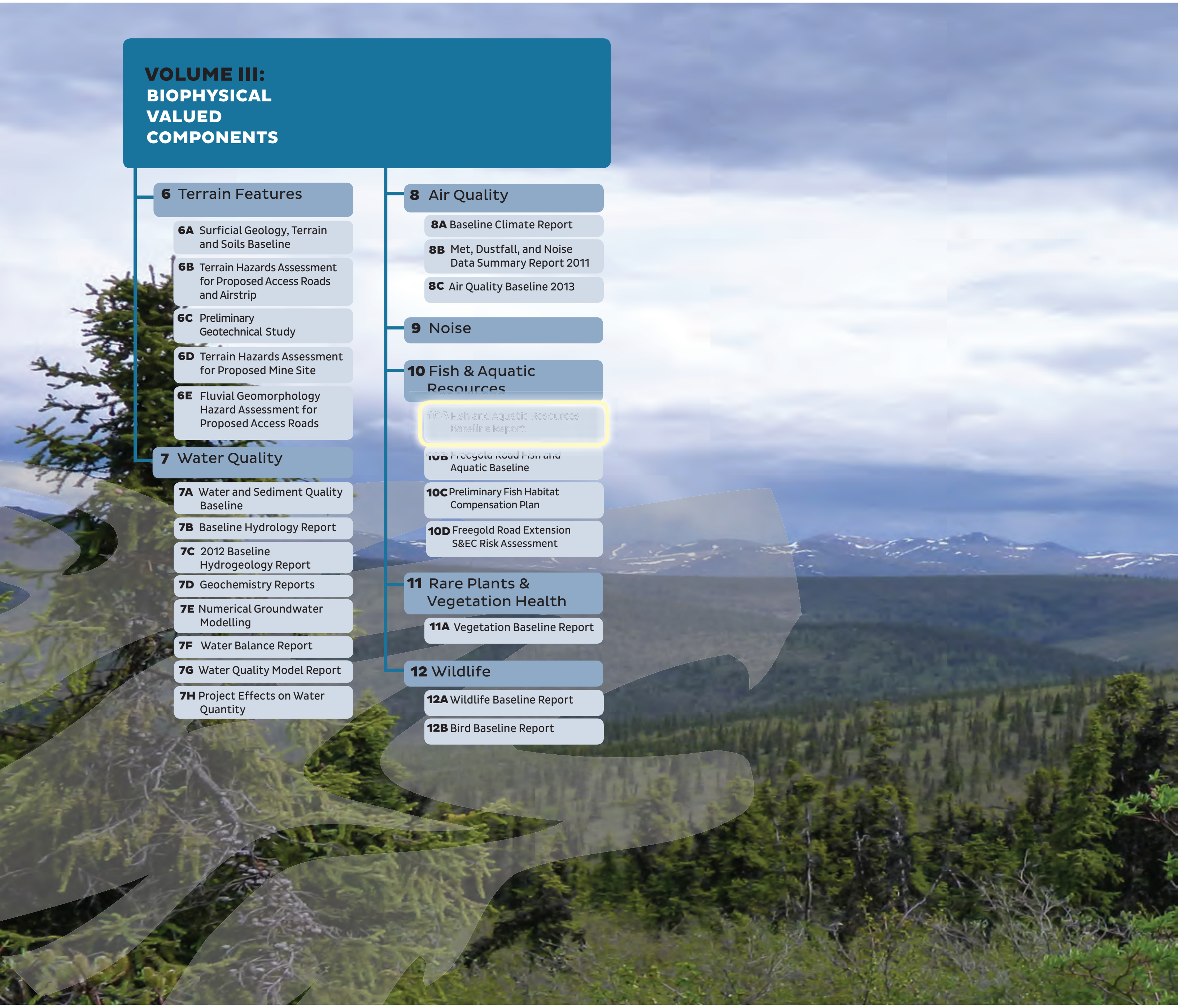
APPENDIX 10A: FISH AND AQUATIC RESOURCES BASELINE REPORT



PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

Casino Project

Fish and Aquatic Resources Baseline Report

Prepared for

Casino Mining Corporation

November 12, 2013

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

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November 12, 2013

Jesse Duke
Project Director
Casino Mining Corporation
2050-1111 West Georgia Street
Vancouver, BC V6E 4M3

Dear Mr. Duke,

Re: Casino Project, Fish and Aquatic Resources Baseline Report

Palmer Environmental Consulting Group Inc. is pleased to submit the attached final report describing results of the fish and aquatic resources baseline assessment conducted as part of the Casino Mine Project's Proposal submission to the Yukon Environmental and Socio-Economic Assessment Board.

This report characterizes the pre-development conditions of the fish and aquatic resources in the study area of the proposed Casino Project and provides a basis for an effects assessment from mine development.

If there are any questions or comments on this report, please contact Rick Palmer at (604) 629-9075.

Thank you for the opportunity to work with you on this project.

Yours truly,

Palmer Environmental Consulting Group Inc.

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Executive Summary

Fish and aquatic resource studies were conducted from 2008 to 2013 in the Casino Project study area. Casino Mining Corporation, formerly Western Copper Corporation, has 100% ownership of the Casino property. The Casino Project is a proposed porphyry copper-gold-molybdenum mine located at 611300E 695800N in west-central Yukon, approximately 300 km northwest of the territorial capital of Whitehorse.

The fish and aquatic resources study program was carried out at 29 fish sampling sites, 18 fish habitat sites, and 14 benthic invertebrate and periphyton sites throughout the Project study area. The six seasonal assessments were completed during July and September of 2008, August 2009, August 2010, August and September 2011, July and September 2012, and June and July 2013. Sites were concentrated in the Casino Creek and Britannia Creek watersheds as they have the potential to be directly affected by the Project.

Backpack electrofishing and minnow trapping were the primary fish sampling methods used. At each site, individual fish data (species, length, weight) was collected to infer fish community composition, relative abundance, and life history use. Ageing structures (e.g., scales, otoliths) and fish tissues were sub-sampled and analyzed to determine fish ages and baseline metal concentrations of resident fish species. Multi-year Chinook salmon spawning surveys were completed in the Dip and Britannia Creek watersheds. Fish habitat in the Project area was surveyed and analyzed relative to the potential for supporting rearing, spawning and overwintering activities of local fish species. To further characterize local fisheries, benthic invertebrate and periphyton studies were conducted to assess the primary productivity, community characteristics, and overall aquatic ecosystem health in the Project area.

Benthic invertebrate communities in the Casino Creek watershed generally displayed lower densities, richness, diversity, and EPT abundances relative to other watersheds in the Project area. Sites in the upper watershed had particularly low values when compared to lower Casino Creek or to reference areas of upper Dip Creek, and were likely due to a combination of cold water temperatures, high velocities, and poor water quality as a result of anthropogenic and natural ARD from Meloy Creek and Proctor Gulch. Similarly, sites in upper Casino Creek displayed low periphyton densities and taxonomic richness in comparison to lower Casino Creek, or to reference areas of upper Dip Creek. Further, periphyton diversity values were significantly lower in Casino Creek in comparison to Britannia Creek, with the lowest values observed in the upper watershed. Notably, future monitoring will focus on comparing Dip Creek reference areas to the near-field site in lower Casino Creek, as sites in the upper watershed will be displaced following project construction of the tailings management facility. Accordingly, baseline periphyton and benthic invertebrate communities were similar in Dip Creek reference areas to lower Casino Creek, thus facilitating the future assessment of potential impacts.

Benthic invertebrate community trends within sites in the Britannia Creek watershed often differed from Dip and Casino Creeks, with the more upstream sites exhibiting higher taxonomic richness, EPT abundance and diversity in comparison to downstream sites. Similarly, periphyton communities in the upper watershed demonstrated higher diversity values, although at lower densities. The reversed trend noted may be in result of fairly recent (1996-2002) placer mining disturbance in lower Canadian Creek.

Slimy sculpin (*Cottus cognatus)* and Arctic grayling (*Thymallus arcticus)* were the most dominant species captured, with low numbers of burbot (*Lota lota)* and round whitefish (*Prosopium cylindraceum)* also present in the lower watersheds. Juvenile Chinook salmon (*Oncorhynchus tshawytscha)* were captured in lower Britannia Creek in 2009 and 2011 near the Yukon River confluence. Sampling of Dip Creek from 2008-2013 by AECOM and PECG yielded no juvenile Chinook salmon, however, historical documentation of juveniles in the lower to mid reaches, and the more recent capture of a single juvenile by Summit (2012) indicates that Dip Creek may provide occasional habitat for low abundances of juvenile Chinook. No Chinook salmon have been captured either recently or historically within Casino Creek. No Chinook salmon spawning was observed in either watershed despite multi-year surveying. No species at risk were caught within the Project study area.

Four years of fish sampling in upper Casino Creek included 11,904 seconds (s) of electrofishing effort and 1,255 hours (h) of minnow trapping, with a total catch of 14 Arctic grayling within reach 2. A medium gradient (8-10%) cascade marks the reach break between reaches 2 and 3, and likely constitutes a high-flow barrier to fish migration in most years. Accordingly, fish sampling over three years yielded no fish in reach 3. However, in 2013 four Arctic grayling were captured within 250 metres (m) of the cascade during exceptionally clear and low flow conditions. No fish were caught in the small (<1m channel width) upper Casino Creek tributary, Meloy Creek. Fish abundance was higher in the lower watershed, with catch-per-unit-effort's (CPUEs) of 0.5-0.9 fish/100s of electrofishing in Brynelson and lower Casino Creeks, respectively. The fish communities were dominated by slimy sculpin (71-89%) followed by Arctic grayling (10-29%). Downstream of Casino Creek, relative fish abundance and community diversity further increased within Dip Creek, with the most downstream site (F20) exhibiting the highest CPUE of any site in the project area at 4.5 fish/100s of electrofishing.

Within the Britannia Creek watershed, site Y1 located proximate to the Yukon River had the second highest CPUE in the project area at 4.4 fish/100s of electrofishing. The fish community at Y1 was comprised of slimy sculpin (64%), juvenile Chinook salmon (34%), and Arctic grayling (2%). At sites upstream of Y1, only Arctic grayling were captured. In the three reaches of Canadian Creek, fish were caught only in the lower two reaches. A 20% gradient fish barrier was located at the junction of reaches 2 and 3, and prohibited fish from moving further upstream.

Three years of sampling yielded a relatively high CPUE (0.8 fish/100s of electrofishing) at the Victor Creek reference site, where the community was predominantly slimy sculpin (88%). However, no fish were caught in 2012 at this site. A site in the upper Coffee Creek watershed was added to the baseline program in 2012 to supplement Victor Creek as a reference site. Two years of sampling yielded a total of 12 Arctic grayling and one round whitefish at a rate of 0.8 fish per 100s of electrofishing effort.

Length-weight relationships of Arctic grayling did not vary among watersheds. The majority of Arctic grayling captured in the project study area were greater than 125mm in length, and thus representing age classes 1+. Sizes corresponding to probable young-of-the-year (<70mm) were only observed in Dip Creek below its confluence with Casino Creek, and at site Y1 on Britannia Creek. The lack of young-of-the-year rearing in the majority of the Project area suggests that Arctic grayling spawning activities are correspondingly minimal. Habitat surveys were consistent with fish sampling results, as the potential for spawning habitat throughout the Project area was mostly rated none to poor, with some moderate spawning potential identified in Dip and Britannia Creeks, as well as in reach 1 of Casino Creek. According to the habitat suitability maps produced by the Yukon Mining Secretariat, watercourses within the Project area do not support spawning activities or provide critical migratory corridors for spawning Chinook salmon.

Rearing habitat was the most common habitat type identified in the Project area, with most sites having rankings from moderate to good. Poor rearing habitat quality was documented in upper Casino Creek and in reach 1 of Brynelson Creek, and was mainly attributed to a lack of potential fish resting or protective locations. In particular, upper Casino Creek had several long medium gradient (5-11%) cascades comprised of a number of potential flow-regulated barriers hindering both juvenile and adult rearing activities. Fish habitat suitability maps from the Yukon Mining Secretariat were in accordance with baseline study results, with Casino, Canadian and Victor Creeks designated as low suitability areas unlikely to support juvenile Chinook rearing. Further, habitat supporting juvenile Chinook rearing activities was most probable in the lower Britannia Creek watershed, and in the lowest 10km of Dip Creek.

Due to the lack of deep pools and the noted occurrence of anchor ice around the Project area, the potential for overwintering habitat was generally sparse. Areas of exception included Dip Creek at F14 and Victor Creek which were deeper and wider channels less likely to freeze to bottom.

Tissue samples from slimy sculpin in Britannia Creek demonstrated the highest metal concentrations with significantly greater aluminum, arsenic, cadmium, iron, lead, nickel and selenium concentrations compared to the other watersheds sampled. As all slimy sculpins analyzed from Britannia Creek were captured adjacent to the Yukon River confluence, higher metal loading was likely due to the influence of Yukon River back-watering in addition to the potential for small-scale movements (<100m) between the two environments. The second overall highest tissue metal concentrations in the study area were observed in Casino Creek, where sculpins had significantly higher arsenic, cadmium, copper and lead concentrations in comparison to sculpins from Dip and/or Victor Creeks. These results were consistent with water and sediment quality studies which have documented consistently poor water quality in Casino Creek as a result of local sources of acid rock drainage (ARD) which enter the upper watershed via Proctor Gulch and Meloy Creek. Mean selenium concentrations in slimy sculpin tissues in Britannia and Victor Creeks exceeded the selenium guidelines for the protection of freshwater aquatic life. Mean estimated methylmercury concentrations exceeded the guideline for the protection of fish-eating (piscivorous) wildlife in all watersheds.

Acronyms and Abbreviations

ARD	Acid Rock Drainage
BC MOE	British Columbia Ministry of Environment
CCME	Canadian Council of Ministers of the Environment
CMC	Casino Mining Corporation
CPUE	Catch-per-unit-effort
DFO	Fisheries and Oceans Canada
DOC	Dissolved Organic Carbon
DW	Dry weight
EEM	Environmental Effects Monitoring
GPS	Global Positioning System
HKP	Hallam Knight Piésold Ltd.
ICP	Inductively coupled plasma
ICP-MS	Inductively coupled plasma mass spectrometry
ISO	International Standards Organization
ISQG	Interim Sediment Quality Guideline
LT_{50}	Lethal Time for 50% of the test organisms
MMER	Metal Mining Effluent Regulations
µS	micro-Siemens
NA	Not applicable
NAN	Not a Number
NS	Not sampled
NTU	Nephelometric unit
PEL	Probable Effects Level
PQL	Practical Quantitation Limit
PYLET	Pacific and Yukon Laboratory for Environmental Testing
QA/QC	Quality Assurance/Quality Control
RDL	Reported Detection Limit
RPD	Relative Percent Difference
SE	Standard error
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMF	Tailings Management Facility
TOC	Total Organic Carbon
TSS	Total Suspended Solids
U.S. EPA	United States Environmental Protection Agency
YESAB	Yukon Environmental and Socio-Economic Assessment Board

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1 Introduction

1.1 Overview

The Casino Project is 100% owned by the Casino Mining Corporation (CMC). It is a proposed porphyry copper-gold-molybdenum mine located in west-central Yukon, at 611379E 6956218N, approximately 300 km northwest of the territorial capital of Whitehorse. The location of the Project is shown in Figures 6-1 and 6-2, surrounded by the fish and aquatic resources study area, in relation to the Yukon River to which all of the streams in the Project area eventually discharge.

This report includes field study results from the 2008-2013 fish and aquatic resources baseline program in the Casino Project study areas. Annual technical reports were developed for the aquatic field studies between 2008 and 2013 and can be found in Appendices A to F.

1.2 Study Objectives

The purpose of the Fish and Aquatic Resources Baseline Program was to characterize the pre-development aquatic environment of the Project area in support of the project proposal to the Yukon Environmental and Socio-economic Assessment Board (YESAB).

The specific objectives of the fish and aquatic resources sampling program were as follows:

- To determine the fish bearing status of streams within the Project footprint;
- To assess the fish community composition, relative abundance and spatial distribution within the Project study area;
- To characterize watershed-specific life history use via the collection and analysis of individual age, length and weight data, and via spawning surveys;
- To measure the baseline metal concentrations of resident fish tissues within the Project study area; and
- To describe fish habitat within the Project study area.

To further characterize local fisheries, benthic invertebrate and periphyton studies were conducted to assess the primary productivity, community characteristics, and overall aquatic ecosystem health in the Project area.

2 Methods

2.1 Study Area

The study area for the fish and aquatic resources of the Casino Project includes the two watersheds surrounding the Project deposit (also known as Patton Hill): the Britannia Creek watershed to the north and the Casino Creek watershed to the south. This area includes the direct footprint of the proposed Project mine and near-field affected areas. These watersheds have the potential to be affected by the Project.

Most of the proposed mine infrastructure will be in the Casino Creek watershed, with some (e.g., the northern corner of the open pit) found within the Britannia Creek watershed. The northern part of the study area is drained by Britannia Creek and its main tributary, Canadian Creek, which flow northward into the Yukon River. The southern part of the property is drained by Casino Creek which flows south to Dip Creek and thence to the Yukon River via the Klotassin, Donjek and White rivers.

The fish and aquatic resources study area also includes water bodies which are either indirectly affected (mid-to-far field effects) or are suitable for providing references sites by the Project activities:

- **Dip Creek Watershed**. The headwaters of Dip Creek are not expected to be affected by Project activities, but the reaches of Dip Creek downstream of the confluence of Dip and Casino Creeks may be affected by a reduction in stream flow from Casino Creek caused by the impoundment of its headwaters within the Tailings Management Facility (TMF). The effects of flow reductions may decrease with downstream distance from the confluence of Dip and Casino Creeks. Reference site R2 was established on Victor Creek, which is a tributary of Dip Creek located upstream of the Project, for benthos, periphyton and fish communities.
- **Isaac Creek Watershed**[1]. This watershed, located to the east of the Britannia Creek Watershed, is not expected to be affected by Project activities. Reference site B10/P10 for periphyton and benthic invertebrate communities was located on Isaac Creek upstream of its confluence with the Yukon River.
- **Excelsior Creek Watershed**. This watershed, located to the west of Britannia Creek watershed, is also not expected to be affected by Project activities. Reference site B9/P9 for periphyton and benthic invertebrate communities was located on Excelsior Creek upstream of its confluence with the Yukon River.
- **Coffee Creek Watershed**. Coffee Creek is located west of the Excelsior Creek watershed and approximately 15 km west of the Britannia Creek watershed. Coffee Creek is not expected to be affected by Project activities, and thus a new fisheries reference site was added on Coffee Creek in 2012 (F19), upstream of the main drilling activities of the Kaminak Coffee Gold Project (SRK, 2013).

[1] Isaac Creek was referred to in the annual technical reports (Appendices A-D) by the name of its main upper tributary, Sunshine Creek

2.2 Historical Review

Historical studies on the aquatic ecosystem of the Project property were first conducted from 1993 to 1995 (HKP, 1997). In 1994, Fisheries and Oceans Canada (DFO) and Indian and Northern Affairs Canada (INAC), then known as the Department of Fisheries and Oceans Canada and Department of Indian Affairs and Northern Development (DIAND), conducted an overview investigation of waters that may be affected by the Project (DFO, 1994). This included the Klotassin River, Dip Creek, Britannia Creek, Selwyn River and Hayes Creek. In 1998, White River First Nation commissioned a study to identify areas of the Lower Donjek River drainage utilized by Chinook salmon (Otto, 1998). This was conducted in order to serve as a pilot study to develop a strategic plan for future Chinook salmon restoration and enhancement work in the lower Donjek. In 2001, on behalf of Selkirk First Nation, studies were conducted on selected Yukon River tributaries between McGregor Creek and Coffee Creek by Laberge Environmental Services (Laberge, 2001). Basic data on flow, water quality, benthic invertebrate and fish were collected.

For the purposes of managing Pacific salmon fisheries in the Yukon River Watershed and for classifying fish habitat in support of the Yukon Placer Authorization, DFO previously conducted surveys of fish and fish habitat in watersheds near the study area (Government of Canada, 2000). DFO surveys were conducted in reaches of the Yukon River adjacent to the Project property and the lower reaches of Dip Creek and the Klotassin, Donjek and White rivers. The results of the DFO surveys are reported in Appendix B10 of AECOM (2009).

As potential future impacts from the Project will be assessed using the aquatic environment characterized in this Fish and Aquatic Resources Baseline Report, only data from the current program (2008-2013) was included in analysis and summaries. The exclusion of historical data was due to (1) varying sampling methodologies used by historical and current programs, and (2) the potential for environmental variability over the past 10-20 years, which would hamper the assessment of any potential future changes. As historical information will still provide a long-term perspective of the aquatic study area, reference to this data is included where applicable throughout the baseline report (e.g., species presence/absence, life history use, productivity and overall aquatic ecosystem health).

2.3 Study Design

The fish and aquatic resources study program was carried out from 2008-2013 at 29 fish sampling sites, 18 fish habitat sites, and 14 benthic invertebrate and periphyton sites throughout the Project study area (Figure 6-1, Figure 6-2). The six seasonal assessments were completed during July and September of 2008, August 2009, August 2010, August and September 2011, July and September 2012, and June and July 2013. A description of the field activities completed during each of the six seasonal assessments is as follows:

2008 Program:

- Fish sampling including electrofishing and minnow trapping from July 8-9 and September 10-13;
- Fish habitat surveying from July 8-11 and September 11-12;
- Fish (slimy sculpins) collected for metal concentration analyses of tissues;
- Aerial Chinook salmon spawning assessment of the Britannia Creek watershed on September 11; and

- Benthic invertebrate and periphyton sampling from September 10-12.

2009 Program:
- Fish sampling including electrofishing and minnow trapping from August 5-8;
- Fish habitat sampling on August 5 (at new reference site R2 on Victor Creek);
- Fish (slimy sculpins) collected for metal concentration analyses of tissues;
- Ground-based Chinook salmon spawning assessment on August 9 in upper Britannia Creek; and
- Benthic invertebrate and periphyton sampling from August 5-8.

2010 Program:
- Fish sampling including electrofishing and minnow trapping from August 10-12;
- Fish barrier assessment on upper Canadian Creek; and
- Aerial Chinook salmon spawning assessment of Dip Creek and the Klotassin River on August 10.

2011 Program:
- Fish sampling including electrofishing and minnow trapping from August 9-11 and September 7-9;
- Fish (slimy sculpins) collected for metal concentration analyses of tissues; and
- Benthic invertebrate and periphyton sampling from August 21-22.

2012 Program:
- Fish sampling including electrofishing and minnow trapping from July 3-4 and September 8-13; and
- Aerial Chinook salmon spawning assessment of Dip Creek on September 13.

2013 Program:
- Fish sampling including electrofishing and minnow trapping on Casino, Dip and Coffee Creeks; and
- Fish habitat surveying.

The number of sites sampled and locations surveyed varied in a given year. Specific sampling variances by year are detailed in the subsequent sections below.

2.4 Periphyton and Benthic Invertebrates

2.4.1 Sampling Sites and Methods

Periphyton and benthic invertebrates were sampled in watercourses within the study area during August-September of 2008, 2009 and 2011 (Figure 6-1, Table 6-1). Field methods and data analysis referred to in this report are only applicable to recent sampling (2008-2009 and 2011), and details of historical data collection (1993-1994) can be found in the study completed by Hallam Knight Piesold (HKP, 1997).

The two aquatic communities were sampled during late summer because they were expected to have reached their maximum density and diversity after a summer of growth. A total of seven sites were sampled in years 2008 and 2009, including four sites in the Britannia Creek watershed, two sites in the Casino Creek watershed, and one site in Dip Creek downstream of its confluence with Casino Creek. In addition, a reference site on Victor Creek in the Dip Creek watershed was sampled in 2009. The 2011 sampling program focused on a different set of sampling sites, including three in the Casino Creek watershed, one reference site in upper Dip Creek, and two reference sites in nearby Excelsior and Isaac Creeks. Both benthic invertebrate and periphyton sampling was carried out at each site, with the exception of B13 on Meloy Creek where no periphyton sampling was conducted due to the dominant sandy substrate material. For each periphyton and benthic invertebrate site, riffle habitats were selected with the aim of standardizing depth, velocity, gradient, substrate, and sunlight exposure among sites.

Periphyton

At each sampling site, rocks were randomly selected from the stream bed, scraped with a scalpel, and then washed into sterile 500mL plastic jars with stream water to produce five individual periphyton samples per site. Each sample was preserved by adding Lugol's iodine solution. In 2008, the scraped surface area (cm^2) was estimated by tracing the outline of the scraped area onto a wax paper template. Wax paper outlines were later scanned to JPG file format at high resolution. The images were then rasterized and imported into AutoCAD where new vector boundaries were created based on the outside edge of the wax paper for each sample. This process ensured minimal margin of error and allowed for quick calculation once the scans were complete. In 2009 and 2011, a surface area of 100 cm^2 was determined in the field using a ruler.

All samples were stored in coolers and kept cool until they could be shipped to Fraser Environmental Services Ltd. (FES) of Surrey, BC, for analysis of taxonomic composition. Chain of Custody forms accompanied all samples.

Periphyton density (cells/cm^2) was calculated for each sample by dividing the total number of cells estimated for a sample by the surface area that was scraped for each sample. Sub-sampling was required to estimate numbers of cells (FES, 1994).

Benthic Invertebrates

In 2008, all benthic invertebrate samples were collected using a Surber sampler with a surface area of 0.093 m^2 and mesh size of 250 µm. The Surber sampler was placed facing into the stream current with the hinged frame resting on the streambed. Substrate within the area defined by the frame was disturbed by hand for approximately five minutes to dislodge benthic organisms, which were swept into the net by the stream current.

In 2009 and 2011, the Canadian Aquatic Biomonitoring Network (CABIN) approach (NWRI, 2009) to benthic invertebrate sampling was used. In addition, two sites (B1 and B2) were sampled using both surber and kick-net methods in 2009 to assess variability between the methods. The switch to a different method in 2009 was made after discussions with representatives at Environment Canada (EC) in Whitehorse. The CABIN approach is maintained by EC and is therefore recommended for all benthic invertebrate sampling programs. Kick-net sampling was carried out using a Lamotte D-net (500 µm mesh) with a 30 cm rim in 2009, followed by a triangular CABIN protocol benthic kick net (400 µm mesh) with a detachable collected cup manufactured by Halltech Aquatic Research Inc. in 2011. In both years, the net opening was faced into the stream current with the flat side of the net resting on the substrate of the stream. The sampler walked backward in the upstream direction, dragging the net along the bottom of the stream while disturbing the substrate with a kicking motion to a depth of ~5-10 cm. Sampling was zig-zagged over the stream bottom from bank to bank in an upstream direction for a timed period of three minutes.

All organisms caught in the sampling nets were washed into a sample bottle and preserved with 85% ethanol. This was repeated four more times at nearby areas to obtain five replicate samples at each site. Samples of benthos were shipped to Cordillera Consulting in Summerland, BC, for taxonomic identification to the lowest practical taxonomic level, which was to the Family level for most aquatic insects, to the Class level for oligochaetes and to the Phylum level for nematodes. Chain of Custody forms accompanied all samples. All organisms in each sample were counted and identified – no sub-sampling was required.

Total density of benthic invertebrates collected by the Surber sampler was calculated by dividing the total number of organisms per sample by the Surber sampling area. Total density of benthic invertebrates collected by the kick net was calculated by total number of organisms per kick net.

2.4.2 QA/QC

Periphyton and benthic invertebrate samples were collected by a qualified aquatic biologist and were carried out by the same individual at each sampling site to insure consistency.

Fraser Environmental Services Ltd. (FES) has over fifteen years experience in analysis of periphyton from streams and rivers of western Canada. FES has the following standard QA/QC procedures (FES, 1994):

- all microscopes are calibrated on a regular basis;
- consistent sample concentration and sub-sampling techniques are employed for identifications;
- taxonomic identifications are verified by comparison with reference collections, including an in-house reference collection;
- difficult, typical or dominant specimens are sent to external experts for confirmation. Part of this process includes compiling a list of experts for different groups of organisms. Verified specimens are incorporated into FES' reference collection; and
- all FES personnel actively participate in a taxonomists' working group.

Cordillera Consulting has over ten years experience in taxonomic analysis of benthic invertebrates from streams, rivers and lakes of western Canada. The following QA/QC procedures are followed by Cordillera Consulting:

- sorting efficiency – 10% of the whole sample number was resorted with an expectation of >90% efficiency in the sorting process;
- taxonomic efficiency – 10% of the identified sample vials were sent to another taxonomist. The two results were compared with simple statistics and the taxonomists discussed how best to correct their differences and make appropriate changes to the results; and
- taxonomic precision – an externally verified reference collection is maintained by Cordillera Consulting. Any new specimens are sent away to experts of that taxon and the collection is reviewed every five years.

2.4.3 Data Analysis

The standard deviation (SD) was the index of dispersion for all arithmetic means shown in this report, and n was the sample size. All statistical analyses were completed using Statistica version 8 (StatSoft Inc.,Tulsa OK, 2008), with significance levels set to α=0.05.

To facilitate periphyton and benthic invertebrate analyses, all years of data were combined at the watershed or site level, when more than one year of site data was available. For benthic invertebrates, surber sampled and kick-net sampled data were analyzed separately, as previous studies have demonstrated that sampling method can bias results (e.g., Page and Sylvestre, 2006). Benthic invertebrate results reported in this study focus on kick-net sampled data as more sites, including multiple reference sites, were incorporated in the study design. Any similarities or variances identified in surber collected data with respect to kick-net sampled data are described on a section by section basis within the results.

