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MEMORANDUM

TO:	**Nechako Water Engagement Initiative Technical Working Group**
FROM:	**Rachel Chudnow, Ph.D. and Jayson Kurtz, R.P.Bio., Ecofish Research Ltd.**
DATE:	**December 12, 2022**
FILE:	**1316-09**
RE:	**Nechako Watershed Resident Fish Backgrounder**

1. INTRODUCTION

During Nechako Water Engagement Initiative (WEI) Main Table and Technical Working Group (TWG) meetings, concerns were raised about potential effects of Rio Tinto (Alcan; RTA) operations on resident fish in the Nechako watershed. The TWG asked Ecofish Research Ltd. (Ecofish) to review literature and summarize the status of current knowledge regarding Nechako watershed resident fish and how they may be affected through multiple pathways of effect related to flow. This background memo provides a general overview of resident fish species, their conservation status, trends in abundance, and life histories to support memos that detail flow-related affects to resident fish (i.e., spawning and rearing habitats, access to tributaries and off-channel habitats, temperature).

2. DEFINITION OF SCOPE

2.1. Resident Fish

For this and other work under the WEI, all fish species within the Nechako watershed excluding White Sturgeon and anadromous salmon[1] are considered resident fish. The timing and duration of resident fish habitat use within the Nechako watershed varies between species. For example, some species complete all life cycle stages within the Nechako watershed by necessity (e.g., Lake Trout in the Cheslatta Lake, isolated by fish barriers), while others migrate between the Nechako watershed and other systems to complete specific life history stages (e.g., Bull Trout, Pacific Lamprey).

2.2. Nechako Watershed

The Nechako watershed is composed of three basins / drainage areas: the Nechako Reservoir, Cheslatta River basin, and Nechako River basin (Map 1). The Nechako Reservoir is located approximately 200 km west of Prince George, BC and was created to provide water for Rio Tinto Alcan's (RTA) Kemano Hydroelectric Project, which was constructed in the 1950s to

[1] White Sturgeon and anadromous salmon are present in the watershed. These species are discussed in Chudnow *et al.* (2022a; White Sturgeon), Carter and Kurtz (2022; Pacific Salmon), and Chudnow *et al.* (2022b, 2022c; Chinook Salmon).

provide energy to operate an aluminium smelter in Kitimat, BC. The reservoir was formed by the construction of the Kenney Dam on the Nechako River (at the east end of the reservoir), which inundated a chain of six major lake and river systems (Ootsa, Whitesail, Knewstubb, Tetachuck, Natalkuz, and Tahtsa, ~420 km total length). Dam construction also dewatered approximately 9 km of the upper Nechako River, creating an impassible barrier to fish movement from the Nechako River upstream into the reservoir. The Nechako Reservoir is ~910 km^2 with a normal annual drawdown of ~3m (10'); low water is in late spring and high water occurs in late summer.

There are two reservoir outflows. The powerhouse intake portal on Tahtsa Lake diverts ~70% of the annual reservoir inflow 16 km west into the Kemano River watershed. The Skins Lake Spillway on Ootsa Lake diverts the remaining flow (~60 m^3/s mean annual discharge) ~80 km through the Cheslatta River and Skins Lake, Cheslatta Lake, and Murray Lake before discharging into the Nechako River at Cheslatta Falls (Map 1). There is no discharge facility at the Kenney Dam.

The Nechako Reservoir provides the majority of flow in the upper Nechako River (there is minimal local inflow); here, flow is reduced to ~30% of pre-dam conditions and mean flow ranges from ~40 to 240 m^3/s (Figure 1). The Nautley River (~95 km downstream of the dam) and local inflow contribute moderately and at Vanderhoof (~150 km downstream of the dam), mean flows range from ~65 to 270m^3/s. The Stuart River contributes significant inflow and by Isle Pierre (~215 km downstream of the dam) mean flows range from ~120 to 560m^3/s. The Nechako River flows into the Fraser River at Prince George ~275 km downstream of the dam.

2.2.1. Nechako Reservoir

The Nechako Reservoir provides lacustrine (i.e., lake) and tributary habitat for 14 fish species including one burbot, (family: Lotidae), three minnows (Cyprinidae), four salmonids (Salmonidae), two sculpins (Cottidae), and four suckers (Catostomidae; Table 1). The Reservoir is oligotrophic (i.e., nutrient poor) with a steep bathymetric transition between the littoral and pelagic zone (Perrin 2021; Stockner 2006). While the littoral zone has relatively sparse macrophyte communities (due to fluctuations in reservoir levels; Perrin, 2021), submerged timber is abundant and provides habitat for fish and benthic communities (Northcote and Atagi 1997). In addition, multiple tributaries have been identified as potentially important fish habitat (see Johnson *et al.* 2022a for a discussion of Nechako Reservoir tributary fish habitat). Fish access in the basin is restricted by Skins Lake Spillway and Kenney Dam. The spillway serves as a barrier to upstream movement of fish from the Cheslatta basin into the reservoir, though fish may be entrained from the reservoir to the basin (Girard *et al.* 2022), while the dam prevents connectivity between the Nechako Reservoir at Knewstubb Lake and the upper Nechako River.

2.2.2. Cheslatta River Basin

The Cheslatta River basin is located north of the Nechako Reservoir, approximately 70 km southwest of Vanderhoof and provides both lacustrine, riverine, and tributary fish habitat for 16 species including one burbot, (family: Lotidae), five minnows (Cyprinidae), six salmonids (Salmonidae), sculpins (Cottidae), and two suckers (Catostomidae; Table 1; see Chudnow *et al.* 2022d for a detailed discussion of Cheslatta basin fish habitat). Prior to construction of Skins Lake Spillway, there was no flow between the upper Nechako lakes (now the reservoir) and the Cheslatta River basin. Rather, the Cheslatta headwaters were formed by a short (approximately 2 km) section of tributary stream at the western extent of Cheslatta Lake (Lyons and Larkin 1952). Since construction of Skins Lake Spillway, the Nechako Reservoir discharges into Skins Lake, downstream through a glacial spillway trench and into the Cheslatta River, then through Cheslatta and Murray lakes, and over Cheslatta Falls to the river's confluence with the Nechako River approximately 10 km downstream of Kenney Dam (Kellerhals *et al.* 1979). Approximately 25 tributaries drain into the basin (Hamilton and Schmidt 2005), the majority of which are not wetted year-round (Envirocon Ltd. 1993). Only four (Holly Cross, Knapp, Bird, and Ootsanee creeks) are thought to support fish (Harder 1986).

Cheslatta Lake was historically moderately productive (mesotrophic) whereas Murray Lake was highly productive (eutrophic) (Lyons and Larkin 1952). Data pertaining to existing productivity in the lakes are generally lacking but current productivity in the lakes has substantially declined, with the unproductive (oligotrophic) surface waters in Nechako Reservoir now the current source of water to the system (see Abell and Lewis in prep. for a detailed discussion of Cheslatta watershed productivity).

Fish access in the basin is constrained at multiple locations. A series of cascades and falls throughout the upper Cheslatta River fragment fish habitat preventing movement along the full extent of the river. Skins Lake Spillway prevents fish access to the reservoir, though fish may be entrained from the reservoir into the Cheslatta basin (see Girard *et al.* 2022). In addition, a series of two naturally occurring falls (approximately 28 m high) in the lower river are an impassible barrier to fish movement and prevent anadromous fish access from the Nechako River.

2.2.3. Nechako River Basin

The Nechako River basin provides riverine and tributary habitat for resident fish species as well as anadromous Pacific Salmon and White Sturgeon (see Johnson *et al.* 2022b for a discussion of Nechako River tributary fish habitat). The resident fish community includes 17 species including one burbot, (family: Lotidae), one lamprey (Petromyzontidae), seven minnows (Cyprinidae), three salmonids (Salmonidae), two sculpins (Cottidae), and four suckers (Catostomidae; Table 1). The River drains a watershed area of ~51,900 km^2 and flows over ~260 km from its confluence with the Cheslatta River to its confluence with the Fraser River just downstream of Prince George (Ableson 1985). The river has two major tributaries (Nautley and Stuart) River and 102 documented smaller tributaries. The basin is highly connected, with the only impediments to fish movement occurring in the upper river at Kenney Dam (i.e., no fish access to reservoir) and Cheslatta Falls (i.e., no fish access to Cheslatta River basin).

