004	1	0.004	2.846	**0.097**
Body Weight	0.107	1	0.107	82.284	**1.63E-12**
Error	0.071	55	0.001		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	0.167	0.008
	Near-Field	36	0.184	0.006

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.027	1	0.027	3.124	**0.083**
Carcass Weight	0.606	1	0.606	69.249	**2.62E-11**
Error	0.482	55	0.009		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-0.800	0.020
	Near-Field	36	-0.755	0.016

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.025	1	0.025	2.054	0.157
Total Length	.423	1	0.423	34.929	**2.25E-07**
Error	0.665	55	0.012		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-0.799	0.023
	Near-Field	36	-0.756	0.018

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 5)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	1.218	1	1.218	5.671	**0.027**
Error	4.509	21	0.215		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	9	7.800	0.482
	Near-Field	14	8.271	0.451

0.777	0.384	0.547	6.0

Gonad Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.000	1	0.000	.003	0.959
Body Weight	0.803	1	0.803	70.483	**1.99E-11**
Error	0.626	55	0.011		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-1.120	0.023
	Near-Field	36	-1.119	0.018

0.973	0.116	0.350	0.2

Gonad Weight @ Carcass Weight

Dependent Variable:Gonad Weight (Log) @ Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.000	1	0.000	.001	0.973
Carcass Weight	0.829	1	0.829	75.999	**5.99E-12**
Error	0.600	55	0.011		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-1.120	0.022
	Near-Field	36	-1.119	0.017

0.931	0.209	0.357	0.2

Gonad Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.000	1	0.000	.012	0.913
Total Length	.731	1	0.731	57.534	**4.15E-10**
Error	0.699	55	0.013		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-1.117	0.024
	Exposure	36	-1.121	0.019

0.397	0.419	0.409	0.9

Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.003	1	0.003	0.106	0.746
Error	1.429	56	0.026		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	22	-1.128	0.171
	Near-Field	36	-1.114	0.152

0.412	0.192	0.897	3.3

Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Carcass Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.594	1	0.594	0.210	0.648
Error	158.197	56	2.825		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	22	5.706	1.604
	Near-Field	36	5.915	1.725

0.525	0.422	0.116	61.6

Total Length

Tests of Between-Subjects Effects

Dependent Variable:Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.146	1	0.146	.313	0.578
Error	26.100	56	0.466		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	22	7.927	0.694
	Near-Field	36	8.031	0.676

0.921	0.723	0.291	26.8

FEMALE

Age

Test Statistics

	Age
Mann-Whitney U	93.500
Wilcoxon W	346.500
Z	-1.165
Asymp. Sig. (2-tailed)	0.244

Between-Subjects Factors

		N	Mean Rank
Area	Reference	11	19.500
	Near-Field	22	15.750

0.297	**0.016**	**<0.0005**	19.2

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.002	1	0.002	0.704	0.408
Total Length	0.193	1.000	0.193	76.647	**9.20E-10**
Error	.075	30	0.003		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	0.760	0.016
	Near-Field	22	0.744	0.011

0.264	**0.021**	0.665	3.6

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.398	1	0.398	0.982	0.330
Total Length	39.161	1.000	39.161	96.792	**9.54E-11**
Error	11.733	29	0.405		

Removed extreme outlier CR-1

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	10	5.892	0.205
	Near-Field	22	5.645	0.137

0.041	0.400	0.381	4.2

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Body Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.005	1	0.005	17.388	**2.39E-04**
Body Weight	0.054	1	0.054	172.761	**5.55E-14**
Error	0.009	30	0.000		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	0.159	0.005
	Near-Field	22	0.188	0.004

0.245	0.506	**0.043**	18.2

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Carcass Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.005	1	0.005	10.187	**3.31E-03**
Carcass Weight	0.049	1	0.049	101.381	**3.90E-11**
Error	0.014	30	0.000		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	0.160	0.007
	Near-Field	22	0.187	0.005

0.506	0.229	0.131	16.9

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.012	1	0.012	2.126	0.155
Total Length	.156	1	.156	27.109	**1.30E-05**
Error	0.172	30	0.006		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	11	-0.790	0.024
	Near-Field	22	-0.747	0.016

