FISHERIES BACKGROUND STUDIES

MORRISON WATERSHED

2004

Prepared by

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for

Pacific Booker Minerals Inc.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

1.0 BACKGROUND

Pacific Booker Minerals Inc. is evaluating the development of a copper/gold deposit in the Morrison-Hearne Hill property located 65 km north-east of Smithers. The property covers approximately 20,000 hectares and is located on the east side of Morrison Lake in the Babine Watershed (Figure 1). Pacific Booker Minerals Inc. retained David Bustard and Associates Ltd. to assemble background fisheries information for the project area to assist them in their development planning of this project.

This report summarizes background fisheries information available for the Morrison Watershed. It focuses on Morrison Creek, Morrison Lake and its inlet tributaries, with the objective of providing an overview of the fisheries resources of the entire watershed. However, because of the large watershed size and significant amount of background fish information, the report presents more detailed information available for the proposed project area and its immediate vicinity (1:20,000 project map – back envelope).

1.1 STUDY AREA

The study area lies within the Babine Lake Watershed located in the sub-boreal spruce biogeoclimatic zone. Babine Lake is the largest natural lake in British Columbia, and is one of the major sockeye salmon producers in the province, accounting for 90 percent of the Skeena River sockeye run. The limnology and sockeye salmon ecology of Babine Lake has been intensively studied since the 1940's and Levy and Hall (1985) provide an excellent review of the extensive historical research conducted on this lake. These studies led to the development of large sockeye spawning channels at the Fulton River and Pinkut Creek during the 1960's. Morrison Creek was identified as a potential spawning channel location but was never developed.

The Morrison Creek Watershed is one of the four main sub-basins of the Babine Lake drainage and comprises just under 500 km^2 or 7% of the overall Babine Lake Watershed (Levy and Hall 1985). The terrain in the lower portions of the watershed has relatively low relief with elevations ranging from 700 to 1300 m. The upper portions of the watershed originate in the Bait Range and have steeper relief to 1800 m.

Lakes are an important feature of the watershed, and Morrison Lake is most predominant with a surface area of 1325 ha and maximum depth of 60 m (FISS database). Other significant lakes include Tahlo (152 ha) and Haul (304 ha) lakes as well as a dozen smaller lakes generally less than 70 ha in area, including several in the vicinity of the proposed mine development near the southeast end of Morrison Lake (Figure 1).

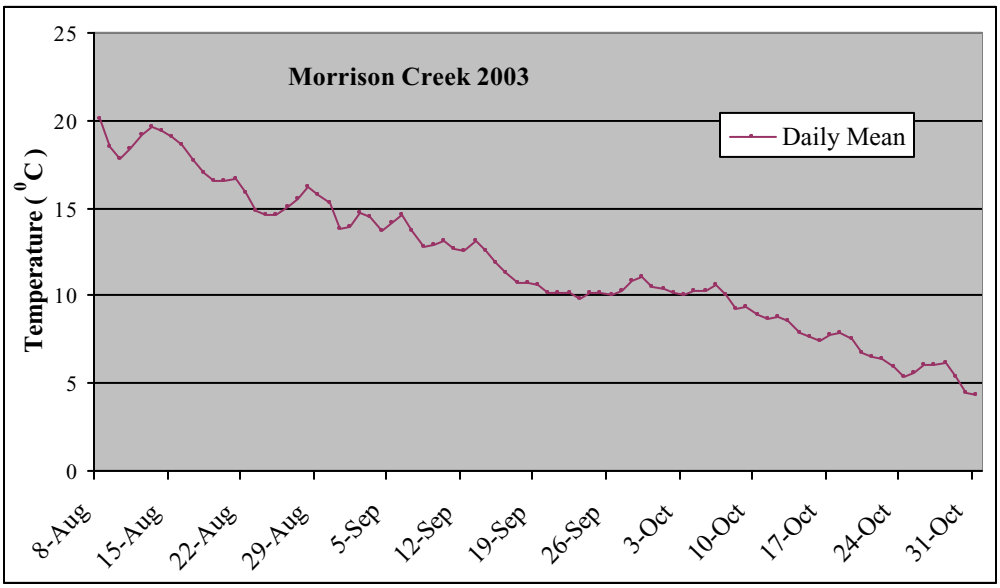
Beavers are active throughout the watershed and extensive ponding and associated dams play a significant role in water retention and influencing fish distributions in the watershed, starting near the bottom end of Morrison Creek (Diversified Ova Tech Ltd. 1996). There are frequent references in old spawning survey reports to beaver dams hindering spawner migrations during low flow years (Hancock et. al. 1983), and

Gottesfeld et al. (2002) report First Nations have been controlling beaver populations and removing beaver dams in Babine tributaries for centuries.

Water Survey of Canada operated a hydrometric gauge at the outlet of Morrison Lake between 1965 and 1970 (Environment Canada 1979). Highest monthly discharge exceeding 15 m^3/sec occurred during the snowmelt freshet in May and June with lowest flows occurring during the late winter March and early April period.

Water temperature data collected in lower Morrison Creek during the summer and fall of 2003 indicate that Morrison Creek mean daily summer temperatures are near 20° C and progressively decline through the fall to 5° C by late October.

Figure 2. Summary of Morrison Creek water temperatures from August through October 2003[1].



FOC studies indicate that Morrison Lake provides a good physical habitat for sockeye fry rearing, and although the lake is oligotrophic, the total phosphorous concentration and phytoplankton biomass is high compared to nine other smaller sockeye rearing lakes in the Skeena Watershed (Shortreed et. al. 1998). Total dissolved solids (57 mg/l) are lower than found in the main basins of Babine Lake (Levy and Hall 1985). Shortreed et al (1998) indicate that Morrison Lake has a relatively shallow thermocline depth of 6.2 m and its stained water results in an average euphotic zone depth of only 4.2 m.

The Morrison Watershed is identified in the Morice LRMP (MSRM, 2004 draft) as having high fisheries values with concerns for the protection of riparian ecosystems, especially along Morrison Lake, and Morrison and Tahlo creeks. Issues concerning recreational experiences and visual quality were identified.

[1] Water temperature provided by D. Lofthouse, FOC, Vancouver.