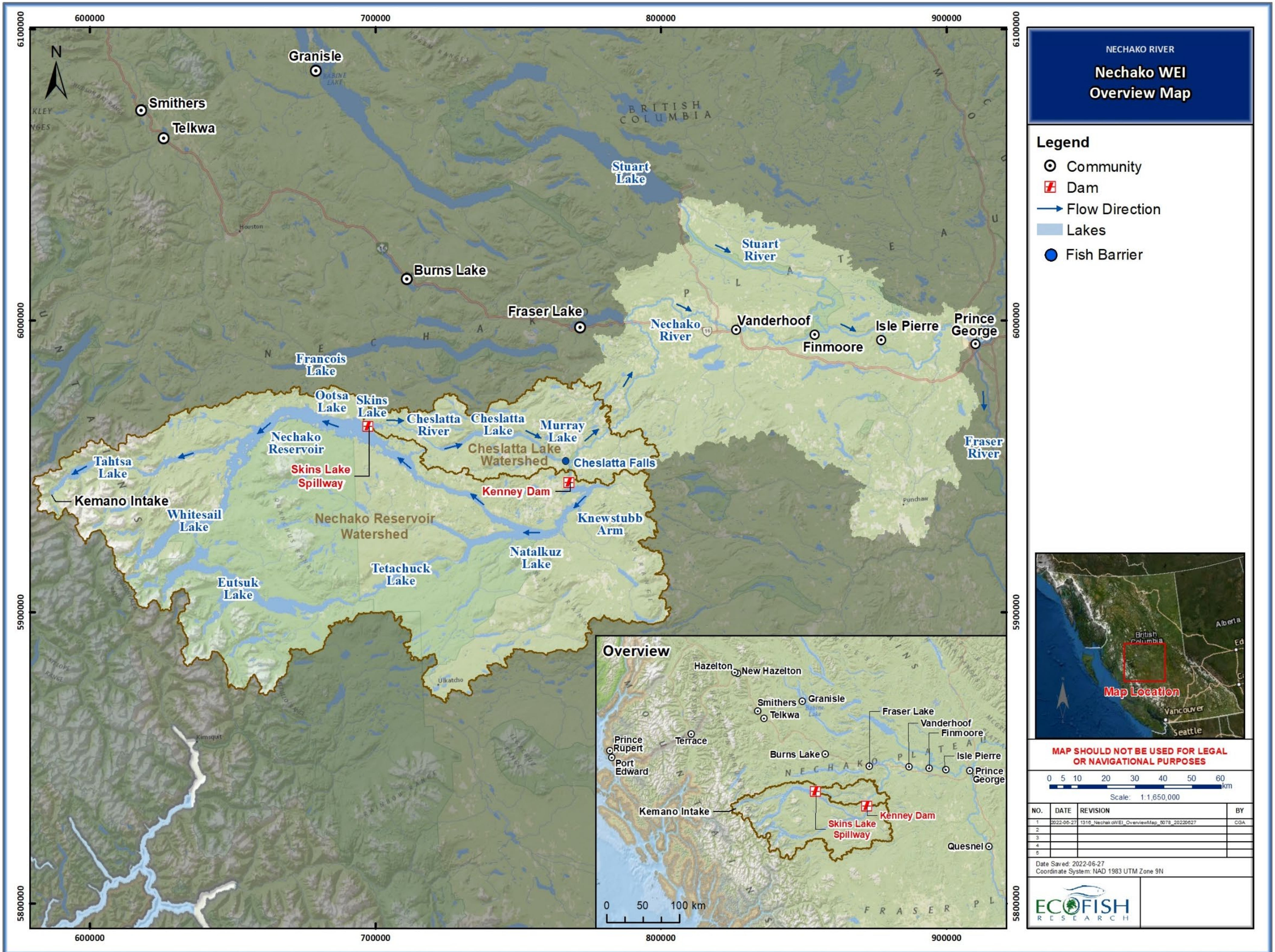

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Figure 1. Mean daily discharge during 1990 - 2020 at selected Nechako River monitoring stations.

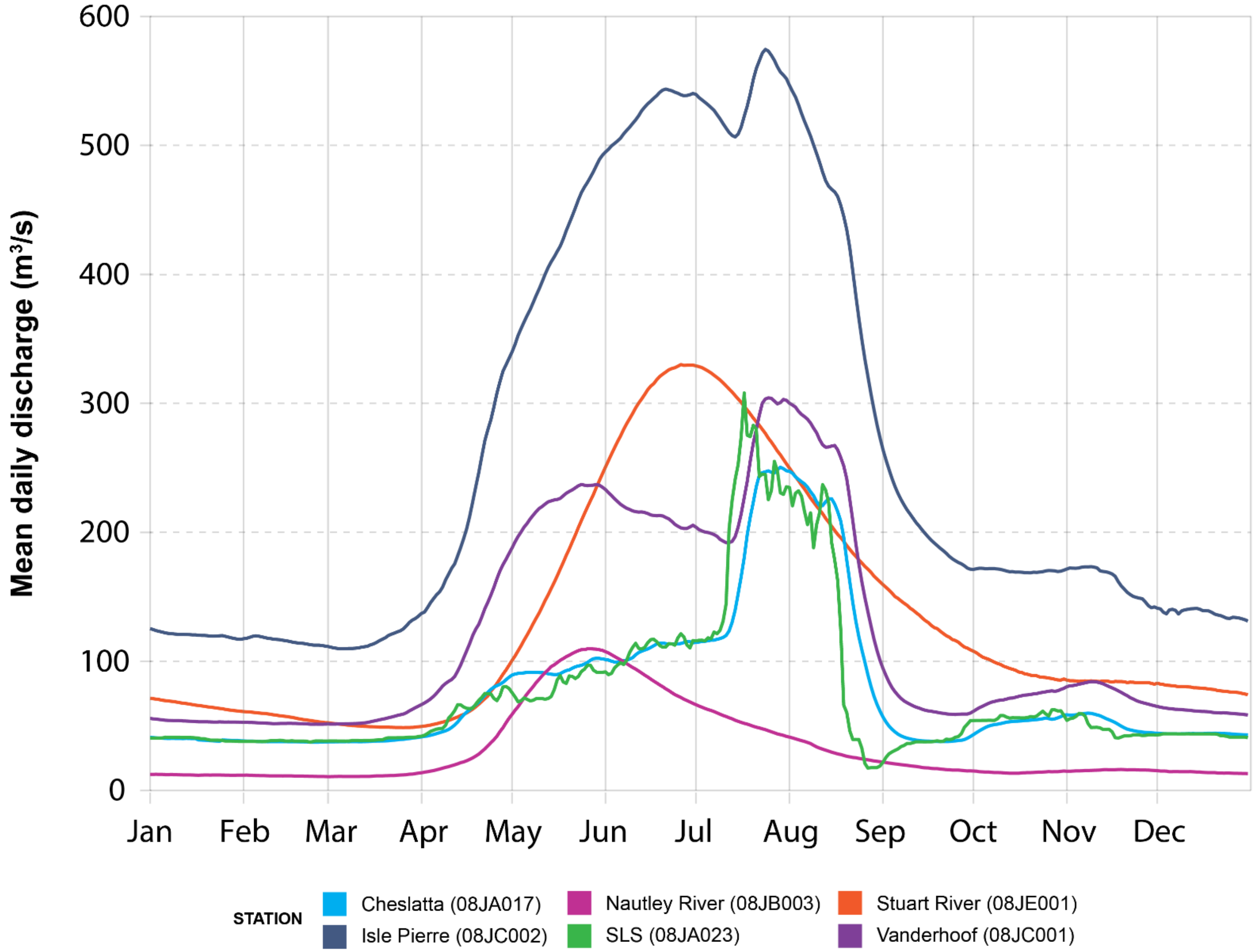

Table 1. Resident fish species observed within the Nechako watershed.

Family	Common Name	Scientific Name[1]	Geographic Region		
			Nechako Reservoir	Cheslatta Watershed	Nechako River
Burbots	Burbot	*Lota lota*	X	X	X
Lampreys	Pacific Lamprey	*Entosphenus tridentatus*	-	-	X
Minnows	Brassy Minnow	*Hybognathus hankinsoni*	X[2]	-	X
	Lake Chub	*Couesius plumbeus*	X[3]	X	X
	Leopard Dace	*Rhinichthys falcatus*	-	-	X
	Longnose Dace	*Rhinichthys cataractae*	-	X	X
	Northern Pikeminnow	*Ptychocheilus oregonensis*	X	X	X
	Peamouth Chub	*Mylocheilus caurinus*	-	X	X
	Redside Shiner	*Richardsonius balteatus*	-	X	X
Salmonids	Bull Trout	*Salvelinus confluentus*	-	-[4]	X
	Kokanee	*Oncorhynchus nerka*	X	X	-[5]
	Lake Trout	*Salvelinus namaycush*	-	X	-[5]
	Lake Whitefish	*Coregonus clupeaformis*	-	X	-
	Mountain Whitefish	*Prosopium williamsoni*	X	X	X
	Umam	*Prosopium* sp.	X[6]	X[6]	
	Rainbow Trout	*Oncorhynchus mykiss*	X	X	X
Sculpins	Prickly Sculpin	*Cottus asper*	X	-	X
	Sculpins[7]	*Cottus spp.*		X	
	Slimy Sculpin	*Cottus cognatus*	X[3]	-	X
Suckers	Bridgelip Sucker	*Catostomus columbianus*	X	-	X
	Largescale Sucker	*Catostomus macrocheilus*	X	X	X
	Longnose Sucker	*Catostomus catostomus*	X	X	X
	White Sucker	*Catostomus commersonii*	X[3]	-	X

"-" indicates no records of species presence in region.

[1] Species presence sourced from: Ableson 1985; Envirocon 1989; Triton 2000a, 2000b, 2000c; Hamilton and Schmidt 2005; NFCP 2005; Triton 2005; Hagen and Decker 2011; BC MOE 2021a, 2021b; Robertson, pers. comm. 2021.

[2] Observations in Skins Lake Spillway plunge pool indicate species could be entrained from Nechako Reservoir (Triton 2005).

[3] Species observed in tributaries of the Nechako River (Triton 2000a, 2000b, 2005) and could potentially use Nechako Reservoir lacustrine habitats.

[4] Historical records indicating species presence in this basin are considered an error (Hagen and Decker 2011).

[5] Species is occassionally present in the Nechako River as the result of entrainment.

[6] Species' taxonomic classification is unclear. This fish is important to the Cheslatta Carrier Nation, and it is unclear if the rough translation ("pygmy" whitefish; Triton 2008) relates to a common translation (i.e., "small" whitefish) or refers to *Prosopium coulterii*. The Nation is undertaking ongoing work to better understand whitefish populations in the basin (Triton 2008; Robertson, pers. comm. 2021).

[7] Sculpins in this system are only identified to the genus level.

3. CURRENT LEVEL OF KNOWLEDGE

Literature review identified over 40 reports describing resident fish species presence / absence and/or resident fish habitat surveys in the Nechako watershed. Further, there are numerous general fish biology and distribution synthesis reports and online databases for British Columbia that include, or can be inferred to include, the Nechako watershed. Most research identified occurred between the 1980s and 1990s with fairly even distribution between the Nechako Reservoir (13 studies), Cheslatta River Basin (17 studies), and Nechako River Basin (11 studies[2]) and associated tributaries. Only two studies were identified that occurred prior to the impoundment of the Nechako Reservoir by construction of Kenney Dam. The first, Larkin (1951) focused on the environmental impacts of dam construction on Cheslatta Lake. While the second, Lyons and Larkin (1952), focused on assessment of upper Nechako watershed lakes (now inundated by the reservoir), Cheslatta River basin lakes, and the Nechako River, with limited survey of the rest of the Cheslatta River or associated tributaries.

Research generally surrounded identifying fish presence, assessing population demographics (e.g., through collection of lengths, weights, and age structures), and assessing habitat quantity and quality through reconnaissance. Beyond demographic population surveys, most information was available for socio-economic and culturally important salmonid species, primarily in the Nechako River (Ableson 1985, 1990; Tredger *et al.* 1985; Harder 1986; Slaney 1986; Ableson and Slaney 1990). No directed studies investigating population structure, abundance trends, local distribution, movements, or life histories were identified in documents reviewed for the majority of species.

Several reports identified additional species in the Cheslatta River basin following construction of Skins Lake Spillway. It is unclear if this variation in observed species composition was the result of fish movement into the Cheslatta River basin via the spillway or a result of differences in survey methodology, sampling techniques, and sampling intensity between surveys (Lyons and Larkin 1952; Ableson 1985; Harder 1986; Hamilton and Schmidt 2005).