0.668	**0.024**	0.337	10.4

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.002	1	0.002	2.000	0.168
Total Length	.040	1	.040	52.600	**5.50E-08**
Error	0.022	29	0.001		

Removed extreme outlier CR-1

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	10	0.169	0.009
	Near-Field	22	0.184	0.006

0.132	0.393	0.172	8.9

Egg Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.038	1	0.038	5.831	**0.022**
Error	0.194	30	0.006		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	-2.192	0.024
	Near-Field	22	-2.265	0.018

Covariate not significant

0.457	**0.012**	0.449	15.5

Egg Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.038	1	0.038	5.831	0.022
Error	0.194	30	0.006		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	-2.192	0.024
	Near-Field	22	-2.265	0.018

Covariate not significant

0.457	**0.012**	0.449	15.5

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) (Age = 5)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.030	1	0.030	4.206	**0.061**
Error	0.092	13	0.007		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	6	0.830	0.071
	Near-Field	9	0.740	0.091

0.531	0.416	0.147	18.9

Gonad Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Body Weight (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.002	1	0.002	.273	0.606
Body Weight	.295	1	.295	41.683	**5.41E-07**
Error	0.198	28	0.007		

Removed Cook's Distance extreme value CR-6 to resolve significant interaction

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	10	0.147	0.028
	Near-Field	21	0.165	0.019

0.117	0.354	0.373	4.2

Gonad Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Carcass Weight (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.002	1	0.002	.175	0.679
Carcass Weight	.222	1	.222	23.008	**4.84E-05**
Error	0.270	28	0.010		

Removed Cook's Distance extreme value CR-6 to resolve significant interaction

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	10	-0.148	0.033
	Near-Field	21	-0.165	0.022

0.059	0.374	0.415	3.8

Gonad Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.013	1	0.013	.798	0.379
Total Length	0.059	1	0.059	3.700	**6.43E-02**
Error	4.62E-01	29	1.59E-02		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	11	-0.133	0.040
	Near-Field	21	-0.178	0.028

0.179	0.211	0.818	9.8

Fecundity @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Fecundity @ Body Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	2023.462	1	2023.462	2.632	0.116
Body Weight	12383.459	1	12383.459	16.108	**3.86E-04**
Error	22295.078	29	768.796		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	112.054	6.461
	Near-Field	21	130.210	6.144

0.444	0.425	0.724	16.2

Fecundity @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Fecundity @ Carcass Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	1975.470	1	1975.470	2.222	0.147
Carcass Weight	8899.367	1	8899.367	10.011	**3.64E-03**
Error	25779.170	29	888.937		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	111.804	9.714
	Near-Field	21	130.341	6.786

0.294	0.328	0.540	16.6

Fecundity @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Fecundity @ Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	595.434	1	595.434	.557	0.461
Total Length	3700.941	1	3700.941	3.465	**7.29E-02**
Error	30977.595	29	1068.193		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	117.556	10.351
	Near-Field	21	127.328	7.323

0.141	0.417	0.295	8.3

Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Body Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	3.22E-02	1	3.22E-02	3.725	**0.063**
Error	0.268	31	0.009		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	0.794	0.080
	Near-Field	22	0.727	0.099

0.493	0.779	0.292	8.3

Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	3.85E-02	1	3.85E-02	4.004	**0.054**
Error	0.298	31	0.010		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	0.662	0.084
	Near-Field	22	0.590	0.104

0.708	0.585	0.206	15.4

Total Length

Dependent Variable:Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	1.044	1	1.044	2.996	**0.093**
Error	10.799	31	0.348		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	7.836	0.676
	Near-Field	22	7.459	0.545

0.392	0.322	0.559	4.8

Statistically significant at $\alpha = 0.1$

Statistical Outputs of Cycle 7 Skookumchuck Sculpin Data - Far-Field

MALE

Canal Flats Reference

	Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
Age	0.138	**<0.0005**	**<0.0005**	25.0
Body Weight @ Total Length	0.911	0.160	**<0.0005**	24.4
Body Weight @ Total Length	0.419	0.058	0.253	6.7
Liver Weight @ Body Weight	0.863	0.853	0.834	52.1
Liver Weight @ Carcass Weight	0.877	0.832	0.800	56.7
Liver Weight @ Total Length	0.952	0.097	0.485	77.0
Body Weight @ Age	0.088	0.511	0.094	36.8