Parameters calculated for periphyton included mean density, community composition, taxonomic richness, and the Shannon-Wiener diversity index. For benthic invertebrate analyses, the set of parameters also included EPT abundance, Simpson's evenness index, and Simpson's diversity index in place of the Shannon-Wiener diversity index. Parameter selection was based on the protocols recommended by the Canadian Aquatic Biomonitoring Network (CABIN), which is supported by the National Water Research Institute (NWRI) of Environment Canada (NWRI 2008). Parameters were defined and calculated as follows:

- Periphyton community composition was determined by calculating the relative proportions of five main algal groups by site including: Diatoms (Bacillariophyceae), green algae (Chlorophyta), blue-green algae (Cyanophyta), yellow-brown algae (Chrysophyta), and red algae (Rhodophyta);
- Benthic invertebrate community composition was determined by calculating the relative proportions of five main invertebrate groups by site including: ringed worms (Annelida), true flies (Diptera), mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera), whereas all other groups (e.g., Acariformes, Amphipoda, Bivalvia, Coleptera, Colembola, Copepoda, Gastropoda, Hemiptera, Heterostropha, Hypsogastropoda, Isopoda, Lepidoptera, Nemata, Ostracoda, Playthelminthes, Tardigrada) which when combined constituted less than 12% of the overall community composition;
- Taxonomic richness (S) was the total number of species present at each site. Where species could not be discerned, the lowest possible taxonomic level identified was substituted;
- The Shannon-Wiener diversity index (H') was calculated using equation (1):

$$H' = -\sum_{i=1}^{S} p_i (\ln p_i) \tag{1}$$

- EPT abundance was defined as the total number of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) in a sample. These three orders of aquatic insects are typically most sensitive to habitat disturbance; and
- The Simpson's diversity index (D) was calculated using equation (2):

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

- The Simpson's evenness index (E) was calculated using equation (3):

$$E = 1/\sum_{i=1}^{S}(p_i)^2/S \tag{3}$$

Where S is taxa richness, and p_i is the total number of individuals in the i^{th} species divided by the total number of organisms in the sample.

The periphyton data reported by FES included less than signs (<) for some species or genera, indicating that the species or genus were present in the sample but not in sufficient numbers to allow density to be calculated. Those data were used to calculate taxonomic richness, but they were not used to calculate densities, community composition, or Shannon-Wiener diversity indices.

Each parameter was compared among watersheds (Britannia, Casino, Dip, Excelsior, Isaac), followed by among site comparisons within each watershed. In addition, comparisons were made between combined sites in upper Casino Creek within the direct project footprint (P12/B12 and P7/B7) and reference sites in upper Dip Creek (P14/B14, PR2/BR2) to aid in the characterization of the predicted habitat loss. However, it should be noted that future monitoring will be comparing conditions in Dip Creek reference sites to lower Casino Creek where near-field effects may occur due to upstream project activities. Accordingly, aquatic communities at the near-field site P4/B4 in lower Casino Creek were assessed relative to reference sites in upper Dip Creek which were the most similar reference habitats to P4/B4 with respect to channel size, substrate, gradient, morphology, nutrients, and elevation. Statistical comparisons of each parameter were made using one-way Analysis of Variance (ANOVA) or one-sample t-test, and followed by post-hoc Tukey HSD tests to identify pairwise differences where appropriate. Data was In-transformed where necessary to facilitate parametric testing. When transformed data did not meet parametric test requirements, a non-parametric Kruskal-Wallis H-test was performed.

2.5 Fish Community

2.5.1 Sampling Sites and Methods

General Fish Sampling Methods

Fish sampling was conducted over the period of 2008-2013 at a total of 29 stream sites within the Project study areas (Figure 6-2, Table 6-2). Backpack electrofishing and minnow trapping were performed during the summer-fall season within the months of June, July, August and September. Sampling effort varied by site, with more effort generally concentrated in areas with greater anticipated project related impacts, e.g., Casino Creek, or in watersheds with the potential to support regionally significant species, e.g., Chinook salmon. Sites in Casino Creek reaches 2 and 3 and in Meloy Creek were within the proposed TMF footprint. Two sites were established as reference sites, being R2 on Victor Creek and F19 on Coffee Creek. Site F17 in the upper Dip Creek watershed was sampled in two consecutive years with the aim of establishing it as an additional reference site. Due to the lack of an additional comparable reference site established in the Casino and Dip Creek watersheds, Coffee Creek was identified as the closest watercourse with similar fish and fish habitat to watercourses in the project area. No fish were caught, and the site was consequently removed from the sampling program. Specific sampling dates and methodologies are further detailed in the annual aquatic studies reports (Appendices A-F).

Electrofishing was conducted using a two-person crew and a backpack electrofishing unit, with the exception of Dip Creek sites in 2013 where a three-person crew was employed. Single-pass and spot fishing methods were primarily used, while walking the stream in an upstream direction repeatedly sweeping the stream from bank to bank with the wand (anode) of the electrofishing unit. Site lengths ranged from 75-400m, whereas effort varied from approximately 250-2400s per electrofishing pass, with an average effort of 767s/pass. Three-pass electrofishing was carried out when flows were low enough to permit stop net deployment. Stop nets were installed at the top and bottom of the sampling site in order to prevent escapement of fish during sampling. Similar effort (e.g., electrofisher settings, time) was put forth during each of the three passes. Fifteen to twenty minutes was allowed to elapse between passes in order to allow any uncaptured fish to recover before sampling recommenced. Fish were captured with a dip net and stored in a bucket of freshwater while processing.

In addition to backpack electrofishing, a shore based fishing unit was employed during the 2013 program at two sites in Dip Creek (F14, F22) to fish deep pools which were not accessible using the backpack electrofisher. A two person crew operated the shore fishing unit while an additional two people were positioned with dip nets at opposite ends of the pool. Voltage was set at 354V and effort per site ranged from 266-289s.

Minnow traps were made of galvanized steel wire and were conical in shape with a length of 42 cm, a width of 23 cm and a mesh size of 0.6 cm. Minnow traps were placed at each site in deep pools or among large woody debris or in slow-moving eddies. They were anchored to large woody debris or rocks and rocks were placed within the traps to weight them down. They were marked with red or yellow fluorescent flagging tape. Each trap was baited with salmon roe placed in a small perforated bag. Traps were soaked for approximately 24 hours.

All fish were identified to species and counted. Fork length was measured to the nearest 1 mm with a measuring board (total length was measured for slimy sculpin), and wet weight was measured to the nearest 0.1 g or 1.0 g with a balance (depending on size of fish). Scales were collected from Arctic grayling in 2008 (n=11) and 2009 (n=36) and sent to North Shore Environmental Services for aging. Otoliths were collected from two Arctic grayling and five slimy sculpin in 2011 and again aged by North Shore Environmental Services.

Watercourse Fish Bearing Status

Fish bearing status was assessed within upper Canadian Creek following the identification of a high gradient cascade which was deemed a probable barrier to fish migration. Assessment methods followed the standards established by the BC Ministry of Forests (BC MoF 1998). Habitat upstream of the barrier was assessed for deep pools or other habitat with potential to support overwintering fish. As the Casino project is situated in an un-glaciated area of the Yukon, no lakes are present. The barrier location and gradient was documented, and fish sampling was performed upstream to assess fish presence (Table 6-3). At minimum, two different sampling methods were employed over two sampling periods.

Spawning Surveys

Chinook salmon spawning surveys were conducted by two qualified fisheries biologists, either on foot or using a helicopter hovering just above the treeline and traveling at a slow enough speed to allow observers seated on both sides of the helicopter to observe spawning activity (Table 6-4). The water was clear, and there were no rain events 72 hours prior to conducting each survey.

Fish Tissue Field and Laboratory Methods

Slimy sculpin whole-body tissue samples were collected in 2008 (n=9), 2009 (n=24) and 2011 (n=19) for metals analysis. As per the Metal Mining Effluent Regulations (MMER), samples sizes from each watershed (Casino Creek, Britannia Creek, Dip Creek downstream of Casino Creek, and Victor Creek) ranged from n=8-22 to ensure a minimum sample size of 8 required for statistical adequacy (EC 2012). The selection of slimy sculpin for metals analysis provided relevant insight into site-specific metal contamination due to (1) the prevalence of the species in the study area, (2) its demonstrated high site fidelity (Gray et al. 2004), and (3) its sensitivity to stream sediment metal loading due to its benthic-dwelling nature.

Each fish was placed in a labeled plastic bag, frozen immediately and then shipped to an analytical laboratory for analysis. Laboratory methods varied among years and full descriptions can be found in the annual reports (Appendices A, B and D). Briefly, the samples were digested with a nitric acid-hydrochloric acid mixture using Inductively Coupled Atomic Emission Spectrometry (ICP-AES), Inductively Coupled Argon Plasma Spectroscopy (ICP) or ICP Mass Spectroscopy (ICP-MS). The concentrations of mercury were measured using either Cold Vapour Atomic Absorption Spectrophotometry (CVAAS) or Cold Vapour Atomic Fluorescence Spectrophotometry (CVAFS). The number of total metals analyzed per year ranged from 31-33, with varying detection limits (Table 6-5).

2.5.2 QA/QC

All fisheries field data were recorded on waterproof paper field notes and then transferred to electronic spreadsheets in the office. The spreadsheets were compared with the field notes to identify and correct transcription errors. A variety of other measures were taken to further ensure the validity of the data. For example, fish weights were plotted against fish lengths for each species separately to identify outliers that may have been due to errors in recording or transcription. Outliers were then corrected, if possible, or excluded from the analyzed dataset.

In 2008 blanks and duplicates were run by CANTEST for each of the two batches of slimy sculpin tissue that were analyzed for metals concentration (Appendix A). In both cases the blanks were below detection limits, indicating no contamination of equipment. Relative Percent Differences (RPDs) were calculated for each metal from the duplicate samples. In all cases, the RPDs were below the 20% limit specified by the *British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment, Biological Material and Discrete Ambient Air Samples* (BC MOE, 2007).

In 2009 and 2011 Quality Assurance (QA) was run by Maxxam Analytics for the batch of Arctic grayling, Chinook salmon and slimy sculpin tissue that was analyzed for metals concentration (Appendices B and D). Maxxam Analytics used spiked blanks and method blanks as their QA methods. A spiked blank is a blank matrix with a known amount of added analyte. A method blank is a blank matrix containing all reagents used in the analytical procedure. All blanks were within the QC limits (75%-125%), indicating no contamination of equipment.

2.5.3 Data Analysis

The standard deviation (SD) was the index of dispersion for all arithmetic means shown in this report, and n was the sample size. All statistical analyses were completed using Statistica version 8 (StatSoft Inc.,Tulsa OK, 2008), with significance levels set to α=0.05. Data for the Dip Creek watershed were split into areas downstream and upstream of the Casino Creek confluence where possible, with the upstream data representing the reference site R2 in Victor Creek. However, as only three Arctic grayling were caught in Victor Creek, these individuals were removed from watershed-specific analyses as to not confound the characterization of grayling downstream. In contrast, all slimy sculpin analyses had sufficient data to separate Victor Creek sculpins from downstream Dip Creek sites.

Catch per unit effort

Relative fish abundance in the study area was determined using a catch per unit effort (CPUE) index, defined as the number of fish caught per 100s of electrofishing effort. CPUE was calculated by species and watershed, with Dip Creek watershed being divided into areas located downstream or upstream of the Casino Creek confluence. For the two sites with shore based electrofishing, CPUE was calculated using the combined total effort from both backpack and shore electrofishing methods.

At the initiation of the baseline program, three-pass electrofishing depletion methods were employed whenever possible in order to obtain more accurate standardized population estimates. However, high flows often precluded the deployment of stop nets, and low total catch numbers often violated population estimate model assumptions. Thus, of the nine three-pass electrofishing sampling events successfully carried out, CPUE calculations were based on the effort and catch of pass 1 only to enable a better comparison with single-pass methods. Single-pass electrofishing abundance, biomass and length-frequency data have been shown to be similar or highly correlated with multiple-pass depletion approaches (Reid et al., 2008).

Size, Age, Condition

The length-age relationship for Arctic grayling was estimated by fitting a von Bertalanffy growth model with non-linear regression. The model was as follows:

$$L_t = L_\infty\left(1 - e^{(-K(t-t_0))}\right) \qquad (4)$$

where L_t = length (mm) at time t, L_∞ = theoretical maximal length, K = growth coefficient measuring the rate at which the maximal size is attained, and t_0 = theoretical age at zero length. A weighted non-linear regression model with weights set equal to age-class sample sizes was implemented to increase model accuracy. Arctic grayling length-at-age was combined from Britannia, Casino and Dip Creek watersheds as watershed-specific sample sizes were too small for producing individual models. No other species were considered for length-at-age analyses due to insufficient age data available.

Weight-length regressions for fish were calculated as:

$$ln(W) = a + b \times ln(L) \qquad (5)$$

where W = weight (g) and L = length (mm), a = the intercept of the regression and b = the slope of the regression. Regressions were completed for each species with sufficient sample sizes (n>30), which included Arctic grayling, slimy sculpin and Chinook salmon. In addition, watershed-specific regressions were performed for Arctic grayling and slimy sculpin.

Watershed-specific length-weight relationships were assessed for significant differences as a method for analyzing fish condition (Wootton, 1998). A preliminary assessment of Arctic grayling growth in the project study area demonstrated two growth patterns, with a much steeper length-weight relationship observed in fish less than 70mm (young-of-the-year) in comparison to individuals greater than 125mm. As weighing small fish (<80mm) in the field can often produce inaccuracies which may bias length-weight relationships, six young-of-the-year Arctic grayling (lengths <70mm) from Britannia and Dip Creeks were excluded from analyses. An analysis of covariance (ANCOVA) was performed on this selected size class using watershed as the categorical factor, weight as the dependent and length as the covariate. Homogeneity of slopes was assessed using an interaction factor between watershed and length.

A common-slope ANCOVA could not be similarly performed on slimy sculpin length-weight data due to significantly different slopes (Homogeneity of slopes test, P<0.01). Instead, a separate slopes ANCOVA model was applied to identify differences among watersheds.

One sample t-tests were performed on estimated weight-length slope coefficients to determine if slopes significantly differed from the isometric growth value of three. Slope coefficients used in t-tests were estimated for Arctic grayling using ANCOVA, and for slimy sculpin and Chinook salmon using watershed-specific linear regressions. Isometric growth is a requirement for calculating fish condition using the Fulton condition factor (K), as it assumes that fish shape does not change with increasing length. The Fulton condition factor was calculated for size-selected (>125mm+) Arctic grayling:

$$K = \frac{W}{L^3} \times 100{,}000 \qquad (6)$$

Where K = Fulton condition factor, W= weight (g) and L= fork length (mm).

Slimy sculpin and juvenile Chinook salmon condition could not be assessed using the Fulton condition factor, due to allometric growth. Instead, the relative condition factor (K_n) was used to characterize fish condition:

$$K_n = \frac{W}{W'} \qquad (7)$$

Where W = fish actual weight (g) and W'= predicted length-specific weight using the length-weight regression outlined in equation 5.

Metals Analysis

Selected total metals were compared among watersheds and included: aluminum, arsenic, barium, cadmium, copper, iron, lead, mercury, manganese, molybdenum, nickel, selenium, strontium, thallium and zinc. Values below detection limits were replaced with one-half the detection limit for analyses. ANOVA was used to investigate statistical differences in mean metal concentrations among watersheds, with a post-hoc Tukey HSD test applied to determine pairwise differences. Significant differences among watersheds were not analyzed if 100% of the samples for a particular watershed were below detection limits. For example, thallium concentrations were all below the reported detection limits in Dip Creek sculpin, and if analyzed would have led to the erroneous conclusion that thallium concentrations were significantly higher in Dip Creek as a result of detection limits varying by sampling year. Identified outliers were removed for statistical analyses, and data was log-transformed where necessary to facilitate parametric testing. When transformed data did not meet parametric test requirements, a non-parametric Kruskal-Wallis H-test was performed.

The mean and standard deviation of each metal were reported by watershed and compared to various guidelines for the protection of aquatic and piscivorous wildlife, as well as to Health Canada standards for mercury levels in fish. Currently, information is lacking for developing safe metal concentration levels for slimy sculpin, with guidelines available only for selenium and mercury. The selenium concentration guideline of 1mg/kg is an interim guideline prescribed by the British Columbia Ministry of Environment (2001) for the protection of freshwater aquatic life, with the aim of preventing selenium bioaccumulation up the food chain (BC MOE, 2001). However, the guideline should be interpreted with caution as the Canadian Council of Ministers of the Environment (CCME) has indicated that currently there is insufficient information required for the development of a full guideline.

The CCME mercury guideline for the protection of piscivorous wildlife is based on methymercury concentrations (0.033mg/kg), which is the biologically relevant form of mercury due to its potent neurotoxicity to humans and wildlife (CCME, 2007). The proportion of mercury in fish tissue in its methylated form varies by species, and previous studies have demonstrated that in slimy sculpin tissue approximately 83% of total mercury levels are methylated (Raymond and Rossmann, 2009). Thus, for comparing mercury levels with the CCME guideline, 83% of total mercury values were calculated as estimated methylmercury levels. In addition, total mercury in slimy sculpin was compared with Health Canada mercury guidelines which range from 0.2mg/kg for subsistence consumers to 0.5mg/kg for the maximum allowable level for sale in Canada. Notably, as slimy sculpin are not consumed by humans the comparison to Health Canada guidelines are not directly relevant, but instead provide an estimation of non-piscivorous fish which may be in turn consumed by piscivorous fish which support an aboriginal, recreational or commercial fishery.

2.6 Fish Habitat

2.6.1 Sampling Sites and Field Methods

A total of 18 sites were assessed for fish habitat in the project study area (Table 6-6). Fish habitat was characterized following a modified version of the methods described in the *Fish Habitat Assessment Procedures* guide for the British Columbia government (Johnston and Slaney, 1996), as there are no available watercourse sampling guides established for Yukon Territory. Stream reaches containing homogeneous channel characteristics were delineated based on a combined desktop and field assessment approach which incorporated channel morphology, confinement, gradient, bank and streambed substrate, and riparian vegetation. At each site, a minimum of 75m was surveyed to assess habitat characteristics. In 2008, sites F07, F08, F03 and F04 were surveyed in July, and the remaining sites including Casino Creek and its tributaries, Britannia Creek, Canadian Creek, and Dip Creek were surveyed in September. Site R2 in Victor Creek was added to the program in 2009, and assessed in August of that year. Site F19 in Coffee Creek was assessed during the 2013 sampling program.

At each habitat site, stream length and stream width (i.e., wetted and bankfull width) was measured with surveyor's measuring tape. Gradient was measured with a Sunnto clinometer. Stream depth was measured with a meter stick. Stream stage was assessed as low, medium or high visually by comparison between stream surface height and bankfull height. Habitat was visually assessed into the following five types:

- ***Pools*** have zero gradient, slow-moving water and a concave bottom;
- ***Runs*** (also called glides) are sections of non-turbulent, fast-flowing water;
- ***Riffles*** are areas of turbulent, fast-flowing water with gravel or cobble substrates and with obvious surface turbulence;
- ***Cascades*** are steep, stepped "riffles" of bedrock or emergent cobble or boulders in channels with gradients greater than about 4%; and
- ***Other*** includes wetland complexes that lack an identifiable primary channel, sloughs, lakes, areas of sub-surface flow or areas where the channel cannot be observed (e.g., under large log jams).

Stream substrate was assessed visually into the following classes:

- fines (or silt);
- small gravel (2-16 mm particle diameter);
- large gravel (16-54 mm);
- small cobble (64-128 mm);
- large cobble (128-256 mm);
- boulder (>256 mm); or
- bedrock.

The percent of the stream surface that provided fish with cover was described using the following classes:

- deep pool (>1m depth);
- large woody debris (LWD);
- boulder;
- cutbank;
- instream vegetation; and
- overhanging vegetation.

The percentage of the overhead forest canopy that was closed was estimated visually.

The percentages of a stream section that belonged to each habitat type had to add to 100%, as did the percentages of the substrate of a stream section that belonged to each size class and the percent of the canopy that was closed. However, the percentages of cover provided by the various classes did not have to add up to 100%.

Stream confinement was assessed as:

- unconfined (UC) – the stream bank is not touching the valley wall;
- occasionally confined (OC) – the stream bank is occasionally confined by the valley wall or terraces;
- frequently confined (FC) – the stream bank is frequently confined by the valley wall or terraces;
- confined (CO) – the stream bank is in continuous or repeated contact at the outside of meander bends;
- entrenched (EN) – the stream bank is in continuous contact with the valley walls or terraces due to downcutting; and
- not applicable (NA) – no valley walls exist (e.g., alluvial fans).

The stream section was classified as braided or non-braided and the percent of the stream surface area made up of gravel bars was recorded.

Biophysical data collected at each fish habitat site was analyzed to determine the potential for supporting varying Arctic grayling life history stages, e.g., spawning, rearing and overwintering. Slimy sculpin habitat requirements were not evaluated as they generally have similar or less restrictive habitat requirements in comparison to Arctic grayling. Habitat ratings from highest to lowest were excellent, good, moderate, poor and none. For example, a site with no deep pools (>1m) was considered to have no overwintering habitat. Spawning habitat potential was based on channel morphology, flow, depth, and substrate. For example, sites with 10-20% of preferred small gravel substrate were generally classified as moderate, whereas sites with <10% of small gravel were considered poor. Sites which were lacking small gravel substrate or low-gradient riffle habitat, or were heavily dominated by fines or boulder substrate (>70% of total area) were generally considered to have no spawning potential. More detailed habitat assessments were completed in reaches 1 and 2 of Casino Creek as part of the in-stream flow and habitat evaluation studies (Normandeau and PECG, 2012). Data recorded on suitable substrate, flow and depths were used to determine spawning habitat availability in these reaches.

***In Situ* Water Quality**

A suite of water quality variables were measured with field instruments (e.g., YSI model 556 or HI 9828 Hanna Meter) including pH, conductivity, total dissolved solids (TDS), and dissolved oxygen concentration. Collected *in situ* water quality data was combined from the fish habitat assessment program with the water quality baseline sampling program (Table 6-7). In addition, water temperature data was obtained from the hydrology baseline sampling program where dataloggers (Model 3001 Levelogger Gold, Solinst Corporation) recorded hourly water temperature measurements at nine hydrometric stations around the local study area. Between three-five years of water temperature data were collected at each site.

Collections of *in situ* water quality data at fish habitat sites were one-time events completed during the physical habitat assessments in July and September of 2008, and in July of 2013 at the Coffee Creek reference site F19. *In situ* water quality data was not collected during the habitat assessment at R2 in 2009, as the site was included in the water quality sampling program. Data collected and used in analyses from fish habitat sites included pH, TDS, and dissolved oxygen. Specific conductivity (adjusted to 25°C) was collected, but not reported here as the data was sparse in comparison to the non-adjusted conductivity database.

In situ water quality data was collected at 11 water quality sites in conjunction with sampling for the water quality baseline program. The number of sampling events at water quality sites ranged from 12-27 samples per site, during both summer (May – October) and winter (November – April) months. Water quality sites in areas without fish sampling were not included in analyses (e.g., sites in Yukon River, Klotassin River, Excelsior Creek, Isaac Creek, sections of Dip Creek, Proctor Gulch and W12). Parameters collected at water quality sites included pH and conductivity. In addition, dissolved oxygen was collected in August 2011, and in March and May of 2012.

2.6.2 Data Analysis

In situ pH and dissolved oxygen data was compared to the guidelines for the protection of freshwater aquatic life (CCME 2007). There are presently no territorial, federal or provincial guidelines for the protection of aquatic life for conductivity or total dissolved solids.

3 Results and Discussion

3.1 Periphyton

Mean Density:

Mean periphyton density was highest in Dip Creek (1,272,387 cells/cm^2) and lowest in Excelsior Creek (67,344 cells/cm^2), however, differences among watersheds were not significant (Figure 6-3; Kruskal-Wallis, H_4=9.15, P=0.06).

Within the Britannia Creek watershed, periphyton density generally increased in a downstream direction, however, there were no significant differences among sites (Kruskal-Wallis, H_3=3.81, P=0.28). Similarly, periphyton density was lower in the upper watershed and progressively increased downstream in Casino Creek, with significantly higher periphyton density noted in reach 1 in comparison to reaches 2 and 3 (ANOVA, $F_{3,36}$=3.7, P=0.02; Tukey HSD tests, P≤0.03). In contrast, periphyton density was highest in upper Dip Creek, with the uppermost site demonstrating significantly higher periphyton density relative to below its confluence with Casino Creek (Kruskal Wallis, H_2=14.68, P<0.01; Post-hoc multiple comparison test, P<0.01). Periphyton density in Brynelson Creek did not significantly differ from any of the three sites on Casino Creek (Tukey HSD tests, P≥0.05).

Mean periphyton densities were significantly higher in reference sites in upper Dip Creek relative to sites within the proposed project footprint in upper Casino Creek (t-test, t_9=3.02, P=0.01). On average, reference densities were sixteen times greater than non-reference densities, with means ±1SD of 2,428,407±2,371,819 cells/cm^2 and 152,354±263,654 cells/cm^2, respectively. However, periphyton densities were more comparable between the near-field site P4 in lower Casino Creek and reference site PR2, which represented the most similar reference habitat to P4 with respect to channel size, substrate, gradient, morphology, nutrients, and elevation.

Data from historical studies were similar, with both upper Canadian and Casino Creeks having notably low periphyton densities and chlorophyll ‘a’ values (HKP, 1997). Chlorophyll ‘a’ was highest in lower Canadian and Britannia Creeks (HKP, 1997).

Community Composition:

Blue-green algae (Cyanophyta) was the most dominant algal group in the study area (Figure 6-4), making up approximately 50% of the overall community composition. Chrysophytes and Diatoms respectively made up between 18-28% of the overall composition, with small percentages (0.2-3.5%) of green (Chlorophyta) and red (Rhodophyta) algae making up the remainder. The Casino and Dip watersheds were dominated by blue-green algae (51-80%), followed by diatoms (14-33%). In contrast, the most dominant algal groups in the Britannia Creek watershed were diatoms (57%), followed by Chrysophytes (19%) and blue-green algae (17%). Isaac Creek was almost entirely comprised of blue-green algae (96%), whereas Excelsior Creek was dominated by Chrysophytes (59%) and Diatoms (32%).

Within watersheds, algal community composition trends were observed in relation to relative site positioning. In both the Britannia and Dip Creek watersheds, the percentage of Diatom cells increased progressively downstream, whereas the percentage of blue-green algae cells decreased. The trend was similar but less pronounced for sites in the Casino Creek watershed, with Brynelson and upper Casino Creeks being comprised of similar blue-green algae dominated communities, and with the relative proportion of Diatoms increasing in lower Casino Creek.

Community composition was similar in 1993-1994, with Diatoms being the most dominant group within the Britannia Creek watershed, lower Casino Creek (P4) and on Dip Creek downstream of Casino Creek (P5) (HKP, 2007).

Taxonomic Richness:

Mean taxonomic richness by watershed ranged from 29 taxa in Isaac Creek to 39 taxa in the Britannia Creek watershed, with no significant differences observed among watersheds (Figure 6-5; ANOVA, $F_{4,95}$=2.36, P=0.06). Richness also did not differ when comparing sites within the Britannia Creek watershed (ANOVA, $F_{3,36}$=2.07, P=0.12). In contrast, differences were observed between sites in the Casino and Dip Creek watersheds, with site P4 in lower Casino Creek having significantly higher richness than the three sites upstream (Tukey HSD tests, P<0.01), and site PR2 in Victor Creek having significantly higher richness than P5 in Dip Creek (Tukey HSD test, P=0.01). Comparisons of future impacted and reference sites in upper Casino and Dip Creeks revealed significantly higher taxonomic richness in Dip Creek (t-test, t_{23}=4.33, P<0.01), whereas the near-field site P4 in lower Casino Creek had a comparable number of taxa (44) to the most similar reference site PR2 (46) in upper Dip Creek.

Shannon-Wiener Biodiversity Index:

Mean watershed biodiversity as measured using the Shannon-Wiener Diversity Index was highest in Excelsior Creek and lowest in Isaac Creek, with values of 1.9 and 1.1, respectively (Figure 6-6). Overall, biodiversity in the Britannia Creek watershed was significantly higher than in the Casino Creek watershed (ANOVA, $F_{4,95}$=4.29, P<0.01; Tukey HSD test, P=0.01), with no other significant among-watershed differences observed (Tukey HSD tests, P>0.05). Biodiversity generally decreased in a downstream direction within the Britannia Creek watershed, whereas an increasing pattern was observed in both Casino and Dip Creek watersheds. Some of the patterns were significant, for example P8 in upper Canadian Creek was more diverse than sites in Britannia Creek (Tukey HSD tests, P≤0.05), P4 in lower Casino Creek was more diverse than P12 in mid Casino Creek (Tukey HSD test, P=0.03), and P5 in mid Dip Creek was more diverse than P14 in upper Dip Creek (Tukey HSD test, P=0.04). Direct comparisons of future impacted and reference sites in upper Casino and Dip Creeks revealed no significant differences in biodiversity (t-test, t_{23}=1.30, P=0.21).

3.2 Benthic Invertebrates

Mean Density:

Mean benthic invertebrate densities were highest in Dip and Excelsior Creeks (299-372 individuals/kick-net), intermediate in Isaac Creek (205 individuals/kick-net), and lowest in Casino and Britannia Creeks (Figure 6-7; 98-99 individuals/kick-net). Both Dip and Excelsior Creeks displayed significantly higher densities than both Casino and Britannia Creek watersheds (ANOVA, $F_{4,65}$=13.54, P<0.01; Tukey HSD tests, P<0.01).

Within the Britannia Creek watershed, benthic invertebrate density was consistent among sites with the exception of B3 in lower Canadian Creek which had a significantly lower density than upstream B8 and downstream B1 (ANOVA, $F_{3,16}$=5.16, P=0.01; Tukey HSD tests, P≤0.02). In the Casino Creek watershed, benthic invertebrate density was lower in the upper watershed and progressively increased downstream, with significantly higher benthic invertebrate density noted in reach 1 in comparison to reach 3 and Meloy Creek (Kruskal Wallis, H_4=19.69, P<0.01; Post-hoc multiple comparison tests, P≤0.01). Moreover, abundances in Casino Creek reach 3 and Meloy Creek were the lowest in the entire project area. Proctor Gulch, an upper Casino Creek tributary with elevated metal concentrations and acid water likely contributed to the low abundances in reach 3 of Casino Creek. Further, the predominantly sandy substrate material in combination with the ARD source from a historical adit located in the upper watershed of Meloy Creek likely contributed to the low abundances in Meloy Creek. Similar to Casino Creek, benthic invertebrate density was generally lower in upper Dip Creek, with the uppermost site demonstrating significantly lower benthic invertebrate density relative to BR2 on Victor Creek (ANOVA, $F_{2,12}$=3.93, P<0.05; Tukey HSD test, P=0.04). Declining benthic invertebrate abundance with stream longitudinal positioning has been noted elsewhere in relation to increasing water temperature and channel stability (e.g., Ward, 1994; Milner et al., 2001). Benthic invertebrate density in Brynelson Creek did not significantly differ from any of the three sites on Casino Creek (Multiple comparisons tests, P≥0.05).