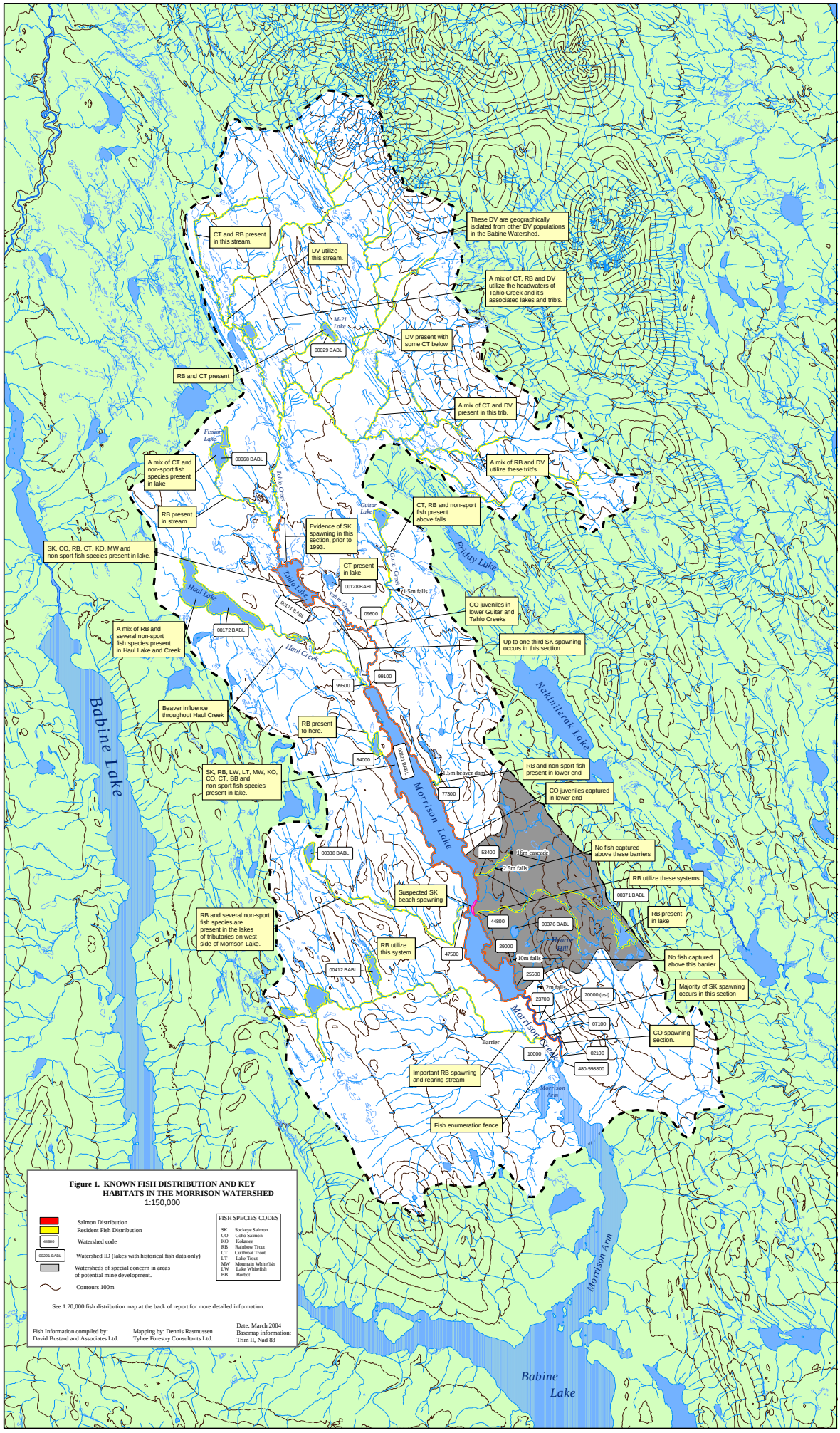


Figure 1. KNOWN FISH DISTRIBUTION AND KEY HABITATS IN THE MORRISON WATERSHED
1:150,000

Salmon Distribution
Resident Fish Distribution
44800 Watershed code
00221 BABL Watershed ID (lakes with historical fish data only)
Watersheds of special concern in areas of potential mine development.
Contours 100m

FISH SPECIES CODES

SK	Sockeye Salmon
CO	Coho Salmon
KO	Kokanee
RB	Rainbow Trout
CT	Cutthroat Trout
LT	Lake Trout
MW	Mountain Whitefish
LW	Lake Whitefish
BB	Burbot

See 1:20,000 fish distribution map at the back of report for more detailed information.

Fish Information compiled by: David Bustard and Associates Ltd.
Mapping by: Dennis Rasmussen Tyhee Forestry Consultants Ltd.
Date: March 2004
Basemap information: Trim II, Nad 83

1.2 HISTORICAL FISH AND HABITAT INFORMATION

First Nations traditional use and occupancy of the Babine Watershed is extensive and well-documented by oral history and early Euro-Canadian visitors. The very abundant and predictable sockeye salmon stocks were key to this use and Gottesfeld et al. (2002) provide a good account of some of the fishing activities undertaken by First Nations people.

The federal government has had a keen interest in fisheries resources in the Morrison Watershed for many years, largely associated with the sockeye salmon populations. The Dominion Department of Fisheries operated a sockeye spawning hatchery at the south end of Morrison Lake from 1907 until 1938 (Gottesfeld et al. 2002; McMahon 1948). Eggs were collected from Morrison Creek sockeye, incubated in a hatchery at the lake outlet and the fry were released into Morrison Lake.

In 1945, the Fisheries Research Board initiated studies on Morrison Lake as part of an overall investigation into the lakes of the Skeena watershed. Detailed limnological and fish diet studies were undertaken during the summer period from 1945 to 1948 (McMahon 1948), and information collected during this period is the most complete information describing the fish populations in Morrison Lake[2]. Lake trawl and acoustic surveys were conducted by Shortreed et al. (1998) to assess sockeye fry rearing in Morrison Lake. Lake surveys have been undertaken on nine other lakes in the Morrison Watershed between 1975 and 2001 (FISS).

Since approximately 1930, the Department of Fisheries and Oceans has maintained estimates of annual salmon escapements into Morrison and Tahlo Creeks. These estimates represent a combination of aerial and ground surveys and are subject to many limitations depending upon survey timing, individual effort and methods.

Extensive research studies mainly associated with enhancement of sockeye salmon have been undertaken on Babine Lake since the 1940's to present. Although most of the work has been conducted in Babine Lake itself, there is often been a "Morrison connection" since it is one of the key sockeye basins. Some of the studies by Groot (1972) describing Morrison sockeye smolt migration have led to new understandings of smolt migration rates and navigation mechanisms.