Age

Test Statistics

	Age
Mann-Whitney U	329
Wilcoxon W	1275
Z	-2.188
Asymp. Sig. (2-tailed)	**0.029**

Between-Subjects Factors

		N	Mean Rank
Area	Reference	22	39.545
	Far-Field	43	29.651

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Rank) @ Total Length (Rank)

Source	Squares	df	Mean Square	F	Sig.
Area	558	1	558	7.144	**9.60E-03**
Total Length	11601	1	11601	148.456	**4.20E-18**
Error	4845	62	78		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	22	28.420	2.034
	Far-Field	43	35.343	1.404

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.008	1	0.008	5.713	**0.020**
Total Length	0.577	1	0.577	405.695	**1.21E-28**
Error	0.087	61	0.001		

Removed FF-73 as extreme outlier

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	0.895	0.009
	Far-Field	42	0.923	0.006

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.328	1	0.328	38.929	**4.37E-08**
Body Weight	0.676	1	0.676	80.134	**8.99E-13**
Error	0.523	62	0.008		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-0.709	0.022
	Far-Field	43	-0.527	0.015

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.389	1	0.389	43.569	**1.05E-08**
Carcass Weight	0.645	1	0.645	72.199	**5.46E-12**
Error	0.554	62	0.009		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-0.718	0.023
	Far-Field	43	-0.523	0.015

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.680	1	0.680	48.046	**2.82E-09**
Total Length	0.321	1	0.321	22.667	**1.20E-05**
Error	0.878	62	0.014		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-0.753	0.028
	Far-Field	43	-0.505	0.019

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) (Age =4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.113	1	0.113	10.408	**2.89E-03**
Error	0.349	32	0.011		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	8	0.817	0.141
	Far-Field	26	0.953	0.091

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Age =5)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	44.281	1	44.281	19.038	**7.68E-04**
Error	30.237	13	2.326		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	9	6.623	1.184
	Far-Field	6	10.130	1.950

0.368	0.751	0.759	53.0

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 4)

Source	Squares	df	Mean Square	F	Sig.
Area	2.098	1	2.098	5.124	**3.05E-02**
Error	13.100	32	.409		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	8	7.988	0.871
	Far-Field	26	8.573	0.558

0.038	0.384	0.787	7.3

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 5)

Source	Squares	df	Mean Square	F	Sig.
Area	4.900	1	4.900	18.131	**9.33E-04**
Error	3.513	13	.270		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	9	7.800	0.482
	Far-Field	6	8.967	0.575

0.752	0.798	0.718	15.0

Gonad Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Body Weight Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.000	1	0.000	.001	0.974
Total Length	0.614	1	0.614	33.713	**2.36E-07**
Error	1.129	62	0.018		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-1.035	0.033
	Far-Field	43	-1.034	0.022

0.364	0.114	**0.033**	0.2

Gonad Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Rank) @ Carcass Weight (Rank)

Source	Squares	df	Mean Square	F	Sig.
Area	1.579	1	1.579	7.64E-03	0.931
Carcass Weight	7436	1	7436	35.984	**1.12E-07**
Error	12811	62	206.635		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	33.255	3.423
	Far-Field	43	32.869	2.327

0.409	**0.012**	0.069	1.2

Gonad Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Carcass Weight (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	5.54E-04	1	5.54E-04	4.29E-02	0.837
Carcass Weight	0.651	1	0.651	50.413	**1.56E-09**
Error	0.788	61	0.013		

Removed extreme outlier FF-24

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-1.039	0.027
	Far-Field	42	-1.046	0.019

0.666	0.170	0.453	1.6

Gonad Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.032	1	0.032	1.454	0.232
Carcass Weight	0.368	1	0.368	16.608	**1.33E-04**
Error	1.374	62	0.022		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	22	-1.070	0.035
	Far-Field	43	-1.016	0.024