Mean benthic invertebrate densities were significantly higher in reference sites in upper Dip Creek relative to future impacted sites in upper Casino Creek (t-test, t_{22}=3.96, P<0.01). On average, reference densities were five times greater than non-reference densities, with means ±1SD of 282±196 individuals/kick-net and 61±48 individuals/kick-net, respectively. However, benthic invertebrate densities were more comparable between the near-field site B4 in lower Casino Creek (209±50 individuals/kick-net) and nearby Dip Creek reference sites.

Surber sampling produced varying results in comparison to kick-net sampling, as the two methods are not directly comparable for benthic invertebrate density sampling (Page and Sylvestre, 2006). However, some similar trends were noted such as significantly lower benthic invertebrate density at B3 in lower Canadian Creek in comparison to B8 (ANOVA, $F_{3,26}$=3.52, P=0.03; Tukey HSD test, P=0.04), and Casino Creek sites having lower density values than both Britannia and Dip Creek watersheds, although differences were only significant between Britannia and Casino Creek watersheds (ANOVA, $F_{2,42}$=20.14, P<0.01; Tukey HSD test, P<0.01). In contrast to kick-net sampling results, benthic invertebrate densities in upper and lower Casino Creek were almost identical (B4: 329 individuals/kick-net, B7: 333 individuals/kick-net).

In 1993-1994, the highest benthic invertebrate densities were noted in upper Canadian Creek and lower Britannia Creek, similar to the surber-collected data from the current program. However, in accordance with both sampling methods, historical densities in upper Casino Creek were markedly lower than all other study sites (upper Casino: 101-140/$m^{2,}$ other sites: 1781-18,619/m^2; HKP, 2007).

Community Composition:

Dipterans were the most dominant benthic invertebrate group in the local study area (Figure 6-8), making up over 50% of the overall community composition. Mayflies (Ephemeroptera) were the second most dominant group at 31% of the overall composition, with small percentages (2-6%) of caddisflies (Trichoptera), annelids (ringed worms), and stoneflies (Plecoptera) making up the remainder. The Casino, Britannia and Dip watersheds were dominated by dipterans (49-60%), followed by mayflies (20-38%). Similarly, a review of benthic invertebrate communities in interior Alaskan streams revealed that Dipterans dominated stream communities, followed by mayflies and stoneflies (Oswood, 1989). However, the pattern was reversed in the Excelsior and Isaac Creek watersheds where mayflies were most dominant (51-63%), followed by Dipterans (26-41%). As sampling sites in Excelsior and Isaac are both low elevation, mid-order streams proximate to the Yukon River, biophysical properties at these sites are not characteristic of conditions in the majority of the Project area.

Within watersheds, benthic invertebrate community composition trends were observed in relation to relative site positioning. In both the Casino and Dip Creek watersheds, the percentage of Dipterans decreased progressively downstream, whereas the percentage of stoneflies increased. Dipteran larvae typically dominate colder habitats at higher elevations, with mayfly and stonefly abundances increasing as temperatures increase, followed by other macroinvertebrates such as caddisflies (Allan and Castillo 2007). The trend was reversed for sites in the Britannia Creek watershed, with sites in lower Britannia Creek having higher proportions of Dipterans and less stoneflies. In addition, annelids (Tubificidae) comprised a substantial proportion (29%) of the most upstream Canadian Creek site. The group Tubificidae is often used as an environmental indicator due to its resilience to habitats with low oxygen and associated high organic material decomposition which many other benthic invertebrates cannot tolerate (Giller and Malmqvist, 1998). Thus, the noted high proportion of Dipterans, even in downstream sites, in combination with the high representation of Annelids in upper Canadian Creek are indicative of previous disturbances in the Britannia Creek watershed.

Results from surber sampling were similar to kick-net results with Dipterans being the most dominant group (44%), followed by a fairly equal representation of stoneflies (16%) and mayflies (17%). A higher number of taxa made up the remaining community composition in comparison to kick-net sampling results, with ‘other’ groups comprising over 10% of the overall community. In contrast, ‘other’ groups only represented 3% of the community using kick-net sampling methods. In previous studies, surber sampling methods collected higher numbers of taxa in comparison to kick-net sampling methods (Page and Sylvestre, 2006), which may have contributed to the differences in community composition observed here.

Taxonomic Richness:

Mean taxonomic richness was lowest in the Casino Creek watershed (13 taxa), intermediate in the Britannia Creek watershed (16 taxa), and highest in Isaac, Dip and Excelsior Creek watersheds (20-21 taxa), however, only differences between Casino and Dip Creek watersheds were significant (Figure 6-9; Kruskal Wallis, H_4=15.95, P<0.01; Post-hoc multiple comparison test, P=0.03).

Within watersheds, taxonomic richness generally increased in a downstream direction in both Casino and Dip Creeks, whereas a less notable but reversed pattern was observed for sites in the Britannia Creek watershed. Taxonomic richness of benthic invertebrate communities typically increases in a downstream direction and has been attributed to longitudinal changes in velocity, turbidity, water temperature, and habitat complexity (Milner and Petts 1994; Milner et al. 2001). Richness did not significantly differ when comparing sites within the Britannia and Dip Creek watersheds (Britannia: ANOVA, $F_{3,16}$=1.09, P=0.38; Dip: ANOVA, $F_{2,12}$=4.00, P<0.05, Tukey HSD tests, P≤0.07). In contrast, many differences were observed between sites in the Casino Creek watershed, including lower richness in upper Casino in comparison to Brynelson and mid-lower Casino, lower richness in Meloy in comparison to Brynelson and lower Casino, and lower richness in mid-Casino in comparison to lower Casino (ANOVA, $F_{4,20}$=19.87, P<0.01; Tukey HSD tests, P≤0.02). Comparisons of future impacted and reference sites in upper Casino and Dip Creeks revealed significantly higher taxonomic richness in Dip Creek (t-test, t_{23}=4.55, P<0.01), whereas the near-field site B4 in lower Casino Creek had a comparable number of taxa (22) to the most similar reference site BR2 (24) in upper Dip Creek. The notably low taxonomic richness in upper Casino Creek was likely attributed to a combination of cold water temperatures, high velocities and turbidity, and poor water quality as a result of sources of anthropogenic and natural acid rock drainage from Meloy Creek and Proctor Gulch.

As expected, surber sampling results generally demonstrated higher site-specific taxonomic richness values when compared to kick-net sampling results (Page and Sylvestre 2006), however the same overall patterns were observed for both methods. Surber-collected data demonstrated that Casino Creek richness was significantly lower than in both Dip and Britannia Creeks (ANOVA, $F_{2,42}$=14.27, P<0.01, Tukey HSD tests, P≤0.01), and that there were no significant differences observed among sites in Britannia Creek (ANOVA, $F_{2,26}$=0.30, P=0.82). Upper Casino Creek had lower taxonomic richness (10 taxa) than lower Casino Creek (16 taxa), however, these differences were not significant (t-test, t_8=2.25, P=0.05).

In 1993-1994, taxonomic richness values in upper Casino Creek varied from 12-17 taxa in comparison to 31-54 taxa at all other sites in the local study area. Highest taxonomic richness values were recorded at site B4 in lower Casino Creek, where 48-54 taxa were present (HKP, 1997).

EPT Abundance:

EPT organisms are considered “pollution sensitive” and thus provide an indication of overall aquatic ecosystem health. Mean EPT abundance was lowest in the Casino and Britannia Creek watersheds (37 EPT individuals), intermediate in the Isaac and Dip Creek watersheds (108 and 153 EPT individuals, respectively), and highest in Excelsior Creek (272 EPT individuals). Some among-watershed comparisons were significantly different, for example, Casino Creek had significantly lower EPT abundance than both Dip and Excelsior Creeks, and Britannia Creek displayed lower EPT abundance than Excelsior Creek (Figure 6-10; Kruskal Wallis, H_4=26.78, P<0.01; Post-hoc multiple comparison tests, P≤0.01).

Similar to taxonomic richness, EPT abundance generally increased in a downstream direction in both Casino and Dip Creeks, whereas a less notable but reversed pattern was observed for sites in the Britannia Creek watershed. Within the Britannia Creek watershed, EPT abundance was consistent among sites with the exception of B8 in upper Canadian Creek which had a significantly higher EPT abundance than the three downstream sites (ANOVA, $F_{3,16}$=12.43, P<0.01; Tukey HSD tests, P≤0.01). The lower percentage of sensitive benthic invertebrates in downstream sites may be in result of fairly recent (1996-2002) placer disturbance in lower Canadian Creek (D. Macdonald, current Canadian/Britannia Cr placer claim holder, personal communication, 2012).

In the Casino Creek watershed, EPT abundance was significantly higher in reach 1 in comparison to reach 3 and Meloy Creek (Kruskal Wallis, H_4=20.35, P<0.01; Post-hoc multiple comparison tests, P≤0.01). Casino Creek reach 3 and Meloy Creek EPT abundances demonstrated the lowest EPT abundances in the project area, likely as a result of the noted poor water quality at these sites. Similar to Casino Creek, EPT abundance was generally higher in lower Dip Creek, with the lower two sites having significantly higher EPT abundance relative to the uppermost site (ANOVA, $F_{2,12}$=7.27, P<0.01; Tukey HSD tests, P≤0.02). Mean EPT abundances were significantly higher in reference sites in upper Dip Creek relative to future impacted sites in upper Casino Creek (t-test, t_{21}=3.38, P<0.01). On average, reference densities were over ten times greater than non-reference densities, with means ±1SD of 120±142 EPT individuals/kick-net and 11±12 EPT individuals/kick-net, respectively. However, EPT abundances for reference sites widely varied from 19 EPT individuals/kick-net at site B14, to 220 EPT individuals/kick-net at site BR2. The near-field site B4 in lower Casino Creek was intermediate (99±31 EPT individuals/kick-net) in comparison to reference sites on upper Dip Creek.

Surber sampling produced varying results in comparison to kick-net sampling, despite the two methods demonstrated as comparable for EPT indices in previous studies (Page and Sylvestre, 2006). Some similar trends were noted such as significantly lower EPT abundance observed in Casino Creek in comparison to Dip and Britannia Creeks (ANOVA, $F_{2,42}$=11.49, P<0.01; Tukey HSD tests, P≤0.01), and site B8 in upper Britannia Creek having higher EPT abundance than all downstream sites (ANOVA, $F_{3,26}$=10.60, P<0.01; Tukey HSD test, P≤0.01). In contrast to kick-net sampling results, EPT abundances in upper and lower Casino Creeks were almost identical (B4: 11 EPT individuals/sample, B7: 10 individuals/sample). As EPT abundance does not vary depending on the sampling method used (Page and Sylvestre 2006), differences noted here may be attributed to natural inter-annual variability.

Simpson's Diversity Index:

Mean watershed biodiversity as measured using Simpson's Diversity Index was lowest in Casino Creek (0.60), intermediate in Britannia and Dip Creeks (0.74 and 0.78, respectively), and highest in Isaac and Excelsior Creeks (0.82 and 0.84, respectively), however, differences among watersheds were not significant (Figure 6-11; Kruskal-Wallis, H_4=4.76, P=0.31).

Biodiversity generally decreased in a downstream direction within the Britannia Creek watershed, whereas increasing patterns were observed in both Casino and Dip Creek watersheds. Some of the patterns were significant, for example B3 in Canadian Creek was more diverse than sites in lower Britannia Creek (Kruskal-Wallis, H_3=14.33, P<0.01, Post-hoc multiple comparison tests, P≤0.02), B7 in upper Casino Creek was less diverse than sites in lower Casino and Brynelson Creeks (Kruskal-Wallis, H_4=19.31, P<0.01, Post-hoc multiple comparison tests, P≤0.01), and B14 in upper Dip Creek was less diverse than the two sites further downstream (ANOVA, $F_{2,12}$=24.42, P<0.01; Tukey HSD tests, P≤0.01). Longitudinal trends of benthic invertebrate diversity observed elsewhere are in accordance with patterns noted in the Casino and Dip Creek watersheds, with biological diversity increasing in a downstream direction due to increasing water temperatures, channel stability and habitat complexity and size (Milner et al. 2001; Allan and Castillo 2007). As sites in upper Casino Creek demonstrated the lowest diversity indices throughout the project study area, both low water temperatures and the noted poor water quality likely contributed to the lack of diversity. Comparisons of future impacted and reference sites in upper Casino and Dip Creeks revealed significantly higher diversity in Dip Creek (separate variances t-test, t_{19}=3.67, P<0.01), whereas the near-field site B4 in lower Casino Creek had a comparable diversity index (0.86) to the most similar reference site BR (0.83) in upper Dip Creek.

Similar to previous studies which examined how differing sampling methods influenced benthic invertebrate diversity indices (Page and Sylvestre, 2006), results for both surber and kick-net methods were generally similar in this study. For surber-collected data, diversity was lower in upper Casino Creek when compared to lower Casino Creek (separate variances t-test, t_5=3.19, P=0.02), and Casino and Britannia Creeks both displayed significantly lower diversity than B5 in Dip Creek (Kruskal-Wallis, H_2=12.82, P<0.01, Post-hoc multiple comparison tests, P≤0.02). In contrast to kick-net results, sites within Britannia Creek did not have significantly different diversity values (ANOVA, $F_{3,26}$=1.39, P=0.27).

The Shannon-Wiener diversity index employed in historical studies produced varying results in comparison to the current program. The highest diversity values were noted in lower Casino and Dip Creeks, whereas the lowest diversity values were found in the Britannia Creek watershed (HKP, 1997). However, impacts from placer mining in Britannia Creek in the mid-1970-1980's may have contributed to lower diversity values observed in 1993-1994 (D. Macdonald, current Canadian/Britannia Cr placer claim holder, personal communication, 2012).

Simpson's Evenness Index:

Mean Simpson's Evenness Index ranged from 0.28 in the Dip Creek watershed to 0.35 in the Casino Creek watershed, with no significant among watershed differences (Figure 6-12; ANOVA, $F_{4,64}$=0.98, P=0.43). Within the Britannia Creek watershed, evenness indices were similar among sites with the exception of B3 in lower Canadian Creek which was significantly more even than the other three sites (ANOVA, $F_{3,16}$=22.00, P<0.01; Tukey HSD tests, P≤0.01). There was no discernible pattern for sites within the Casino Creek watershed, with the only noted difference between site B12 in mid Casino Creek and B11 in Brynelson Creek (Kruskal-Wallis, H_4=13.98, P=0.01, Post-hoc multiple comparison test, P=0.02). Evenness in the Dip Creek watershed demonstrated a subtle increasing pattern in a downstream direction, although there were no significant differences among sites (ANOVA, $F_{2,12}$=1.43, P=0.28). Comparisons of future impacted and reference sites in upper Casino and Dip Creeks revealed no significant differences in evenness (separate variances t-test, t_{17}=1.52, P=0.14).

Surber sampling produced varying results in comparison to kick-net sampling, despite the two methods demonstrated as comparable for evenness indices in previous studies (Page and Sylvestre, 2006). Using surber-collected data, the Britannia Creek watershed was significantly less even than Casino and Dip Creek watersheds (ANOVA, $F_{2,42}$=19.50, P<0.01; Tukey HSD tests, P≤0.01). Within Britannia Creek, site-specific evenness displayed a similar pattern to kick-net results, although site B3 was not significantly more even (ANOVA, $F_{3,26}$=1.17, P=0.34). Within the Casino Creek watershed, evenness patterns did not reflect kick-net data patterns, with upper Casino Creek being significantly less even than both lower Casino Creek and site B5 on Dip Creek (ANOVA, $F_{2,12}$=5.09, P=0.03; Tukey HSD tests, P<0.05).

Similar to current results, historical benthic invertebrate communities displayed lower evenness values in the Britannia Creek watershed, and higher evenness at sites in Casino and Dip Creeks (B4, B8, B5) (HKP, 1997).

3.3 Fish Community

3.3.1 Species composition, relative abundance and distribution

Slimy sculpin and Arctic grayling were the most dominant species captured in the Project area, with low numbers of burbot and round whitefish also present in the lower watersheds (Figure 6-13, Table 6-8). Juvenile Chinook salmon were captured in lower Britannia Creek, but adults were not observed in any watershed despite multi-year surveying. No species at risk were caught within the Project study area.

3.3.1.1 Casino Creek

Casino Creek was divided into three reaches, with reaches 2 and 3 located within the proposed TMF. Four years of fish sampling in upper Casino Creek included 11,904s of electrofishing effort and 1,255 hours of minnow trapping, with a total catch of 14 Arctic grayling within reach 2. A medium gradient (8-10%) cascade marks the reach break between reaches 2 and 3, and likely constitutes a high-flow barrier to fish migration in most years (Figure 6-14, refer to Appendix D for further detail). Accordingly, fish sampling over three years (2008, 2011-2012: total electrofishing effort: 3135s, total minnow trapping effort: 773.5 hours) yielded no fish in reach 3. However, in 2013 four Arctic grayling were captured within 250m of the cascade during exceptionally clear and low flow conditions. Historically, low numbers of slimy sculpin were also noted at sites in lower reach 2 (HKP, 1997). As sculpins tend to have high site fidelity and limited instream movements (Gray et al., 2004), the absence of sculpins suggests that opportunities for year-round survival are limited in upper Casino Creek.

Fish abundance was higher in the lower watershed, with approximately 0.9 fish caught per 100s of electrofishing over three years of sampling in reach 1. A total of 61 fish were captured in this section, with the majority being slimy sculpin (89%) and Arctic grayling (10%). In addition, one burbot was caught in 2009.

3.3.1.2 Casino Creek tributaries

Meloy Creek is a very small (<1m channel widths) tributary of upper Casino Creek (reach 2) and within the proposed TMF. Two years of sampling which included 973s of electrofishing effort and 216 hours of minnow trapping yielded no fish. The noted poor water quality in Meloy Creek as a result of the local source of ARD from the historical adit likely contributed to the lack of fish observed. Furthermore, historical sampling in Meloy Creek from 1994 similarly did not capture any fish despite 691s of electrofishing effort (HKP, 1997).

Two years of sampling effort on Brynelson Creek yielded a total of 29 fish captured. The fish community composition was similar to lower Casino Creek, with 71% of the catch being slimy sculpin and 29% being Arctic grayling. The total catch per unit effort was intermediate in comparison to upper and lower Casino Creek, with approximately 0.5 fish caught per 100s of electrofishing.

Austin Creek is a very small (<2m channel width), potentially non-fish bearing tributary of Casino Creek reach 1. No fish were caught over a two year sampling period which included 824s of electrofishing effort. In accordance with results from the current program, historical sampling in 1994 (effort: 515s of electrofishing) also produced no fish in Austin Creek. As there are no known barriers to fish movement, the lack of fish caught in Austin Creek may be related to the shift in substrate from coarser to finer bed material. Fine substrates have been associated with reductions in benthic invertebrate and periphyton abundance and diversity (Wood and Armitage, 1997), and lower salmonid growth and survival rates (Suttle et al., 2004).

3.3.1.3 Dip Creek

Fish community diversity increased further downstream in Dip Creek, with Arctic grayling (11%) and slimy sculpins (87%) making up the majority of fish caught, in addition to low abundances (<3%) of burbot and round whitefish. A total number of 179 fish were captured, at the highest CPUE rate exhibited in the project area of 1.5 fish per 100s of electrofishing. CPUE's ranged from 0.4-1.6 fish/100s of electrofishing at all sites with the exception of the most downstream site (F20), which exhibited the highest CPUE of any site in the project area at 4.5 fish/100s of electrofishing. The high CPUE at F20 was mainly attributed to a high density of slimy sculpins present.

Within the 2008-2013 sampling program, no juvenile Chinook salmon were captured in Dip Creek. Similarly, historical sampling by Knight Piesold in 1994 yielded no Chinook salmon during 2,807s of electrofishing effort at site F14 (HKP, 1997). In contrast, Summit Environmental (2012) captured a single juvenile Chinook in Dip Creek near its confluence with Casino Creek in July 2011. Historically, there is some evidence of juvenile Chinook salmon rearing in lower Dip Creek from studies conducted by DFO in 1994 and 1998 (DFO, 1994; Otto, 1998). In DFO (1994), minnow trapping was carried out at the confluence of the Klotassin River and Dip Creek, as well as at two sites on Dip Creek located approximately 10 and 27km upstream of the Dip Creek outlet. A total of 38 young-of-the-year Chinook salmon were captured at the Dip-Klotassin site, and 25 more were captured at the intermediate Dip Creek station which is located approximately 18 linear kilometers downstream from the Casino Creek confluence. No salmon were captured at the furthest upstream site on Dip Creek. In Otto (1998), two minnow traps were set 100m upstream of the Dip-Klotassin confluence on Dip Creek, with one young-of-the-year Chinook salmon captured. No sites further upstream were assessed.

3.3.1.4 Britannia and Canadian Creeks

Surveying of reach 1 of Britannia Creek yielded a total of 103 fish from 3,724s of electrofishing effort and 348 hours of minnow trapping. The fish community was comprised of slimy sculpin (61%), juvenile Chinook salmon (32%), and Arctic grayling (7%), with an average catch per unit effort of 1.7 fish per 100s of electrofishing. Site Y1 had the second highest CPUE in the project area (4.4 fish/100s electrofishing), and was also the only location where juvenile Chinook salmon was caught during the baseline program years. The close proximity of the Yukon River to this site (0-100m) likely explains both the high CPUE and the presence of juvenile Chinook salmon. The importance of small non-natal streams within the Yukon River as habitat for juvenile Chinook salmon has been previously documented, particularly where deeper pools and slow-moving water was available (Bradford et al. 2001). Historically, low numbers of juvenile Chinook salmon were also noted at sites further upstream in reach 1 (HKP, 1997).

Of the three reaches of Canadian Creek, fish were caught only in the lower two reaches. A 20% gradient fish barrier was located at the junction of reaches 2 and 3, and prohibited fish from moving further upstream. In the lower two reaches, a total of 6 Arctic grayling were captured, with a mean catch per unit effort of approximately 0.2 fish per every 100s of electrofishing effort. No other fish species have been captured within Canadian Creek during the baseline program or during historical sampling by Knight Piesold in 1993-1994 (HKP, 1997).

3.3.1.5 Reference Sites

Sampling in Victor Creek was conducted over three years, with a total of 24 fish caught at a rate of 0.8 fish per 100s of electrofishing. The majority of fish caught were slimy sculpin (88%), in addition to a low abundance of Arctic grayling (12%). No fish were caught in 2012 in contrast to high CPUE's generated during the previous two years of sampling, indicating potentially high year to year variability at this site.

A site in the upper Coffee Creek watershed was added to the baseline program in 2012 to supplement Victor Creek as a reference site. Two years of sampling yielded a total of 12 Arctic grayling and one round whitefish at a rate of 0.8 fish per 100s of electrofishing effort.

3.3.2 Watercourse Fish Bearing Status

In June 2010 upper Canadian Creek was assessed for barriers to fish migration (Figure 6-15, Figure 6-16). A 20% gradient barrier was documented using a Sunnto field clinometer over a distance of 43m. Several other high gradient barriers ranging from 15-19% spanning distances of 27-39m were also noted proximate to the 20% cascade barrier. Sampling effort at sites F05 and F05-b upstream of the documented barrier was completed in 2008 and 2010, with no fish observed (Table 6-3).

3.3.3 Spawning Surveys

No Chinook salmon spawning was observed in Dip Creek despite multi-year surveying during the current program (Table 6-4). Previous spawning surveys have noted salmon spawning in the adjacent Klotassin River, however, no spawning activity was observed during a concurrent assessment of Dip Creek in 1994 (DFO, 1994; Otto, 1998).

No Chinook salmon adults were captured within Britannia Creek, and no spawning was recorded, with the exception of a single carcass noted at the confluence with the Yukon River in 2000 by DFO (Laberge, 2001). Subsequent spawning surveys in 2008 and 2009 confirmed the lack of salmon spawning occurring in Britannia Creek (Table 6-4).

3.3.4 Size, Age and Condition

3.3.4.1 Arctic grayling

Arctic grayling length-at-age was characterized for the local study area using a von Bertalanffy growth curve (R^2=0.997, $P<0.05$ for all parameters; Figure 6-17). Ages from the Casino, Britannia and Dip Creek watersheds ranged from 1-8 years, with mean ages of 4-5. On average, Arctic grayling from Casino Creek exhibited the lowest length-at-age, whereas Dip Creek Arctic grayling had the highest length-at-age (Table 6-9). However, due to low sample sizes, statistical differences were not tested.

The majority of Arctic grayling captured in the project study area were greater than 125mm in length, and thus representing age classes 1+ (Figure 6-18, Figure 6-19, Figure 6-20, Figure 6-21). For example, in Casino Creek sizes of Arctic grayling ranged from 128-327mm, indicating that young-of-the-year were not present. Similarly, Arctic grayling in Brynelson Creek ranged from 141-320mm. Sizes corresponding to probable young-of-the-year (<70mm) were observed in both Dip Creek below its confluence with Casino

Creek, and at site Y1 on Britannia Creek. The lack of young-of-the-year rearing in the majority of the project area suggests that Arctic grayling spawning activities are correspondingly minimal.

Arctic grayling length-weight regressions for each watershed were significant (Linear regressions $R^2 \geq 0.88$, df≥1,8, $P<0.01$) with the common model having a slope close to the isometric growth value of 3 (Figure 6-22). Length-weight relationships for each watershed were statistically similar, with the exception of Dip Creek. However, when only similar length classes were compared (125mm+), there were no statistical differences among watersheds (Homogeneity of slopes test P=0.10; Common-slope ANCOVA, $R^2=0.97$, Watershed $F_{3,68}=0.22$, P=0.88), and all growth was isometric (t-test, $t_{72}=1.45$, P=0.15). Fish condition (Fulton's Condition factor) for the same size class (125mm+) was similar among all watersheds, ranging from 1.06 in Dip Creek to 1.16 in Coffee Creek (Figure 6-23).

3.3.4.2 Slimy sculpin

Slimy sculpin lengths ranged from 5-131mm, with most individuals being between 50-100mm (Figure 6-24, Figure 6-25, Figure 6-26, Figure 6-27). A wide range of sizes were present in each watershed, with only minimal differences among watersheds observed. The smallest sculpin observed was the only probable young-of-the-year at 5mm, captured from site D1 on Dip Creek. The subsequent smallest individuals (20-50mm) were captured primarily in lower Britannia, Dip and Victor Creeks and likely ranged from 0-1 years (Craig and Wells 1976; McDonald et al. 1982). Site F20 in mid-Dip Creek had the highest frequency of small individuals (<50mm), followed by Y1 in Britannia Creek. The relatively low presence of larger sculpins at Y1 suggests that lower Britannia Creek serves as size-dependent rearing habitat, with larger fish moving downstream into the Yukon River. Larger sculpins (>100mm) were also scarce in the other watersheds, with Casino Creek having the highest sample size of 4 individuals. Maximum slimy sculpin size observed in the project study area was higher than literature reported values (70-105mm) obtained from populations at comparable high latitudes (Craig and Wells 1976; McDonald et al. 1982).

Length-weight regressions for each watershed were significant (Figure 6-28; Linear regressions, $R^2 \geq 0.87$, df≥1,19, $P<0.01$). Slimy sculpin growth was allometric (slope<3) in Dip and Britannia Creeks (t-tests, t≥4.31, df≥61, $P<0.01$), with fish becoming lighter as length increased. Sculpins in Casino and Victor Creeks exhibited isometric growth (slope=3), meaning they did not change shape as they increased in length (t-tests, t≤1.30, df≥20, P≥0.21). Sculpins in Britannia Creek had significantly higher initial sizes (intercepts) and lower growth (slopes) than sculpins in Casino, Dip and Victor Creeks (Separate slopes ANCOVA, $R^2=0.96$, $F_{8,292}=845.61$, $P<0.01$). Further, sculpins in Dip Creek had lower growth (slope 95% confidence intervals=2.70-2.86) than sculpins in Victor Creek (slope 95% confidence intervals=2.87-3.35). Relative condition factors based on the combined length-weight regression were similar among all watersheds (Figure 6-29).

3.3.4.3 Chinook salmon

Juvenile Chinook salmon at site Y1 in lower Britannia Creek ranged from 48-73mm. Chinook salmon in the Yukon exhibit stream-type life history strategies, spending 1-2 winters in freshwater prior to entering the ocean (Healey, 1991). All juvenile Chinook were captured in August, and the small sizes observed relatively late in the season suggest that they were young-of-the-year (Bradford et al., 2001).

The length-weight relationship was significant (Figure 6-30; Linear regression, R^2=0.62, df=1,31, P<0.01), and growth was allometric (slope<3), with Chinook juveniles getting lighter as they increased in length (t-test, t_{32}=3.19, P<0.01). The mean relative condition factor was 1.02, with a standard deviation of 0.18.

3.3.5 Tissue Metal Concentrations

Selected metal concentrations in slimy sculpin tissues were compared among watersheds including Britannia Creek, Casino Creek, Victor Creek, and Dip Creek downstream of its confluence with Casino Creek (Raw data can be found in Appendices A, B and D). Certain metals are required for fish physiological processes but may become toxic above certain thresholds (e.g., copper, selenium, zinc). In contrast, there are several non-essential metals which have no determined biological role and may be toxic even at low concentrations (e.g., cadmium, lead, nickel). The only guidelines currently available to determine safe metal concentrations in slimy sculpin are for selenium and mercury. As there are no other guidelines developed, noted significant differences among watersheds may not provide insight into adverse metal effects. However, as guidelines may be developed in the future, it is important to characterize baseline metal concentrations within the Project study area prior to development.