Monitoring studies in Babine Lake associated with two low-grade open pit copper mines near Granisle have been underway since the mid-1970's (Gottesfeld et. al. 2002) and log booming and transport studies in Morrison Arm led to an extensive 3-year investigation by Westwater Research (Levy and Hall 1985; Levy et al. 1985)

The most recent fisheries studies have been associated with a fence operation on lower Morrison Creek and assessments of sockeye and coho spawner populations in Morrison

[2] McMahon (1948) summarizes the 1946 and 1947 information. More detailed information has subsequently been located in the Pacific Biological Station archived files and covers the period 1945 to 1948 including the information presented in McMahon (1948).

and Tahlo Creeks (Diversified Ova Tech 1996 and 1999; Doug Lofthouse, FOC, pers. comm.). Experimental outlplantings of coho fry have been undertaken for three years (2001 to 2003) in response to the collapse of upper Skeena coho stocks during the mid-1990's. Some fisheries surveys have also been initiated by the Lake Babine Nation that include assessments of adult and juvenile fish populations in Morrison Creek (eg., Lake Babine Nation 2003).

Limited broad biophysical stream surveys of some of the main stream systems in the Morrison Watershed were first described by Graham (1976). Rapid forest development expansion into the Morrison in the early 1980's led to a joint stream sampling initiative between the Fish and Wildlife Branch and Northwood Pulp and Timber[3] resulting in increased stream information and fish sampling (Hatlevik 1981). Additional stream sampling in the watershed was undertaken as part of a rainbow trout study in Babine Lake by Bustard (1989a), and various other smaller scale inventory studies (Bustard 1989b; Bustard 2000 to 2002).

However the most detailed stream habitat descriptions specific to the Morrison Watershed have been undertaken as part of forestry planning activities during the past decade. Largescale 1:20,000 reconnaissance level fish and fish habitat inventory have been conducted throughout the Morrison Watershed. This work has been coordinated by the two forest companies operating in the watershed – Houston Forest Products Ltd. (SKR Consultants Ltd. 2000 and 2001) and Canadian Forest Products Ltd. (Triton 1999 and 2003).

2.0 MORRISON WATERSHED FISH RESOURCES

Over twenty species of fish have been documented in the Morrison Watershed based on data from a range of stream and lake studies outlined above.

The Morrison Watershed has high fish values and is a significant producer of sockeye and coho salmon with infrequent use by pinks and chinook salmon. Sport fish present in the watershed include rainbow and cutthroat trout, lake trout, Dolly Varden, kokanee, and burbot. Other fish species reported in the watershed include coarsescale and longnose suckers, mountain and lake whitefish, redside shiners, lake and peamouth chub, northern pike minnows, and prickly sculpins.

2.1 SOCKEYE SALMON

2.1.1 Distribution and Abundance

The Babine Watershed supports the largest sockeye salmon population in Canada, with a mean escapement for the 1990's of 1.4 million fish. Enhanced stocks from Fulton and

[3] Now Canfor.

Pinkut comprise the highest proportion of this escapement. Wild (not enhanced) stocks originate from 25 enumerated streams in the watershed with escapements averaging in the range of 200,000 to 300,000 based on 10-year averages since 1950 (Gottesfeld et al. 2002). The Morrison sockeye are wild fish and comprise approximately 2.5% of the overall Babine sockeye escapement since 1950.

Morrison sockeye are divided into three stocks. The main spawning stock utilizes Morrison Creek downstream from Morrison Lake (Figure 1). A second significant spawner population uses lower Tahlo Creek just above Morrison Lake, while a third group of sockeye spawn in upper Tahlo Creek upstream from Tahlo Lake.

McMahon (1948) refers to a small component of the Morrison sockeye spawning on the lake shoreline, but does not outline the specific locations. Beach spawning sockeye were observed during September 2003 on the southeast shoreline of Morrison Lake (J. Chaplin, pers. comm.).

Sockeye annual escapement estimates in the Morrison Watershed since 1950 are summarized in Figure 3 (FOC 2003). In some years, sockeye spawning escapements in Morrison Creek can exceed 30,000 fish, with the most recent occurrence of this in 2001.

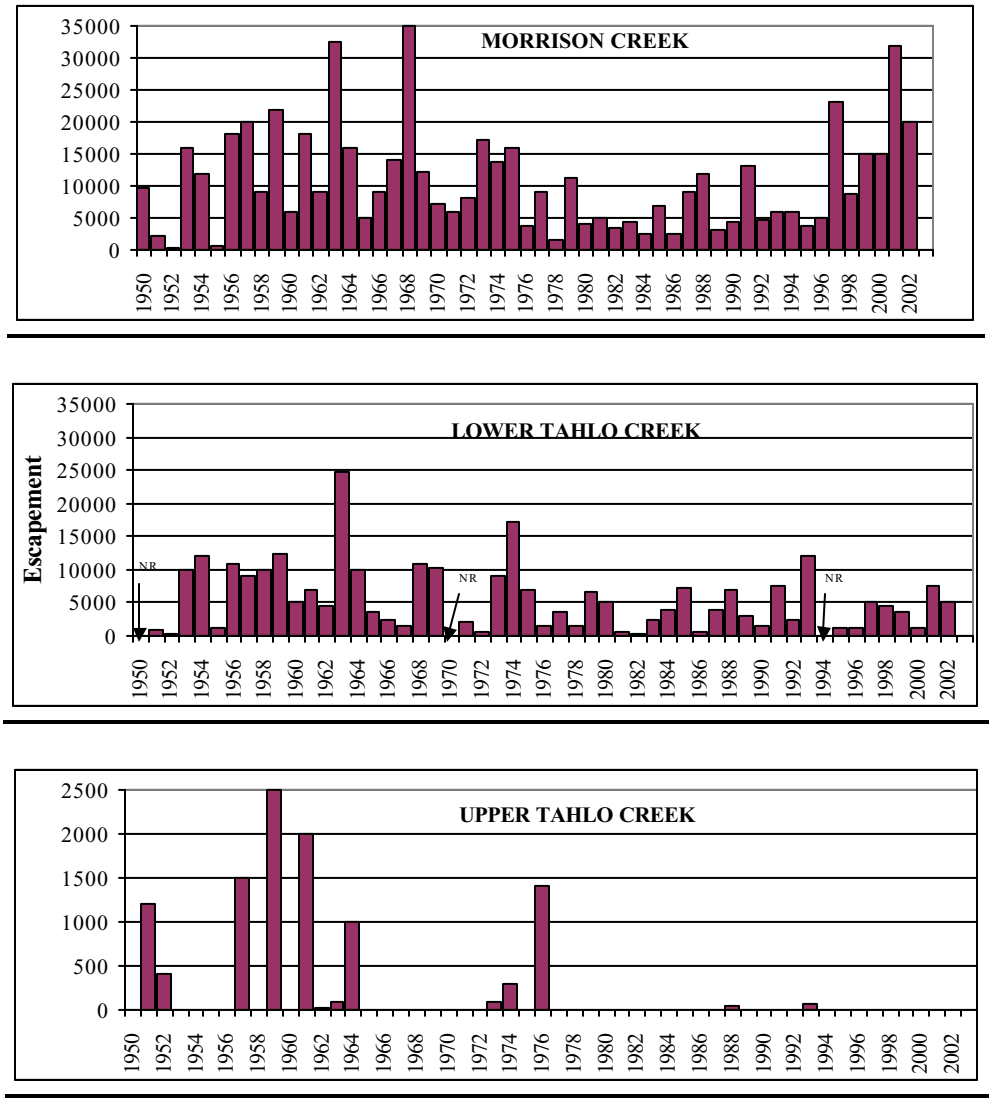
Mean escapements in Morrison Creek since 1950 are 10,700 sockeye, with a higher mean for the past decade of over 13,000 spawners (Table 1). Sockeye spawn throughout Morrison Creek with the highest concentrations occurring approximately 1 to 2 km upstream from Babine Lake (Diversified Ova Tech 1996).