0.597	0.390	**0.028**	13.2

Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.326	1	0.326	29.552	**9.40E-07**
Error	0.694	63	0.011		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	22	0.818	0.121
	Far-Field	43	0.967	0.096

0.218	0.609	0.189	41.1

Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.308	1	0.308	26.011	**3.35E-06**
Error	0.746	63	0.012		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	22	0.740	0.124
	Far-Field	43	0.885	0.100

0.289	0.598	0.261	39.8

Total Length

Tests of Between-Subjects Effects

Dependent Variable:Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	7.480	1	7.480	18.708	**5.54E-05**
Error	25.190	63	0.400		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	22	7.927	0.694
	Far-Field	43	8.644	0.599

0.313	0.723	0.733	9.0

FEMALE

Age

Test Statistics[b]

	Age
Mann-Whitney U	75
Wilcoxon W	211
Z	-.741
Asymp. Sig. (2-tailed)	0.459

Between-Subjects Factors

		N	Mean Rank
Area	Reference	11	15.227
	Near-Field	16	13.156

0.588	**0.010**	**<0.0005**	13.6

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	.000	1	.000	.194	0.663
Total Length	3.056E-01	1	3.056E-01	174.979	**3.09E-12**
Error	.040	23	.002		

Removed Cook's Distance extreme value CR-1 to resolve significant interaction

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	10	0.857	0.014
	Far-Field	16	0.865	0.011

0.105	0.543	0.182	1.9

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Body Weight (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.108	1	0.108	27.396	**2.30E-05**
Body Weight	0.297	1	0.297	75.646	**6.97E-09**
Error	0.094	24	0.004		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	-0.697	0.020
	Far-Field	16	-0.554	0.016

0.283	0.236	0.127	39.0

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Carcass Weight (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.118	1	0.118	31.342	**9.22E-06**
Carcass Weight	0.302	1	0.302	80.367	**3.97E-09**
Error	0.090	24	0.004		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	-0.700	0.020
	Far-Field	16	-0.552	0.016

0.220	0.074	0.113	40.6

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Rank) @ Total Length (Rank)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	508.166	1	508.166	36.099	**3.34E-06**
Total Length	341.727	1	341.727	24.276	**5.00E-05**
Error	337.847	24	14.077		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	11	8.417	1.177
	Far-Field	16	17.839	0.964

0.585	**<0.0005**	**0.028**	111.9

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Rank) @ Total Length (Rank)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	271.307	1	271.307	34.899	**5.07E-06**
Total Length	463.533	1	463.533	59.625	**7.83E-08**
Error	178.804	23	7.774		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	10	13.302	0.958
	Far-Field	16	23.578	1.058

0.071	0.544	**0.004**	77.3

Egg Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Egg Weight @ Body Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	6.02E-06	1	6.02E-06	2.826	0.106
Body Weight	8.41E-06	1	8.41E-06	3.947	**0.058**
Error	5.11E-05	24	2.13E-06		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	11	0.007	4.68E-04
	Far-Field	16	0.006	3.81E-04

0.316	0.191	0.190	14.3

Egg Weight @ Carcass Weight

Test Statistics

	Carcass Weight
Mann-Whitney U	80
Wilcoxon W	216
Z	-.395
Asymp. Sig. (2-tailed)	0.693

Between-Subjects Factors

		N	Mean Rank
Area	Reference	11	14.727
	Far-Field	16	13.500

0.050	**0.012**	**0.031**	8.3

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Age = 5)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	26.477	1	26.477	5.067	**0.042**
Error	67.934	13	5.226		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	6	6.8	1.087
	Far-Field	9	9.6	2.785

0.132	0.547	0.089	39.6

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 5)

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean	Std. Dev.				
Area	1.849	1	1.849	4.428	**0.055**	Area	Reference	6	8.017	0.560	0.705	0.472	0.799	8.9
Error	5.428	13	0.418				Far-Field	9	8.733	0.695				

Gonad Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Rank) @ Body Weight (Rank)

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean Rank	Std. Error				
Area	.083	1	.083	.008	0.932	Area	Reference	10	13.077	1.105	0.110	**0.012**	**<0.0005**	1.0
Body Weight	906.686	1	906.686	81.981	**7.13E-09**		Far-Field	15	12.949	0.888				
Error	243.314	22	11.060											