[2] Count includes only studies that specifically reference the Nechako River or associated tributaries. Additional research related to other portions of the basin (e.g., Stuart River) are not included.

4. RESIDENT FISH SPECIES DESCRIPTIONS

The Nechako watershed provides habitat for 22 resident fish species including Lamprey (Petromyzontidae), Burbot (Lotidae), minnows (Cyprinidae), salmonids (Salmonidae), sculpins (Cottidae), and suckers (Catostomidae). Though there is considerable overlap in species assemblage between the Nechako Reservoir, Cheslatta River Basin, and Nechako River Basin, there are also differences, and most species are not present across all three basins. A complete list of species, and their presence/absence in each basin is summarized in Table 1. Below we provide a brief summary of Nechako watershed resident fish native distribution, conservation status, population trends, life history trends, and preferred habitats by taxonomic family. In addition, Appendix A presents detailed life history summaries of all resident fish species and highlights specific life history stage attributes (e.g., habitat use, periodicity, movements, temperature preferences).

4.1. Lamprey (Petromyzontidae)

4.1.1. Native Distribution

There is one lamprey species (Pacific Lamprey; *Entosphenus tridentatus*) present in the Nechako watershed. The species has a widespread distribution across British Columbia (Scott and Crossman 1973; Hart and Clemens 1988; McPhail and Carveth 1993). Within the Nechako watershed, Pacific Lamprey's distribution is limited to the Nechako River.

4.1.2. Conservation Status

British Columbian Pacific Lamprey populations have been assessed by the British Columbia provincial government as "Secure" / "Least Risk" and the species does not have federal conservation listing (MOE 2021a, 2021b).

4.1.3. Population Trends

A thorough literature and report review did not identify any quantitative monitoring or qualitative descriptions of population trends for Pacific Lamprey in the Nechako watershed.

4.1.4. Life History and Habitat Use

Pacific Lamprey present within the Nechako River are anadromous (Hart and Clemens 1988; McPhail 2007). Beyond this information, there is no life history or life stage specific habitat use data regarding Pacific lamprey in the Nechako River. Therefore, the following information is sourced from general biological knowledge of this species from other portions of its range. Anadromous Pacific Lamprey populations generally begin spawning migrations to freshwater habitats between April and June, spawning the following spring (i.e., approximately one year after entering freshwater; Hart and Clemens 1988). Most individuals are semelparous (i.e., die after spawning; McPhail 2007). Spawning females deposit eggs in gravel nests built in pool tailouts with gravel substrate (> 4 cm diameter; McPhail 2007). Eggs hatch after a 2-4 week incubation period and larvae (known as amnocoetes) remain in the nest for approximately 2-3 weeks before emerging and making flow-mediated dispersal to appropriate rearing habitats (Scott and Crossman 1973; Hart and Clemens 1988; McPhail 2007). Larval habitat use is size dependent, but always occurs in areas with fine substrates that allow individuals to burrow (i.e., mud, silt, leaf litter; McPhail 2007). Small amnocoetes (i.e., 10 – 25 mm) have been observed rearing in shallow, low velocity water, near stream margins (Pletcher 1963). As individuals grow, they are more commonly found in deep (60-80 cm), low velocity, pool habitats, with the largest individuals common in higher velocity areas with larger substrate (i.e., large gravel; McPhail 2007). After approximately five years, amnocoetes undergo metamorphosis, which generally begins in July, then out-migrate to marine habitats (Scott and Crossman 1973; Hart and Clemens 1988; McPhail 2007). Timing and duration of downstream migrations vary significantly by population, and is thought to be related to watershed size, migration distance, and flow conditions (Beamish and Levings 1991). Adults then spend up to 3.5 years in the ocean before making return migrations to freshwater spawning habitats.

4.2. Burbots (Lotidae)

4.2.1. Native Distribution

There is one resident Burbot species (Burbot; *Lota lota*) present in the Nechako watershed. The species is broadly distributed across British Columbia and is present in all three Nechako watershed basins (Scott and Crossman 1973; Hart and Clemens 1988; McPhail and Carveth 1993).

4.2.2. Conservation Status

British Columbian Burbot populations have been assessed by the British Columbia provincial government as "Secure" / "Least Risk" and the species does not have federal conservation listing (MOE 2021a, 2021b).

4.2.3. Population Trends

A thorough literature and report review did not identify any quantitative monitoring or qualitative descriptions of population trends for Burbot in the Nechako watershed.

4.2.4. Life History and Habitat Use

There is no life history or life stage specific habitat use data regarding Burbot in the Nechako watershed. Therefore, the following information is sourced from general biological knowledge of this species from other portions of its range. Burbot are the only freshwater cod species and can exhibit one of three life-history patterns (i.e., lacustrine, riverine, and adfluvial; Roberge *et al.* 2002; McPhail 2007). They spawn in winter, usually under ice, in low-velocity, shallow habitats (Roberge *et al.* 2002; McPhail 2007). Emergence occurs approximately 30 to 60 days after egg deposition (McPhail 2007). Larvae are initially planktonic and aspects of early life history including how individuals maintain position within flowing water is unknown (McPhail 2007). Juveniles are generally found in shallow (< 2 m) water with associated cover (Scott and Crossman 1973). Adults are benthic specialists in deeper river and lake habitats.

4.3. Minnows (Cyprinidae)

4.3.1. Native Distribution

There are seven resident minnow species present in the Nechako watershed. Most species (five of seven) are broadly distributed across the province of British Columbia, while two species have substantially smaller distributions in the province and are found in only two zoogeographic regions (Brassy Minnow is limited to the Fraser and Mackenzie systems while Leopard Dace is limited to the Columbia and Fraser systems; McPhail and Carveth 1993). Only Lake Chub and Northern Pike Minnow are broadly distributed across the three Nechako basins with the Nechako River having the broadest minnow assemblage (all seven species present).

4.3.2. Conservation Status

All resident minnow species occurring in the Nechako watershed have been assessed at the provincial level by the British Columbia provincial government as "Secure" / "Least Risk" and do not have federal conservation listing (MOE 2021a, 2021b).

4.3.3. Population Trends

A thorough literature and report review did not identify any quantitative monitoring or qualitative descriptions of population trends for any minnow species in the Nechako watershed.

4.3.4. Life History and Habitat Use

Information is generally limited for this family, and there is no life history or life stage specific habitat use data regarding resident minnow species in the Nechako watershed. Therefore, the following information is sourced from available general biological knowledge of these species from other portions of their range. All minnow species present within British Columbia are spring or summer spawning (Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007). Spawning and juvenile rearing most commonly occurs in shallow, low velocity (i.e., < 1 m/s) water with gravel substrate or vegetative cover (Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007). There is limited available information regarding the general seasonal distribution and movement patterns of British Columbian minnows present within the Nechako watershed. Some species are known to undertake seasonal movements between lakes or rivers to associated tributaries in other portions of their range (e.g., Lake Chub spawning; Peamouth Chub rearing; McPhail 2007), suggesting similar movements may occur within the Nechako watershed.

4.4. Salmonids (Salmonidae)

4.4.1. Native Distributions

There are seven resident salmonid species present in the Nechako watershed. Some species (i.e., Bull Trout and Rainbow Trout) have significant variation in life history strategies including landlocked (freshwater) forms and anadromy (McPhail 2007), although only freshwater, resident populations are discussed here. Presence and distribution data and local knowledge for several salmonid species within the Nechako watershed is complicated by conflicting information. Accounts of Bull Trout and Dolly Varden in the Cheslatta River Basin are unreliable. Extensive sampling has not detected either species in this basin, and historical records indicating their presence are considered to be an error (Hagen and Decker 2011). In addition, local residents and others often refer to Bull Trout, Dolly Varden, and Lake Trout (confirmed in the Cheslatta watershed) as "char" and have even been reported as Arctic Char, perhaps further confusing the reported distribution of these species. Given best available information, in this document all char species in the Cheslatta River Basin are considered Lake Trout, Bull Trout's distribution within the watershed is assumed to be restricted to the Nechako River only, and Dolly Varden are assumed to be absent from the Nechako watershed.

The taxonomic classification and distribution of Umam is also unclear. This fish is of high importance to the Cheslatta Carrier Nation, and although its name roughly translates to "pygmy" whitefish (Triton 2008), it is unclear if this is a somewhat more common translation (i.e., "small" whitefish – Mountain Whitefish and Lake Whitefish are confirmed present) rather than specifically meaning the taxonomic species Pygmy Whitefish (*Prosopium coulterii*). Although the Cheslatta River Basin is outside the known distribution of *P. coulterii* (McPhail 2007), this document will continue to discuss Pygmy Whitefish as (*Prosopium spp.*) in addition to Mountain Whitefish and Lake Whitefish. There is ongoing work by the Cheslatta Carrier Nation to better understand whitefish populations in the Cheslatta River basin (e.g., Sparks 2021).

Other than Pygmy Whitefish, all resident salmonids in the Nechako Watershed are relatively common and broadly distributed across British Columbia (Scott and Crossman 1973; Muhlfeld *et al.* 2019). Despite having broad general distributions, resident salmonid distributions within the Nechako watershed are more fragmented, due in part to migration barriers and changes in basin connectivity due to impoundment (see Section 2.2 above). Only Mountain Whitefish and Rainbow Trout are found within all three basins.

4.4.2. Conservation Status

One Nechako watershed resident fish species has been assessed conservation listing. Across their provincial distribution, Bull Trout are assessed by the British Columbia provincial government as a "Species of Special Concern". All other Nechako watershed resident salmonids have been assessed at the provincial level as "Secure" / "Least Risk" and no Nechako resident salmonid species present in the Nechako watershed have federal conservation listing (MOE 2021a, 2021b).

4.4.3. Population Trends

There has been no long-term quantitative monitoring for any Nechako watershed resident salmonid populations. However, available information from scientific studies, Indigenous and local knowledge, and general species knowledge provides insight into population demographics and / or abundance trends for some salmonid species (i.e., Bull Trout, Kokanee, Rainbow Trout, and whitefish).

Within the reservoir, quantitative information is limited to Oosta Lake fishing derby records (1994 – 2021, Appendix B). Preliminary analysis of these records did not detect a change in maximum fish size through time. However, local residents have stated that Kokanee and Rainbow Trout size and abundance has declined since impoundment (Blackwell, pers. comm. 2021; Plesco, pers. comm. 2021). The Cheslatta Carrier Nation have also observed declines in Kokanee abundance within the reservoir (Robertson, pers. comm. 2021). There is no quantitative information regarding resident fish population abundance trends in the Cheslatta River Basin, though the Cheslatta Carrier Nation have observed the loss of Umam from the basin (last observation of species occurred in in the 1990s; Triton 2008).