Sockeye estimates in lower Tahlo Creek have exceeded 20,000 fish historically, and have a long-term mean of approximately 5600 fish since 1950 (Table 1). The mean for the past decade is just under 4600 sockeye spawning in lower Tahlo Creek annually. Most sockeye spawn in a 3-km long section located from 0.5 km to 3.5 km upstream from Morrison Lake (Figure 1).

The upper Tahlo sockeye stock is substantially reduced from early escapement estimates of up to 2500 sockeye using the upper creek (Figure 3). Small numbers of sockeye spawners have only been reported in the upper Tahlo twice since 1976 when 1400 fish were reported in this section. Morrell (2000) identified the upper Tahlo sockeye stock as at high risk of extinction. Poor fish access due to low flows during the migration period combined with beaver activity is definitely an issue in upper Tahlo Creek.

It should be emphasized that this section of the Morrison Watershed is also more difficult to enumerate, and counts are less reliable than the lower creek. In many years, the records indicate upper Tahlo Creek was not inspected. For the entire system, a combination of tannic staining in the streams, thick riparian canopy and unreliable weather conditions causing variable streamflow conditions all limit reliable adult counts.

Figure 3. Sockeye salmon escapement estimates in Morrison Creek, lower and upper Tahlo Creek spawning areas from 1950 to 2002.



Although historical escapement estimates suggest the Tahlo Creek component comprised approximately one-third of the Morrison escapement, more specific tagging and stream walk counts in 1996 suggested the Tahlo sockeye comprised between 15 and 20% of the run in that year (Diversified Ova Tech 1996). All of the Tahlo Creek fish were in the lower 3 km of Tahlo Creek, with no spawners observed upstream from a main beaver dam at this location.

Information presented in Shortreed et al. (2001) suggests that the optimum spawner escapement to the Morrison Watershed is closer to 48,000 spawners based on the lake

Table 1. Summary of sockeye escapements for Morrison and Tahlo stocks since 1950 and for the past 10 years.

Year	Morrison Creek	Lower Tahlo	Upper Tahlo
1950-2002	10757	5658	507
1993-2002	13460	4587	25

capability. Improvements to spawning grounds through beaver dam removal and increased escapements through harvest reductions are suggested as means of achieving higher fry recruitment.

2.1.2 Timing of Sockeye Migration and Spawning

Several tagging studies provide information describing the timing of migration and spawning of Morrison sockeye. Studies conducted by Pritchard in 1946 and 1947 (Pritchard 1953 a and b) using fish tagging at the fence indicated that Morrison sockeye had a 15-36 day residency time in Babine Lake prior to entering the creek. These studies indicated a 10 to 15 day period of migration and spawning in the creek itself. Smith and Jordan (1973) identified Morrison Creek sockeye returning to the lake in the middle of the run, passing the Babine fence between August 1 and 18th.

Sockeye spawners appear in Morrison Creek from early August onward to the end of September. Spawning occurs from late August through September. In 1996, spawning in Morrison Creek peaked between September 12 and 22nd (Diversified Ova Tech. 1996). Sockeye first appeared in lower Tahlo in early September and most spawning was finished by late September. This timing can vary by several weeks depending upon the year.

Table 2. Summary of 1996 sockeye escapement in Morrison based on two methods of estimation[4].

	Morrison Ck	Lower Tahlo Ck	Total	% Tahlo Ck
1996 stream counts	5225	975	6200	15.7
1996 tag recoveries	4851	1350	6201	21.8

[4] Adapted from Diversified Ova Tech. (1996).

2.1.3 Sockeye Fry Rearing and Smolt Migrations

Extensive limnological studies during the late 1950's suggested that the main basin of Babine Lake was under-utilized by sockeye fry (reviewed in Levy and Hall 1985), setting the stage for the development of the sockeye spawning channels on Babine Lake. Current thinking is that the addition of further spawning channel development (e.g., Morrison Creek) is not warranted given the poor adult returns relative to high levels of smolt output, and the complexities of the mixed stock fisheries associated with harvesting enhanced stocks of Babine sockeye.

McMahon (1948) also suggested that the "limited" spawning areas associated with Morrison Lake inlets was probably not adequate to utilize the high potential rearing opportunities in Morrison Lake. The early hatchery program on Morrison was directed at increasing the fry inputs into Morrison Lake. Brett (1952) also suggests that spawning capacity of the major inlet (Tahlo Creek) was limited relative to the lake rearing capacity. Shortreed et al. (1998) assumed that sockeye spawning capacity of the inlet stream was one-half of the lake rearing capacity.

Sockeye fry dominate the trawl catches in Morrison Lake (Table 3). Shortreed et al. (1998) used a combination of hydroacoustic surveys and lake trawls to estimate the limnetic fish densities of sockeye fry in Morrison Lake in 1994. They estimated sockeye fry densities of 377 fry/ha, and concluded these were low relative to the lake's potential and to results estimated in some Skeena sockeye rearing lakes. The large size of Morrison sockeye fry (4.3 g) was indicative of an ample food resource during the growing season. No age 1+ sockeye juveniles were sampled during the Morrison trawls.

Table 3. Summary of number and size of fish captured in lake trawls on September 29, 1995.

Species	Number	Mean Wt. (g)	Length (mm)	
			Mean	Range
Sockeye fry[5]	39	4.3	70	42-90
Redside shiner	1			
Sculpin	2			
Whitefish	7	5.8	81	68-93
Unknown	4			
Total	53			

Studies of sockeye fry and smolt migration associated with Babine sockeye have been undertaken in conjunction with the Pinkut and Fulton enhancement projects (reviewed in

[5] It should be noted that both kokanee and sockeye fry rearing occurs in Morrison Lake and some of the fry identified as sockeye in Shortreed et al. (1998) may be kokanee.