Overall, Britannia Creek slimy sculpin tissues demonstrated the highest metal concentrations with significantly greater aluminum, arsenic, cadmium, iron, lead, nickel and selenium concentrations in comparison to sculpins from at least two of the other watersheds (Table 6-10, Table 6-11, Figure 6-31). The second overall highest tissue metal concentrations in the study area were observed in Casino Creek, where sculpins had significantly higher arsenic, cadmium, copper and lead concentrations in comparison to sculpins from Dip and/or Victor Creeks. Dip Creek sculpins exhibited higher arsenic and cadmium than sculpins in Victor Creek, whereas sculpins in Victor Creek demonstrated the lowest metal concentrations overall.

Fish metal results were in general agreement with water and sediment quality results for most watersheds (PECG, 2013d), with exceedances of the water and sediment quality guidelines for the protection of aquatic life (CCME, 2007) regularly observed for arsenic, cadmium, and copper in Casino Creek, and the fewest exceedances observed in the relatively un-impacted area of Victor Creek. However, water and sediment quality measured in Britannia Creek did not explain the high metal concentrations found in resident sculpins. Thus, higher metal concentrations exhibited may be due to Yukon River back-watering, or the potential for sculpins utilizing adjacent (<100m) Yukon River habitat containing higher metal concentrations. Yukon River water and sediment quality results supported this notion, with several elevated metal concentrations in resident sculpins being concurrently elevated in Yukon River water and sediment samples in relation to other watersheds around the Project area.

Mean selenium concentrations in slimy sculpin tissues in Britannia and Victor Creeks exceeded the selenium guidelines for the protection of freshwater aquatic life. The selenium guideline is based on safe selenium levels in aquatic tissues with the aim of preventing bioaccumulation up the food chain (BC MOE, 2001). However, the developed guideline is still interim in British Columbia, as the CCME has indicated that currently there is insufficient information required for the development of a full guideline. Mean estimated methylmercury concentrations exceeded the guideline for the protection of piscivorous wildlife in all watersheds. In contrast, Health Canada total mercury guidelines were not exceeded by sculpin tissues in any watershed. However, as slimy sculpin are not consumed by humans the comparison to Health

Canada guidelines are not directly relevant, and do not rule out the potential for mercury concentrations to increase through the food web into unsafe levels in fish consumed by humans.

3.4 Fish Habitat

General Overview of Physical Habitat:

A total of 18 sites were assessed for fish habitat quality around the study area (Figure 6-2; Table 6-12; refer to site photos in annual aquatic studies reports). Dip Creek downstream of Casino Creek had the largest channel width of 10.5m, and Austin and Meloy Creeks, both Casino Creek tributaries, had the smallest channel widths ranging from 0.9-1.7m. Mean channel widths of the Casino Creek mainstem and its main tributary, Brynelson Creek, were between 4.9-6.3m and 4.1-5.4m, respectively. Similarly, Victor Creek had a mean channel width of 5.8m. On the Britannia watershed side, channel widths ranged from 3m in upper Canadian Creek to 8.9m in lower Canadian Creek. Reference site F19 on Coffee Creek had a mean channel width of 3.0m.

Channel gradients were consistently low (0-4%) throughout the project area with a few exceptions including upper Casino and Canadian Creeks where gradients were between 5-20%. Probable barriers in upper Canadian Creek were documented and are discussed in the context of demonstrating fish absence in Section 3.3.2 Watercourse Fish Bearing Status.

Most fish habitat sites consisted of riffle-pool or riffle-run morphologies, including Britannia Creek, most of Canadian and Casino Creeks, Meloy Creek, Brynelson Creek, Coffee Creek, Victor Creek and Dip Creek. Higher gradient cascade-pools were noted in sections of upper Casino Creek at sites F07 and F08, as well as in reach 2 of upper Canadian Creek. Austin Creek had little to no riffles observed, and mainly consisted of pools (70%) followed by runs (20-30%). The dominant substrate in the project area was cobble, with a few sites in the upper watersheds dominated by boulder (F07 in upper Casino Creek, upper Brynelson Creek, F04 in upper Canadian Creek) or fine substrate (F14 in Dip creek, Meloy Creek, Austin Creek). In-stream cover was abundant (>20%) at most sites, with the exceptions of lower Britannia creek, lower Canadian and lower Brynelson Creeks where cover was moderate (10-15%). Riparian canopy closure was low across all sites, ranging from 0-20%.

Current and historical placer mining has been documented within the Project study area. The most notable activity was in Canadian Creek where extensive mining was carried out in the mid-1970s and 1980s, and more recently from 1996-2002 (D. Macdonald, current Canadian/Britannia Cr placer claim holder, personal communication, 2012). During the most recent activity, nearly 5km of lower Canadian Creek was disturbed by mining activities which included a 3.8 km-long channel realignment, major sediment loading, riparian vegetation disturbance, and a general re-contouring of valley bottom alluvium (Figure 6-32). Further downstream, historical placer mining was carried out on Britannia Creek (1911-1914), and an extensive drilling program was carried out in 1993 by the current claim holders (D. Macdonald, pers. comm. 2012). Other current and historical placer mining claims in the local study area include a current claim on Rude Creek in the upper Dip Creek watershed, and a historical claim on Dip Creek upstream of its confluence from Casino (Yukon Placer Secretariat, 2010a).

The lower reach of Britannia Creek has experienced notable alteration likely due to both upstream disturbances and local road development (PECG, 2013b). A fluvial geomorphologic assessment of the watershed determined that lower Britannia Creek abandoned its natural, meandering channel for its current location sometime between years 1965-1988. The creek divergence occurred at a creek ford located approximately 1.15km upstream from the Britannia Creek mouth. The existing channel drains alongside the road right-of-way for the majority of its length, creating a fairly uniform shallow channel with little to no in-stream habitat features (Figure 6-33). Within 350m of the Yukon River, the creek exhibits notable disturbance including debris jams and channel and floodplain aggradation (Figure 6-34). Immediately downstream of this disturbance, Britannia Creek has high habitat quality (e.g., meandering pattern, deep pools) extending to its confluence with the Yukon River.

Rearing, Spawning and Overwintering Habitat Potential

Rearing habitat was the most common habitat type identified in the project area, with most sites having rankings from moderate to good. Rearing habitat quality was evaluated on the basis of known habitat requirements for resident fish species in the study area in addition to general criteria including the quantity/quality of protective cover and resting locations, stream morphology, gradient, and riparian habitat. For example, at all life stages Arctic grayling are associated with riffles, slow-moving shallows, and pools, with smaller fish utilizing low-velocity high-cover areas in the lower-middle watershed. Larger, adult Arctic grayling are more likely to move seasonally into the mid-upper watershed, however, all life stages avoid velocities >150cm/s (Stewart et al. 2007). Thus, Dip and Victor creeks had excellent rearing habitat due to high habitat heterogeneity, low gradient riffle-pool morphologies, good in-stream cover (e.g., large woody debris, deep pools, undercut banks) and moderate riparian vegetation (Figure 6-35, Figure 6-36). Poor rearing habitat quality was documented in upper Casino Creek (Figure 6-37) and in reach 1 of Brynelson Creek (Figure 6-38), and was mainly attributed to a lack of potential fish resting or protective locations. In particular, upper Casino Creek had several long medium gradient (5-11%) cascades comprised of a number of potential flow-regulated barriers hindering both juvenile and adult rearing activities. (e.g., Figure 6-39). In addition to the lack of protective and resting locations, the riparian forest thinned in the upper watershed, which may lower the contribution of allochthonous materials to the stream (e.g., food, woody debris habitat).

The fish habitat suitability maps produced by the Yukon Mining Secretariat provided insight into rearing habitat quality in the project area (Yukon Placer Secretariat, 2010a, 2010b). Low suitability areas were identified in the Casino Creek watershed, Victor Creek, and Canadian Creek, and indicated that juvenile Chinook rearing is unlikely but that there was potential for rearing of resident fish species (Table 6-13; Yukon Placer Secretariat, 2010c). Habitat supporting juvenile Chinook rearing activities was most probable in the lower Britannia Creek watershed and in the lowest 10km of Dip Creek.

Potential spawning habitat for salmonids (Arctic grayling and Chinook salmon) was generally lacking throughout the project area. Arctic grayling spawn around the same time as ice break-up in clear, fast-flowing tributaries with temperatures between 4-16°C (Stewart et al. 2007). Some unembedded gravel substrate and suitable depths required for spawning were noted in Britannia Creek, lower Canadian Creek and Dip Creek. More detailed habitat assessments carried out as part of the in-stream flow program in Casino Creek reaches 1 and 2 concluded that available spawning habitat was 16% of the total habitat area in reach 1, and only 1% of the total habitat area in reach 2. Similar studies were not conducted in reach 3, although the general habitat assessment noted no suitable spawning habitat.

Chinook spawning requirements are even more stringent as spawning occurs in the fall, and the eggs require flowing water with sufficient oxygen over the winter season. Many streams in the study area freeze to bottom during the winter, including Casino Creek where anchor ice formation has been documented. Incubating embryos and alevin survival are susceptible to both freezing temperatures and the formation of anchor ice which can cause reduced flows or even complete de-watering (Bjornn and Reiser, 1991). According to the habitat suitability maps produced by the Yukon Mining Secretariat, watercourses within the project area do not support spawning activities or provide critical migratory corridors for spawning Chinook salmon (Table 6-13; Yukon Placer Secretariat, 2010a, 2010b, 2010c).

Due to the lack of deep pools (>1m) and the noted occurrence of anchor ice around the project area, overwintering habitat was generally sparse. Areas of exception included Dip Creek at F14 and Victor Creek which were deeper and wider channels less likely to freeze to bottom. There was also moderate overwintering habitat noted in lower Britannia and Casino Creeks, where for example, deep pools in lower Casino Creek made up approximately 20% of the total area.

***In situ* Water Quality: Stream Temperature, Conductivity, pH and Dissolved Oxygen**

In situ water quality data was collected at 29 sites within the Casino, Dip, Coffee, and Britannia Creek watersheds (Figure 6-2). Mean temperatures for all sites combined were highest in July and August with values of 5.5°C and 5.4°C, respectively. Individual temperature measurements around the study area ranged from 1.6-12.0°C in July and August, with sites in the Casino and Dip Creek watersheds having the coldest (4.6°C) and warmest (6.2°C) mean summer water temperatures, respectively. Measured summer temperatures in the project area are within the range of temperatures reported for adult Arctic grayling elsewhere (Stewart et al., 2007 and references therein). However, documented juvenile rearing temperatures were between 5-17°C, indicating that certain watersheds such as Casino Creek may be at the lower limit of thermal preference even during the warmest summer months. Winter temperatures in the project area neared 0°C, with freeze up occurring by the end of October, and the spring freshet occurring mid-late May of each year.

Mean monthly conductivity varied year-round with highs of 320-323 µs/cm observed in late fall and late winter. Conductivity was lowest in the early spring, with a mean value of 120 µs/cm observed in May. In general, conductivity was highest in Casino, Meloy, Canadian and Britannia Creeks (means=194-290 µs/cm) and lowest in Dip, Victor, Coffee and Brynelson Creeks (means=118-185 µs/cm). Similarly, pH was lower early spring and late summer at around 7.3-7.4, and increased to a high of 7.9 in December. For pH measurements, there were no observed differences among fish-bearing watercourses in the project area. PH values of representative fish-bearing streams were all within the CCME guidelines for the protection of aquatic life. However, of note is that Proctor Gulch, a small non fish-bearing tributary of upper Casino Creek, was naturally acid generating and consistently displayed pH values between 3-5. Noted poor water quality in the upper Casino Creek is discussed in the accompanying water quality baseline report, and likely contributed to fish absence in the upper watershed.

Dissolved oxygen measurements in the study area ranged from 7.8-13.2/L with a mean value of 10.8 mg/L. All dissolved oxygen values were above the minimum CCME guideline of 6.5mg/L for cold water fish, however, some did not meet the more stringent guideline of 9.5mg/L required for early life, e.g., the embryo and larval stages (CCME, 2007). Notably, all dissolved oxygen concentrations in May, during the most critical time for both Arctic grayling and slimy sculpin early life development, exceeded 9.5mg/L.

Mean total dissolved solids for all sites combined was 0.13 g/L in July and 0.11 g/L in September, with minimal variability among sites.

4 Summary

The fish and aquatic resources study program was carried out during the summer months of 2008 - 2013 at 29 fish sampling sites, 18 fish habitat sites, and 14 benthic invertebrate and periphyton sites throughout the Casino Project study area. Watersheds within the local study area included Casino Creek, Dip Creek downstream of Casino Creek, and Britannia Creek, with reference sites located in upper Dip Creek, Coffee Creek, Isaac Creek and Excelsior Creek.

Key Findings:

Slimy sculpin and Arctic grayling were the most dominant species captured in the project area, with low numbers of burbot and round whitefish also present in the lower watersheds. Juvenile Chinook salmon were captured in lower Britannia Creek in 2009 and 2011 near the Yukon River confluence. Sampling of Dip Creek from 2008-2013 by AECOM and PECG yielded no juvenile Chinook salmon, however, historical documentation of juveniles in the lower to mid reaches, and the more recent capture of a single juvenile by Summit (2012) indicates that Dip Creek may provide occasional habitat for low abundances of juvenile Chinook. No Chinook salmon have been captured either recently or historically within Casino Creek. No Chinook salmon spawning was observed in either watershed despite multi-year surveying. No species at risk were caught within the project study area.

The only guidelines currently available to determine safe metal concentrations in slimy sculpin tissue are for selenium and mercury. Mean selenium concentrations in slimy sculpin tissues in Britannia and Victor Creeks exceeded the selenium guidelines for the protection of freshwater aquatic life. Mean estimated methylmercury concentrations exceeded the guideline for the protection of fish-eating (piscivorous) wildlife in all watersheds.

Watershed-specific results are summarized below:

Casino Creek Watershed:

- Low fish abundances were observed in Casino Creek, particularly in the upper watershed;
- Lower Casino Creek (reach 1) and its major tributary, Brynelson Creek, were dominated by slimy sculpin (71-89%) followed by Arctic grayling (10-29%), with CPUE's ranging from 0.5-0.9 fish/100s of electrofishing;
- In Casino Creek reach 2, there were low abundances of Arctic grayling (0.2 fish/100s electrofishing);
- Sampling in upper Casino Creek (reach 3) yielded no fish over three years of sampling (2008, 2011, 2012), however, four Arctic grayling were captured in 2013 during exceptionally clear and low flow conditions at a rate of 0.1 fish/100s electrofishing;
- The medium gradient (8-10%) cascade reach break between reaches 2 and 3 likely constitutes a high-flow barrier to fish migration in most years;

- Arctic grayling were juveniles and adults (>125mm length), suggesting that the watershed primarily supports seasonal rearing activities of these older less critical life stages;
- No fish were caught in the small (<1m channel width) upper Casino Creek tributary, Meloy Creek;
- Habitat quality greatly declined upstream; mainly due to several long medium-gradient (5-11%) cascades which acted as potential flow-regulated barriers hindering both juvenile and adult rearing activities;
- No overwintering habitat was observed throughout the watershed;
- Spawning habitat potential was moderate (16% of total area) in reach 1 but was nonexistent in reaches 2 and 3;
- Sites in upper Casino Creek exhibited the lowest benthic invertebrate densities, richness, diversities, and EPT abundances within the project area, likely due to low water temperatures, high velocities and turbidity, low habitat complexity, and acid rock drainage present in the upper watershed;
- Sites in upper Casino Creek displayed low periphyton densities and taxonomic richness in comparison to lower Casino Creek, or to reference areas of upper Dip Creek; and
- Baseline periphyton and benthic invertebrate communities were similar in Dip Creek reference areas to the near-field site in lower Casino Creek, thus facilitating the future assessment of potential impacts.

Dip Creek Watershed:

- Relative fish abundance and community diversity increased in Dip Creek downstream of its confluence with Casino Creek;
- The fish community was comprised of slimy sculpin (87%), Arctic grayling (11%), burbot (<2%), and round whitefish (<1%);
- The most downstream site (F20) had the highest CPUE of any site in the project area at 4.5 fish/100s of electrofishing. The community at this site was predominantly slimy sculpin (99%);
- Habitat size and complexity increased, along with more opportunities for spawning and overwintering; and
- Probable young-of-the-year Arctic grayling and slimy sculpin were both captured.

Britannia Creek Watershed:

- Site Y1 located proximate to the Yukon River had the second highest CPUE in the project area (4.4 fish/100s electrofishing);
- The fish community at Y1 was comprised of slimy sculpin (64%), juvenile Chinook salmon (34%), and Arctic grayling (2%);
- At sites upstream of Y1, only Arctic grayling were captured;
- A 20% gradient fish barrier was located at the junction of Canadian Creek reaches 2 and 3, and prohibited fish from moving further upstream;
- Spawning habitat potential was moderate, and young-of-the-year Arctic grayling were observed in lower Britannia Creek;
- Deep pools required for overwintering were limited, particularly in the upper watershed;
- Slimy sculpins from the mouth of Britannia Creek displayed the highest overall metal concentrations (including aluminum, arsenic, cadmium, iron, lead, nickel and selenium) in the project area, and was likely due to the influence of Yukon River water;

- Benthic invertebrate community trends within sites in the Britannia Creek watershed often differed from Dip and Casino Creeks, with the more upstream sites exhibiting higher taxonomic richness, EPT abundance and diversity in comparison to downstream sites;
- Similarly, periphyton communities in the upper watershed demonstrated higher diversity values, although at lower densities; and
- The reversed trend noted may be a result of fairly recent (1996-2002) placer mining disturbance in lower Canadian Creek.

Fish Reference Sites:

- Two fish reference sites were established, with three years of sampling carried out at Victor Creek in the upper Dip Creek watershed, and two years of sampling on Coffee Creek;
- Fish were caught in two of three years of sampling at the Victor Creek reference site, yielding a CPUE of 0.8 fish/100s of electrofishing;
- The Victor Creek community was predominantly slimy sculpin (88%), with low abundances of Arctic grayling (12%);
- In Coffee Creek, two years of sampling yielded a total of 12 Arctic grayling and one round whitefish at a rate of 0.8 fish per 100s of electrofishing effort;
- Rearing habitat potential was good to excellent at both sites;
- Deep pools required for overwintering were noted in Victor Creek only; and
- Spawning habitat potential was low for both sites.

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6 Tables and Figures

Table 6-1 Periphyton and Benthic Invertebrate Sampling Sites, Casino Project, 1993-1994, 2008-2009 and 2011

Watershed	Creek	Reach	Site	UTM Co-ordinates (Zone 7V)		Dates sampled					Description
				Easting	Northing	1993[a]	1994[a]	2008	2009	2011	
Britannia	Canadian	3	B8/P8	609,807	6,958,838	Aug	Aug	Sep 11	Aug 07	-	Within proposed pit footprint
		1	B3/P3	616,043	6,966,702	Aug	Aug	Sep 09	Aug 07	-	Upstream of the confluence of Canadian and Britannia Creeks
	Britannia	1	B2/P2	616,163	6,967,197	Aug	Aug	Sep 09	Aug 06	-	Downstream of the confluence of Canadian and Britannia Creeks
		1	B1/P1	617,661	6,973,246	Aug	Aug	Sep 10	Aug 05	-	Upstream of its confluence with the Yukon River
Casino	Casino	3	B7/P7	613,396	6,956,247	Aug	Aug	Sep 09	Aug 05	-	Within proposed tailings management facility (TMF)
		2	B12/P12	613,081	6,954,572	-	-	-	-	Aug 20	Within proposed TMF
	Meloy	n/a	B13	612,258	6,953,302	-	-	-	-	Aug 20	Within proposed TMF
	Brynelson	1	B11/P11	610,718	6,951,624	-	-	-	-	Aug 20	Lower Brynelson Creek
	Casino	1	B4/P4	610,115	6,947,946	Aug	Aug	Sep 09	Aug 04	-	Upstream of the confluence of Dip and Casino Creeks
Dip	Dip	n/a	B14*/P14*	617,447	6,951,308	-	-	-	-	Aug 20	Approximately 10km upstream of the confluence with Casino Creek
	Victor	n/a	BR2*/PR2*	611,102	6,946,387	-	-	-	Aug 04	-	Reference site
	Dip	n/a	B5/P5	609,363	6,947,024	Aug	Aug	Sep 09	Aug 04	-	Downstream of the confluence of Casino and Dip Creeks
Excelsior	Excelsior	n/a	*B9/*P9	603,878	6,974,354	-	-	-	-	Aug 21	Lower Excelsior Creek, upstream of its confluence with the Yukon River
Isaac	Isaac	n/a	*B10/*P10	626,768	6,968,801	-	-	-	-	Aug 21	Lower Isaac Creek, upstream of its confluence with the Yukon River

Notes: *B=Benthic invertebrate site and P=Periphyton Site, *Reference site, n/a=not applicable, Dashes indicate not sampled,*
[a]1993-1994 sampling was conducted by Hallam Knight Piesold (1997)

Table 6-2 Fish Sampling Sites, Casino Project, 2008-2013

Watershed	Creek	Reach	Site	UTM Co-ordinates (Zone 7V)		Years sampled	Number of sampling events		Total Effort		Description
				Easting	Northing		EF	MT	EF (s)[1]	MT (h)	
Britannia	Canadian	3	F05-b	609904	6959022	2010	1	1	1278	83.0	above cascade barrier (>20% gradient)
	Canadian	3	F05	609631	6960021	2008	1	1	577	72.0	above cascade barrier (>20% gradient)
	Canadian	2	F04	610392	6963879	2008	1	0	756	0.0	
	Canadian	1	F03	616015	6966696	2008	1	0	2293	0.0	
	Britannia	1	F01	617561	6971369	2008, 2009	2	1	2415	72.0	
	Britannia	1	Y1	617641	6973666	2009, 2011	2	1	1309	276.0	near confluence of Yukon River
Casino	Casino	3	F07	613449	6956383	2008, 2012	2	2	2265	354.5	in proposed tailings management facility (TMF)
	Casino	3	F08-b	613100	6954628	2011, 2012, 2013	3	3	1825	467.0	in proposed TMF
	Casino	2	F08	613044	6954528	2008, 2011, 2012	3	2	5557	118.0	in proposed TMF
	Meloy	n/a	F09	611689	6954068	2008, 2011	2	2	873	216.0	in proposed TMF
	Casino	2	S2-b	612476	6953792	2013	1	0	597	0.0	in proposed TMF
	Casino	2	S2	612135	6952897	2012, 2013	2	2	692	260.0	in proposed TMF
	Casino	2	F21	611015	6951285	2013	1	1	958	55.0	in proposed TMF, just upstream of confluence with Brynelson
	Brynelson	2	F10	609456	6953369	2008, 2009, 2012	2	1	1350	93.0	
	Brynelson	1	F11	610346	6952105	2008, 2009, 2012	2	2	5105	139.5	
	Casino	1	F16	610402	6949554	2011	1	0	2370	0.0	just upstream of confluence with Austin
	Austin	1	F12	610190	6949589	2008, 2009	2	0	824	0.0	

Watershed	Creek	Reach	Site	UTM Co-ordinates (Zone 7V)		Years sampled	Number of sampling events		Total Effort		Description
				Easting	Northing		EF	MT	EF (s)[1]	MT (h)	
	Casino	1	F13	610245	6948318	2008, 2009, 2011, 2012	3	1	6104	90.0	
Dip	Dip	n/a	F17	617420	6951285	2011, 2012	2	0	2214	0.0	attempted reference site in the upper watershed
	Victor	n/a	R2*	610965	6946908	2009, 2011, 2012	3	1	2877	150.0	reference site upstream of Casino Creek confluence
	Dip	n/a	F14	609367	6947025	2008, 2009, 2012, 2013	3	3	3600	270.0	
	Dip	n/a	FM2	608536	6947307	2010	0	1	0	23.0	
	Dip	n/a	D3	608284	6947399	2009	1	0	872	0.0	
	Dip	n/a	F22	606258	6945924	2013	1	1	1869	80.0	
	Dip	n/a	D2	604666	6944580	2009	1	0	919	0.0	
	Dip	n/a	D1	602898	6942475	2009	1	0	854	0.0	
	Dip	n/a	F20	600395	6942437	2012, 2013	1	2	2373	141.0	at water quality site W16
	Dip	n/a	FM1	593032	6938516	2010	0	1	0	22.0	
Coffee	Coffee	n/a	F19*	595767	6958310	2012, 2013	2	2	1724	141.0	reference site

Notes: [1]*Includes both single and multiple pass methods*
**Reference site*
n/a=not applicable
EF=electrofishing
MT=minnow trapping

Table 6-3 Fish Sampling Effort above an Identified Barrier, Casino Project, 2008-2010

Watershed	Barrier Location (Zone 7V, Easting, Northing)	Site	Creek	Reach	Date	Method	Electrofishing				Minnow Trapping	
							Section Length (m)	# Passes	Voltage (V)	Effort (s)	# Traps	Effort (h)
Britannia	609,391, 6,960,354	F05	Canadian	3	9-Jul-08	EF	226	1	550	577	-	-
					11-Jul-08	MT	-	-	-	-	3	72
		F05-b	Canadian	3	12-Aug-10	EF	250	1	270-437	1278	-	-
					10-Aug-10	MT	-	-	-	-	2	83
									Total	1855		155

Notes: *EF=Electrofishing*
MT=Minnow Trapping

Table 6-4 Chinook Salmon Spawning Surveys, Casino Project, 2008-2012

Date	Location	Method	UTM Co-ordinates (Zone 7V, Easting, Northing)	
			Start	End
11-Sep-08	Britannia and Canadian Creeks	aerial	617641 6973666	609631 6960021
9-Aug-09	Britannia Creek reach 2	ground assessment	616234 6966886	616778 6963517
10-Aug-10	Dip Creek	aerial	583290 6935577	589671 6936790
10-Aug-10	Klotassin River	aerial	576564 6938058	583295 6935574
13-Sep-12	Dip Creek	aerial	609367 6947025	590758 6937333

Table 6-5 Fish Tissue Metals and Detection Limits, Casino Project, 2008-2011

Metal	Reported Detection Limit		
	20008	2009	2011
Aluminum	0.5	1	0.2-0.4
Antimony	0.1	0.1	0.001-0.002
Arsenic	0.1	0.01	0.01-0.02
Barium	0.1	0.1	0.02-0.04
Beryllium	0.02	0.1	0.02-0.04
Bismuth	NS	0.1	0.02-0.04
Boron	2	5	0.4-0.8
Cadmium	0.02	0.01	0.002-0.004
Calcium	1	10	2-4
Chromium	0.1	0.5	0.04-0.08
Cobalt	0.1	0.1	0.004-0.008
Copper	0.1	0.5	0.01-0.02
Iron	5	10	2-4
Lead	0.1	0.01	0.002-0.004
Magnesium	0.5	10	2-4
Manganese	0.1	0.1	0.02-0.04
Mercury	0.01	0.01	0.002-0.004
Molybdenum	0.1	0.1	0.01-0.02
Nickel	0.1	0.1	0.01-0.02
Phosphorus	0.5	10	2-4
Potassium	1	10	2-4
Selenium	0.2	0.01	0.01-0.02
Silicon	10	NS	NS
Silver	0.01	0.05	0.004-0.008
Sodium	1	10	2-4
Strontium	0.05	0.1	0.02-0.04
Tellurium	0.1	NS	NS
Thallium	0.02	0.05	0.0004-0.0008
Tin	0.1	0.1	0.02-0.04
Titanium	0.3	1	0.2-0.4
Uranium	0.04	0.05	0.0004-0.0008
Vanadium	0.5	2	0.04-0.08
Zinc	0.5	0.1	0.04-0.08
Zirconium	3	NS	NS

Notes: All units are mg/kg wet weight
NS=Not sampled

Table 6-6 Fish Habitat Sites, Casino Project, 2008-2013

Watershed	Creek	Reach	Site	UTM Co-ordinates (Zone 7V) Easting	UTM Co-ordinates (Zone 7V) Northing	Description
Britannia	Canadian	3	Upper Reach of Canadian Creek	609,622	6,958,679	Above cascade barrier (>20% gradient)
		2	F04	610,392	6,963,879	
		1	Placer Mine on Canadian Creek	614,725	6,965,616	Downstream end of placer mining area
		1	Lower Reach of Canadian Creek	615,314	6,966,030	Downstream of placer mining activity
		1	F03	616,015	6,966,696	Just upstream of confluence with Britannia Creek
	Britannia	1	Lower Reach of Britannia Creek	617,126	6,970,199	Upstream of F01
Casino	Casino	3	F07	613,449	6,956,383	In proposed tailings management facility (TMF)
		3	(F08-b) Upper Reach of Casino Creek	613,087	6,954,573	In proposed TMF
		2	F08	613,044	6,954,528	In proposed TMF
	Meloy	n/a	F09	611,661	6,954,143	In proposed TMF
	Brynelson	2	(F10) Upper Reach of Brynelson Creek	609,448	6,953,393	
		1	(F11) Lower Reach of Brynelson Creek	610,209	6,952,288	
	Casino	1	Lower Reach of Casino Creek	610,515	6,950,136	Upstream of site F16
	Austin	2	Upper Reach of Austin Creek	608,816	6,951,236	
		1	(F12) Lower Reach of Austin Creek	610,157	6,949,620	
Dip	Victor	n/a	R2*	610,965	6,946,908	Reference site
	Dip	n/a	F14	609,367	6,947,025	
Coffee	Coffee	n/a	F19*	595,767	6,958,310	Reference site

Notes: *n/a=not applicable*
**Reference site*
Parentheses indicate proximate fish sampling site

Table 6-7 Number of *in situ* water quality sampling events by season, Casino Project, 2008-2013

Watershed	Creek	Summer				Winter		
		Conductivity (µs/cm)	Dissolved oxygen (mg/L)	pH	Total Dissolved Solids (g/L)	Conductivity (µs/cm)	Dissolved oxygen (mg/L)	pH
Britannia	Britannia	28	3	29	1	12	-	13
	Canadian	33	8	38	5	12	1	12
	Total	**61**	**11**	**67**	**6**	**24**	**1**	**25**
Casino	Austin	-	2	2	2	-	-	-
	Brynelson	16	4	18	2	6	1	5
	Casino	46	10	50	4	14	3	16
	Meloy	10	3	11	1	2	1	2
	Total	**72**	**19**	**81**	**9**	**22**	**5**	**23**
Dip	Dip	31	4	32	1	9	1	11
	Victor	11	1	11		7	1	7
	Total	**42**	**5**	**43**	**1**	**16**	**2**	**18**
Coffee	Coffee	1	1	1	1	0	0	0
	Total	**1**	**1**	**1**	**1**	**0**	**0**	**0**