In the Nechako River, enumeration data from the 1980's suggests Bull Trout and Rainbow Trout populations were severely depressed at that time. Low abundances were attributed to recreational fishing pressure in combination with reservoir impoundment and subsequent flow manipulation induced impacts on downstream habitats (Ableson 1985; Slaney 1986). Rainbow Trout abundances increased following the fishery closure in 1983 and the standing stock increased three-fold by 1986 (Slaney 1986). However, no contemporary abundance information is available. Bull trout abundance in the Nechako River is generally unknown, although their abundance in the upper Fraser watershed is generally stable (Hagen and Decker 2011).

4.4.4. Life History and Habitat Use

Nechako watershed specific information regarding resident salmonid macro-habitat use is available for all species (i.e., lacustrine vs. fluvial), primarily as reconnaissance level presence / absence surveys and limited habitat quality data. However, for species generally known to use different macro-habitat types for specific life history stages (e.g., Kokanee and Lake Whitefish are generally known to spawn in both lacustrine and fluvial habitats; McPhail 2007), whether Nechako watershed populations of these species use multiple macro-habitat types, and if so what proportions of the populations use each habitat is generally unknown. Therefore, discussion of Nechako watershed resident salmonid life history and habitat use presented below is supplemented with available information from research across the species range.

Most Nechako watershed salmonids (i.e., all species excluding Rainbow Trout) spawn in fall, with fry emergence in late winter and spring (i.e., February – May; Scott and Crossman 1973; McPhail 2007). In contrast, Rainbow Trout are spring spawning (April – June) with fry emergence in summer (Scott and Crossman 1973; McPhail 2007). Habitats used for spawning and juvenile rearing (and the duration of juvenile rearing in these habitats) varies significantly between species. Several species are dependent on small streams (i.e., tributaries or lake inlet or outlet streams) for portions of their life history, described below.

Bull Trout are only seasonally present in the Nechako River and undertake large-scale, seasonal movements to upper Fraser River tributaries in late summer with post-spawning dispersal back to the Nechako River in October (Pillipow and Williamson 2004; Chudnow 2021). Early juvenile rearing is believed to occur exclusively in upper Fraser watershed tributary habitats, and only larger sub-adult and adult fish are present within the Nechako River (Chudnow 2021). Both Mountain Whitefish and Rainbow Trout usually spawn in small streams (i.e., tributaries or lake inlet / outlet streams; McPhail 2007), and both species have been identified using these habitats in portions of the Nechako watershed (see Ableson and Slaney 1990; Slaney 1986). For stream spawning populations, juvenile dispersal back to lakes generally occurs after a rearing period in stream habitat (i.e., Mountain Whitefish, by end of first summer; Rainbow Trout, one year following hatching; Roberge *et al.* 2002). Spawning and juvenile rearing for Kokanee and Lake Whitefish is more variable, with populations known to spawn in both streams and lakes (Roberge *et al.* 2002). When stream spawning, post-emergent Kokanee usually migrate to lake habitat immediately (McPhail 2007). In contrast, Lake Trout spawn exclusively in lacustrine habitats (McPhail 2007).

In both lacustrine and fluvial habitats, most species rear in shallow, low velocity water, near lake or stream margins, and are often associated with areas that have abundant cover in the form of boulders, woody debris, or vegetation (Roberge *et al.* 2002). Adult salmonids are often associated with higher velocity areas or found in deep, cold water either in pools with adjacent cover or within lakes (Roberge *et al.* 2002).

4.5. Sculpins (Cottidae)

4.5.1. Native Distributions

There are two known resident sculpin species present in the Nechako watershed (i.e., Prickly Sculpin, *Cottus asper* and Spiny Sculpin, *C. cognatus*). Both are broadly distributed across the province of British Columbia and have been identified in the Nechako Reservoir and Nechako River (McPhail and Carveth 1993). Fisheries data for the Cheslatta River basin are highly limited, and sculpins species have only been identified to the genus level (MOE 2021a). Given their presence in both the Nechako Reservoir and Nechako River, it is likely that Prickly Sculpin and / or Slimy Sculpin are also present in the Cheslatta River basin.

4.5.2. Conservation Status

Both Slimy Sculpin and Prickly Sculpin have been assessed at the provincial level by the British Columbia provincial government as "Secure" / "Least Risk" and do not have a federal conservation listing (MOE 2021a, 2021b).

4.5.3. Population Trends

A thorough literature review did not identify any quantitative monitoring or qualitative descriptions of population trends for any sculpin species in the Nechako watershed.

4.5.4. Life History and Habitat Use

There is no life history or life stage specific habitat use data regarding resident sculpin species in the Nechako watershed. Therefore, the following information is sourced from available general biological knowledge of these species from other portions of their range. Sculpins are benthic specialists (McPhail 2007). Both Prickly Sculpin and Spiny Sculpin are nest builders with spawning occurring in areas with flat rock substrate or embedded woody debris (McPhail 2007). Prickly Sculpin have a relatively long spawning window, occurring over an approximately seven-month period, while Slimy Sculpin spawning is restricted to a shorter period (Scott and Crossman 1973; McPhail 2007). Eggs are deposited on the underside of nest rocks and are guarded by the male until hatching (McPhail 2007). Juvenile rearing occurs in shallow, low velocity areas with ample cover (e.g., marginal habitats with vegetation, woody debris, or gravel cover; (Roberge *et al.* 2002; McPhail 2007). Neither species undertake substantial seasonal movements and Slimy Sculpin are known to be highly sedentary, rarely undertaking movements greater than 100 m (McPhail 2007; Gray *et al.* 2018).

4.6. Suckers (Catostomidae)

4.6.1. Native Distributions

There are four resident sucker species present in the Nechako watershed. The species are comparatively less broadly distributed across the province of British Columbia than other resident fish families and are naturally occurring in four or less of the province's seven zoogeographic regions (McPhail and Carveth 1993). All four species are present in two or more of the three geographic regions within the Nechako watershed with the Nechako River having the broadest sucker species assemblage (McPhail 2007; MOE 2021a).

4.6.2. Conservation Status

All resident sucker species within the Nechako watershed have been assessed at the provincial level by the British Columbia provincial government as "Secure" / "Least Risk" and do not have federal conservation listing (MOE 2021a, 2021b).

4.6.3. Population Trends

Thorough literature review did not identify any quantitative monitoring or qualitative descriptions of population trends for any sucker species in the Nechako watershed.

4.6.4. Life History Summary

There is no life history or life stage specific habitat use data regarding resident sucker species in the Nechako watershed. Therefore, the following information is sourced from available general biological knowledge of these species from other portions of their range. Suckers are benthic specialists (McPhail 2007). All species found in the Nechako watershed spawn in spring in shallow water with gravel substrate, often adjacent to deep water (Roberge *et al.* 2002; McPhail 2007). Juvenile rearing generally occurs within shallow water with seasonally flooded or littoral vegetation and fine substrates (McPhail and Baxter 1996; Roberge *et al.* 2002). There is evidence that Largescale and Longnose suckers undertake seasonal spawning migrations (McPhail 2007). However, the extent of movements in the Nechako watershed is generally unknown.

Yours truly,

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APPENDICES

Appendix A. Nechako Watershed Fish Life History Summaries

Appendix B. Ootsa Lake Fishing Derby Analysis

Appendix A. Nechako Watershed Fish Life History Summaries

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Table 1. Species life stage periodicity and spatial behaviour summary.