Levy and Hall 1985; Gottesfeld et. al. 2002). The downstream migration of sockeye fry from Morrison Creek into Babine Lake occurs in mid-May to the beginning of June (Table 4). While most sockeye fry rearing occurs in lake environments, it is interesting to note that sockeye fry were captured in slow-flowing marginal areas along Morrison Creek and to a lesser extent in lower Tahlo Creek during mid-June while conducting a juvenile fish sampling program from 2000 to 2002 (Bustard 2002).

An average of 1 million sockeye smolts typically emigrate from Babine Lake every day over a 40 day period between May 5 – June 15 (MacDonald and Smith 1980). Scale analyses indicate most smolts (98%) leave the lake as one-year old fish (Levy and Hall 1985). Sockeye smolts migration from Morrison Lake was highest during the mid-to late May period based on a downstream trap operation on Morrison Creek conducted from 1983 to 1985 (Hamilton 1988). The Morrison Creek component of Babine Lake smolts probably migrate out of Babine Lake mainly during June (Levy and Hall 1985).

Table 4. Summary of juvenile sockeye, coho, and pink salmon catch data in an inclined plane trap located in lower Morrison Creek during May and early June 1983 to 1985[6].

Year	Date	Temperature	Species			
		Range (ºC)	SK fry	SK smolts	CO fry	PK fry
1983	May-14 to June-1	8.0-16.0	37122	32	51	0
1984	May-10 to June-4	5.3-9.6	6183	92	875	276
1985	May-16 to June-7	5.6-16.3	4675	121	576	12

2.2 COHO SALMON

Babine Watershed coho together are estimated to comprise approximately 3% of the Skeena coho escapement (Gottesfeld 2002). The run is dominated by stocks that spawn in several sections of the upper Babine River, Fulton River and Morrison Creek with scattered use of other Babine Lake tributaries (Gottesfeld 2002). The Babine coho escapements have been depressed since the early 1970's and are a high conservation concern.

A complete closure of the commercial fisheries for coho in B.C. was initiated in 1998. At the same time Fisheries and Oceans Canada increased assessment work on the Babine coho, including extending the period of operation of a counting fence on Morrison Creek

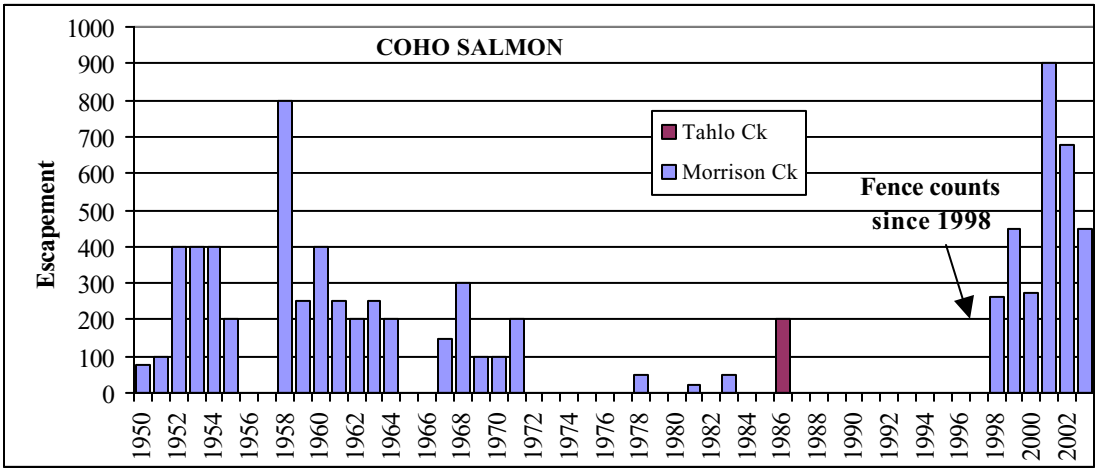
[6] From Hamilton (1988)

to encompass the coho migration period. Coho production in the Morrison Watershed was supplemented from 2000 to 2002 by collecting and incubating coho eggs and out-planting fry to areas within the watershed that appear to be under-seeded.

2.2.1 Distribution and Abundance

Estimated escapements of coho in the Morrison Watershed are summarized in Figure 4. It should be emphasized that without a fence, coho spawners are difficult to enumerate. They tend to move in late during the season, often on higher flow conditions, hide within instream cover, and spawn over a long time period, making stream counts difficult.

Figure 4. Coho salmon escapement estimates in the Morrison Watershed from 1950 to 2003.



The escapement estimates since 1998 are most reliable since these were collected at a counting fence in lower Morrison Creek, usually operated for most of the migration period. Since the fence was installed in 1998, coho escapements into Morrison Creek have averaged just over 500 spawners per year. Coho spawner estimates collected at the Morrison fence comprised approximately 6% of the Babine River fence counts during this same period (Table 5). It should be noted that three of the four highest ever coho fence counts for Babine since 1950 have occurred during this recent period (FOC 2003).

Table 5. Summary of adult coho spawners counted at a fence located in lower Morrison Creek from 1998 to 2003.

Year	Total Fence Count			Migration Period	Clips (%)[7]
	Morrison	Babine	% Morrison	Morrison	
1998	265	4291	6.2	Sept 2-Nov 18	
1999	448	14907	3.0	Oct 2-Nov 21	
2000	271	2230	12.2	Sept 30-Nov 13	
2001	904	21618	4.2	Oct 4-Nov 24	
2002	677	13613	5.0	Oct 6-Nov 25	44 (6.4)
2003	450			Oct 3-Nov 18	63 (14.0)

Specific coho spawning locations are not well documented in the Morrison Watershed, presumably reflecting the widespread and late spawning. A key coho spawning area is located in the lower 1 km section of Morrison Creek (Hancock et al. 1983; Diversified Ova Tech Ltd. 1999).

However, coho fry have been captured throughout Morrison Creek and the lower reaches of Tahlo and Guitar creeks (Figure 1), and we assume the presence of coho fry in these locations reflects coho spawning. Lake survey information indicates that coho juveniles have been present as far upstream as Tahlo Lake in some years[8].

2.2.2 Timing of Coho Migration and Spawning

Timing of coho spawner migration through the lower Morrison Creek fence is summarized in Table 5. Most spawners movements into Morrison Creek occur during October and early November. Upstream migration was influenced by rising streamflows and declining temperatures (Diversified Ova Tech Ltd. 1999). Some fish initiated spawning shortly after stream entry during early October, and all spawning activity in lower Morrison Creek was completed by November 16 during the 1998 studies (Diversified Ova Tech Ltd. 1999).

2.2.3 Coho Fry Rearing and Smolt Migrations

Recently-emerged coho fry were captured during the operation of an incline plane trap in lower Morrison Creek. Peak downstream catches in the traps coincided with rising water temperatures and discharge in Morrison Creek, with peaks from the middle to end of May in 1984 and in early June of 1985 (Hamilton 1988).