Notes: Summer months are from May – October, Winter months are from November – April
Dashes indicate no sampling occurred

Table 6-8 Electrofishing Catch Per Unit Effort by Site, Casino Project, 2008-2013

Watershed	Creek	Reach	Site	GR	CCG	CH	BB	RW	Total
Britannia	Canadian	3	F05-b	0.00	0.00	0.00	0.00	0.00	0.00
	Canadian	3	F05	0.00	0.00	0.00	0.00	0.00	0.00
	Canadian	2	F04	0.53	0.00	0.00	0.00	0.00	0.53
	Canadian	1	F03	0.08	0.00	0.00	0.00	0.00	0.08
	Britannia	1	F01	0.21	0.00	0.00	0.00	0.00	0.21
	Britannia	1	Y1	0.15	3.44	0.84	0.00	0.00	4.43
			Mean	**0.16**	**0.60**	**0.15**	**0.00**	**0.00**	**0.90**
Casino	Casino	3	F07	0.00	0.00	0.00	0.00	0.00	0.00
	Casino	3	F08-b	0.22	0.00	0.00	0.00	0.00	0.00
	Casino	2	F08	0.16	0.00	0.00	0.00	0.00	0.16
	Meloy	n/a	F09	0.00	0.00	0.00	0.00	0.00	0.00
	Casino	2	S2-b	0.34	0.00	0.00	0.00	0.00	0.34
	Casino	2	S2	0.72	0.00	0.00	0.00	0.00	0.72
	Casino	2	F21	0.10	0.00	0.00	0.00	0.00	0.10
	Brynelson	2	F10	1.04	0.00	0.00	0.00	0.00	1.04
	Brynelson	1	F11	0.11	0.16	0.00	0.00	0.00	0.27
	Casino	1	F16	0.00	0.00	0.00	0.00	0.00	0.00
	Austin	1	F12	0.00	0.00	0.00	0.00	0.00	0.00
	Casino	1	F13	0.08	1.00	0.00	0.03	0.00	1.11
			Mean	**0.19**	**0.22**	**0.00**	**0.01**	**0.00**	**0.42**
Coffee	Coffee	n/a	F19*	0.70	0.00	0.00	0.00	0.06	0.75
			Mean	**0.70**	**0.00**	**0.00**	**0.00**	**0.06**	**0.75**
Dip	Victor	n/a	R2*	0.10	0.73	0.00	0.00	0.00	0.83
			Mean	**0.10**	**0.73**	**0.00**	**0.00**	**0.00**	**0.83**
	Dip	n/a	F14	0.08	0.50	0.00	0.00	0.00	0.58
	Dip	n/a	D3	0.23	0.80	0.00	0.00	0.00	1.03
	Dip	n/a	F22	0.11	0.21	0.00	0.11	0.00	0.43
	Dip	n/a	D2	0.65	0.87	0.00	0.00	0.11	1.63
	Dip	n/a	D1	0.47	1.05	0.00	0.00	0.00	1.52
	Dip	n/a	F20	0.04	4.47	0.00	0.00	0.00	4.51
			Mean	**0.16**	**1.32**	**0.00**	**0.02**	**0.01**	**1.50**

Notes: *GR=Arctic Grayling, CCG=slimy sculpin, CH=juvenile Chinook salmon, BB=burbot and RW=round whitefish*
All values are number of fish caught per 100s of electrofishing
**Reference site*
n/a=not applicable

Table 6-9 Arctic grayling length-at-age by Watershed, Casino Project, 2008-2011

Watershed	Age	n	Length (mm)	
			Mean	SD
Britannia	3	1	244	n/a
	4	1	260	n/a
	5	3	270	17
	6	3	283	8
	8	1	320	n/a
	Total	**9**	**276**	**23**
Casino	1	1	128	n/a
	2	9	172	24
	3	4	197	11
	4	3	227	7
	5	4	256	3
	6	2	297	5
	7	1	302	n/a
	8	1	320	n/a
	Total	**27**	**219**	**56**
Dip	2	1	186	n/a
	3	1	213	n/a
	4	1	298	n/a
	5	2	290	25
	6	1	322	n/a
	7	1	328	n/a
	8	2	364	16
	Total	**9**	**295**	**62**

Notes: *n=sample size*
SD=Standard deviation

Table 6-10 Selected total metal concentrations in slimy sculpin muscle tissue, Casino Project, 2008-2009 and 2011

Analyte	Britannia (n=8)		Casino (n=22)		Dip (n=13)		Victor* (n=9)		Guidelines	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Wildlife	Human Health
Aluminum	48.44	15.78	22.07	14.45	28.81 (49.21)	20.74 (76.19)	14.84	14.35		
Arsenic	0.19	0.08	0.11	0.03	0.11	0.06	0.07	0.02		
Barium	4.79	0.97	3.57	1.59	3.76	1.12	4.07	1.09		
Cadmium	0.34	0.20	0.09	0.04	0.03	0.01	0.02	0.00		
Copper	1.16	0.36	1.51	0.45	0.87	0.15	0.84	0.21		
Iron	109.13	41.35	57.23	35.57	71.08 (118.92)	41.24 (176.95)	40.56	28.29		
Lead	0.14	0.09	0.14	0.12	0.06	0.08	0.04	0.03		
Mercury	0.05	0.01	0.05	0.02	0.05	0.01	0.06	0.02		0.2-0.5[a]
Methylmercury[b]	**0.04**	0.01	**0.04**	0.02	**0.04**	0.01	**0.05**	0.02	0.033[c]	
Manganese	11.58	3.13	8.90	2.85	10.85	5.00	7.17	2.88		
Molybdenum	0.05	0.01	0.04	0.01	<0.1	0.00	0.04	0.01		
Nickel	0.22	0.06	0.05	0.01	0.07	0.07	0.04	0.01		
Selenium	**1.52**	0.33	0.85	0.22	0.83	0.20	**1.15**	0.51	1.0[d]	
Strontium	19.51	4.78	20.36	8.41	18.70	2.28	22.17	4.97		
Thallium	0.01	0.01	0.01	0.01	<0.05	0.01	0.02	0.01		
Zinc	36.63	12.25	28.34	7.58	25.85	3.00	27.52	6.26		

Notes: *All units are mg/kg wet weight*
SD=Standard deviation
**Reference site*
Values calculated including outlier concentrations (n=1 for aluminum and iron) are noted in brackets
[a] Health Canada mercury guidelines range from 0.2-0.5 for subsistence consumers (Health and Welfare Canada 1979) and maximum allowable level for sale (Canadian Food Inspection Agency 2011), respectively
[b] Methylmercury is estimated based on 83% of total mercury for slimy sculpin (Raymond and Rossmann 2009)
[c] Canadian Council of Ministers of the Environment tissue residue guideline (CCME 2000) to protect piscivorous wildlife from methylmercury toxicity
[d] British Columbia Ministry of Environment Interim aquatic life (tissue) selenium guideline (BC MOE 2001) for the protection of freshwater aquatic life
Bolded values exceed guidelines for the protection of aquatic and piscivorous wildlife

Table 6-11 Post-hoc HSD Tukey test results for selected total metal concentrations in slimy sculpin muscle tissue among watersheds, Casino Project, 2008-2009 and 2011

Analyte	Significant differences
Aluminum	Britannia > Casino & Victor
Arsenic	Britannia > Casino & Dip > Victor
Barium	n/a
Cadmium	Britannia > Casino > Dip > Victor
Copper	Casino > Dip & Victor
Iron	Britannia > Casino & Victor
Lead	Britannia & Casino > Dip & Victor
Manganese	n/a
Mercury	n/a
Molybdenum	n/a
Nickel	Britannia > Casino & Dip & Victor
Selenium	Britannia > Casino & Dip
Strontium	n/a
Thallium	n/a
Zinc	n/a

Note: Significant differences at the P<0.05 level.

Table 6-12 Fish Habitat Characteristics, Casino Project 2008-2013

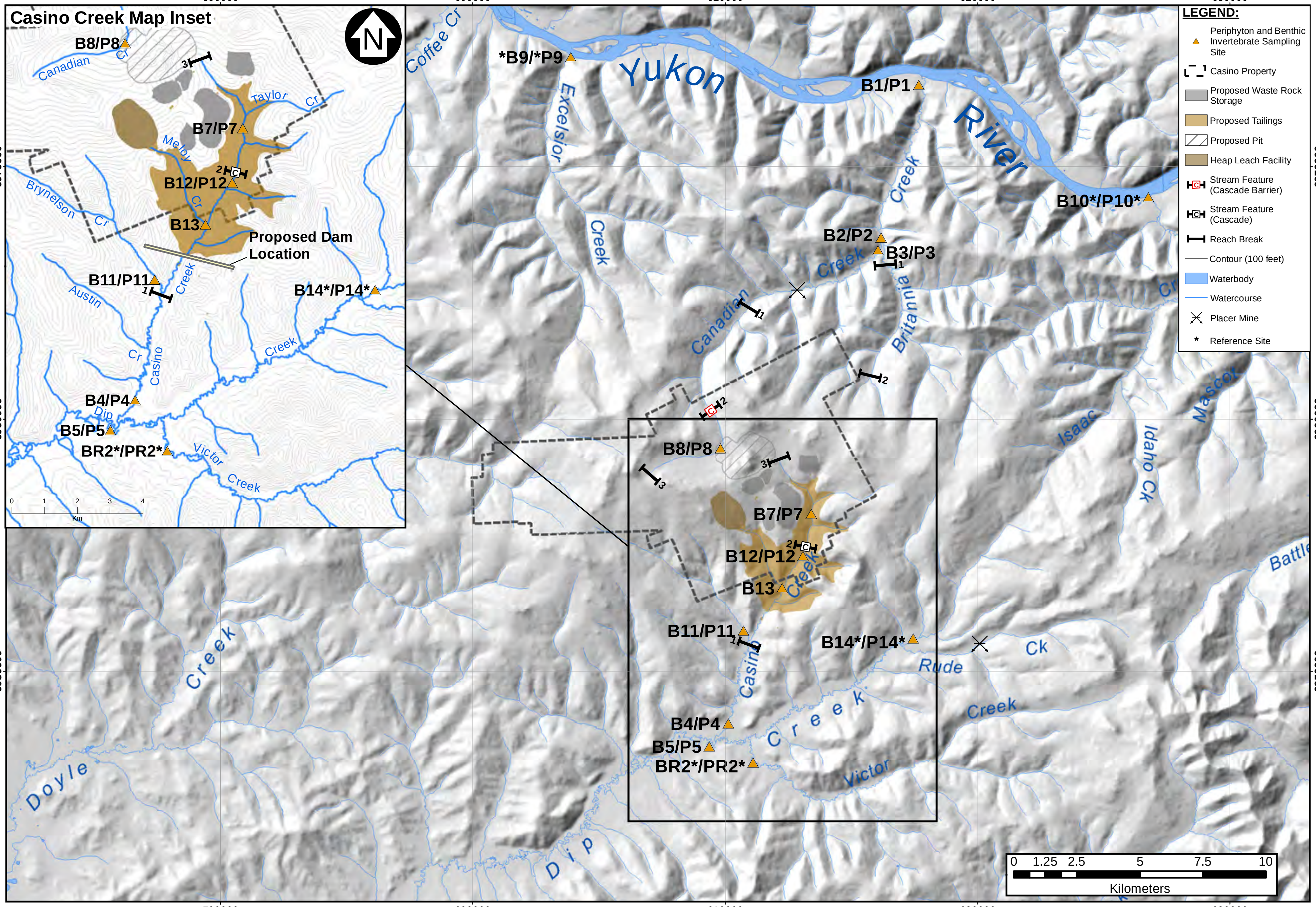
Watershed	Creek	Reach	Site	Mean channel width (m)	Mean gradient (%)	Fish species caught	Habitat quality		
							Spawning	Rearing	Overwintering
Britannia	Canadian	3	Upper Reach of Canadian Creek	3	3	NFC	None	Moderate	None
		2	F04	6.5	4	GR	None	Moderate	None
		1	Placer Mine on Canadian Creek	5.2	0	GR	Poor	Moderate	None
		1	Lower Reach of Canadian Creek	7.9	0	GR	Moderate	Moderate	Poor
		1	F03	8.9	3	GR	Moderate	Moderate	None
	Britannia	1	Lower Reach of Britannia Creek	7.0	0	GR, CCG, CH	Moderate	Good	Moderate
Casino	Casino	3	F07	6.3	9	NFC	None	Poor	None
		3	Upper Reach of Casino Creek	5.4	3	GR	Poor	Moderate	None
		2	F08	4.9	3	GR	Poor	Moderate	Poor
	Meloy	n/a	F09	1.1	2.5	NFC	None	Poor	Poor
	Brynelson	2	Upper Reach of Brynelson Creek	4.1	2.5	GR	None	Moderate	None
		1	Lower Reach of Brynelson Creek	5.4	2	GR, CCG	Poor	Poor	None
	Casino	1	Lower Reach of Casino Creek	5.7	2	GR, CCG, BB	Moderate	Good	Moderate
	Austin	2	Upper Reach of Austin Creek	0.9	NR	NFC	None	Moderate	Poor
		1	Lower Reach of Austin Creek	1.7	0	NFC	None	Moderate	None
Dip	Victor	n/a	R2*	5.8	2	GR, CCG	Poor	Excellent	Good
	Dip	n/a	F14	10.5	0	GR, CCG, RW	Moderate	Excellent	Good
Coffee	Coffee	n/a	F19*	3.0	2	GR, RW	Poor	Good	Poor

Notes: Habitat qualifiers from low to high are: None<Poor<Moderate<Good<Excellent
GR=Arctic Grayling, CCG=slimy sculpin, CH=juvenile Chinook salmon, BB=burbot, NFC= no fish caught
*NR=not recorded, *Reference site, n/a=not applicable*

Table 6-13 Yukon Placer Fish Habitat Suitability Designations, Casino Project

Fish habitat suitability	Watercourse	Juvenile Chinook salmon rearing	Chinook salmon spawning and/or critical migratory corridor for spawning	Resident fish species
Low	Casino Creek, Victor Creek, Canadian Creek	Unlikely	No	Potentially suitable
Moderate-Low	Dip Creek[1], Coffee Creek, Britannia Creek[2]	Potentially Suitable	No	Highly suitable
Moderate-Moderate	Britannia Creek[3]	Suitable	No	Highly suitable
Moderate-High	Dip Creek[4]	Highly Suitable	No	Highly suitable
High (Chinook salmon production)	None	n/a	Yes	n/a
High (Area of special consideration)	Britannia Creek[5]	n/a	Potentially suitable	Potentially suitable

Notes: Fish habitat suitability maps are available at http://www.yukonplacersecretariat.ca/maps.html. Areas of special consideration are watercourses that contain ecologically or culturally important fisheries or aquatic resources, and may be based on either anadromous or non-anadromous species of fish. Fish habitat suitability designations reported here are based on the current operational standards and may not reflect long-term restoration standards.
[1]Between Casino Creek and 10km upstream of the Klotassin River confluence
[2]Upper part of Britannia Creek reach 1
[3]Mid part of Britannia Creek reach 1
[4]Lowest 10km of Dip Creek
[5]Within approximately 1.8km of the Yukon River
n/a=not applicable



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APP'D	A. Murdoch
REV	-
DATE	7Oct'13

NOTES:
1. BASE MAP: Digital Elevation Model and 1:250,000 and 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca)
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:200,000

CASINO COPPER AND GOLD

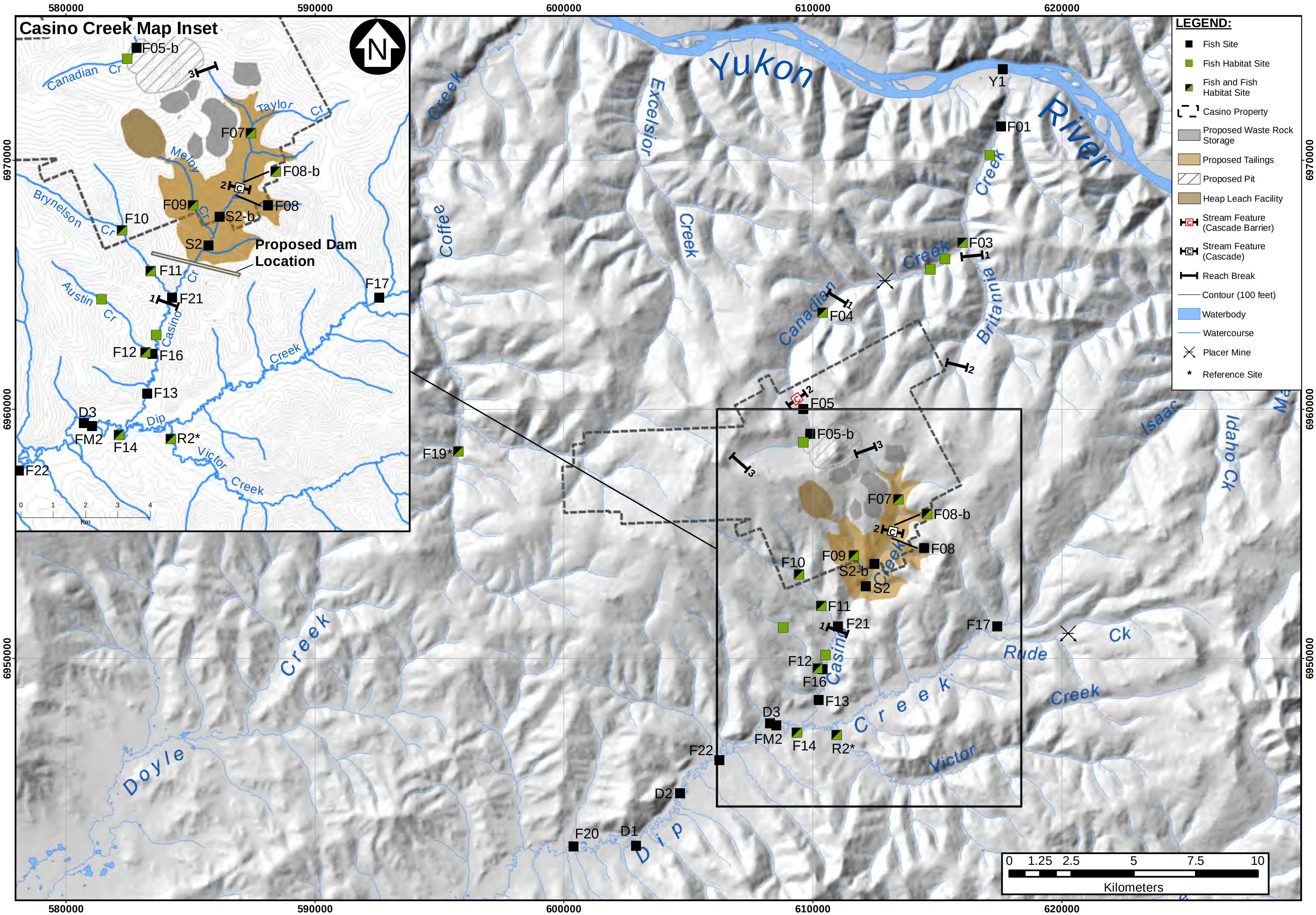
CASINO PROJECT

Casino Benthic Invertebrate and Periphyton Sampling Sites

FIGURE 6.1

REF REPORT 1

P/A VA101-325/15



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3. COORDINATE GRID: METRES
4. SCALE: 1:200,000

CASINO COPPER AND GOLD

CASINO PROJECT

Casino Fish and Fish Habitat Sampling Sites

FIGURE 6.2

REF	REPORT 1
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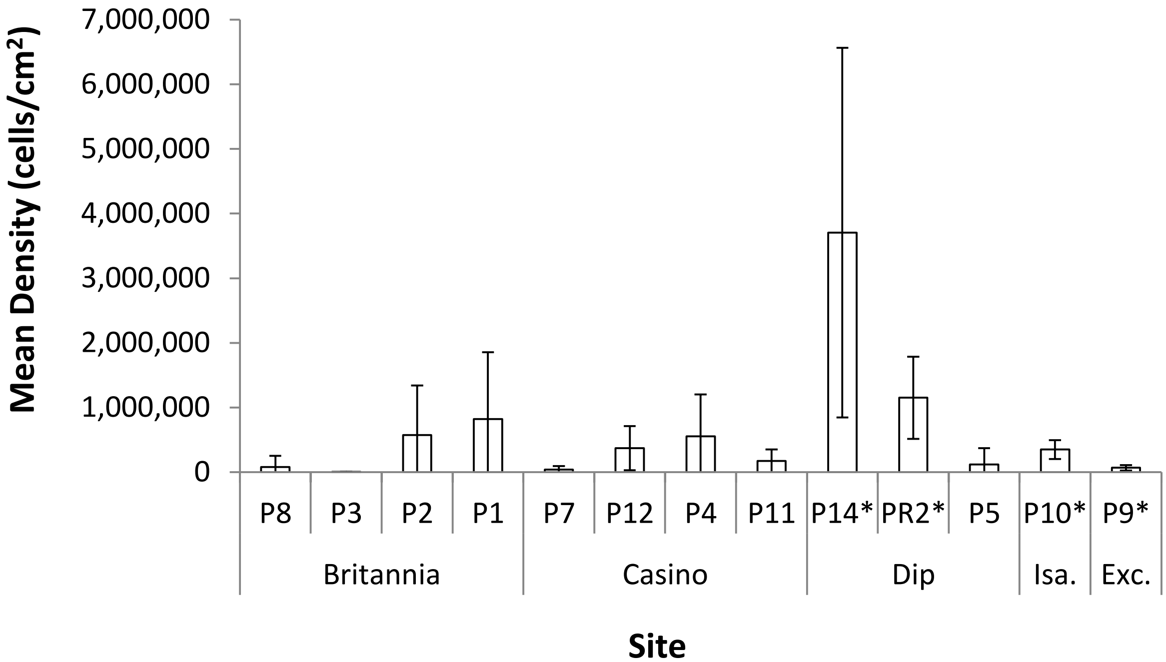


Figure 6-3 Mean periphyton density by site, Casino Project, 2008-2011. Sites are grouped by watershed including: Britannia=Britannia Creek watershed, Casino=Casino Creek watershed, Dip=Dip Creek watershed, Isa.= Isaac Creek, and Exc.=Excelsior Creek. Bars represent standard deviation and asterisks (*) indicate periphyton reference sites

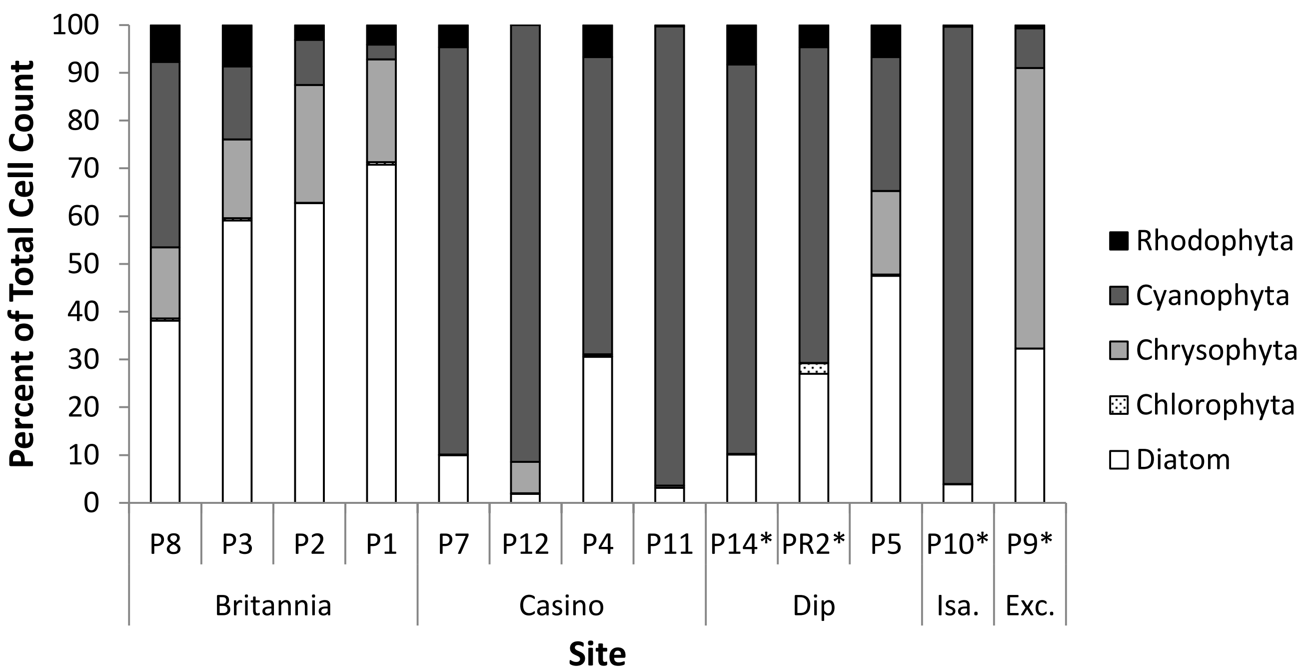


Figure 6-4 Relative cell densities of periphyton communities by site, Casino Project, 2008-2011. Sites are grouped by watershed including: Britannia=Britannia Creek watershed, Casino=Casino Creek watershed, Dip=Dip Creek watershed, Isa.=Isaac Creek, and Exc.=Excelsior Creek, and asterisks (*) indicate periphyton reference sites

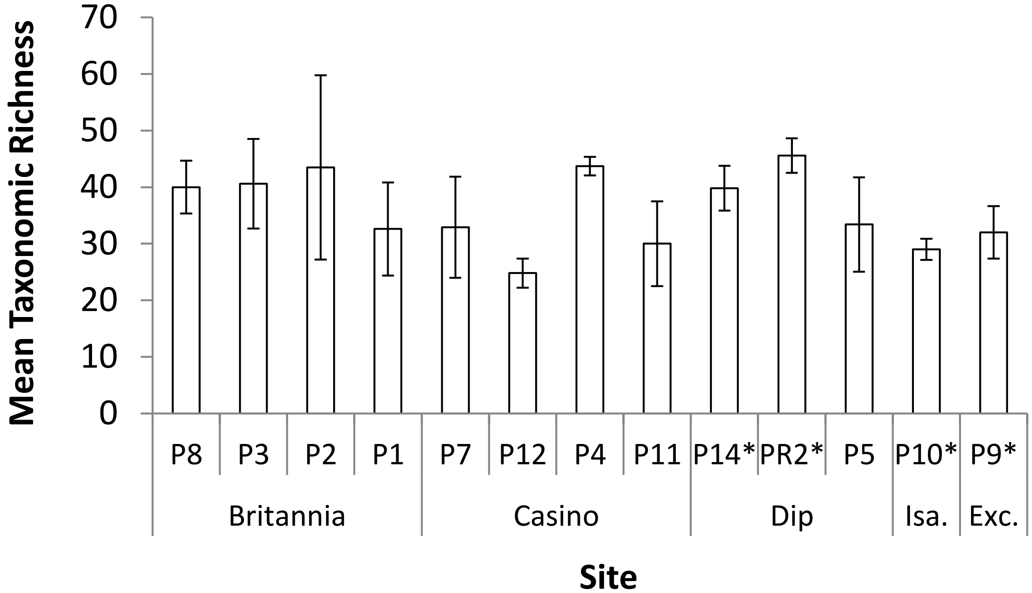


Figure 6-5 Mean Taxonomic Richness of Periphyton Communities by site, Casino Project, 2008-2011. Sites are grouped by watershed including: Britannia=Britannia Creek watershed, Casino=Casino Creek watershed, Dip=Dip Creek watershed, Isa.=Isaac Creek, and Exc.=Excelsior Creek. Bars represent standard deviation and asterisks (*) indicate periphyton reference sites

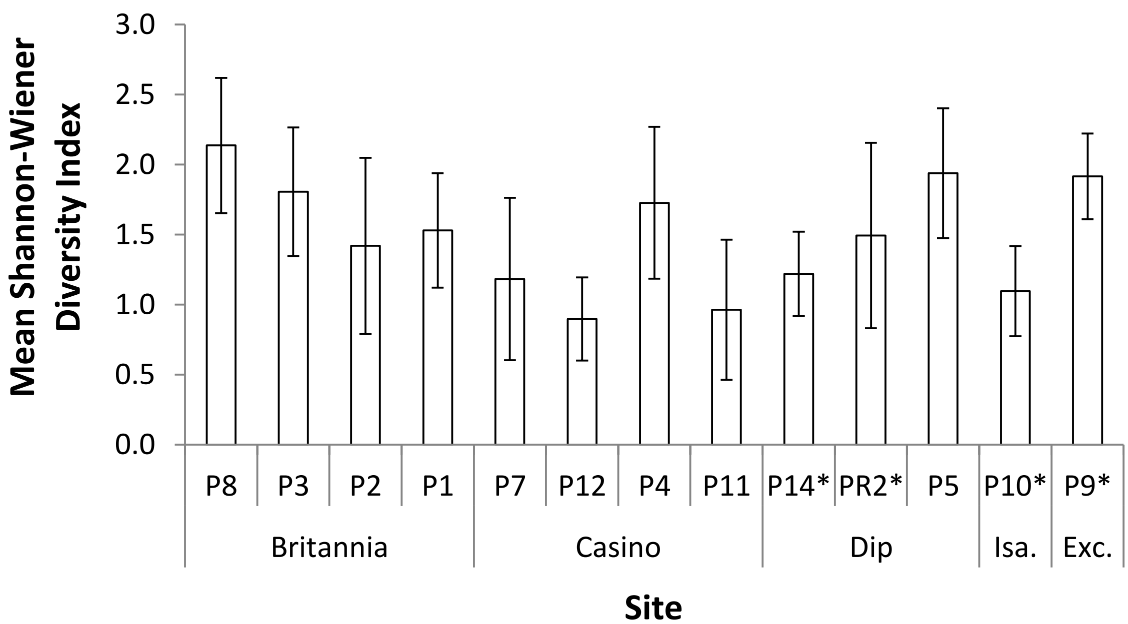


Figure 6-6 Mean Shannon-Wiener Diversity Index of Periphyton Communities by site, Casino Project, 2008-2011. Sites are grouped by watershed including: Britannia=Britannia Creek watershed, Casino=Casino Creek watershed, Dip=Dip Creek watershed, Isa.=Isaac Creek, and Exc.=Excelsior Creek. Bars represent standard deviation and asterisks (*) indicate periphyton reference sites