Removed Cook's Distance extreme outliers CR-6 and FF-19

Gonad Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Rank) @ Carcass Weight (Rank)

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean Rank	Std. Error				
Area	11.459	1	11.459	.424	0.522	Area	Reference	10	15.354	1.757	0.174	0.072	**0.013**	13.1
Carcass Weight	794.674	1	794.674	29.373	**1.66E-05**		Far-Field	16	13.341	1.357				
Error	622.264	23	27.055											

Removed Cook's Distance extreme outlier CR-6

Gonad Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight @ Carcass Weight

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean	Std. Error				
Area	.000	1	.000	.004	0.952	Area	Reference	10	0.986	0.075	0.137	0.888	0.052	0.6
Carcass Weight	2.072	1	2.072	42.058	**1.59E-06**		Far-Field	15	0.980	0.060				
Error	1.084	22	.049											

Removed extreme outliers CR-6 and FF-19

Gonad Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Gonad Weight (Rank) @ Total Length (Rank)

Between-Subjects Factors

Source	Type III Sum of Squares	df	Mean Square	F	Sig.			N	Mean	Std. Dev.	**Covariate not significant**			
Area	35.287	1	35.287	.696	0.413	Area	Reference	11	11.182	5.510	-	-	-	21.8
Error	1.11E+03	22	5.07E+01				Far-Field	13	13.615	8.221				

Removed FF-14,FF-33,FF-55 due to overlap issues

Fecundity @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Fecundity (Rank) @ Body Weight (Rank)

Between-Subjects Factors

Source	Type III Sum of Squares	df	Mean Square	F	Sig.			N	Mean	Std. Error				
Area	179.247	1	179.247	4.796	**0.038**	Area	Reference	11	10.658	1.927	0.124	0.553	**<0.0005**	52.9
Body Weight	291.617	1	291.617	7.802	**0.010**		Far-Field	16	16.297	1.576				
Error	897.042	24	37.377											

Fecundity @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Fecundity (Log) @ Body Weight (Log)

Between-Subjects Factors

Source	Type III Sum of Squares	df	Mean Square	F	Sig.			N	Mean	Std. Error				
Area	0.081	1	0.081	11.062	**0.003**	Area	Reference	11	2.115	0.028	0.949	0.536	0.352	35.2
Body Weight	0.069	1	0.069	9.346	**5.77E-03**		Far-Field	14	2.246	0.024				
Error	0.161	22	0.007											

Removed extreme outliers FF-19 and FF-23

Fecundity @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Fecundity @ Carcass Weight

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean	Std. Error				
Area	4437.957	1	4437.957	1.971	0.173	Area	Reference	11	136.282	15.134	**0.030**	0.413	0.129	21.0
Carcass Weight	15254.466	1	15254.466	6.773	**0.016**		Far-Field	16	164.868	12.339				
Error	54051.698	24	2252.154											

Fecundity @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Fecundity @ Total Length

Between-Subjects Factors

Source	Squares	df	Mean Square	F	Sig.			N	Mean	Std. Error				
Area	7178.542	1	7178.542	2.868	0.103	Area	Reference	20	132.124	15.746	**0.046**	0.298	0.096	26.9
Total Length	9232.487	1	9232.487	3.688	**6.67E-02**		Far-Field	11	167.728	12.887				
Error	60073.678	24	2503.070											

Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log)

Between-Subjects Factors

Source	Type III Sum of Squares	df	Mean Square	F	Sig.			N	Mean	Std. Dev.				
Area	0.085	1	0.085	6.100	**0.021**	Area	Reference	11	0.794	0.080	0.052	0.779	**0.037**	30.0
Error	0.348	25	0.014				Far-Field	16	0.908	0.138				

Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Carcass Weight (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.078	1	0.078	5.465	**0.028**
Error	0.356	25	0.014		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	0.662	0.084
	Far-Field	16	0.771	0.138

0.134	0.585	0.064	28.6

Total Length

Dependent Variable:Total Length

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	2.071	1	2.071	3.777	**0.063**
Error	13.705	25	0.548		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	11	7.836	0.676
	Far-Field	16	8.400	0.781