[7] These fish were outplanted as fry into Morrison Creek.
[8] A single coho juvenile was sampled during the Tahlo Lake survey 1975 (Data on file, WLAP Smithers).

Several juvenile assessment studies have been conducted in the Morrison Watershed that provide an indication of the key rearing locations and relative abundances of juvenile coho. Three years of juvenile sampling in the mid-reaches of Morrison Creek indicated high densities of coho fry were present with densities ranging from 1.6 to 5.4 coho fry/m^2 in the two index sites over the sample period from 2000 to 2002 (Bustard 2002). Coho fry were consistently present, but at lower densities (typically 0.2 to 0.7 fry/m^2) at two index sites in the lower 2.2 km of Tahlo Creek upstream from Morrison Lake.

It is interesting to note that most juvenile surveys in Morrison Creek indicate that coho fry are present at mainstem locations. However, there is little indication of older coho juveniles present at the samples sites or of coho smolts in the downstream trapping, although some yearling coho were captured in the 1984 trapping (Hamilton 1988).

The importance of Morrison and Tahlo lakes to coho rearing has not been fully evaluated. Although minnow trapping (Bustard 2002)[9], gillnetting (McMahon 1948), and lake trawls in Morrison Lake (Table 3) did not indicate significant coho use, the sampling is limited in extent and the gillnet mesh sizes were typically too large to capture most coho juveniles. Lakes can provide important coho rearing habitat. However, the lack of coho juveniles captured in any of the sampling to date suggests that the use of Morrison Lake by juvenile coho is probably not significant. FOC did not include the lake in calculations of habitat for outplanting (Doug Lofthouse, FOC, pers. comm.). Past observations in Babine Lake suggest that coho juveniles may move along the lake shorelines and migrate up into the lower sections of smaller inlets streams to rear (Bustard 1990b).

Frequent juvenile sampling throughout many of the smaller watersheds in Morrison Creek indicate infrequent use by coho juveniles of only a few tributaries other than mainstem Morrison and Tahlo creeks. These include the lowest reach of Creek 10000 on the west side of Morrison Creek, the lower reach of Creek 61100 on the east side of Morrison Lake and the lowermost reach of Guitar Creek (Figure 1). It should be emphasized that juvenile coho distribution can vary considerably between years depending upon escapements, streamflows and areas of difficult passage (beaver dams). However, the most extensive small stream inventories have been conducted during years of better coho escapements since 1998 (SKR Ltd. 2000 and 2001; Triton 1999 and 2003).

2.3 OTHER SALMON SPECIES

2.3.1 Pink Salmon

Low numbers of pink salmon spawn in Morrison Creek during some years, typically years of high general escapements. Pink spawners have been reported during five years since the early 1980's, with 50 as the highest reported escapement (FOC 2003). Most (98%) Babine pink salmon spawning occurs in the Babine River (Gottesfeld et al. 2002).

[9] 30 minnow traps set during June from 2000 to 2002 (10 per season)

Small numbers of pink fry were captured in the downstream inclined plane trap on Morrison Creek in 1984 and 1985 (Table 4).

2.3.2 Chinook

Chinook salmon are infrequent users of Morrison Creek during some years. For example, two adult chinook were passed through the Morrison fence in 1996 (Diversified Ova Tech Ltd. 1996).

2.3.3 Kokanee

Kokanee (the non-anadromous form of sockeye salmon) spawning in Morrison Creek appears to be minimal based on the capture of less than 20 kokanee during the 1996 fence operation and no kokanee reported during the 1998 fence counts (Diversified Ova Tech Ltd. 1996 and 1999). The counting fence on lower Morrison in 1996 was operated from late July through to October, covering the period when kokanee spawners from Babine would move into the creek. In Babine, kokanee and sockeye demonstrate some overlap in spatial and temporal use of the same spawning ground, typically in tributaries with "early timing" (Levy and Hall 1985). The subject of kokanee-sockeye interbreeding at Pierre Creek on Babine Lake has been the subject of a PhD dissertation (Foote 1987).

Kokanee are present in Morrison Lake and comprised 11% of the overall catch reported during a netting program conducted in 1946 and 1947 (Table 6). The mean weight of kokanee captured in the net set was 0.23 kg. A sample of 68 fish all ranged in fork length from 18 to 28 cm (Appendix 1 Table 1) and were age 2+ and 3+ (Appendix 1 Table 2). Kokanee were also netted in Tahlo Lake during a 1975 survey (Lake survey data on file, WLAP, Smithers). A 26 cm male was maturing on the August 26 netting date in Tahlo Lake.

Spawning areas for kokanee using Morrison and Tahlo lakes are not well documented. A review of fishery officer annual reports (on file, FOC Smithers) indicated kokanee spawners were only noted in 1978, with 1000 spawners reported in lower Tahlo Creek and another 1000 kokanee in Tahlo Creek upstream from Tahlo Lake in that year. The lack of kokanee spawner observations in streams associated with Morrison Lake suggests the kokanee populations in these lakes are primarily shoreline spawners.

2.4 TROUT SPECIES

Both rainbow and cutthroat trout are present in the Morrison Watershed. Based on extensive sampling throughout tributaries in the Morrison Watershed, SKR Consultants Ltd. (2001) concluded that rainbow trout were the dominant species in streams in the lower half of the watershed, and that cutthroat were found at comparatively low densities, mainly centered in the lower half of the Tahlo Creek Watershed.

Table 6. Summary of fish species captured in gillnetting conducted in Morrison Lake during 1946 and 1947[10].

Species	CPUE (catch/net set)	Number	% of Total Catch	Mean wt (kg)	Kg/ set
Lake whitefish	2.25	275	48.0	0.455	1.02
Northern pikeminnow	0.72	88	15.3	0.114	0.08
Kokanee	0.52	63	11.0	0.227	0.12
Peamouth chub	0.43	53	9.2	0.114	0.05
Lake trout	0.43	53	9.2	2.273	0.98
Rainbow trout	0.09	11	1.9	0.341	0.03
Mountain whitefish	0.09	11	1.9	0.227	0.02
Longnose & largescale sucker	0.07	9	1.5	0.682	0.05
Burbot	0.07	9	1.5	1.136	0.08
Cutthroat trout	0.02	2	0.4	-	
Coho	0.01	1	0.2		
TOTAL	4.67	574	100		2.43

2.4.1 Rainbow Trout

2.4.1.1 Distribution and Life History Strategies

Rainbow trout are present throughout many of the lakes and streams of the Morrison Watershed. Based on two years of stream and small lake sampling throughout the watershed, SKR Consultants Ltd. (2001) concluded that adult rainbow trout are generally associated with lake environments, but spawn and initially rear in stream environments. Their sampling suggests rainbow juveniles spend up to three winters in stream environments prior to lake entry.