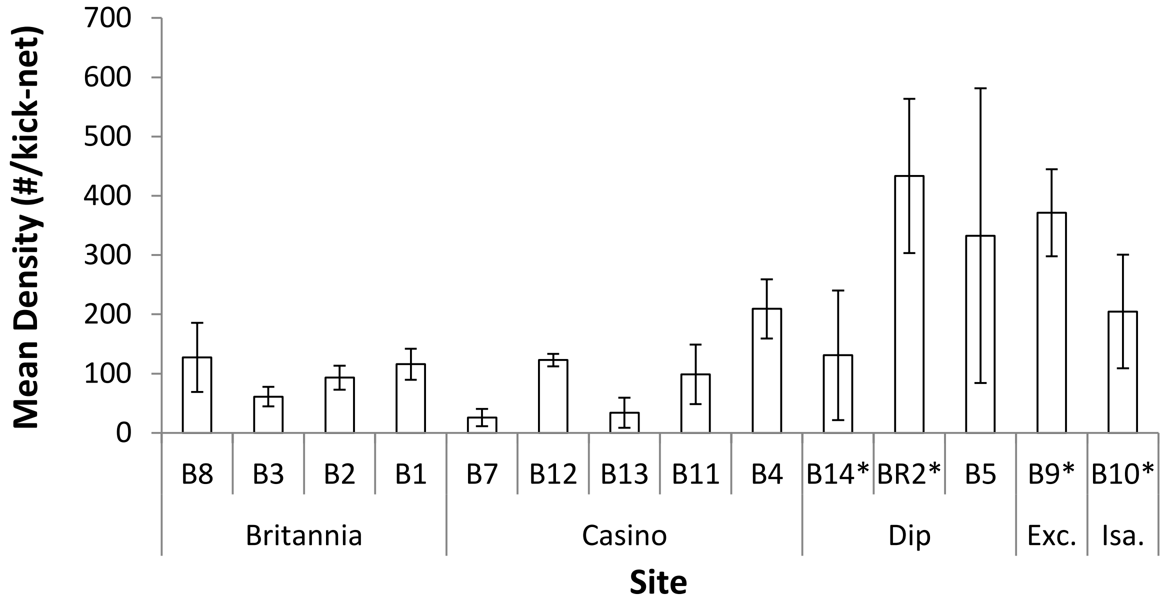
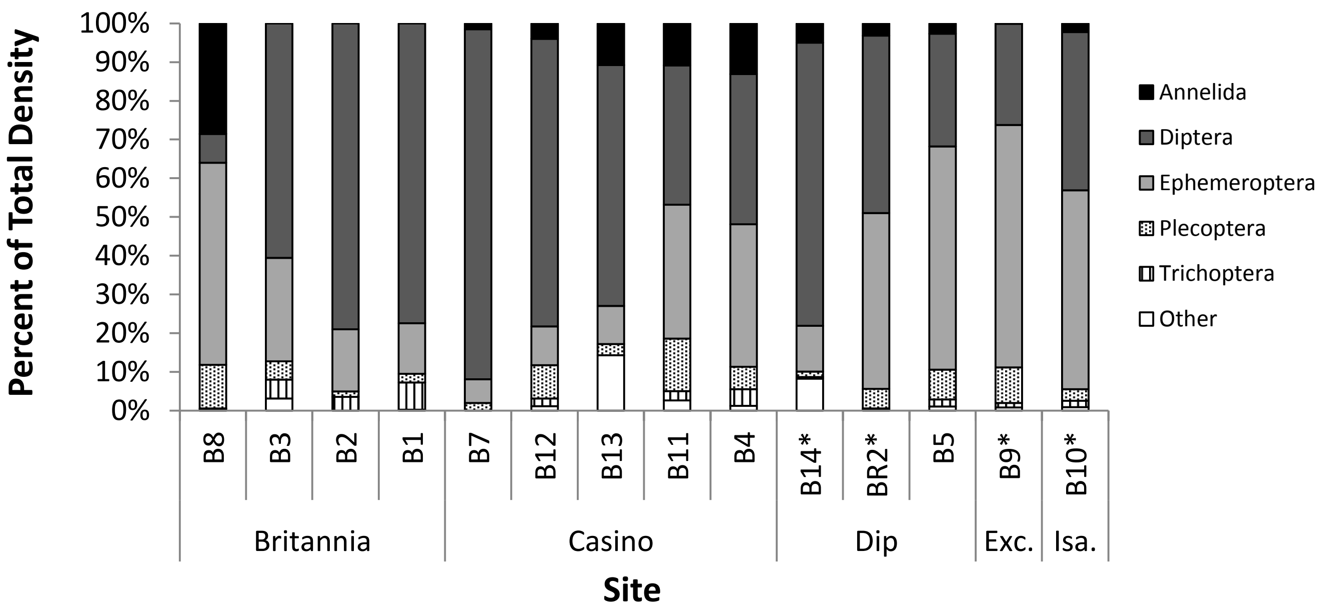


Figure 6-7 Mean density of benthic invertebrates by site using the kick-net sampling method, Casino Project, 2009 and 2011. Sites are grouped by watershed including: Britannia=Britannia Creek watershed, Casino=Casino Creek watershed, Dip=Dip Creek watershed, Isa.=Isaac Creek, and Exc.=Excelsior Creek. Bars represent standard deviation and asterisks (*) indicate benthic invertebrate reference sites



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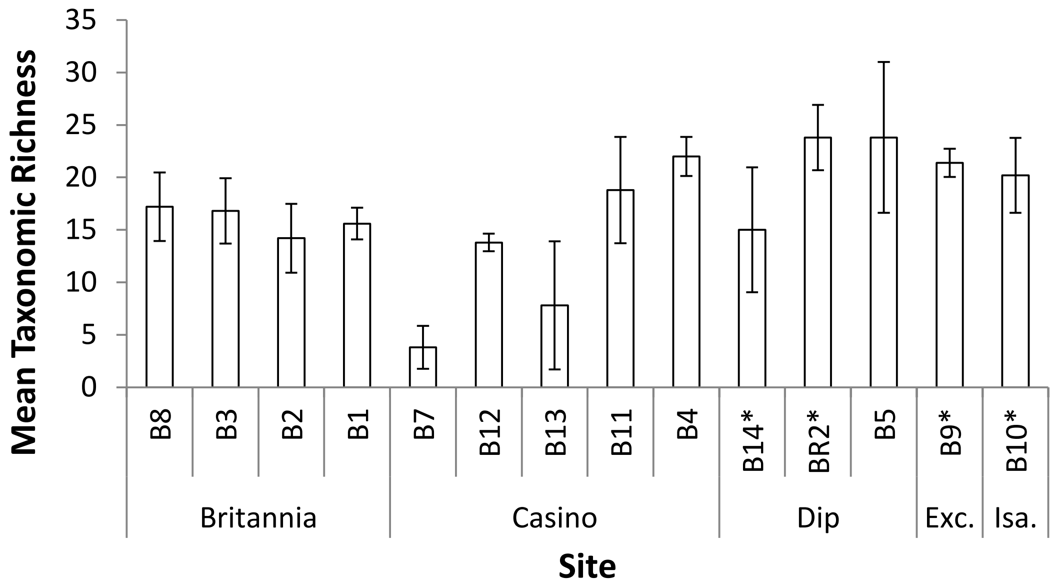

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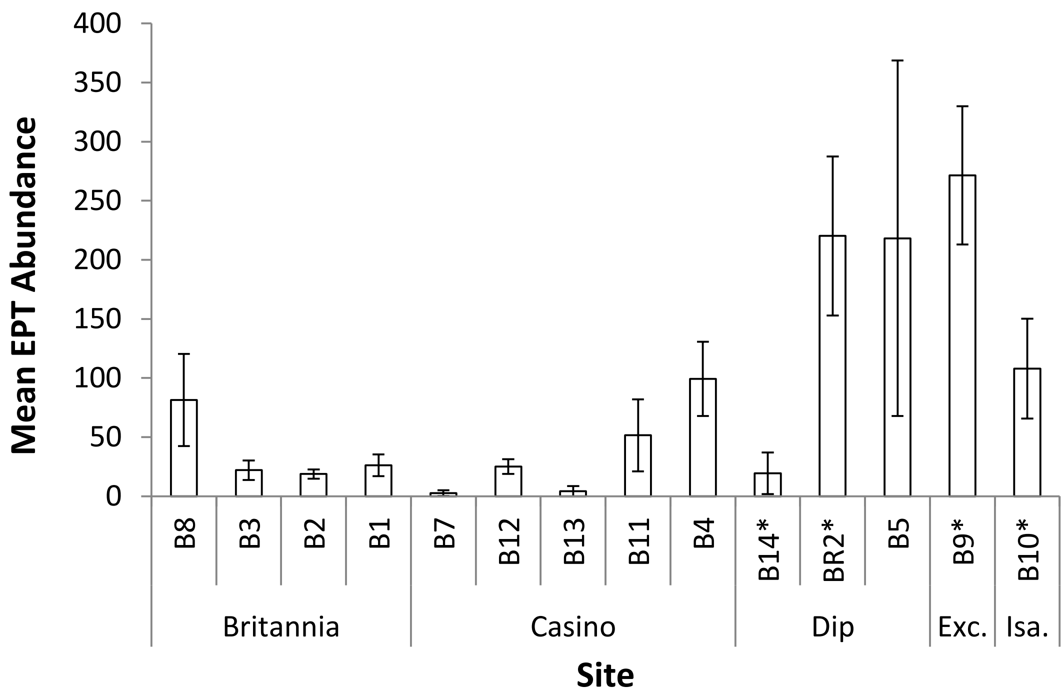

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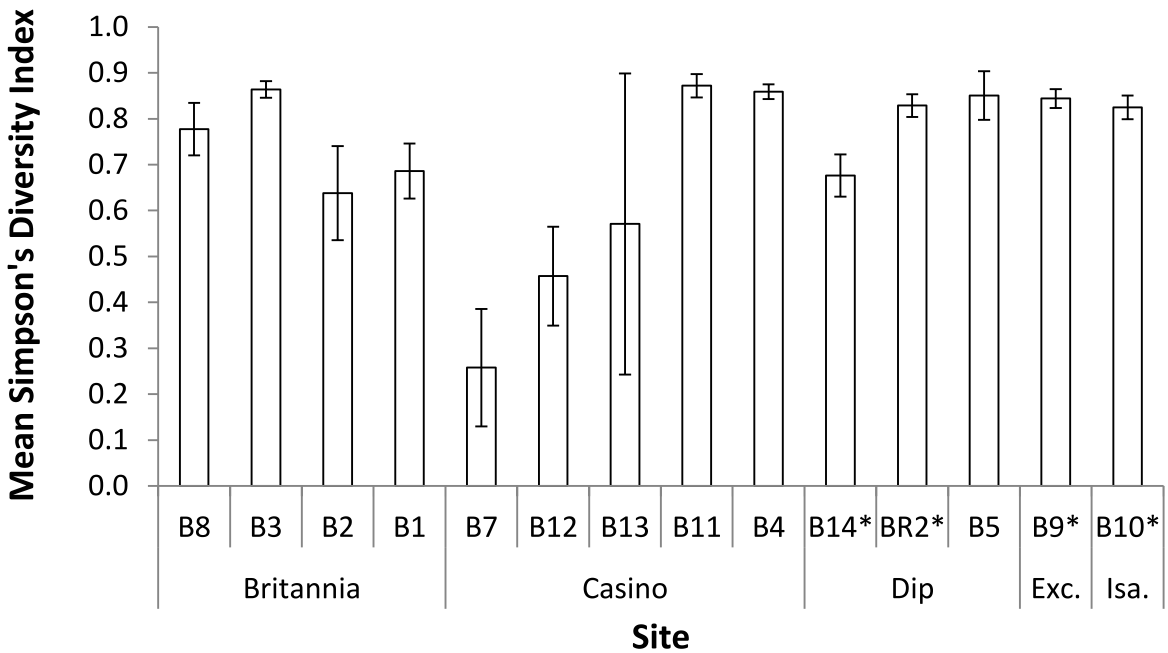

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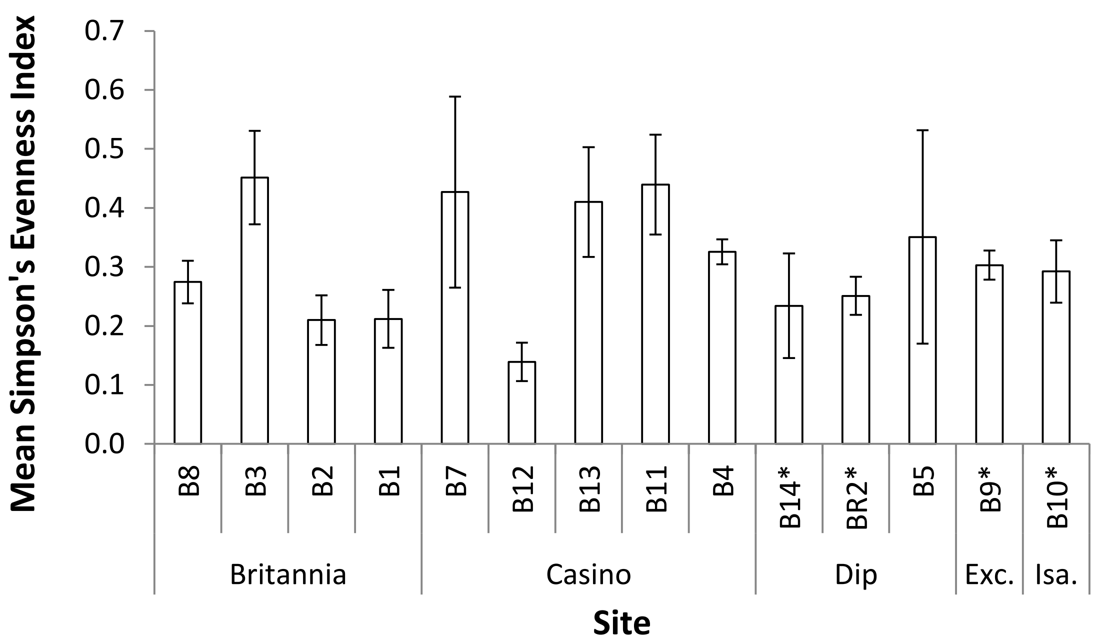

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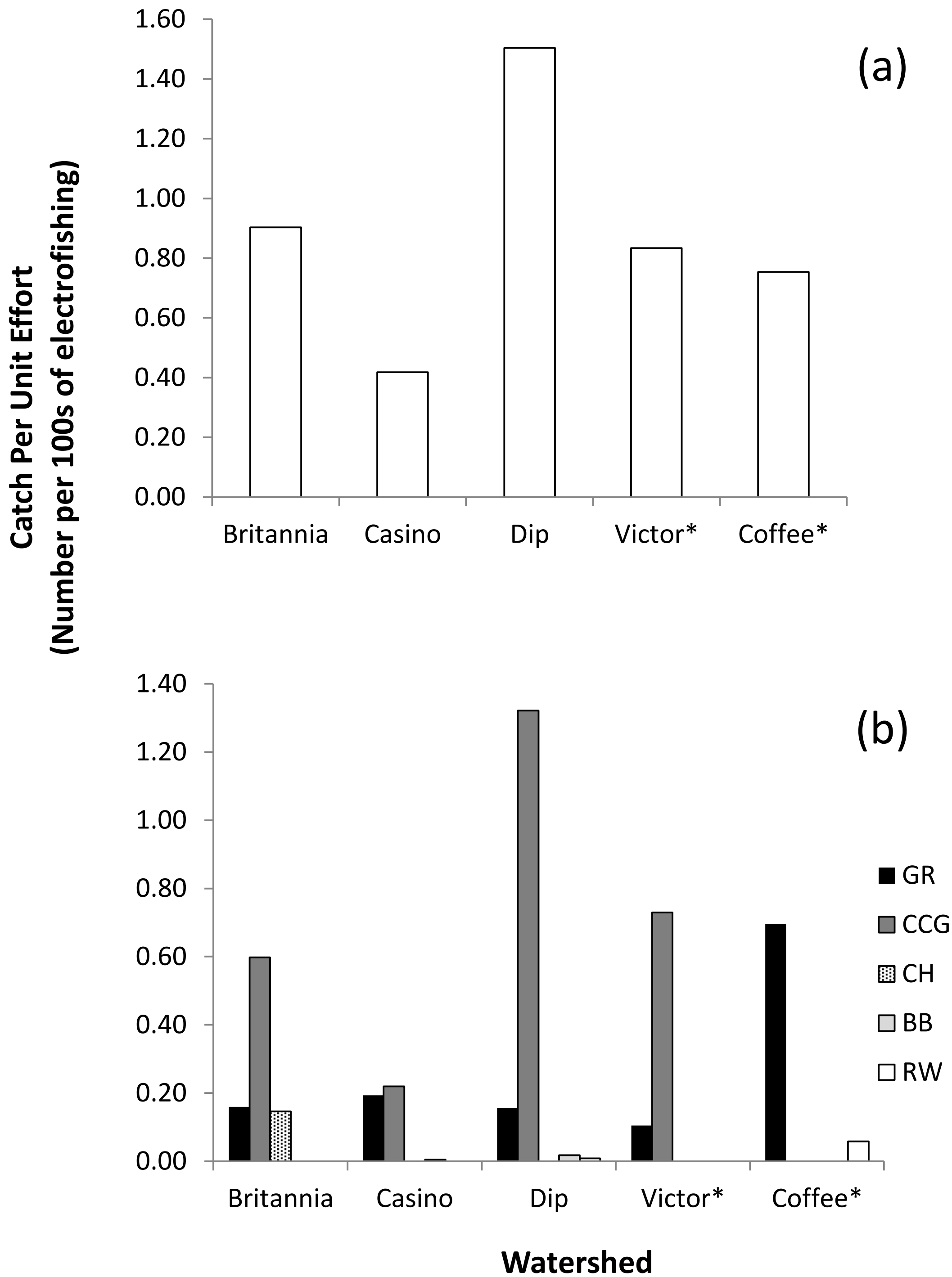

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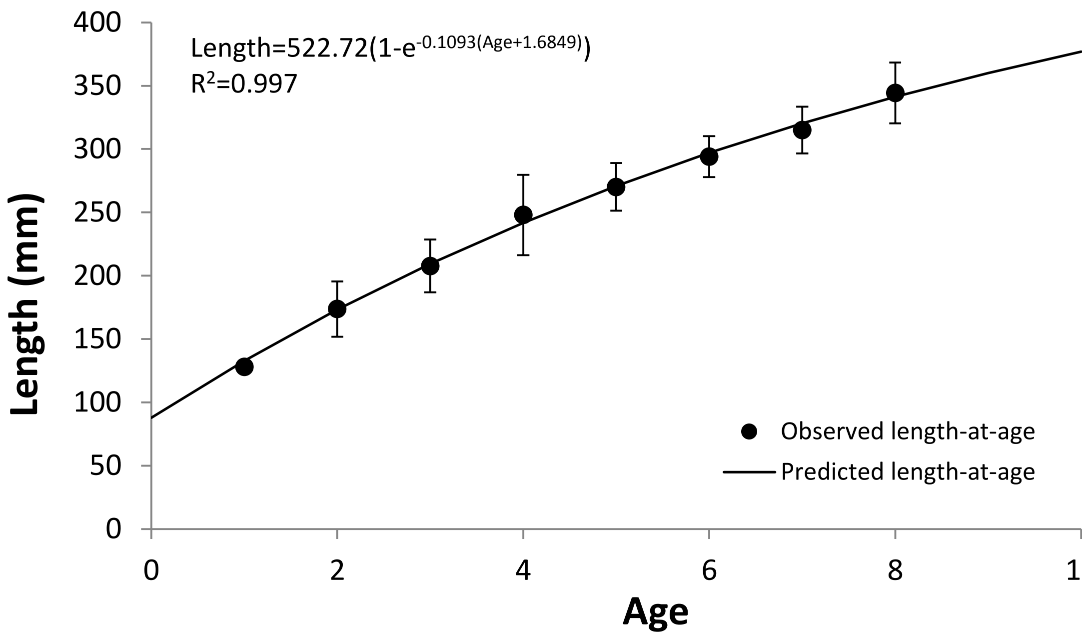

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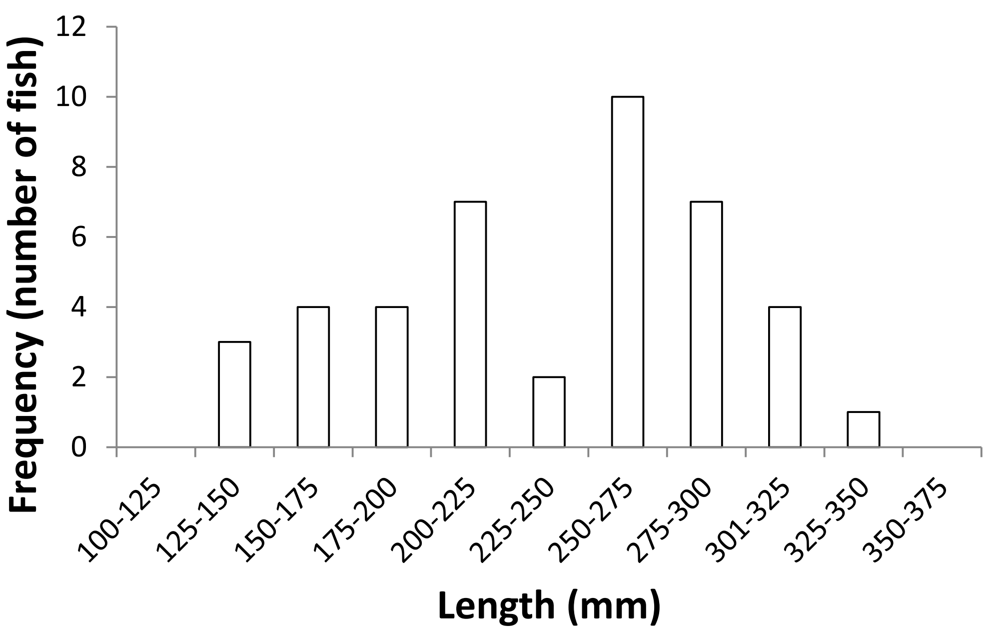

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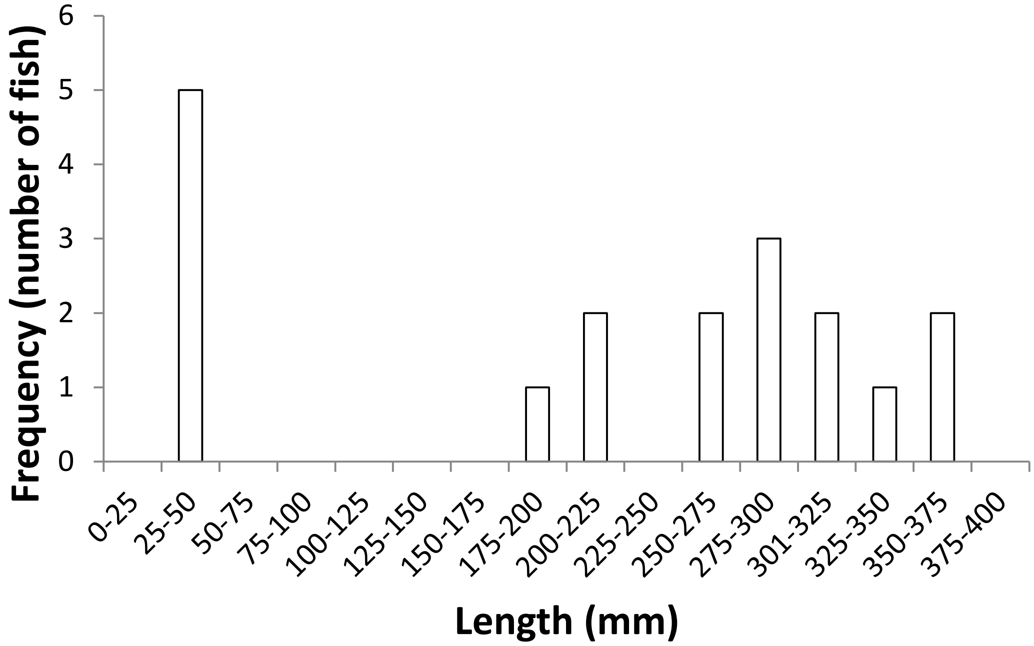

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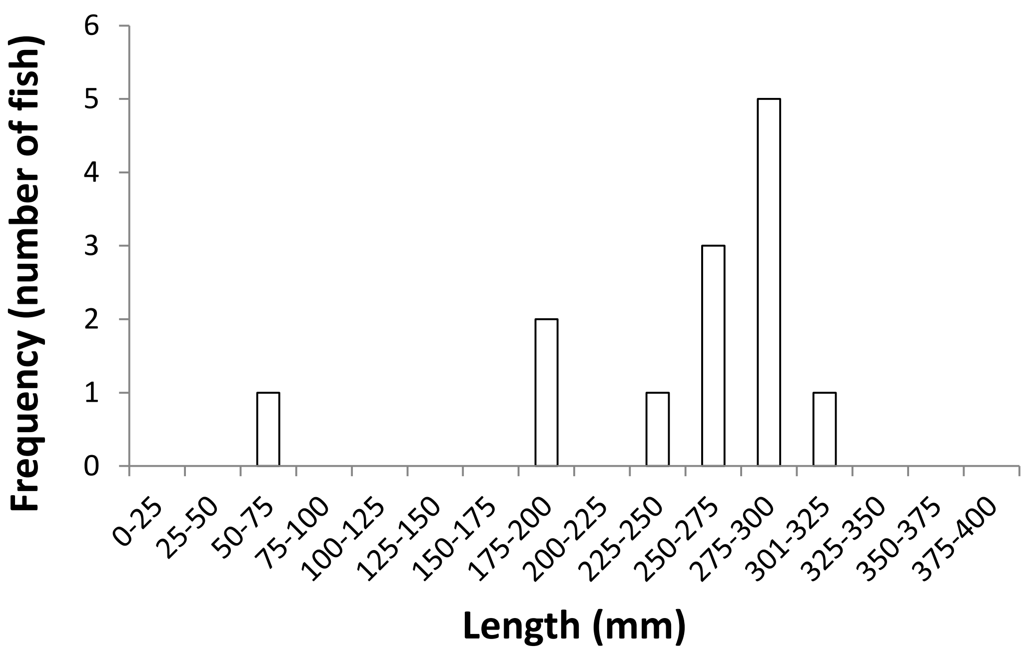

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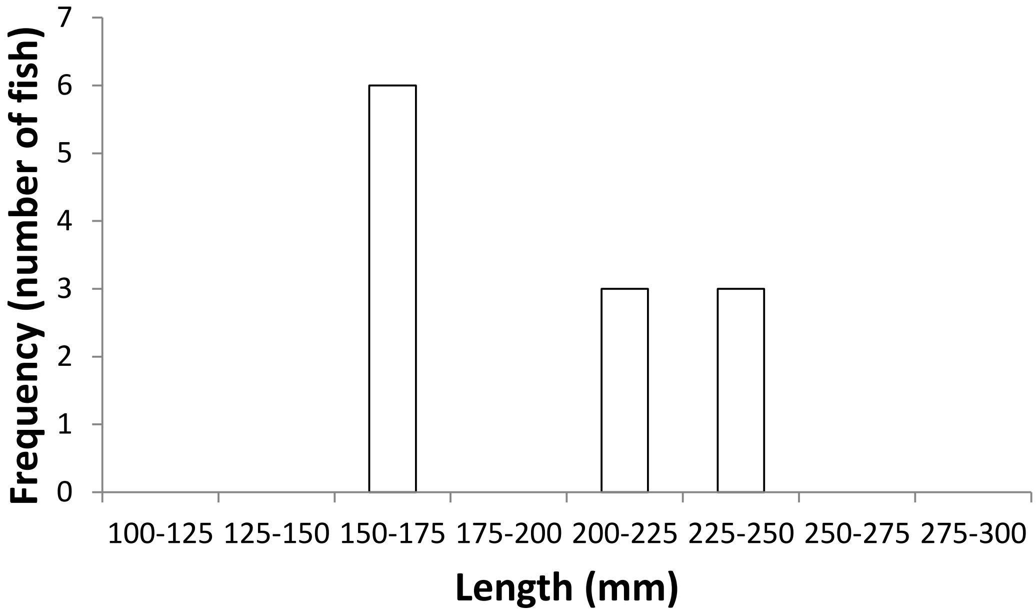