0.529	0.322	0.215	7.2

Statistically significant at $\alpha = 0.1$

Statistical Analyses of Cycle 7 EEM Skookumchuck Sculpin Data - Immatures

Canal Flats Reference
Reference vs Near-Field

Gender	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis					Power Analysis Effect Size = 25% except Condition = 10%	Post Hoc Power Analysis	Interaction Resolution Method[5]
				Interaction Statistic[1] (P)	Intercept Statistic[2] (P)	SSD[3]	Direction	Magnitude[4] (%)			
Immature	Survival	Age[6]	Effect	n/a	0.802	No	-	-	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[10]	Effect	0.390	0.290	No	-	-	nc	nc	-
		Relative liver size (liver weight @ body weight)	Effect	0.843	0.147	No	-	-	29	0.633	-
		Relative liver size (liver weight @ carcass weight)	Support	0.583	0.121	No	-	-	-	-	-
		Relative liver size (liver weight @ total length)[7]	Support	0.918	0.497	No	-	-	-	-	-
	Energy Use	Size (Body Weight) @ Age (Ages 3 and 4)[9]	Effect	Insufficient data for analysis				-	nc	nc	-
		Size (Total Length) @ Age (Ages 3 and 4)[9]	Support	Insufficient data for analysis				-	-	-	-
		Body weight[7,8]	Support	n/a	0.209	No	-	-	-	-	-
		Carcass weight[7,8]	Support	n/a	0.196	No	-	-	-	-	-
		Total length[8]	Support	n/a	0.486	No	-	-	-	-	-

[1] test for equal slopes
[2] test for equality of test groups
[3] statistically significant difference
[4] difference between reference and exposure relative to reference mean
[5] Interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
[6] calculated using Mann-Whitney non-parametric test due to non-normality
[7] calculated using $\log_{10}$-transformed data
[8] Used t-test assuming unequal variance due to non-homogeneity of variance
[9] Insufficient age classes for proper ANCOVA and only age class with sufficient data
[10] Used ranked data due to violations of assumptions (homogenity of variance/normality)
n/a - not applicable

Canal Flats Reference
Reference vs Far-Field

Gender	Type of Response	Endpoint	Endpoint Effect or Support Analysis	Primary Analysis					Power Analysis Effect Size = 25% except Condition = 10%	Post Hoc Power Analysis	Interaction Resolution Method[5]
				Interaction Statistic[1] (P)	Intercept Statistic[2] (P)	SSD[3]	Direction	Magnitude[4] (%)			
Immature	Survival	Age[6]	Effect	n/a	**0.026**	Yes	FF < Ref	33	nc	nc	-
	Energy Storage	Condition (body weight @ total length)[7]	Effect	0.468	0.191	No	-	-	10	0.969	-
		Condition (body weight @ total length)[7,12]	Effect	0.275	0.211	No	-	-	8	0.989	-
		Relative liver size (liver weight @ body weight)	Effect	0.328	**3.93E-04**	Yes	FF > Ref	45	33	-	-
		Relative liver size (liver weight @ carcass weight)	Support	0.258	**4.67E-04**	Yes	FF > Ref	48	-	-	-
		Relative liver size (liver weight @ total length)[7]	Support	0.329	**2.14E-04**	Yes	FF > Ref	52	-	-	-
	Energy Use	Size (Body Weight) @ Age (Age = 3)[8]	Effect	n/a	Insufficient data for analysis				nc	nc	-
		Size (Body Weight) @ Age (Age = 4)[8]	Effect	n/a	**0.015**	Yes	FF > Ref	50	nc	nc	-
		Size (Body Weight) @ Age (Age = 4)[8,13]	Effect	n/a	**3.40E-04**	Yes	FF > Ref	67	-	-	-
		Size (Total Length) @ Age (Age = 3)[8]	Support	n/a	Insufficient data for analysis				-	-	-
		Size (Total Length) @ Age (Age = 4)[8]	Support	n/a	**0.060**	Yes	FF > Ref	20	-	-	-
		Body weight[6]	Support	n/a	0.788	No	-	-	-	-	-
		Carcass weight[6]	Support	n/a	0.711	No	-	-	-	-	-
		Total length	Support	n/a	0.749	No	-	-	-	-	-