Family	Species	Scientific Name	Distribution[1]	Life History Periods[2]			Spatial Behaviour	References
				Spawning	Fry Emergenc	Overwinterin g		
Lings (Lotidae)	Burbot	*Lota lota*	NR, CRB, and NRB	Dec - Mar	Dec - Apr	None	Multiple kilometer spawning movements.	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007; Ashton *et al.* 2019
Lampreys (Petromyzontidae)	Pacific Lamprey	*Entosphenus tridentatus*	NRB	Apr - Jul	Aug - Nov	Unknown	Anadromous species. Adult: Upstream freshwater migrations (Jul - Jun). Juveniles: Out-migration (Sep - Jun/Jul).	Scott and Crossman 1973; Hart and Clemens 1988; McPhail 2007
Minnows (Cyprinidae)	Brassy Minnow	*Hybognathus hankinsoni*	NR and NRB	Jun - Aug	Jun - Aug	Nov - Mar[3]	Schooling behaviour, seasonal habitat shifts to fluvial habitats.	Roberge *et al.* 2002; Scheurer *et al.* 2003; McPhail 2007; Radford and Sullivan 2014
Minnows (Cyprinidae)	Lake Chub	*Couesius plumbeus*	NR, CRB, and NRB	May - Aug	May - Aug	Nov - Mar[3]	Schooling behavior when appropriate cover unavailable. Evidence of spawning and post-spawning dispersal.	Brown *et al.* 1970; Lane *et al.* 1996; Roberge *et al.* 2002; McPhail 2007; Davis 2016
Minnows (Cyprinidae)	Leopard Dace	*Rhinichthys falcatus*	NRB	Jul	Jul - Aug	Nov - Mar[3]	Juveniles move into higher velocity habitats during freshet.	Roberge *et al*. 2002; McPhail 2007; Zimmerman 2009
Minnows (Cyprinidae)	Longnose Dace	*Rhinichthys cataractae*	CRB and NRB	May - Jul	May - Aug	Nov - Mar[3]	Seasonal shift from riffles to slower, deeper water. Evidence of major seasonal movements.	McPhail and Lindsay 1970; Peden 1991; Roberge *et al.* 2002; McPhail 2007
Minnows (Cyprinidae)	Northern Pikeminnow	*Ptychocheilus oregonensis*	NR, CRB, and NRB	May - Jun	May - Aug	Nov - Mar[3]	Upstream spawning migration.	Jeppson and Platts 1959; Beamesderfer 1992; Roberge *et al.* 2002; McPhail 2007
Minnows (Cyprinidae)	Peamouth Chub	*Mylocheilus caurinus*	CRB and NRB	May - Jun	May - Jun	Nov - Mar[3]	Schooling behavior and seasonal migrations. Juveniles move into low-gradient tributaries (summer) and return to main river (overwinter).	Scott and Crossman 1973; Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007; Davis 2016
Minnows (Cyprinidae)	Redside Shiner	*Richardsonius balteatus*	CRB and NRB	Apr - Jul	May - Aug	Nov - Mar[3]	Some evidence of movements from lakes to small lake head tributaries.	Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007
Salmonids (Salmonidae)	Bull Trout	*Salvelinus confluentus*	NRB	Aug - Sep	Apr - May	Oct - Apr	Long distance spawning migrations and post-spawning dispersal. Fidelity to spawning and wintering sites.	Post and Johnston 2002; McPhail 2007; Starcevich *et al.* 2012
Salmonids (Salmonidae)	Kokanee	*Oncorhynchus nerka*	NR and CRB	Sep - Nov	Mar - May	Oct - Apr	Diel vertical migrations for prey or predator avoidance.	Scott and Crossman 1973; Roberge et al., 2002; McPhail
Salmonids (Salmonidae)	Lake Trout	*Salvelinus namaycush*	CRB	Jul - Nov	Feb - Jun	None	Post spawning dispersal distances up to 160 km. Evidence of homing to spawning locations.	Scott and Crossman 1973; Roberge et al., 2002; McPhail 2007
Salmonids (Salmonidae)	Lake Whitefish	*Coregonus clupeaformis*	CRB	Sep - Nov	Early spring	None	Spawning migrations to tributary habitat with post-spawning dispersal to lakes.	Scott and Crossman 1973; Roberge et al., 2002; McPhail 2007; Gorsky et al. 2012
Salmonids (Salmonidae)	Mountain Whitefish	*Prosopium williamsoni*	NR, CRB, and NRB	Oct - Nov	Mar - Jun	Nov - Mar	Spawning, foraging movements and schooling behavior.	Ford *et al.* 1995; McPhail and Troffe 1998; McPhail 2007; Schmidt *et al.* 2019
Salmonids (Salmonidae)	Rainbow Trout	*Oncorhynchus mykiss*	NR, CRB, and NRB	Apr - Jun	Jun - Aug	Oct - May	Spawning migrations to tributary habitat and post-spawning dispersal.	Scott and Crossman 1973; Raleigh *et al.* 1984; Roberge *et al.* 2002; McPhail
Salmonids (Salmonidae)	Umam	*Prosopium* sp.	NR and CRB	Oct	Spring	Unknown	Juvenile schooling.	McPhail 2007; Sparks *et al.,* 2021
Sculpins (Cottidae)	Prickly Sculpin	*Cottus asper*	NR and NRB4	Feb - Jul	Feb - Aug	None	Coastal populations make spawning migrations to estuary environments; interior population movement patterns unknown.	Porter and Rosenfeld 1999; Roberge *et al.* 2002; EBA 2006; McPhail 2007
Sculpins (Cottidae)	Slimy Sculpin	*Cottus cognatus*	NR and NRB4	Apr - May	Apr - Jun	None	Relatively stationary (i.e., movements generally < 100 m).	Roberge *et al.* 2002; McPhail 2007; Gray *et al.* 2018
Suckers (Catostomidae)	Bridgelip Sucker	*Catostomus columbianus*	NR and NRB	Apr - Jun	Jul	Nov - Mar[5]	Unknown.	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007
Suckers (Catostomidae)	Largescale Sucker	*Catostomus macrocheilus*	NR, CRB, and NRB	Apr - Jul	May - Aug	Nov - Mar[3]	Evidence of spawning migrations, otherwise relatively sedentary. Some observed diel movements (i.e., inshore at night and off-shore during day).	McEvoy 1998; Roberge *et al.* 2002; McPhail 2007
Suckers (Catostomidae)	Longnose Sucker	*Catostomus catostomus*	NR, CRB, and NRB	Apr - Jun	Apr - Jul	Nov - Mar[3]	Evidence of complex spawning, foraging, and overwintering migrations, otherwise relatively sedentary. Diel movements (i.e., inshore (night) and off-shore (day)).	Geen *et al.* 1966; McPhail 2007; McPhail and Lindsay 1970; Scott and Crossman 1973
Suckers (Catostomidae)	White Sucker	*Catostomus commersonii*	NR and NRB	May - Jun	May - Jul	Nov - Mar[3]	Movement into tributary streams to spawn.	Roberge *et al.* 2002; McPhail 2007

[1] NR = Nechako Reservoir, CRB = Cheslatta River Basin, NRB = Nechako River Basin

[2] Quantified estimates of habitat features are based on available literature. Where no quantitative estimate is available qualitative estimates (i.e., shallow, deep, low, medium, high / shallow, deep / fine, medium, large) are used.

[3] Species (or closely-related species) are known to overwinter, but specific months are unknown. November-March assigned based on minimum winter season in the study area.

[4] Sculpins in the Cheslatta River basin have only been identified to the family level, it is likely that this species is present in the basin.

Table 2. Species and life stage specific habtat use summary.

Family	Species	Scientific Name	Habitat Type	Preferred Habitat Characteristics[1]: Spawning	Incubation	Juvenile Rearing: Young of Year	Juvenile Rearing: Juveniles	Adult Rearing	Overwintering	References
Lings (Lotidae)	Burbot	*Lota lota*	**Lacustrine**	1.0 - 10.0 m deep, sand to gravel substrate.	Non-adhesive, demersal on substrate.	Limnetic larvae.	Benthic areas, cover (e.g., boulders).[2]	> 2 m deep.	Deep water.[2]	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007; Ashton *et al.* 2019
			Riverine	Low velocity, silt to fine gravel substrate, e.g., behind deposition bars.		Unknown, may concentrate behind deposition bars until shifting to benthic habitat.		Deep main channels, turbid water.		
Lampreys (Petromyzontidae)	Pacific Lamprey	*Entosphenus tridentatus*	**Riverine**	0.3 - 4.0 m deep, 0.37 - 0.46 m/s velocities, e.g., pool tailouts, gravel shoals.	Demersal in substrate nest.	Shallow, low velocity water, buried in fine substrate, near river margins.	0.6 - 0.8 m deep, 0.0 - 0.1 m/s velocity, buried in fine substrate.	Under rocky substrate.	Migration timing dependent. Can occur in freshwater or ocean.	Scott and Crossman 1973; Hart and Clemens 1988; McPhail 2007
Minnows (Cyprinidae)	Brassy Minnow	*Hybognathus hankinsoni*	**Lacustrine** **Riverine**	Shallow, vegetative cover, fine substrate.[2]	Adhesive, demersal on substrate of vegetation.	< 1.5 m deep, fine substrate, vegetative cover.[2]		< 0.5 m/s velocity, fine substrate, vegetative cover.[2]	Deep water.[2]	Roberge *et al.* 2002; Scheurer *et al.* 2003; McPhail 2007; Radford and Sullivan 2014
Minnows (Cyprinidae)	Lake Chub	*Couesius plumbeus*	**Lacustrine** **Riverine**	Shallow, substrate unimportant.[2]	Non-adhesive, demersal eggs.	< 1 m deep margins or shorelines, vegetative cover, fine substrates.[2]	Demersal in littoral or marginal habitats, vegetative cover, fine substrates.[2]	Demersal in littoral or marginal habitats, vegetative cover, fine substrates.[2]	Deep water.[2]	Brown *et al.* 1970; Lane *et al.* 1996; Roberge *et al.* 2002; McPhail 2007; Davis 2016
Minnows (Cyprinidae)	Leopard Dace	*Rhinichthys falcatus*	**Riverine**	Flowing water, rock substrate.	Adhesive, demersal in substrate (i.e., in intersitial space).	< 0.10 m deep, < 0.50 m/s velocity, fine substrate (e.g., shallow pools, backwaters).		< 1 m deep, < 0.40 m/s, fine to cobble substrates (e.g., gravel deposition areas, braided channels).	Deep water (i.e., pools).[4]	Roberge *et al*. 2002; McPhail 2007; Zimmerman 2009
Minnows (Cyprinidae)	Longnose Dace	*Rhinichthys cataractae*	**Lacustrine**	Wave-swept shores or shallow offshore arears, cobble, rubble, or boulder substrate.	Adhesive, demersal in substrate nest.	Limnetic, shallow, nearshore areas, overhanging vegetation, sand to cobble substrate.	Unknown.	Gravel to boulder substrate, vegetative cover.	Deep water.[2]	Gee and Machniak 1972; Brazo *et al.* 1978; McPhail and Lindsay 1970; Peden 1991; Roberge *et al.* 2002; McPhail 2007
			Riverine	0.4 - 1.0 m/s surface velocities, coarse gravel substrate, riffles.		Shallow pools, riffles, and other low velocity areas, fine substrate.		0.4 - 0.5 m/s velocity, coarse gravel to boulder substrates, vegetative cover.		
Minnows (Cyprinidae)	Northern Pikeminnow	*Ptychocheilus oregonensis*	**Lacustrine**	Shallow, sand-free gravel/cobble substrate.	Adhesive, demersal on substrate.	Inlet streams or lakes,< 0.25 m deep, vegetative cover, fine substrate.[2]		Shallow, submerged vegetation or deep water.	Deep water.[2]	Jeppson and Platts 1959; Beamesderfer 1992; Roberge *et al.* 2002; McPhail 2007
			Riverine	< 0.4 m/s velocity, gravel or cobble substrate.				> 1 m deep, < 1 m/s velocity.		
Minnows (Cyprinidae)	Peamouth Chub	*Mylocheilus caurinus*	**Lacustrine**	Shallow nearshore areas, rubble substrate.	Adhesive, demersal on substrate.	Shallow, nearshore areas.	Deeper water.	Shallow depths.	Deep water.[2]	Scott and Crossman 1973; Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007; Davis 2016
			Riverine	Flowing water, gravel substrate.		Inlet / outlet streams / tributary mouths, shallow, low velocity water.	< 0.5 m deep, < 0.1 m/s velocity, vegetative cover, gravel substrate.	Low velocity, vegetative cover, gravel or rubble substrate.		

[1] Quantified estimates of habitat features are based on available literature. Where no quantitative estimate is available qualitative estimates (i.e., shallow, deep, low, medium, high / shallow, deep / fine, medium, large) are used.

[2] Habitat characteristics shared between lacustrine and riverine habitats.

[3] Assigned based on information available for similar species.

"-" denotes life stage does not occur in habitat type.

Table 2. Continued (2 of 3).