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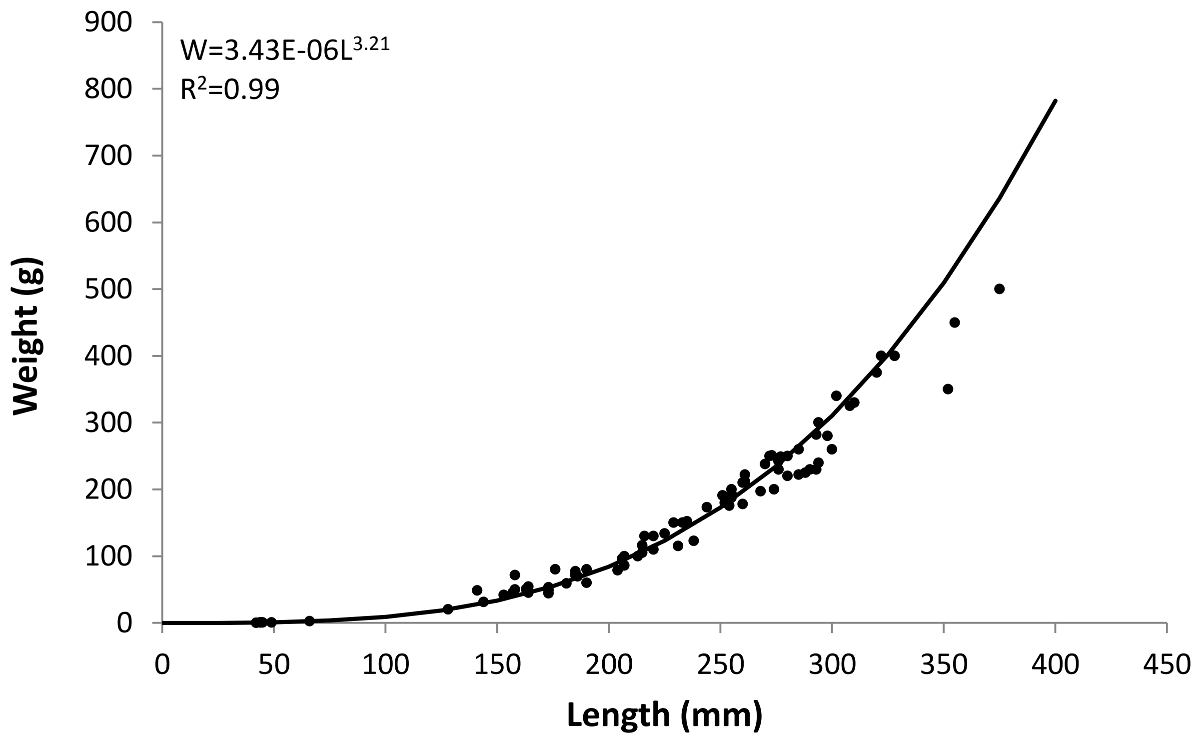

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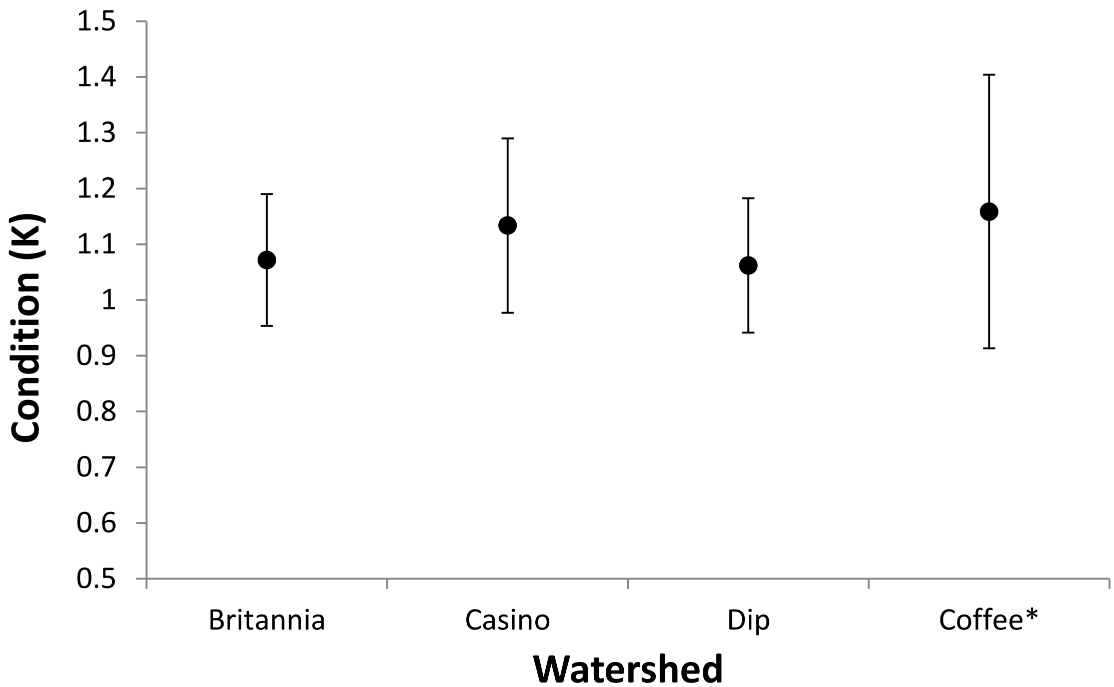

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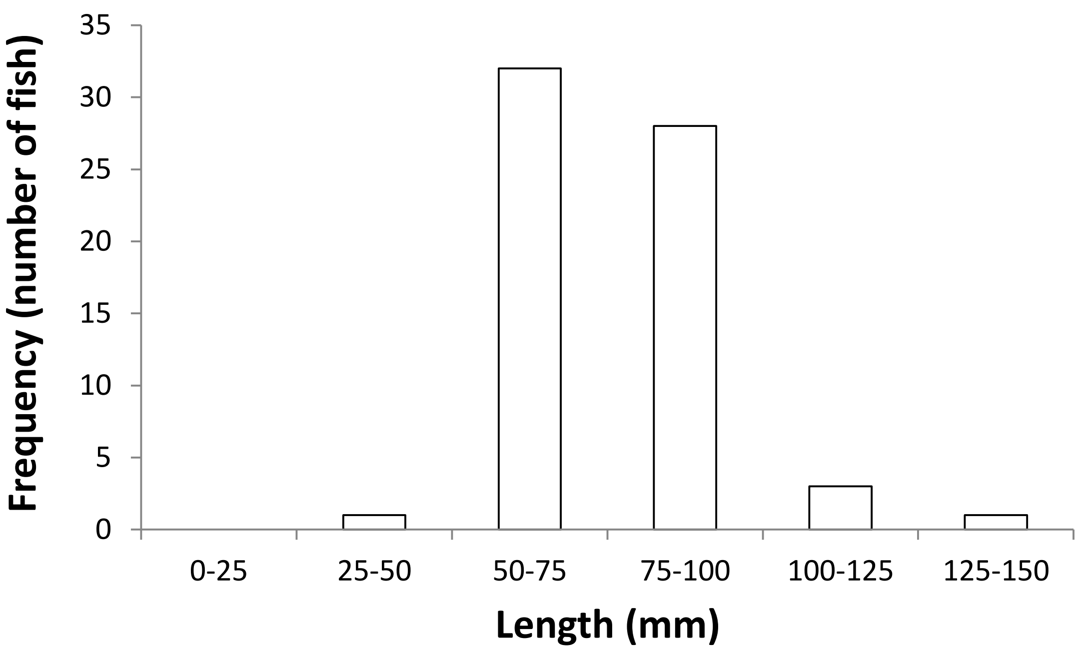

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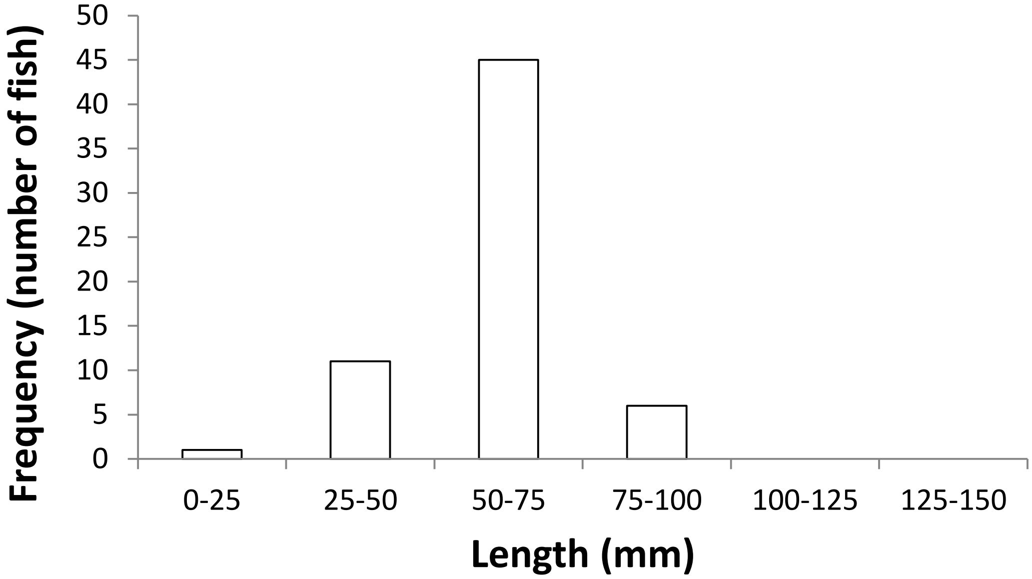

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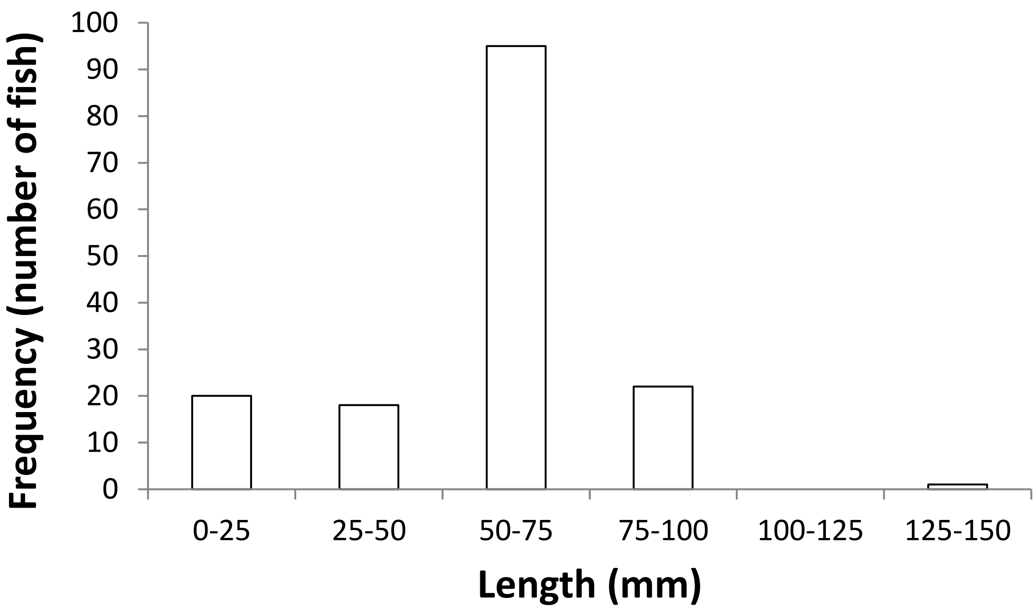

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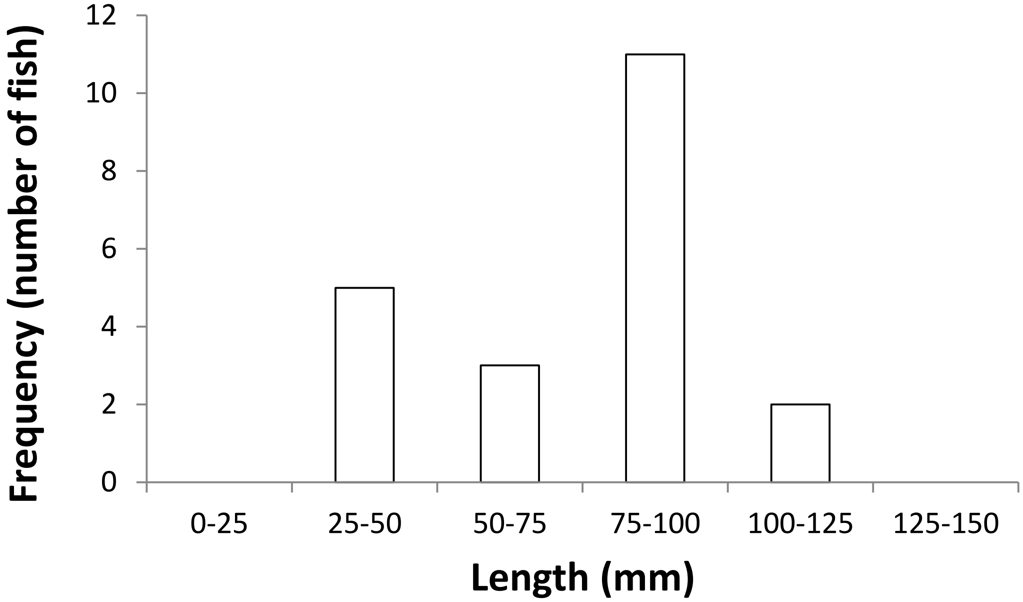

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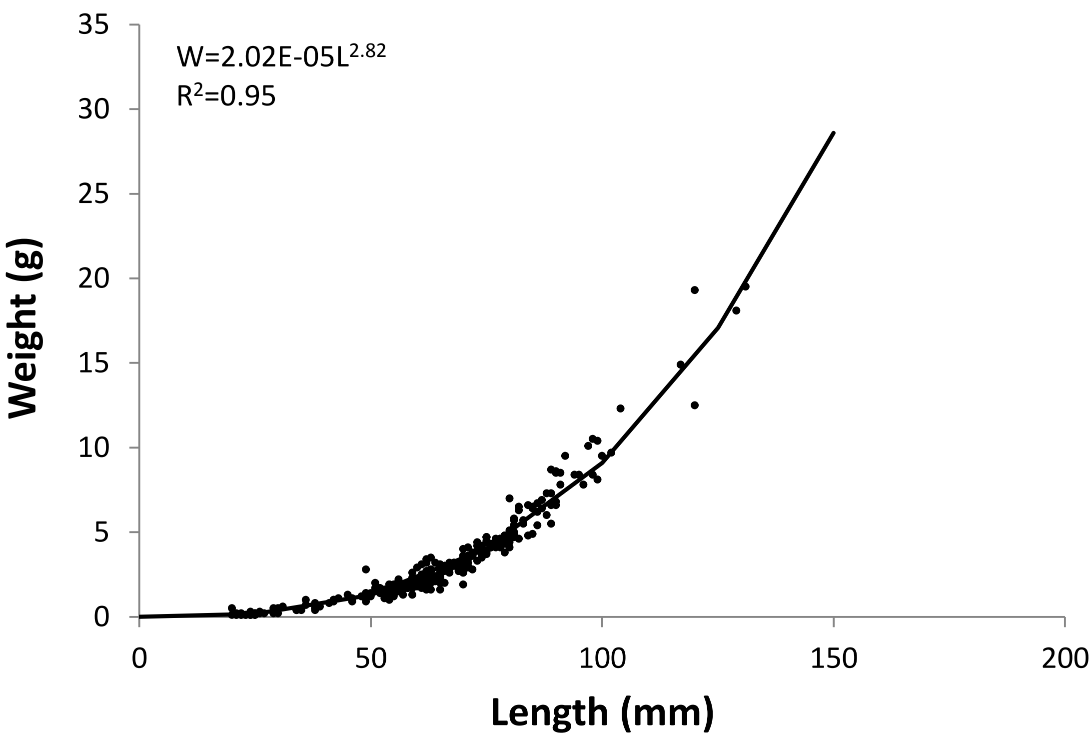

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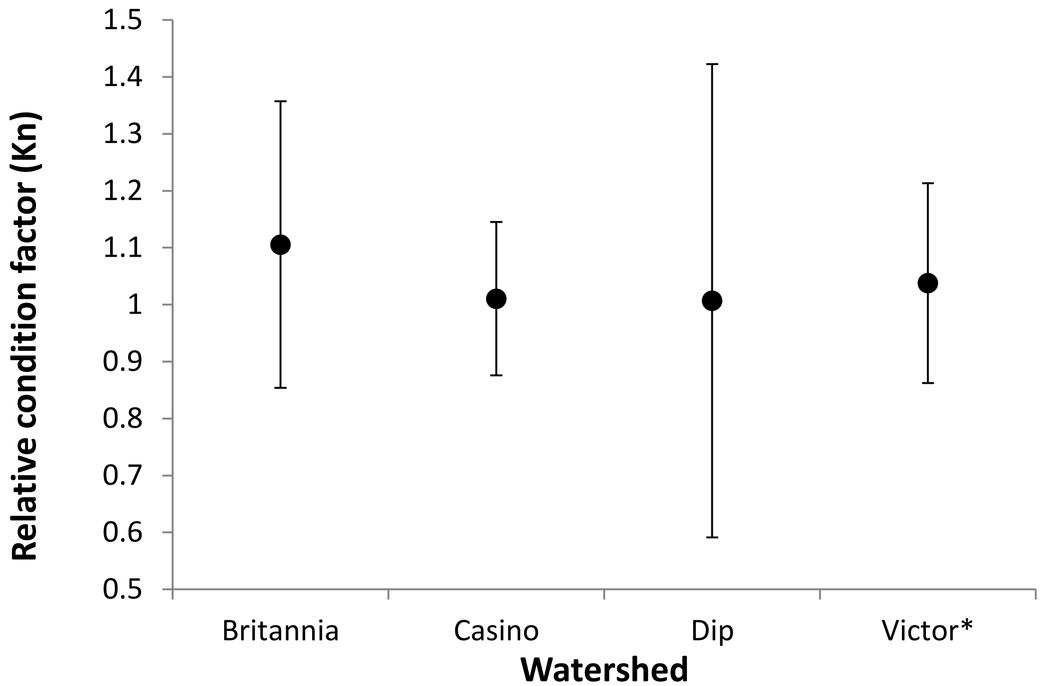

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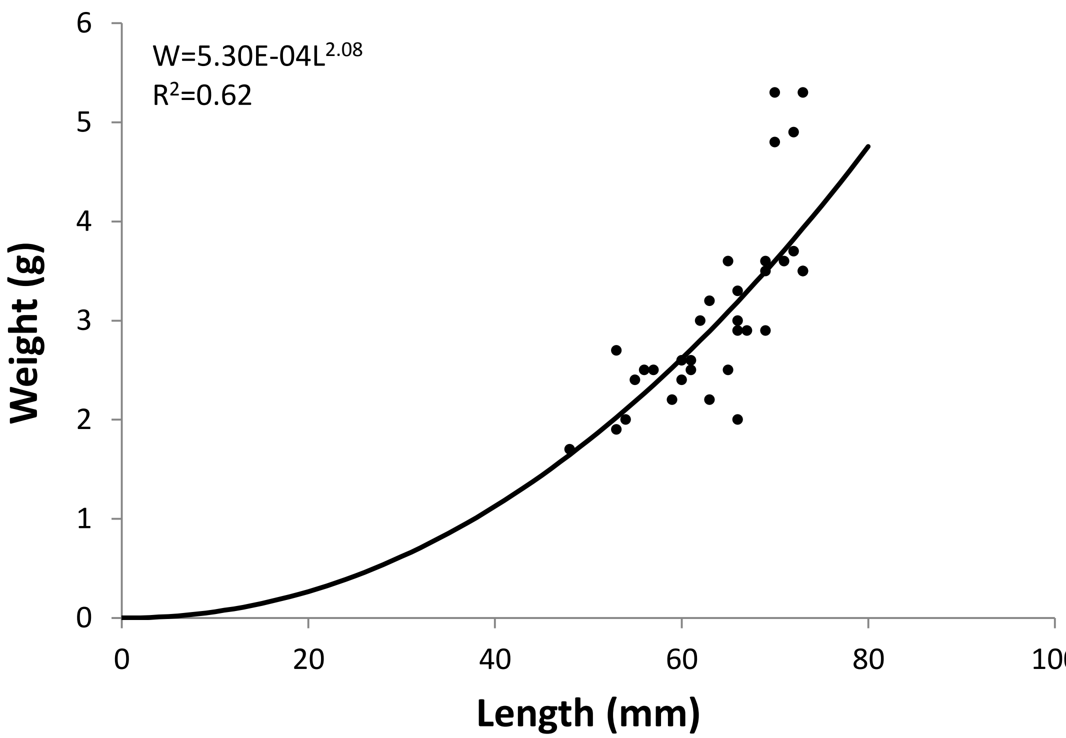

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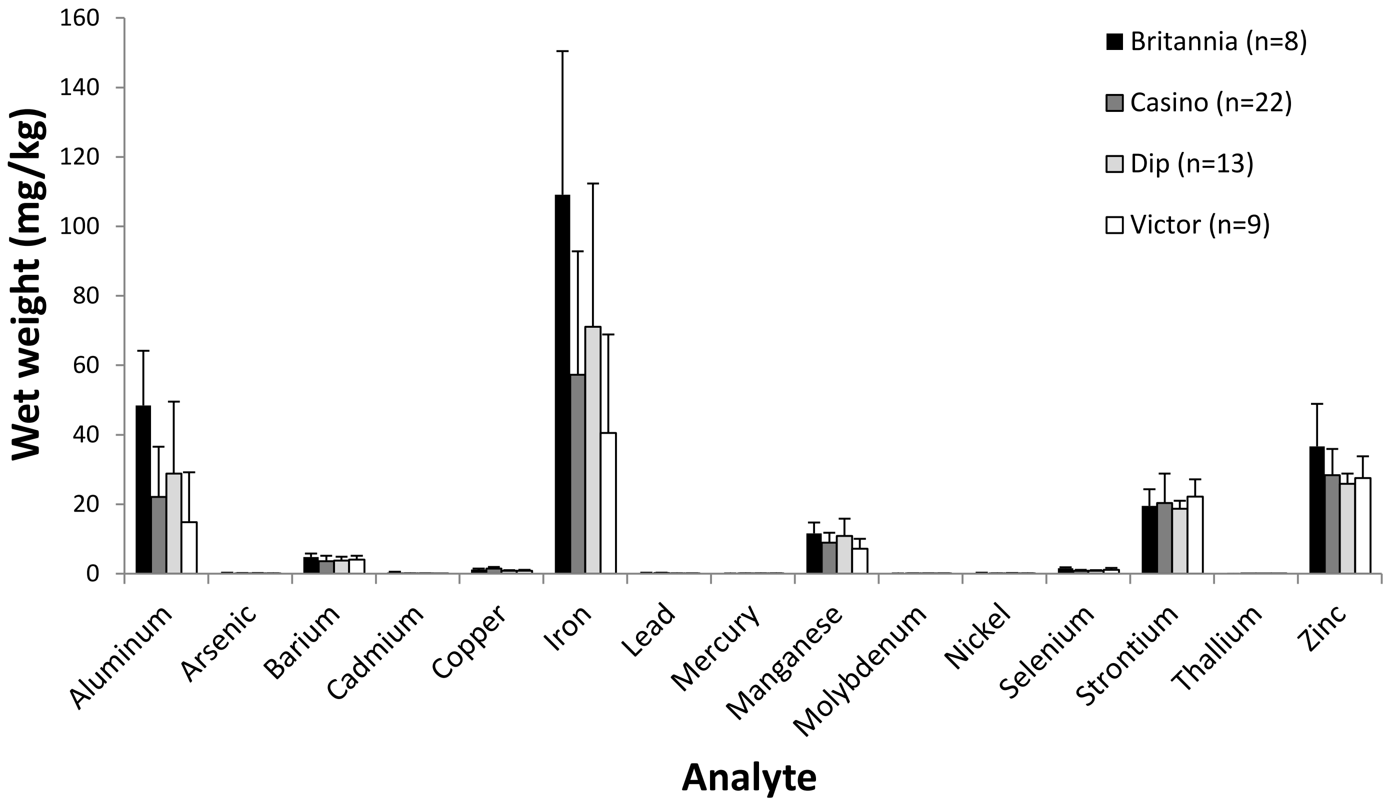

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Casino Project 2008: Environmental Studies Report

Appendix B

Casino Project: 2009 Aquatic Studies Report

Appendix C

Casino Project: 2010 Aquatic Studies Report

Appendix D

Casino Project: 2011 Aquatic Studies Report

Appendix E

Casino Project: 2012 Aquatic Studies Report

Appendix F

Casino Project: 2013 Aquatic Studies Technical Memo

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Casino Project: 2013 Aquatic Studies Technical Memo

Prepared for

Casino Mining Corporation

October 15, 2013

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

*475 Howe Street, Suite 1030, Vancouver, BC V6C 2B3 **t** 604-629-9075*

October 15, 2013

Jesse Duke
Project Director
Casino Mining Corporation
2050-1111 West Georgia Street
Vancouver, BC V6E 4M3

Dear Mr. Duke,

Re: Casino Project: 2013 Aquatic Studies Technical Memo

Palmer Environmental Consulting Group Inc. is pleased to submit the attached technical memo describing the fish and fish habitat studies conducted in 2013 in the Casino Project area. If there are any questions or comments on this report, then please contact the undersigned.

Thank you for the opportunity to work with you on this project.

Yours truly,

Palmer Environmental Consulting Group Inc.

R. Palmer

Rick Palmer, M.Sc. R.P. Bio
President, Senior Fisheries Biologist

Distribution List

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1	Yes	Casino Mining Corporation
1	Yes	Palmer Environmental Consulting Group

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	Rick Palmer	October 16, 2013	Senior Review

Signatures

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Acknowledgements

The studies described in this report were carried out by the following PECG staff:

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- Rick Palmer, M.Sc., R.P. Bio., Senior Fisheries Biologist

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- Eric Cleveland, Environmental Technician
- Alyssa Murdoch, M.Sc., R.P. Bio., Aquatic Biologist
- Laura Richards, Fisheries Co-op Student
- Laura Grieve, B.Sc. Environmental Biologist

Report Preparation:

- Alyssa Murdoch, M. Sc., R.P. Bio., Aquatic Biologist

Senior Review:

- Rick Palmer, M.Sc., R.P. Bio., Senior Fisheries Biologist

Acronyms and Abbreviations

ARD	Acid Rock Drainage
BC MOE	British Columbia Ministry of Environment
CCME	Canadian Council of Ministers of the Environment
CPUE	Catch-per-unit-effort
DFO	Fisheries and Oceans Canada
DIAND	Department of Indian Affairs and Northern Development
DOC	Dissolved Organic Carbon
EEM	Environmental Effects Monitoring
FISS	Fisheries Information Summary System
GPS	Global Positioning System
HKP	Hallam Knight Piésold Ltd.
INAC	Indian and Northern Affairs Canada
ISQG	Interim Sediment Quality Guideline
LSA	Local Study Area
LT_{50}	Lethal Time for 50% of the test organisms
MMER	Metal Mining Effluent Regulations
μS	micro-Siemens
NA	Not applicable
NAN	Not a Number
NS	Not sampled
NTU	Nephelometric unit
PEL	Probable Effects Level
PQL	Practical Quantitation Limit
QA/QC	Quality Assurance/Quality Control
RDL	Reported Detection Limit
RPD	Relative Percent Difference
RSA	Regional Study Area
SE	Standard error
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMF	Tailings Management Facility
TOC	Total Organic Carbon
TSS	Total Suspended Solids
U.S. EPA	United States Environmental Protection Agency
YESAB	Yukon Environmental and Socio-Economic Assessment Board

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1 Introduction

1.1 Overview

This memo describes the fisheries studies conducted in 2013 by Palmer Environmental Consulting Group Inc. (PECG) on the aquatic environments of the Casino Project (Project). The purpose of this memo is to report a general overview of the 2013 fisheries studies methods and results conducted in support of the project proposal to the Yukon Environmental and Socio-economic Assessment Board (YESAB), with a more detailed discussion provided in the Casino Fish and Aquatic Resources Baseline Report.

The Project is owned by the Casino Mining Corporation (CMC). It is a proposed porphyry copper-gold-molybdenum mine located in west-central Yukon, at 611379E 6956218N, approximately 300 km northwest of the territorial capital of Whitehorse. The location of the Project is shown in Figure 1, surrounded by the aquatic study area, in relation to the Yukon River – to which all of the streams in the Project area eventually discharge.

Limited historical data are available on the aquatic environmental of the Project area. Historical studies on the aquatic ecosystem of the Project property were first conducted from 1993 to 1995 (Hallam Knight Piésold, 1997). In 1994, Fisheries and Oceans Canada (DFO) and Indian and Northern Affairs Canada (INAC), then known as the Department of Fisheries and Oceans Canada and Department of Indian Affairs and Northern Development (DIAND), conducted an overview investigation of waters that may be affected by the Project (DFO, 1994). This included the Klotassin River, Dip Creek, Britannia Creek, Selwyn River and Hayes Creek. In 1998, White River First Nation commissioned a study to identify areas of the Lower Donjek River drainage utilized by Chinook salmon (Otto, 1998). This was conducted in order to serve as a pilot study to develop a strategic plan for future Chinook salmon restoration and enhancement work in the lower Donjek. In 2001, on behalf of Selkirk First Nation, studies were conducted on selected Yukon River tributaries between McGregor Creek and Coffee Creek by Laberge Environmental Services (Laberge, 2001). Basic data on flow, water quality, benthic invertebrate and fish were collected.

For the purposes of managing Pacific salmon fisheries in the Yukon River Watershed and for classifying fish habitat in support of the Yukon Placer Authorization, DFO previously conducted surveys of fish and fish habitat in watersheds near the study area (Government of Canada, 2000). DFO surveys were conducted in reaches of the Yukon River adjacent to the Project property and the lower reaches of Dip Creek and the Klotassin, Donjek and White rivers. The results of the DFO surveys are reported in Appendix B10 of AECOM (2009).

Recent studies of the aquatic ecosystem of the RSA began in 2008 with sampling trips in May, July, September and October. Study components included stream flows, water quality, sediment quality, periphyton, benthic invertebrates, fish and fish habitat. The results of those surveys were reported in "*Casino Project: 2008 Environmental Studies Report*" (AECOM, 2009). The continuation of these studies was carried out in 2009 with monthly water quality sampling completed between May and December and sediment quality, periphyton, benthic invertebrates, fish and fish habitat sampling completed in August. The results of these surveys are reported in "*Casino Project: 2009 Aquatic Studies Report*" (PECG, 2011a). Monthly water quality sampling continued in 2010, 2011 and 2012, with some sediment, periphyton, benthic invertebrate and fish sampling to fill in data gaps (PECG, 2011b; PECG, 2012; PECG, 2013a). The studies conducted in 2013 and reported herein are continuations of the 2008 program. All data from 2008-2013 was compiled into a separate report describing the baseline aquatic environment of the Project Area (PECG 2013b).