[1] test for equal slopes
[2] test for equality of test groups
[3] statistically significant difference
[4] difference between reference and exposure relative to reference mean
[5] Interaction resolution approach applied according to Environment Canada TGD (2010) - Section 7
[6] calculated using Mann-Whitney non-parametric test due to non-normality
[7] calculated using $\log_{10}$-transformed data
[8] ANOVA conducted due to limited covariate range
[9] Used ranked data due to non-normality of data
[10] Removed extreme outlier FF-63
[11] Removed extreme outlier FF-28
[12] Removed extreme outlier FF-3
[13] Removed extreme outlier FF-23
n/a - not applicable
nc - not calculable due to use of non-parametric test (non-normality)

Statistical Outputs of Cycle 7 Skookumchuck Sculpin Data - Near-Field

IMMATURES

Canal Flats Reference

	Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
Age	0.358	**<0.0005**	**<0.0005**	5.2
Body Weight @ Total Length	**0.006**	0.397	0.309	3.9
Liver Weight @ Body Weight	0.172	0.104	0.094	15.6
Liver Weight @ Carcass Weight	0.293	0.164	0.070	17.5

Age

Test Statistics

	Age
Mann-Whitney U	186
Wilcoxon W	291
Z	-0.292
Asymp. Sig. (2-tailed)	**0.770**

Between-Subjects Factors

		N	Mean Rank
Area	Reference	14	20.786
	Near-Field	28	21.857

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Rank) @ Total Length (Rank)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	6.826	1	6.83E+00	1.152	0.290
Total Length	5934.168	1	5934.168	1001.516	**2.00E-29**
Error	231.082	39	5.925		

Between-Subjects Factors

		N	Mean Rank	Std. Error
Area	Reference	14	22.070	0.651
	Exposure	28	21.215	0.460

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Body Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.001	1	0.001	2.185	0.147
Body Weight	0.064	1	0.064	161.092	**2.00E-15**
Error	0.016	39	0.000		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	14	0.064	0.005
	Exposure	28	0.074	0.004

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Carcass Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.001	1	0.001	2.516	0.121
Carcass Weight	0.064	1	0.064	153.573	**4.23E-15**
Error	0.016	39	0.000		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	14	0.063	0.005
	Exposure	28	0.074	0.004

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Total Length (Log)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.009	1	0.009	.470	0.497
Total Length	3.370	1	3.370	173.750	**5.99E-16**
Error	0.757	39	0.019		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	14	-1.271	0.037
	Exposure	28	-1.239	0.026

0.186	0.886	0.348	7.6

Body Weight

Independent Samples Test - Body Weight (Log)

t-test for Equality of Means - Equal variances not assumed						
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
1.277	38.011	0.209	0.084	0.066	-0.049	0.217

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	14	0.420	0.115
	Exposure	28	0.336	0.308

0.003	0.275	0.062	20.0

Carcass Weight

Independent Samples Test - Carcass Weight (Log)

t-test for Equality of Means - Equal variances not assumed						
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
1.316	38.496	0.196	0.088	0.067	-0.047	0.223

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	14	0.339	0.121
	Exposure	28	0.251	0.310

0.004	0.427	0.073	26.0

Total Length

Independent Samples Test - Total Length

t-test for Equality of Means - Equal variances not assumed						
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
0.703	40.000	0.486	0.196	0.279	-0.368	0.761

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	14	6.107	0.597
	Exposure	28	5.911	1.214

0.006	0.116	0.167	3.2

Statistical Outputs of Cycle 7 Skookumchuck Sculpin Data - Far-Field

IMMATURES

Canal Flats Reference

	Levene's Test for Homogeneity of Variance	Anderson-Darling Test for Normality - Reference	Anderson-Darling Test for Normality - Exposure	%Difference
Age	0.193	**<0.0005**	**0.002**	33.1
Body Weight @ Total Length	0.536	0.422	0.111	3.0
Body Weight @ Total Length	0.985	0.264	0.115	2.8
Liver Weight @ Body Weight	0.224	0.072	0.191	45.3
Liver Weight @ Carcass Weight	0.275	0.183	0.287	47.6