Family	Species	Scientific Name	Habitat Type	Preferred Habitat Characteristics[1]						References
				Spawning	Incubation	Juvenile Rearing		Adult Rearing	Overwintering	
						Young of Year	Juveniles			
Minnows (Cyprinidae)	Redside Shiner	*Richardsonius balteatus*	**Lacustrine**	-	Adhesive, demersal on substrate or vegetation.	-		Littoral-profundal zone, vegetative c	Deep water.[2]	Porter and Rosenfeld 1999; Roberge *et al.* 2002; McPhail 2007
			Riverine	Tributary streams, 0.1 m deep, gravel substrate, vegetative cover, riffles.		< 0.5 m deep, < 0.1 m/s velocity, fine to gravel substrate.		1 - 2 m deep, < 20 m/s velocity, fine substrate, vegetative or woody cover.		
Salmonids (Salmonidae)	Bull Trout	*Salvelinus confluentus*	**Riverine**	Tributary streams, low gradient, 0.03 - 0.80 m/s velocity, gravel, cover, e.g., (undercut banks, pools).	Demersal in redd.	Tributary streams, low velocity margins, unembedded gravel.	Tributary streams, pools, large woody debris.	Pools, overhead cover, groundwater input.	Low velocity, instream or overhead cover, groundwater input.	Post and Johnston 2002; McPhail 2007; Starcevich *et al.* 2012
Salmonids (Salmonidae)	Kokanee	*Oncorhynchus nerka*	**Lacustrine**	Inshore areas or tributaries, limnetic, littoral, near upwellings or sub-surface flow, small to medium cobble.	Demersal in substrate (i.e., in interstitial spaces).	Littoral or limnetic zone.	Offshore areas	Offshore areas	Offshore, deep water	Scott and Crossman 1973; Roberge et al., 2002; McPhail 2007
Salmonids (Salmonidae)	Lake Trout	*Salvelinus namaycush*	**Lacustrine**	5 - 50 m deep, course substrate (e.g., gravel to boulder).	Demersal in substrate (i.e., in interstitial spaces).	Shallow, immediate or delayed movement to deep water.		All depths, deep water after lake stratification.	Distributed across available habitats.	Scott and Crossman 1973; Roberge et al., 2002; McPhail 2007
Salmonids (Salmonidae)	Lake Whitefish	*Coregonus clupeaformis*	**Lacustrine**	< 30 m deep, hard/rocky substrate.	Demersal in substrate (i.e., in interstitial spaces).	Shallow, < 1 m of shore, rocky reefs, beaches w/ gravel & rubble substrate, emergent vegetative cover.	Deeper water.	All depths, shift to deeper water during summer.	Deep water.[2]	Scott and Crossman 1973; Roberge et al., 2002; McPhail 2007; Gorsky et al. 2012
			Riverine	Riffles or runs, shallow, gravel to cobble substrate.		Unknown.	Unknown.	Unknown.		
Salmonids (Salmonidae)	Mountain Whitefish	*Prosopium williamsoni*	**Lacustrine**	Generally inlet / outlet / tributary spawning, upwelling water.	Adhesive, demersal on substrate.	< 0.5 m deep, low velocity, sand to fine gravel substrate.[2]		Deep water.	Shallow (< 1 m), large cobble substrate.[2]	Ford *et al.* 1995; McPhail and Troffe 1998; McPhail 2007; Schmidt *et al.* 2019
			Riverine	Upwelling inflow, pool heads, riffles.				0.6 - 1.1 m deep, 30 - 80 m/s velocity, coarse gravel or cobble substrate (e.g., pools, riffles, runs).		
Salmonids (Salmonidae)	Rainbow Trout	*Oncorhynchus mykiss*	**Lacustrine**	-	Demersal in redd.	-	Inshore, cover (e.g., gravel to boulder substrate, woody debris).	Vegetative cover, woody debris. In large lakes > 50 m from shore.	Deep water.[2]	Scott and Crossman 1973; Humpesch 1985; Raleigh *et al.* 1984; Bjornn and Reiser 1991; Flebbe and Dolloff 1995; Meyer and Gregory 2000; Roberge *et al.* 2002; McPhail 2007
			Riverine	Tributary streams, inlet or outlet streams, 0.3 - 0.9 m/s velocity, fine substrate, vegetated banks, riffle, pools, pool tailouts.		Tributary steams, shallow, low velocity margins, gravel substrate.	Tributary streams, < 0.25 m deep, 0.2 -0.4 m/s velocity margins, cobble to boulder substrate.	Riffles, runs, glides, pools, cover (e.g., riparian vegetation, large woody debris, cobble to boulder substrates).	Daytime concealment (e.g., cobble-boulder substrate or woody debris).	

[1] Quantified estimates of habitat features are based on available literature. Where no quantitative estimate is available qualitative estimates (i.e., shallow, deep, low, medium, high / shallow, deep / fine, medium, large) are used.

[2] Habitat characteristics shared between lacustrine and riverine habitats.

[3] Assigned based on information available for similar species.

"-" denotes life stage does not occur in habitat type.

Table 2. Continued (3 of 3).

Family	Species	Scientific Name	Habitat Type	Preferred Habitat Characteristics[1]						References
				Spawning	Incubation	Juvenile Rearing		Adult Rearing	Overwintering	
						Young of Year	Juveniles			
Salmonids (Salmonidae)	Umam	*Prosopium* sp.	**Lacustrine**	-	Demersal on or in substrate (i.e., interstitial spaces).	Unknown.	<1 m deep, margins.	Demersal in deep water, but may come to depths of ~ 2.5 m.	Deep water.[2]	McPhail 2007, Sparks *et al.* 2021.
			Riverine	Inlet steams, riffles, course gravel.			Unknown.	Moderate to high velocity, gravel or cobble substrate.		
Sculpins (Cottidae)	Prickly Sculpin	*Cottus asper*	**Lacustrine**	Low velocity areas with boulders, cobble, or flat rock bottom substrate, embedded woody debris.[2]	Adhesive, under nest rock (i.e., in substrate).	Nearshore limnetic zones, vegetative cover.		Cover (e.g., cobble, boulder, woody debris).	Deep water, cover.[2]	Porter and Rosenfeld 1999; Roberge *et al.* 2002; EBA 2006; McPhail 2007; Tabor *et al.* 2007
			Riverine			Low velocity margins, cover (e.g., woody debris).		Low velocity, boulder substrate, large woody debris.		
Sculpins (Cottidae)	Slimy Sculpin	*Cottus cognatus*	**Lacustrine**	Shallow, rocky substrate.[2]	Adhesive, under nest rock (i.e., in substrate).	Nearshore limnetic zones, vegetative cover.[3]		Cover (e.g., cobble, boulder, woody debris).	Unknown	Roberge *et al.* 2002; McPhail 2007; Gray *et al.* 2018
			Riverine			Low velocity margins, seasonally flooded vegetation.	Shallow, low velocity, gravel to cobble substrate.	Moderate velocity riffles or runs, coarse gravel or cobble substrates.		
Suckers (Catostomidae)	Bridgelip Sucker	*Catostomus columbianus*	**Lacustrine**	< 2 m deep, gravel substrate.	Adhesive, demersal on or in substrate (i.e., interstitial spaces).	Unknown.		Diurnal variation in depth: Deep (day) & shallow (night).	Unknown.	Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007
			Riverine	Riffles adjacent to lower velocity areas.		Shallow, margins, fine substrate.	0.1 -0.2 m/s velocity backwaters.	0.4-0.9 m/s velocity, rocky substrate.	Pools, riffles.[3]	
Suckers (Catostomidae)	Largescale Sucker	*Catostomus macrocheilus*	**Lacustrine**	Shoals, course gravel substrate.	Adhesive, demersal on or in substrate (i.e., interstitial spaces).	Unknown.	Benthic.	Benthic, < 25 m.	Unknown.	McEvoy 1998; Roberge *et al.* 2002; McPhail 2007
			Riverine	Riffles or deep areas (e.g., pool tailouts) near areas of slower water.		Shallow or open areas, low velocity, seasonally flooded vegetation.	0.25-0.50 m depth, low velocity, fine to cobble substrates.	Low to moderate gradient, low velocity areas, deep pools.	Deeper pools, shallow riffles.[3]	
Suckers (Catostomidae)	Longnose Sucker	*Catostomus catostomus*	**Lacustrine**	Generally tributary spawning, < 20 cm deep, shorelines.	Adhesive, demersal on or in substrate (i.e., interstitial spaces).	Shallow margins, vegetative or woody cover.	Nearshore areas.	Below thermocline during day, shallow inshore ares at night	Unknown.	Geen *et al.* 1966; McPhail 2007; McPhail and Lindsay 1970; Scott and Crossman 1973
			Riverine	0.30 - 0.45 m/s velocity riffles, gravel (0.5 - 10.0 cm) substrate.		< 0.1 m deep water, low velocity, soft substrate, submerged vegetative cover.	Shallow, low velocity areas, soft cover, (e.g., side-channels, beaver ponds).	Low to moderate gradient, low velocity, deep pools.	Deeper pools, shallow riffles.[3]	
Suckers (Catostomidae)	White Sucker	*Catostomus commersonii*	**Lacustrine**	Littoral zone, gravel substrate, submerged deltas or shallow gravel shoals.	Adhesive, demersal on or in substrate (i.e., interstitial spaces).	Shallow, weedy areas, soft substrate.[2]	Low velocity, silt-sand substrate, vegetative cover.[2]	Littoral zone.	Unknown.	Geen *et al.* 1966; Nelson 1968; Corbett and Powles 1983; Quinn and Ross 1985; Brown *et al.* 2001; Roberge *et al.* 2002; McPhail 2007
			Riverine	< 1 m deep riffles adjacent to deeper pools, coarse gravel substrate.				1 - 2 m deep, low gradient, low velocity, fine substrate.	Backwater channels, pools, runs.	

[1] Quantified estimates of habitat features are based on available literature. Where no quantitative estimate is available qualitative estimates (i.e., shallow, deep, low, medium, high / shallow, deep / fine, medium, large) are used.

[2] Habitat characteristics shared between lacustrine and riverine habitats.

[3] Assigned based on information available for similar species.

"-" denotes life stage does not occur in habitat type.

Table 3. Resident fish thermal preferences summary.