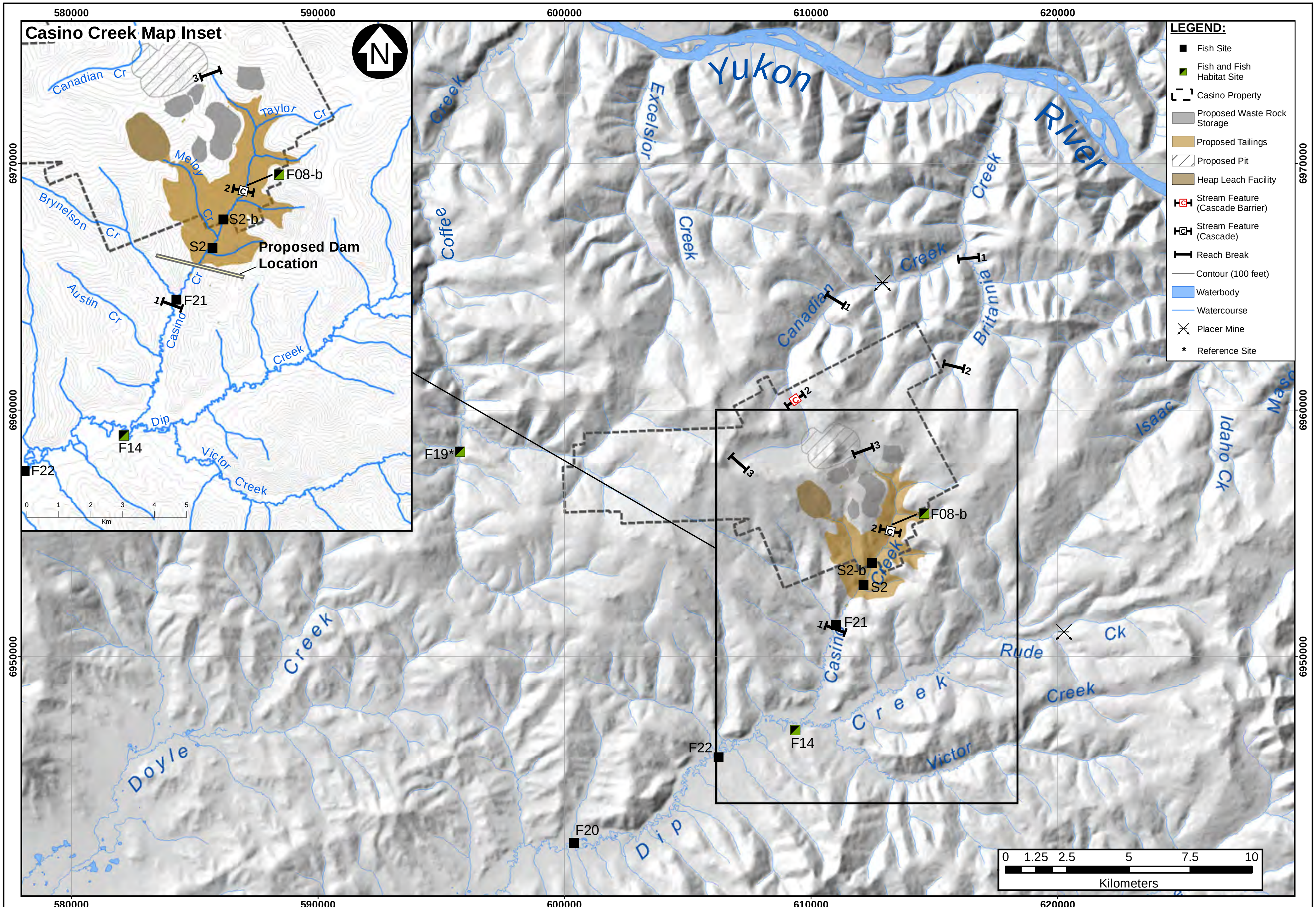
1.2 Study Areas

The study area for the fish and aquatic resources of the Casino Project includes the two watersheds surrounding the Project deposit (also known as Patton Hill): the Britannia Creek watershed to the north and the Casino Creek watershed to the south. This area includes the direct footprint of the proposed Project mine and near-field affected areas. These watersheds have the potential to be affected by the Project.

Most of the proposed mine infrastructure will be in the Casino Creek watershed, with some (e.g., the northern corner of the open pit) found within the Britannia Creek watershed. The northern part of the study area is drained by Britannia Creek and its main tributary, Canadian Creek, which flow northward into the Yukon River. The southern part of the property is drained by Casino Creek which flows south to Dip Creek and thence to the Yukon River via the Klotassin, Donjek and White rivers.

The fish and aquatic resources study area also includes water bodies which are either indirectly affected (mid-to-far field effects) or are suitable for providing references sites by the Project activities:

- **Dip Creek Watershed**. The headwaters of Dip Creek are not expected to be affected by Project activities, but the reaches of Dip Creek downstream of the confluence of Dip and Casino Creeks may be affected by a reduction in stream flow from Casino Creek caused by the impoundment of its headwaters within the Tailings Management Facility (TMF). The effects of flow reductions may decrease with downstream distance from the confluence of Dip and Casino Creeks. Reference site R2 was established on Victor Creek, which is a tributary of Dip Creek located upstream of the Project, for benthos, periphyton and fish communities.
- **Coffee Creek Watershed**. Coffee Creek is located west of the Excelsior Creek watershed and approximately 15 km west of the Britannia Creek watershed. Coffee Creek is not expected to be affected by Project activities, and thus a new fisheries reference site was added on Coffee Creek in 2012 (F19), upstream of the main drilling activities of the Kaminak Coffee Gold Project (SRK, 2013).



PREPARED BY:

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

DESIGNED	D. Turner
DRAWN	D. Turner
CHK'D	A. Murdoch
APP'D	A. Murdoch
REV	-
DATE	7Oct'13

NOTES:
1. BASE MAP: Digital Elevation Model and 1:250,000 and 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca)
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:200,000

CASINO COPPER AND GOLD

CASINO PROJECT

Casino Fish and Fish Habitat Sampling Sites, 2013

FIGURE 1

REF REPORT 1

P/A VA101-325/15

1.3 Study Objectives

As in 2008 to 2012, the overall objective of the 2013 aquatic studies was to collect information that will be used to characterize the pre-development aquatic environment of the Project area. A significant amount of aquatic baseline data has previously been collected, therefore the 2013 studies focused on continued monitoring and filling in gaps in the established data sets.

The specific objectives for the 2013 aquatic studies were the following:

- Complete fish assessments at sites within the TMF footprint of mid-upper Casino Creek to further develop understanding of species distribution, fish abundance and habitat utilization;
- Investigate the potential usage of Dip Creek by juvenile Chinook salmon for rearing, as documented for lower Dip Creek in previous reports (DFO 1994; Otto 1998), but remains unsupported during more recent sampling (e.g., 2008-2011 period);
- Collect a second year of fisheries data at the Coffee Creek fisheries reference site.

2 Methods

2.1 Dates and Locations of Sampling Surveying

2.1.1 General

The study design for the 2013 fisheries work was a reduced version of the study design used in 2008-2012. The same sampling techniques were employed, although fewer sites were sampled overall. All sampling was completed from June 28 – July 7.

2.1.2 Fish Assessment

Fish communities within Dip, Casino, and Coffee Creeks were sampled using minnow traps and electrofishing. The location of each fish sampling site is shown on Figure 1.

Prior to the 2013 field program, fisheries data from previous years of sampling was analyzed to identify any outstanding data gaps for the Casino baseline assessment. Generally, sites that were located within the TMF (upper Casino Creek), or that may contain regionally important species such as juvenile Chinook salmon (Dip Creek), were established or re-sampled to strengthen previous datasets. Additionally, a second year of sampling was completed at the fisheries reference site in Coffee Creek.

A total of eight sites were sampled in 2013 for fish (Table 1):

- F08-b, F21, S2 and S2-b on Casino Creek, above the proposed tailing management facility;
- F14 on Dip Creek downstream of the confluence with Casino Creek;
- F22 on Dip Creek, approximately halfway between F14 and F20;
- F20 on middle Dip Creek; and
- F19 on Coffee Creek (reference site).

In addition, a physical and environmental fish habitat assessment was carried out at reference site F19. Physical fish habitat and *in situ* water quality data was collected using methods detailed in the 2008 Aquatic Studies Report (AECOM 2009).

Table 1. Summary of Fish Sampling Sites, Casino Project, 2013

Creek/River	Site	Minnow Trapping	Backpack Electrofishing	Shore-based Electrofishing	UTM Co-ordinates	
					Easting	Northing
Casino	F08-b	July 4	July 4	-	613,100	6,954,628
Casino	F21	July 4	June 28	-	611,015	6,951,285
Casino	S2-b	-	July 4	-	612,476	6,953,792
Casino	S2	July 4	July 4	-	612,135	6,952,897
Dip	F14	July 6	July 6	July 6	609,367	6,947,025
Dip	F22	July 6	July 6	July 6	606,258	6,945,924
Dip	F20	July 7	July 7	-	600,395	6,942,437
Coffee	F19*	July 6	July 7	-	595,767	6,958,310

Note: Dashes indicate no sampling at that site and date.

****reference site***

2.2 Sample Collection

2.2.1 Fish Assessment

Electrofishing and minnow trapping were both used in 2013 for sampling fish communities. Between two and three minnow traps were installed at seven of the eight sites in June or July, 2013 (Table 1). Minnow traps were made of galvanized steel wire and were conical in shape with a length of 42 cm, a width of 23 cm and a mesh size of 0.6 cm. Minnow traps were placed at each site in deep pools or among large woody debris or in slow-moving eddies. They were anchored to large woody debris or rocks, and rocks were placed within the traps to weigh them down. The traps were marked with red or yellow fluorescent flagging tape. Each trap was baited with salmon roe placed in a small perforated bag. Traps were soaked for approximately 24 hours.

Electrofishing was conducted using a two-person crew and a backpack electrofishing unit, with the exception of Dip Creek sites where a three-person crew was employed. Single-pass fishing methods were used, while walking the stream in an upstream direction repeatedly sweeping the stream from bank to bank with the wand (anode) of the electrofishing unit. In addition to backpack electrofishing, a shore based fishing unit was employed at two sites in Dip Creek (F14, F22) to fish deep pools which were not accessible using the backpack electrofisher. A two person crew operated the shore-based fishing unit while an additional two people were positioned with dip nets at opposite ends of the pool. Voltage was set at 354V and effort per site ranged from 266-289s. Fish were captured with a dip net and stored in a bucket of freshwater while processing.

All fish captured were identified to species level and counted. Fork length was measured to the nearest 1 mm with a measuring board (total length was measured for slimy sculpin), and wet weight was measured to the nearest 0.1 g or 1.0 g with a balance (depending on size of fish).

2.3 QA/QC

2.3.1 Fisheries Assessment

All fisheries field data were recorded on waterproof paper field notes and then transferred to electronic spreadsheets in the office. The spreadsheets were compared with the field notes to identify and correct transcription errors. A variety of other measures were taken to further ensure the validity of the data. For example, fish weights were plotted against fish lengths for each species separately to identify outliers that may have been due to errors in recording or transcription. In the 2013 dataset, no outliers were observed.

2.4 Data Analysis

2.4.1 Fisheries Assessment

There was no data analysis conducted for the 2013 field data, as fish data from 2013 was combined with data from previous years in a separate baseline report (PECG, 2013b).

3 Results

3.1 Fish Assessment

A total of eight sites were sampled in 2013 for fish (Figure 1 and Table 1). Appendices B1 and B2 show the fish catch, effort and catch per unit effort (CPUE) for electrofishing and minnow trapping. Minnow trapping was completed at all sites except S2-b, and electrofishing was conducted at all eight sites. Backpack electrofishing effort ranged from 241 to 2373 seconds with a mean of 1157 seconds. Shore-based electrofishing was 266s at F14 and 289s at F22.

A total of 145 fish from four species were captured from the Project study area in June and July of 2013 (Table 2 and Appendix A). The four species captured were Arctic grayling (*Thymallus arcticus*), slimy sculpin (*Cottus cognatus*), round whitefish (*Prosopium cylindraceum*), and burbot (*Lota lota*). Unlike previous sampling years, four Arctic grayling were captured upstream of the cascade reach break during exceptionally clear and low flow conditions

Table 2. Fish Catch, Casino Project, 2013

Site	Creek	Arctic Grayling	Slimy Sculpin	Round Whitefish	Burbot	Total
F08-b	Casino	4	-	-	-	4
F21	Casino	1	-	-	-	1
S2-b	Casino	2	-	-	-	2
S2	Casino	4	-	-	-	4
F14	Dip	1	11	-	-	12
F22	Dip	2	5	-	2	9
F20	Dip	1	106	-	-	107
F19*	Coffee	5	-	1	-	6
Totals		20	122	1	2	145

Note: Dashes indicate no fish captured

****reference site***

Sampling results in mid-upper Casino Creek were similar to previous years, with only adult and sub-adult Arctic grayling captured at lengths ranging from 216-310mm. Notably, four Arctic grayling were captured upstream of the medium gradient (8-10%) cascade reach break, under exceptionally clear and low-flow conditions. The reach break likely constitutes a high-flow barrier to fish migration in most years, as three years of previous sampling upstream yielded no fish.

Fish sampling in Dip Creek using several methods was carried out to gain additional insight into the potential use by juvenile Chinook salmon for rearing, as documented for lower Dip Creek in previous reports (DFO, 1994; Otto, 1998). No Chinook salmon were caught in 2013, or in any of the previous years of the Casino baseline program (AECOM, 2009; PECG, 2011a, 2011b, 2012, 2013a). Sites in Dip Creek were dominated by slimy sculpin, with CPUE's ranging from 0.3-1 fish/100s of electrofishing with the exception of the most downstream site F20 which supported a high density of slimy sculpins (4.5 fish/100s of electrofishing effort). Arctic grayling lengths in Dip Creek varied from 209-285mm, with no young-of-the-year sized individuals captured.

Coffee Creek fish sampling in 2013 had similar results to 2012, with 5 Arctic grayling and 1 round whitefish captured at a rate of 0.70 fish/100s of electrofishing. Arctic grayling lengths varied from 173-238mm, which suggests that the site generally supports sub-adult and adult rearing, but no young-of-the-year. The single round whitefish was 265mm long. Fish habitat data is reported in Appendix A.

4 References

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Appendix A

Fisheries Data

- **A1. Electrofishing Effort, Catch and CPUE, Casino Project, 2013**
- **A2. Minnow Trapping Effort and Catch, Casino Project, 2013**
- **A3. Fish Biological Characteristics, Casino Project, 2013**
- **A4. Fish Habitat Data, Casino Project, 2013**

Appendix A1. Electrofishing Effort, Catch, and CPUE, Casino Project, 2013

Date	Site	Method	Section Length (m)	Voltage (V)	Effort (s)	Catch						CPUE (fish/100s of electrofishing)				
						GR	CCG	CH	BB	RW	Total	GR	CCG	CH	BB	RW
28-Jun-13	F21	EF	250	300	958	1	0	0	0	0	1	0.10	0.00	0.00	0.00	0.00
04-Jul-13	F08-b	EF	230	300	965	4	0	0	0	0	4	0.41	0.00	0.00	0.00	0.00
04-Jul-13	S2	EF	120	300	241	4	0	0	0	0	4	1.66	0.00	0.00	0.00	0.00
04-Jul-13	S2-b	EF	270	300	597	2	0	0	0	0	2	0.34	0.00	0.00	0.00	0.00
06-Jul-13	F14	EF	400	300	1685	0	9	0	0	0	9	0.00	0.53	0.00	0.00	0.00
06-Jul-13	F14	SH	N/A	354	266	1	0	0	0	0	1	0.38	0.00	0.00	0.00	0.00
06-Jul-13	F22	EF	300	300	1580	1	4	0	0	0	5	0.06	0.25	0.00	0.00	0.00
06-Jul-13	F22	SH	N/A	354	289	1	0	0	2	0	3	0.35	0.00	0.00	0.69	0.00
07-Jul-13	F20	EF	400	300	2373	1	106	0	0	0	107	0.04	4.47	0.00	0.00	0.00
07-Jul-13	F19*	EF	162	300	854	5	0	0	0	1	6	0.59	0.00	0.00	0.00	0.12

Notes:
CPUE=catch per unit effort, EF=backpack electrofishing, SH=shore-based electrofishing, GR=Arctic Grayling, CCG=slimy sculpin,
CH=juvenile Chinook salmon, BB=burbot, RW=round whitefish, N/A=not applicable, and asterisks (*) indicate fisheries reference sites

Appendix A2. Minnow Trapping Effort and Catch, Casino Project, 2013

Date	Site	Trap number	Effort (hours)	Catch
04-Jul-13	F21	MT1	27.5	0
04-Jul-13	F21	MT2	27.5	0
04-Jul-13	S2	MT3	25	0
04-Jul-13	S2	MT4	25	0
04-Jul-13	F08-b	MT5	24	0
04-Jul-13	F08-b	MT6	24	0
06-Jul-13	F14	MT7	24	2
06-Jul-13	F14	MT8	24	0
06-Jul-13	F14	MT9	24	0
06-Jul-13	F22	MT10	20	1
06-Jul-13	F22	MT11	20	0
06-Jul-13	F22	MT12	20	0
06-Jul-13	F22	MT13	20	0
06-Jul-13	F19*	MT14	21	0
06-Jul-13	F19*	MT15	21	0
06-Jul-13	F19*	MT16	21	0
07-Jul-13	F20	MT17	19	0
07-Jul-13	F20	MT18	19	0
07-Jul-13	F20	MT19	19	0

Notes:
Only slimy sculpin was captured.
**Fisheries reference site*

Appendix A3. Fish Biological Characteristics, Casino Project, 2013

Sampling date	Watershed	Site	Method	Fish Number	Species	Length (mm)	Weight (g)
04-Jul-13	Casino	S2	EF	1	GR	276	230
04-Jul-13	Casino	S2	EF	2	GR	294	300
04-Jul-13	Casino	S2	EF	3	GR	216	130
04-Jul-13	Casino	S2	EF	4	GR	261	212
04-Jul-13	Casino	S2-b	EF	5	GR	293	282
04-Jul-13	Casino	S2-b	EF	6	GR	273	251
04-Jul-13	Casino	F08-b	EF	7	GR	277	249
04-Jul-13	Casino	F08-b	EF	8	GR	310	330
04-Jul-13	Casino	F08-b	EF	9	GR	270	238
04-Jul-13	Casino	F08-b	EF	10	GR	261	222
06-Jul-13	Dip	F14	EF	11	CCG	100	9.5
06-Jul-13	Dip	F14	EF	12	CCG	69	3.2
06-Jul-13	Dip	F14	EF	13	CCG	58	1.7
06-Jul-13	Dip	F14	EF	14	CCG	61	3.1
06-Jul-13	Dip	F14	EF	15	CCG	84	4.8
06-Jul-13	Dip	F14	EF	16	CCG	52	1.7
06-Jul-13	Dip	F14	EF	17	CCG	62	3.4
06-Jul-13	Dip	F14	EF	18	CCG	68	3.1
06-Jul-13	Dip	F14	EF	19	CCG	56	2
06-Jul-13	Dip	F14	SH	20	GR	276	242
06-Jul-13	Dip	F22	EF	21	CCG	62	2.7
06-Jul-13	Dip	F22	EF	22	CCG	60	2
06-Jul-13	Dip	F22	EF	23	CCG	54	1.9
06-Jul-13	Dip	F22	EF	24	CCG	56	1.6
06-Jul-13	Dip	F22	EF	25	GR	285	222
06-Jul-13	Dip	F22	SH	26	GR	209	NR
06-Jul-13	Dip	F22	SH	27	BB	278	109
06-Jul-13	Dip	F22	SH	28	BB	230	71
07-Jul-13	Dip	F20	EF	29	CCG	62	1.9
07-Jul-13	Dip	F20	EF	30	CCG	99	10.4
07-Jul-13	Dip	F20	EF	31	CCG	67	2.8
07-Jul-13	Dip	F20	EF	32	CCG	66	3
07-Jul-13	Dip	F20	EF	33	CCG	55	1.3
07-Jul-13	Dip	F20	EF	34	CCG	22	0.1
07-Jul-13	Dip	F20	EF	35	CCG	66	3
07-Jul-13	Dip	F20	EF	36	CCG	70	3.1
07-Jul-13	Dip	F20	EF	37	CCG	56	2.1
07-Jul-13	Dip	F20	EF	38	CCG	49	1.4
07-Jul-13	Dip	F20	EF	39	CCG	52	1.4
07-Jul-13	Dip	F20	EF	40	CCG	58	1.8
07-Jul-13	Dip	F20	EF	41	CCG	55	1.5
07-Jul-13	Dip	F20	EF	42	CCG	62	1.9
07-Jul-13	Dip	F20	EF	43	CCG	70	3.3
07-Jul-13	Dip	F20	EF	44	CCG	78	4.3
07-Jul-13	Dip	F20	EF	45	CCG	70	1.9

Appendix A3. Fish Biological Characteristics, Casino Project, 2013

Sampling date	Watershed	Site	Method	Fish Number	Species	Length (mm)	Weight (g)
07-Jul-13	Dip	F20	EF	46	CCG	78	4.6
07-Jul-13	Dip	F20	EF	47	CCG	63	1.6
07-Jul-13	Dip	F20	EF	48	CCG	59	1.7
07-Jul-13	Dip	F20	EF	49	CCG	72	2.8
07-Jul-13	Dip	F20	EF	50	CCG	57	1.9
07-Jul-13	Dip	F20	EF	51	CCG	34	0.4
07-Jul-13	Dip	F20	EF	52	CCG	59	2.3
07-Jul-13	Dip	F20	EF	53	CCG	56	1.5
07-Jul-13	Dip	F20	EF	54	CCG	89	5.5
07-Jul-13	Dip	F20	EF	55	CCG	60	1.9
07-Jul-13	Dip	F20	EF	56	CCG	70	2.6
07-Jul-13	Dip	F20	EF	57	CCG	65	2.5
07-Jul-13	Dip	F20	EF	58	CCG	62	2.4
07-Jul-13	Dip	F20	EF	59	CCG	50	1.2
07-Jul-13	Dip	F20	EF	60	CCG	54	1.9
07-Jul-13	Dip	F20	EF	61	CCG	65	2.3
07-Jul-13	Dip	F20	EF	62	CCG	25	0.1
07-Jul-13	Dip	F20	EF	63	CCG	58	1.7
07-Jul-13	Dip	F20	EF	64	CCG	67	3.2
07-Jul-13	Dip	F20	EF	65	CCG	79	3.8
07-Jul-13	Dip	F20	EF	66	CCG	38	0.5
07-Jul-13	Dip	F20	EF	67	CCG	62	1.6
07-Jul-13	Dip	F20	EF	68	CCG	62	2.4
07-Jul-13	Dip	F20	EF	69	CCG	61	2.4
07-Jul-13	Dip	F20	EF	70	CCG	60	2
07-Jul-13	Dip	F20	EF	71	CCG	66	2
07-Jul-13	Dip	F20	EF	72	CCG	61	2.1
07-Jul-13	Dip	F20	EF	73	CCG	57	1.3
07-Jul-13	Dip	F20	EF	74	CCG	61	1.7
07-Jul-13	Dip	F20	EF	75	CCG	34	0.4
07-Jul-13	Dip	F20	EF	76	CCG	59	1.3
07-Jul-13	Dip	F20	EF	77	CCG	54	1
07-Jul-13	Dip	F20	EF	78	CCG	65	2.2
07-Jul-13	Dip	F20	EF	79	CCG	53	1.3
07-Jul-13	Dip	F20	EF	80	CCG	62	2.2
07-Jul-13	Dip	F20	EF	81	CCG	26	0.3
07-Jul-13	Dip	F20	EF	82	CCG	55	1.5
07-Jul-13	Dip	F20	EF	83	CCG	30	0.5
07-Jul-13	Dip	F20	EF	84	GR	268	197
07-Jul-13	Dip	F20	EF	85	CCG	55	1.6
07-Jul-13	Dip	F20	EF	86	CCG	22	0.2
07-Jul-13	Dip	F20	EF	87	CCG	65	2.6
07-Jul-13	Dip	F20	EF	88	CCG	60	2.2
07-Jul-13	Dip	F20	EF	89	CCG	48	1.2
07-Jul-13	Dip	F20	EF	90	CCG	71	3.6

Appendix A3. Fish Biological Characteristics, Casino Project, 2013

Sampling date	Watershed	Site	Method	Fish Number	Species	Length (mm)	Weight (g)
07-Jul-13	Dip	F20	EF	91	CCG	54	1.5
07-Jul-13	Dip	F20	EF	92	CCG	50	1.3
07-Jul-13	Dip	F20	EF	93	CCG	27	0.2
07-Jul-13	Dip	F20	EF	94	CCG	31	0.6
07-Jul-13	Dip	F20	EF	95	CCG	25	0.2
07-Jul-13	Dip	F20	EF	96	CCG	24	0.3
07-Jul-13	Dip	F20	EF	97	CCG	30	0.2
07-Jul-13	Dip	F20	EF	98	CCG	25	0.2
07-Jul-13	Dip	F20	EF	99	CCG	20	0.5
07-Jul-13	Dip	F20	EF	100	CCG	56	2.2
07-Jul-13	Dip	F20	EF	101	CCG	21	0.2
07-Jul-13	Dip	F20	EF	102	CCG	54	1.5
07-Jul-13	Dip	F20	EF	103	CCG	95	8.4
07-Jul-13	Dip	F20	EF	104	CCG	59	1.8
07-Jul-13	Dip	F20	EF	105	CCG	25	0.1
07-Jul-13	Dip	F20	EF	106	CCG	63	2
07-Jul-13	Dip	F20	EF	107	CCG	68	3.2
07-Jul-13	Dip	F20	EF	108	CCG	85	4.9
07-Jul-13	Dip	F20	EF	109	CCG	26	0.2
07-Jul-13	Dip	F20	EF	110	CCG	63	2.4
07-Jul-13	Dip	F20	EF	111	CCG	62	2
07-Jul-13	Dip	F20	EF	112	CCG	22	0.1
07-Jul-13	Dip	F20	EF	113	CCG	55	1.4
07-Jul-13	Dip	F20	EF	114	CCG	59	1.7
07-Jul-13	Dip	F20	EF	115	CCG	64	2.1
07-Jul-13	Dip	F20	EF	116	CCG	75	3.9
07-Jul-13	Dip	F20	EF	117	CCG	56	1.5
07-Jul-13	Dip	F20	EF	118	CCG	20	0.1
07-Jul-13	Dip	F20	EF	119	CCG	23	0.1
07-Jul-13	Dip	F20	EF	120	CCG	21	0.1
07-Jul-13	Dip	F20	EF	121	CCG	70	2.6
07-Jul-13	Dip	F20	EF	122	CCG	53	1.6
07-Jul-13	Dip	F20	EF	123	CCG	24	0.1
07-Jul-13	Dip	F20	EF	124	CCG	64	2.4
07-Jul-13	Dip	F20	EF	125	CCG	63	2.3
07-Jul-13	Dip	F20	EF	126	CCG	21	0.1
07-Jul-13	Dip	F20	EF	127	CCG	99	8.1
07-Jul-13	Dip	F20	EF	128	CCG	24	0.1
07-Jul-13	Dip	F20	EF	129	CCG	25	0.1
07-Jul-13	Dip	F20	EF	130	CCG	57	1.7
07-Jul-13	Dip	F20	EF	131	CCG	53	1.4
07-Jul-13	Dip	F20	EF	132	CCG	57	1.6
07-Jul-13	Dip	F20	EF	133	CCG	38	0.5
07-Jul-13	Dip	F20	EF	134	CCG	24	0.1
07-Jul-13	Dip	F20	EF	135	CCG	23	0.1

Appendix A3. Fish Biological Characteristics, Casino Project, 2013

Sampling date	Watershed	Site	Method	Fish Number	Species	Length (mm)	Weight (g)
07-Jul-13	Coffee	F19*	EF	136	GR	238	123
07-Jul-13	Coffee	F19*	EF	137	GR	231	115
07-Jul-13	Coffee	F19*	EF	138	GR	225	134
07-Jul-13	Coffee	F19*	EF	139	GR	173	49
07-Jul-13	Coffee	F19*	EF	140	GR	204	79
07-Jul-13	Coffee	F19*	EF	141	RW	265	144
28-Jun-13	Casino	F21	EF	142	GR	254	175.5
06-Jul-13	Dip	F22	MT	143	CCG	69	NR
06-Jul-13	Dip	F14	MT	144	CCG	72	NR
06-Jul-13	Dip	F14	MT	145	CCG	63	NR

Notes:

AG: Arctic grayling
CCG: Slimy sculpin
EF: Backpack Electrofishing
MT: Minnow Trap (Gee Trap)
SH: Shore-based Electrofishing
NR: Not recorded
**Fisheries reference site*

Appendix A4. Fish Habitat Data, Casino Project, July 2013

Site	Date	Distance Surveyed (m)	STREAM CHARACTERISTICS						Habitat Type (%)					Side Channel (%)	Bed Material (%)						
															Fines	Gravels		Larges			Bedrock
			Stage (H/M/L)	Gradient (%)	Wet Width (m)	Channel Width (m)	Wet Depth (m)	Channel Depth (m)	Pool	Run	Riffle	Cascade	Other			Small (2-16mm)	Large (16-64mm)	Small Cobble (64-128mm)	Large Cobbles (128-256mm)	Boulder (>256mm)	
F19	7-Jul	100m	L	2.0	3.3	3.0	0.4	0.6	5	55	40	0	0	0	30	5	0	5	50	10	0

Appendix A4. Fish Habitat Data, Casino Project, July 2013

Site	Cover Type (%)							Crown Closure (%)	Banks (F, G, L, R)	Confinement (EN, CO, FC, OC, UC, N/A)	Braided (Y or N)	pH	Water Temp (°C)	TDS (g/L)	Conductivity (25°C) (µs/cm)	DO (%)	DO (mg/L)	Comments
	Total Overall	Deep Pool	LOD	Boulder	Cutbank	Instream Veg	Overstream Veg											
F19	30	5	20	5	20	0	50	10	F	UC	N	7.58	5.96	59	75	84	9.67	Coffee Creek reference site