This life-history strategy is similar to that found during a broad assessment of rainbow trout tributaries throughout Babine Lake that indicated that rainbow trout remain in spawning tributaries for up to 3 years (Bustard 1989a).

Griffith (1968) confirmed the lack of rainbow trout yearlings and fry in Babine Lake after examining the catches of extensive seining and trawling program conducted by DFO while assessing sockeye rearing in Babine Lake in 1967. Rainbow trout less than age 2+ were completely absent from the sample. Analysis of scales from the lake showed a period of rapid growth that coincided with juvenile entry into the lake during the third

[10] Gillnets were comprised of 5 nets each 50 yds long with 1,2,3,4,and 5" mesh sizes. Specific dates and locations for net sets are not given, but netting was done from July through September in 1946 and 1947.

and fourth summer. We suspect rainbow trout strategy is similar in the Morrison Watershed. Shortreed et al. (1998) did not report rainbow trout in the trawl catches they conducted on the lake (Table 3).

Rainbow trout were present in seven of 10 lakes with species information in the Morrison Watershed (Table 7)[11]. They occurred together with cutthroat in two of these lakes and were the only fish species present in one lake (00371BABL) located east of Hearne Hill in the project area. No fish were sampled based on overnight minnow trap sets in a second small lake located in the project area (00376BABL).

Rainbow trout comprised approximately 2% of the total fish catch during gillnetting in Morrison Lake (Table 6). Only 15 rainbow trout were captured in four years of gillnet surveys in Morrison Lake (Appendix 1 Table 1). These fish ranged in size from 16 to 46 cm fork length and were age 2+ to 5+ (Appendix 1 Table 2). Dave Hooper (pers. comm.) also indicates the largest rainbow he has angled on Morrison Lake is 46 cm, similar to the netting results. The netting and reports from locals suggest that rainbow trout are a minor component of the Morrison Lake fish population, with the highest concentrations associated with stream inlets and around salmon spawners.

Table 7. Summary of trout information collected at 10 lakes in the Morrison Watershed[12].

Lake	Waterbody Identifier	Species	Fork Length (cm)	Age	Comment
Morrison	00221BABL	Rbt	16-46		Gillnet
		Ct	17-33		Gillnet
Hearne Hill	00371BABL	Rbt	10-32	2+ to 6+	Only rainbow
Haul	00172BABL	Rbt	20-28		Gillnet
Tahlo	00171BABL	Rbt	20-36		Angling/gillnet
		Ct	21-30		Gillnet
Fission	00068BABL	Ct	17-32		Gillnet
Guitar	00128BABL	Ct	29	4+	Only single fish
M-21 (Tahlo)	00029BABL	Rbt	27-36		Gillnet
		Ct	23-25		
Unnamed	00338BABL	Rbt	19-28	4+ to 6+	Angling
Unnamed	00412BABL	Rbt	23		Angling
Unnamed	00376BABL	Neither			MT only - No fish

[11] Local anglers also indicate rainbow trout are present in three lakes that have not been surveyed: 00368BABL; 00436BABL; and 00451BABL.

[12] Data source for this information is lake survey files, WLAP, Smithers.

Rainbow trout captured in the small lakes tended to range in size from 10 to 32 cm fork length, with rainbow to 36 cm recorded in lower Tahlo Creek and in a lake identified as M-21 or 00029BABL. The limited aging data available for these lakes suggests most fish are age 2+ to 6+. The best aging information for lakes in the Morrison Watershed is presented in Degisi and Schell (1997) for the Hearne Hill lake (00376BABL) located in the project area.

Past sampling and trapping information suggests that Morrison Creek itself is probably not a significant rainbow trout spawning tributary despite good rainbow trout fishing. The key sport fishery for rainbow trout in the study area occurs in lower Morrison Creek and in Morrison Arm. Rainbow up to 1-2 kg are angled at these locations. Locals indicate a key time for angling in Morrison Arm is during the period of sockeye fry/smolt migration during late May and June. A sport fishery for rainbow occurs through the summer period (angling is restricted on the creek until June 15), including guided anglers based out of a lodge located on Morrison Arm (Ookpik Lodge operated by Carol Morey). Rainbow captured at this time appear to be mending post-spawned fish (Dave Hooper, pers. comm.).

The suggestion that spawning may not be significant in Morrison Creek itself is based on lack of fry during juvenile sampling programs conducted in the creek. For example only a single rainbow fry was captured at four enclosed electrofishing sites in Morrison Creek in 1988 (Bustard 1989a). Subsequent sampling (Bustard 2000 to 2002) during the spring yielded low rainbow trout yearling abundances in Morrison Creek during most years of sampling. Less than 10 rainbow trout were passed through the Morrison counting fence during the fall programs (D. Lofthouse, FOC, pers. comm.).

Rainbow trout recruitment studies throughout tributaries to Babine Lake suggest that those streams that are most heavily utilized by sockeye spawners tend to be of lesser importance as rainbow trout nursery streams (Bustard 1989a). High water temperatures may also be an issue for rainbow use of the mainstem Morrison Creek. These earlier studies on Babine Lake did identify a tributary entering from the west side of Morrison Creek (598800-10000) as one of the key rainbow trout nursery streams in Babine Lake. This stream has up to 10 km of accessible stream habitat depending upon beaver activity and spring flows, with some reaches heavily used by rainbow fry and parr. Estimates suggest this stream could potentially account for up to 5% of the overall Babine Lake rainbow trout recruitment during some years.

There are six tributaries to Morrison Lake other than Tahlo Creek that have juvenile rainbow trout present and are assumed to be potential spawning and juvenile rearing streams (Figure 1). We assume that rainbow trout from Morrison Lake utilize these streams up to impassable barriers for spawning and juvenile rearing. At the same time, headwater lake populations in most of these streams may account for rainbow presence in their mid and upper reaches.

2.4.1.2 Spawning Timing and Emergence

There is no detailed timing information for rainbow trout spawners in the Morrison Watershed. Telemetry studies of rainbow trout spawning in the Sutherland River at the south end of Babine Lake indicated a peak of rainbow trout spawning occurred at the end of May and into early June in the one year of study (Bustard 1990a). Detailed studies in another interior stream (Nithi River) suggest rainbow spawning may occur in the first two weeks of May (Lough and Bustard 1991). Timing of rainbow trout spawning in the Morrison Watershed probably varies annually depending upon water temperatures and the run-off regime in each tributary, and this can be strongly influenced by weather and the presence of headwater lakes.