Family	Species	Scientific Name	Temperature Preference / Tolerance[1]				References
			Spawning	Incubation	Rearing	Adult	
Lings (Lotidae)	Burbot	*Lota lota*	**Opt**: 0.6 - 1.7 °C **SOpt**: > 4 °C	**Opt**: 2 - 6 °C **SOpt**: > 6 °C	Unknown	**Opt**: 15.6 - 18.3 °C **Lethal**: > 23.3 °C	Scott and Crossman 1973; Taylor 2001; McPhail 2007
Lampreys (Petromyzontidae)	Pacific Lamprey	*Entosphenus tridentatus*	**SOpt**: > 20 °C	**Opt**: 10 - 18 °C **SOpt**: > 22 °C	**Lethal**: 27.7 - 28.5 °C	**SOpt**: > 20 °C	Meeuwig *et al.* 2005; Uh and Whitesel 2016
Minnows (Cyprinidae)	Brassy Minnow	*Hybognathus hankinsoni*	**Opt**: 16 - 17 °C	**Opt**: 18 °C	**Opt**: 15.7 - 23.5 °C	**SOpt**: > 35.5 °C	Coker *et al.* 2001; Roberge *et al.* 2002; Scheurer *et al.* 2003; McPhail 2007; Radford and Sullivan 2014
Minnows (Cyprinidae)	Lake Chub	*Couesius plumbeus*	**Opt**: 10 - 19 °C	**Opt**: 8 - 19 °C	Unknown	**SOpt**: 25 - 30 °C	Brown *et al.* 1970; Coker *et al.* 2001; Roberge *et al.* 2002; McPhail 2007; Darveau *et al.* 2012
Minnows (Cyprinidae)	Leopard Dace	*Rhinichthys falcatus*	Unknown	Unknown	**Opt**: 21.2 °C	**Opt**: 15 - 19 °C **SOpt**: 23 - 28 °C	Coker *et al.* 2001; Roberge *et al.* 2002; McPhail 2007; Zimmerman 2009
Minnows (Cyprinidae)	Longnose Dace	*Rhinichthys cataractae*	**Opt**: 11.7 °C	**Opt**: 15.6 °C	Unknown	**Opt**: 15 - 20.5 °C **SOpt**: 28 - 31.4 °C	Black 1953; Coker *et al.* 2001; Roberge *et al.* 2002; Hasnain *et al.* 2010
Minnows (Cyprinidae)	Northern Pikeminnow	*Ptychocheilus oregonensis*	**Opt**: 12 - 18 °C	**Opt**: > 18 °C	**Opt**: 20 - 23 °C	**Opt**: 21.4 - 29°C	Black 1953; Roberge *et al.* 2002; FERC 2011
Minnows (Cyprinidae)	Peamouth Chub	*Mylocheilus caurinus*	**Opt**: 10 - 15 °C	**Opt**: < 12 °C	**Opt**: < 21.3 °C	**SOpt**: < 27 °C	Schultz 1935; Black 1953; Porter and Rosenfeld 1999; Coker *et al.* 2001; Roberge *et al.* 2002; FERC 2011
Minnows (Cyprinidae)	Redside Shiner	*Richardsonius balteatus*	**Opt**: 14.5 - 18 °C	**Opt**: 21 - 23 °C	**Opt**: 12.5 - 20 °C **SOpt**: 24 °C	**SOpt**: > 25 °C	Black 1953; Porter and Rosenfeld 1999; Coker *et al.,* 2001; Roberge *et al.,* 2002; FERC 2011
Salmonids (Salmonidae)	Bull Trout	*Salvelinus confluentus*	**Opt**: 2 - 9 °C **SOpt**: > 9 °C	**Opt**: 2 - 4 °C **SOpt**: < 8 °C	**Opt**: 12 - 14 °C **SOpt**: 16 - 22 °C	**Opt**: < 15 °C **SOpt**: > 18 °C	McPhail and Murray 1979; Ford *et al.* 1995; Hillman and Essig 1998; Selong *et al.* 2001; FERC 2011
Salmonids (Salmonidae)	Kokanee	*Oncorhynchus nerka*	**Opt**: 5 - 14 °C	Unknown	**Opt**: 10 °C **Lethal**: > 22 °C	**Opt**: 10 - 15 °C **Lethal**: > 24.4 °C	Scott and Crossman 1973; Roberge et al., 2002; FERC 2011
Salmonids (Salmonidae)	Lake Trout	*Salvelinus namaycush*	**Opt**: 10 - 12.8 °C	**Opt**: 0.3 - 1.0 °C	**Opt**: 10 °C	**Opt**: 15 - 17 °C **Lethal**: > 23.5 °C	Gibson and Fry 1954; Scott and Crossman 1973; Edsall and Cleland 2000; Roberge et al., 2002; McPhail 2007; FERC 2011
Salmonids (Salmonidae)	Lake Whitefish	*Coregonus clupeaformis*	**Opt**: < 10 °C	**Opt**: 0.5 - 6.1 °C	**Opt**: 15.5 - 19.5 °C	**Opt**: 16.8 °C	Scott and Crossman 1973; Roberge et al., 2002; McPhail 2007; Gorsky et al. 2012
Salmonids (Salmonidae)	Mountain Whitefish	*Prosopium williamsoni*	**Opt**: 4.5 - 7 °C	**Opt**: 6 - 8.8 °C **SOpt**: > 9 °C	**Opt**: 8.8 - 12 °C **SOpt**: 18.8 - 21.6 °C	**Opt**: 9.6 - 17.4 °C **SOpt**: > 22 °C	Rajagopal 1979; Ford *et al.* 1995; McPhail and Troffe 1998; Coker *et al.* 2001; Brinkman *et al.* 2013; FERC 2011; Schmidt *et al.* 2019
Salmonids (Salmonidae)	Rainbow Trout	*Oncorhynchus mykiss*	**Opt**: 10 - 15.5 °C	**Opt**: 10 - 12 °C **SOpt**: > 18 °C	**Opt**: 10 - 18 °C **SOpt**: > 22 °C	**Opt**: 12 - 18 °C **SOpt**: > 18 °C	Scott and Crossman, 1973; Humpesch 1985; Ford *et al.* 1995; Coker *et al*. 2001; Bear *et al.* 2007; FERC 2011
Salmonids (Salmonidae)	Umam	*Prosopium* sp.*	**Opt**: < 5 °C	Unknown	Unknown	**Opt**: < 10 °C	McPhail 2007
Sculpins (Cottidae)	Prickly Sculpin	*Cottus asper*	**Opt**: 8 - 13 °C	Unknown	**Opt**: 13 - 18 °C **SOpt**: > 21 °C	**SOpt**: > 24 °C	Black 1953; EBA 2006; Porter and Rosenfeld 1999; Coker *et al.* 2001; Roberge *et al.* 2002; McPhail 2007; Tabor *et al.* 2007; FERC 2011
Sculpins (Cottidae)	Slimy Sculpin	*Cottus cognatus*	**Opt**: 8 - 10°C	**Opt**: 7.7 °C	**Opt**: 13 - 18 °C **SOpt**: < 21 °C	**Opt**: 13 - 15 °C **SOpt**: 23 - 25 °C	Symons *et al.* 1975; Coker *et al.* 2001; Roberge *et al.* 2002; McPhail 2007; FERC 2011; Gray *et al.* 2018
Suckers (Catostomidae)	Bridgelip Sucker	*Catostomus columbianus*	**Opt**: 10 - 15 °C	Unknown	Unknown	**Opt**: 21.4 - 29 °C	Roberge *et al.* 2002
Suckers (Catostomidae)	Largescale Sucker	*Catostomus macrocheilus*	**Opt**: 7.5 - 15 °C	Unknown	**SOpt**: > 29 °C	**Opt**: 21.4 - 29 °C	Black 1953; Coker *et al.* 2001; Roberge *et al.* 2002; FERC 2011
Suckers (Catostomidae)	Longnose Sucker	*Catostomus catostomus*	**Opt**: 5 - 10 °C	**Opt**: 8 - 17 °C	**SOpt**: > 27 °C	**SOpt**: > 27 °C	Black 1953; Coker *et al.,* 2001; Roberge *et al.* 2002; FERC 2011; Hasnain *et al.* 2010
Suckers (Catostomidae)	White Sucker	*Catostomus commersonii*	**Opt**: 10 - 12 °C	**Opt**: 10 - 16 °C	**Opt**: 19 - 26 °C	**Opt**: 23.4 - 25.5 °C **SOpt**: 27.8 - 31.6 °C	Koenst and Smith 1982; Corbett and Powles 1983; Coker *et al.* 2001; Roberge *et al.* 2002; Hasnain *et al.* 2010

[1] Opt = Optimum, SOpt = Sub - optimal. Temperature thresholds that are unknown are excluded.

* Temperature preference assigned based on that of similar species.

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Appendix B. Ootsa Lake Fishing Derby Analysis

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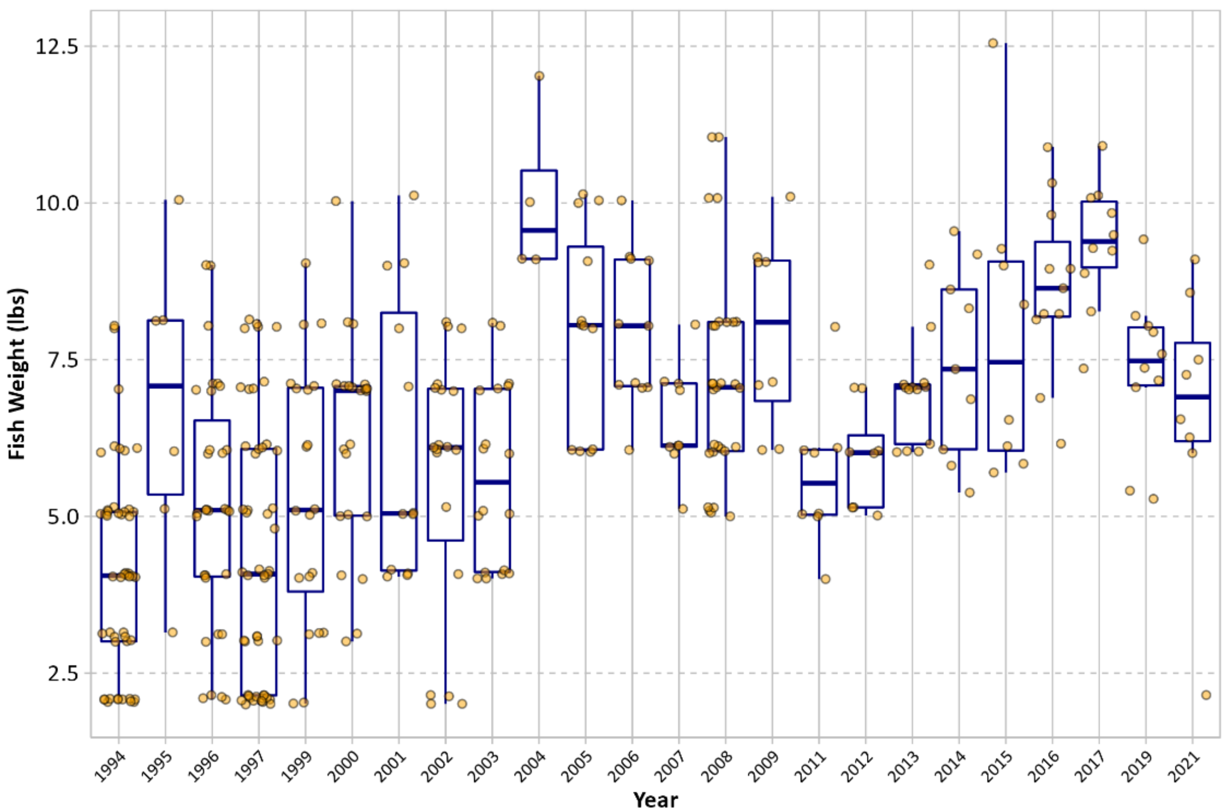
1. AVAILABLE DATA

Ootsa Lake derby records (hereafter the dataset) present the recorded weights of 383 angled fish, including the winning fish in each derby annually from 1994 to 2021 (Figure 1). Available information suggests all captured fish were Rainbow Trout, however, the dataset did not identify species captured. The number of fish recorded in the derby varied substantially between years (i.e., range of 4 individuals in 2004 to 49 in 1997). In addition, no fish population demographic information (e.g., sex, length, or age) or angling effort was available.