Age

Test Statistics

	Age
Mann-Whitney U	85
Wilcoxon W	316
Z	-2.228
Asymp. Sig. (2-tailed)	**0.026**

Between-Subjects Factors

		N	Mean Rank
Area	Reference	14	22.464
	Near-Field	21	15.024

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.001	1	1.48E-03	1.788	0.191
Total Length	2.565	1	2.565	3107.137	**1.91E-33**
Error	0.026	32	0.001		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	14	0.339	0.008
	Exposure	21	0.352	0.006

Body Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) @ Total Length (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.001	1	1.03E-03	1.632	0.211
Total Length	2.441	1	2.441	3850.848	**4.37E-34**
Error	0.020	31	0.001		

Removed extreme outlier FF-3

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	14	0.352	0.007
	Exposure	20	0.364	0.006

Liver Weight @ Body Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Body Weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	0.007	1	0.007	15.670	**3.93E-04**
Body Weight	0.107	1	0.107	233.791	**2.90E-16**
Error	0.015	32	0.000		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	14	0.064	0.006
	Exposure	21	0.093	0.005

Liver Weight @ Carcass Weight

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight @ Carcass Weight

Source	Squares	df	Mean Square	F	Sig.
Area	0.008	1	0.008	15.187	**4.67E-04**
Carcass Weight	0.105	1	0.105	200.440	**2.50E-15**
Error	0.017	32	0.001		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	14	0.063	0.006
	Exposure	21	0.093	0.005

Liver Weight @ Total Length

Tests of Between-Subjects Effects

Dependent Variable:Liver Weight (Log) @ Total Length (Log)

Source	Squares	df	Mean Square	F	Sig.
Area	0.261	1	0.261	17.431	**2.14E-04**
Total Length	2.272	1	2.272	151.910	**1.08E-13**
Error	0.479	32	0.015		

Between-Subjects Factors

		N	Mean	Std. Error
Area	Reference	14	-1.295	0.033
	Exposure	21	-1.114	0.027

0.955	0.663	0.935	51.7

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	4.754	1	4.754	8.543	**0.015**
Error	5.565	10	0.556		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	7	2.537	0.481
	Exposure	5	3.814	1.022

0.261	0.676	0.095	50.3

Body Weight @ Age

Tests of Between-Subjects Effects

Dependent Variable:Body Weight (Log) (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	7.293	1	7.293	31.204	**3.40E-04**
Error	2.104	9	0.234		

Removed Extreme outlier FF-28

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	7	2.537	0.481
	Exposure	4	4.230	0.488

0.739	0.694	0.349	66.7

Total Length @ Age

Tests of Between-Subjects Effects

Dependent Variable:Total Length (Age = 4)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Area	1.453	1	1.453	4.516	**0.060**
Error	3.217	10	0.322		

Between-Subjects Factors

		N	Mean	Std. Dev.
Area	Reference	7	0.745	0.052
	Exposure	5	0.824	0.024

0.332	0.557	0.412	20.2

Body Weight

Test Statistics

	Body Weight
Mann-Whitney U	139
Wilcoxon W	370
Z	-0.269
Asymp. Sig. (2-tailed)	0.788

Between-Subjects Factors

		N	Mean Rank
Area	Reference	14	18.571
	Exposure	21	17.619

0.001	**0.039**	**0.004**	5.1

Carcass Weight

Test Statistics

	Carcass Weight
Mann-Whitney U	136
Wilcoxon W	367
Z	-0.370
Asymp. Sig. (2-tailed)	0.711

Between-Subjects Factors

		N	Mean Rank
Area	Reference	14	18.786
	Exposure	21	17.476

0.001	**0.043**	**0.005**	7.0

Total Length

Test Statistics

	Total Length
Mann-Whitney U	138
Wilcoxon W	369
Z	-0.320
Asymp. Sig. (2-tailed)	0.749

Between-Subjects Factors

		N	Mean Rank
Area	Reference	14	18.679
	Exposure	21	17.548

5.84E-06	0.116	**0.002**	6.1