Figure 1. Distribution of Ootsa Lake derby angled fish weights from 1994 and 2021 (orange points). Boxplots (blue) depict the annual 25th (lower hinge), median (horizontal bar), and 75th (upper hinge) weight percentiles for individual fish.



2. ANALYSIS

We conducted a preliminary analysis of the dataset using two complementary trend analyses, one assessing trends in maximum weight and a second assessing trends in average weight. First, we investigated weight trends of prize-winning fish between 1994 and 2021. We assumed that all winning fish resulted from similar angling effort which may be representative of the upper weight bound of the local trout population for a given year. It is therefore assumed that any observed changes in trend between years may reflect changes in the maximum size of fish in the population. We first subset the available fish weight data to only the largest weight record each year and then modeled these weights as a function of derby year using a generalized additive model (GAM; Wood 2017). This approach allowed us to estimate[1] a non-linear relationship between fish weight and year.

Second, we investigated trends in the average weight of the four heaviest fish caught each year (i.e., from 1994 to 2021). This analysis complements the maximum weight approach by providing additional weight variability to the analysis. First, we extracted values of the four heaviest fish caught at each derby and estimated annual weight averages. We then fitted a similar GAM as described for maximum weight above.

Overall significance of both models was tested using an Analysis of Variance (ANOVA). All statistical analyses were done in R statistical software, version 4.2.0 (R Core Team 2022) using the *mgcv* package, version 1.80-40 (Wood 2022).

3. RESULTS AND DISCUSSION

The number of fish recorded in the derby was inconsistent throughout the time series. Therefore, annual fish weight averages may not be representative of temporal size changes and instead may reflect changes in angling. We therefore focused our analysis on only prize-winning (Figure 2) and the top four award-winning (as average) individuals (Figure 3).

Overall, on average, prize-winning trout weighed 9.52 lbs (± 1.37 SD). The weight range across years was 7.06 lbs (in 2012) to 12.55 lbs (in 2015). The GAM showed no significant weight changes between 1994 and 2021 ($F = 0.80$, $p\text{-value} > 0.5$), suggesting no evidence for shifts in the weight of trout caught through time.

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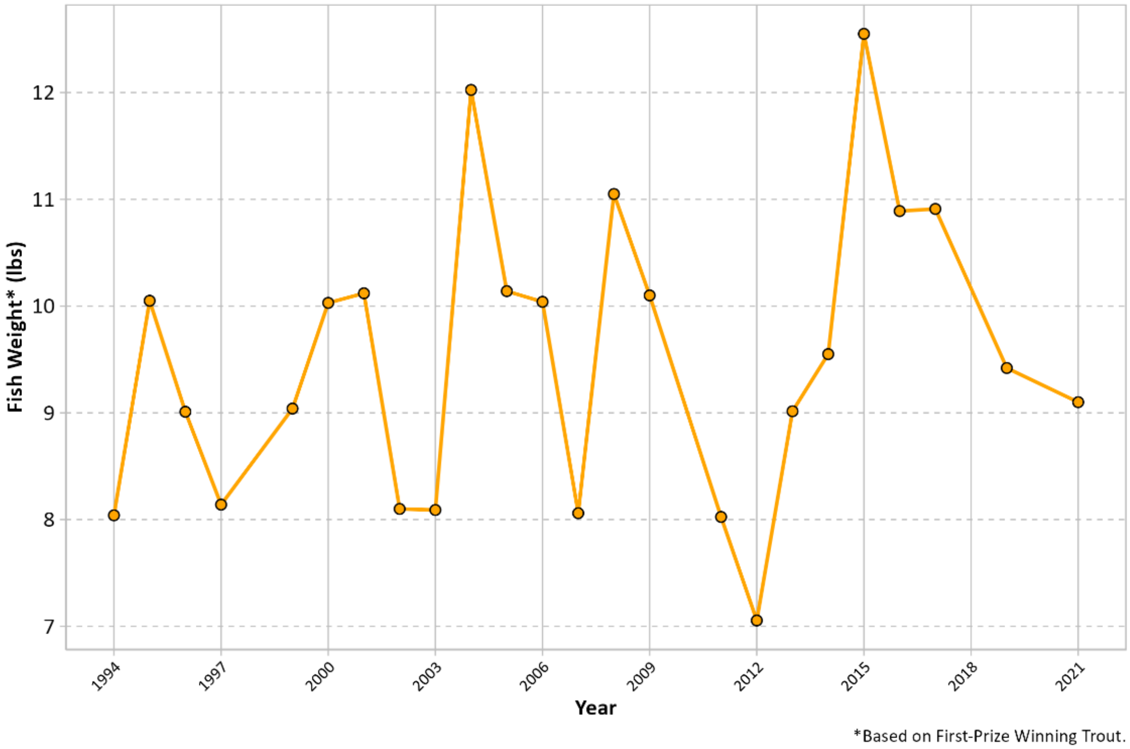
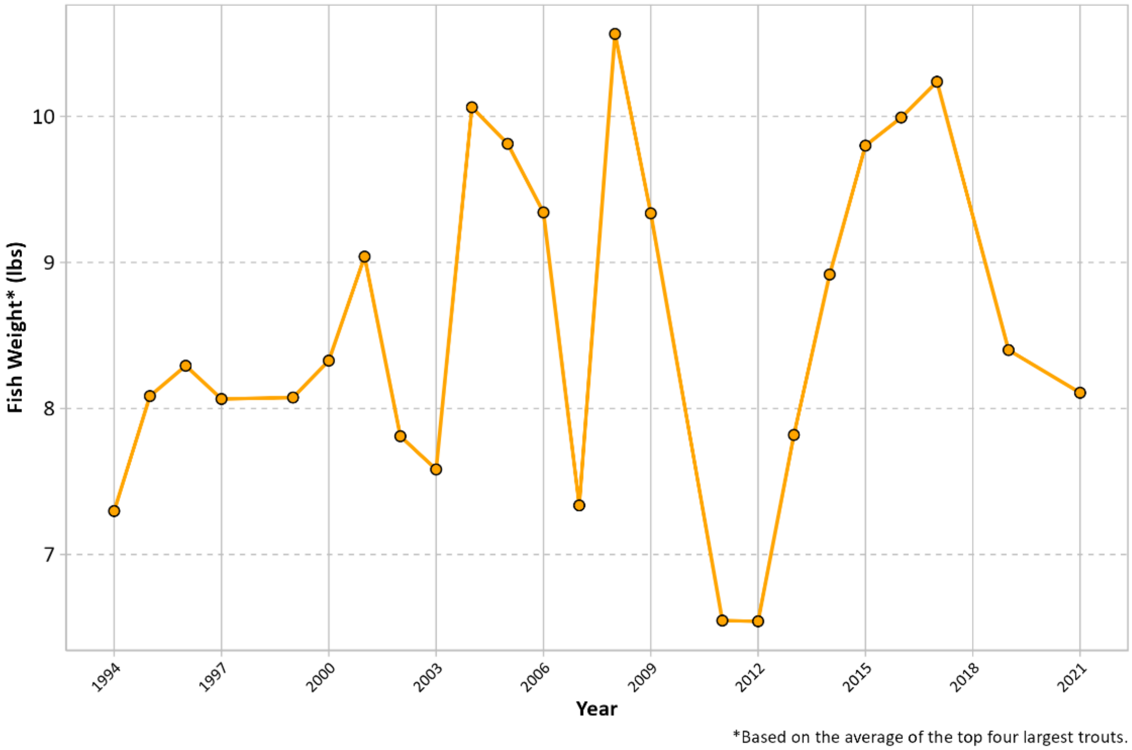
[1] Specifically, we modeled the temporal trend of maximum fish weight as a function of cubic regression spline of year.

Figure 2. Time series of first-prize trout weight angled during the Ootsa Lake trout derby from 1994 to 2021. No temporal trend was significant detected (not shown; F = 0.80, p-value > 0.05).



The four winning fishes weighed on average 8.56 lbs (± 1.15 SD). The average ranged from a minimum of 6.54 lbs (± 0.59 SD) in 2012 to a maximum of 10.57 lbs (± 0.56 SD) in 2008. Similar to observed trends for prize-winning fish, the GAM showed no significant weight changes between 1994 and 2021 (*F = 1.87, p-value > 0.1*), suggesting no evidence for shifts in the weight of trout caught through time.

Figure 3. Time series of average weight of four largest fish angled per year during Ootsa Lake derby from 1994 to 2021. No temporal trend was significant detected (not shown; F = 1.87, p-value > 0.1*).*



In general, our analyses did not show evidence for a change in trout weight between 1994 and 2021. However, the quality and quantity of availability data and its source may limit our conclusions. The purpose of derby events is not to provide a sampling protocol. Thus, fish derby data records lack standardized temporal or spatial effort and are sized selective. Further, the dataset lacked any information on the sex, length, and age of angled individuals, confounding the comparison between years. To partly resolve these challenges, we limited our analysis to two indicators, the weight of the winning-prize fish each year and the average of the four top winning fish each year. However, the data set may only represent the heaviest cohort of the trout population, and given the lack of effort in each record, no conclusion can be provided about the general population.

REFERENCES

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