Rainbow trout fry emergence is also poorly documented for specific streams in the watershed. In a study of 34 rainbow tributaries of Babine Lake, there was considerable variability in the best estimate of rainbow trout fry emergence (Bustard 1989a). Although several streams had newly-emerged rainbow fry present by mid-July, most emergence was suspected to occur from mid-July through to the first week of August in the colder streams. Some newly-emerged rainbow trout fry (<30 mm fork length) were collected by SKR (2001) during July sampling in the Morrison Watershed.

2.4.2 Cutthroat Trout

Cutthroat trout are generally uncommon in the Morrison Watershed. They have been identified in five lakes (Table 7), including three that also have rainbow present (Tahlo, M-21, and Morrison lakes) and two with only cutthroat present (Guitar and Fission lakes).

Extensive sampling throughout the Morrison Watershed indicates that juvenile cutthroat trout were present in streams in low abundance, mainly in the upper sections of Tahlo Creek (SKR 2001). Their studies suggest both stream and lake resident populations appear to be present.

We suspect lake populations have a similar life history strategy as rainbow trout, with spawning mainly in late May and emergence in late July and early August. A small sample of cutthroat sampled in streams by SKR (2001) ranged in size from 4 to 8 cm fork length and we assume these fish typically move into lake environments by age 2+. Three cutthroat samples from Morrison Lake ranged from age 2+ to 5+ (Appendix 1 Table 2). Some stream resident cutthroat may also occur in the watershed.

Lake cutthroat trout ranged from 17 to 33 cm fork length (Table 7), with the largest cutthroat reported in Fission and Morrison Lake. Cutthroat trout are only occasionally angled in Morrison Lake with most fish typically in the 30 cm size. However, the occasional cutthroat up to 46 cm may be angled (Dave Hooper, pers. comm.). Some sport fishing for cutthroat occurs on Fission Lake (Carol Morey, pers. comm.).

2.5 CHAR SPECIES

Two char species have been identified in the Morrison Watershed – Dolly Varden and lake trout. No bull trout have been documented in this watershed.

2.5.1 Dolly Varden

The northern headwaters of the Tahlo Creek Watershed support a population of Dolly Varden that are present in nearly all of the upper stream reaches with suitable habitat (Figure 1). These Dolly Varden appear to be geographically isolated from other Dolly Varden populations in the Babine Watershed. They do not appear in lake or stream samplng in the lower areas of the Morrison Watershed.

Dolly Varden reported in SKR (2001) ranged in size from 4 to 18 cm long. Two maturing fish in the 16-18 cm range suggest that these Dolly Varden are primarily stream resident fish that mature at a small size by age 3+.

There is no specific information describing the timing of spawning or fry emergence for this population of Dolly Varden in upper Tahlo Creek. However, based on information gathered in other northern interior streams we suspect Dolly Varden spawning occurs from mid-September through to mid-October (Bustard and Schell 2002). Dolly Varden often associate closely with groundwater-fed seepages that help them to survive in what appears to be the harshest of environments.

2.5.2 Lake Trout

Morrison Lake is the only location in this watershed where lake trout have been captured. Lake trout comprised a significant proportion of fish biomass (40%) during netting conducted in the mid-1940's (Table 6). The angling that does occur on Morrison Lake is primarily targeting on lake trout, with use largely coming from staff at the logging camp, a guide outfitter for this area, and a fishing guide located on Morrison Arm, with most activity during the summer and early fall period.

A sample of 56 lake trout captured in Morrison Lake ranged from 25 to 84 cm (Appendix 1 Table 1). The mean weight of 2.3 kg per lake trout reported in Table 6 is identical to the mean weight of a sample of 78 lake trout measured during a creel survey in Babine Lake in 1986 (Bustard 1987). Locals report the largest lake trout angled in Morrison Lake was just over 7 kg, with fish 5 to 6 kg not uncommon (Dave Hooper, pers. comm.).

Life history information is available describing Babine lake trout (Bustard 1987), but this may be quite different for Morrison fish due to a long period of angler exploitation of the Babine lake trout population compared to Morrison Lake where access for fishermen has been limited.

Detailed stomach content analyses of lake trout sampled in Morrison Lake is summarized in Appendix 2. Whitefish, kokanee, sockeye and other fish species were all present in lake trout's diet.

Lake trout spawning areas in Morrison Lake have not been identified. Generally lake trout spawn in the fall in shallow shoal areas of the lake at night.

2.6 BURBOT

Burbot have only been sampled in Morrison Lake, where they comprised less than 2% of the gillnet catch (Table 6). Nine burbot captured in Morrison Lake during the mid-1940's netting program ranged in size from 50 to 62 cm fork length (Appndix 1).

Life history information for Babine Lake burbot is summarized in Bustard (1987). Most of the Babine information was collected while the burbot were concentrated and feeding on sockeye smolts migrating through Nilkitkwa Lake.

Setline permit information suggested that Babine Lake had the most important burbot fishery in the 74 lakes of Skeena Region where burbot were fished in the period 1979 to 1985 (Information on file, WLAP Smithers) [13]. The old setline information also indicates that a fishery for burbot does occur on Morrison Lake with up to 60 burbot taken in some years during the period of record. Burbot fishing still occurs on Morrison Lake, mainly during the fall hunting season (Dave Hooper, pers. comm.).

Burbot spawn during the winter under ice typically over sand and gravel in shallow bays or shoals (Scott and Crossman 1973). Some movements of juveniles may occur into streams, and a single juvenile burbot was sampled in Morrison Creek (Bustard 1989).

2.7 WHITEFISH

Two species of whitefish occur in the study area - lake and mountain whitefish. Both species have been reported in Morrison and Tahlo lake surveys (FISS).

Lake whitefish were the predominant fish species captured in Morrison Lake comprising over 48% of the catch while mountain whitefish comprised 2% of the gillnet catch (Table 6). Detailed length information describing the two species is presented in Appendix 1. Whitefish were also present in the trawl catches in Morrison Lake (Table 3).

Sub-adult mountain whitefish have been captured in low abundance in Morrison Creek (Diversified Ova Tech Ltd. 1996; Bustard 2002) and in lower Tahlo Creek (Bustard 2001). Extensive sampling in smaller streams throughout the watershed did not indicate whitefish use of these smaller streams (SKR 2001; Triton 2003). Spawning and early fry rearing locations for lake populations have not been well documented.

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[13] Preliminary enquiries indicate that this information is no longer collected.

It is interesting to note that large numbers of whitefish spawners were observed at the Morrison Creek counting fence during late October and early November. The migration began during the second week of October, peaked around October 20-25th, and was over by the second week of November. At their peak, fence operators were passing "high hundreds per day" at the Morrison fence (Doug Lofthouse, FOC, pers. comm.).

2.8 OTHER FISH SPECIES

Other fish species have been reported throughout the lakes and streams of Morrison Watershed. Redside shiners and longnose dace were common in Morrison and lower Tahlo and Haul creeks (Bustard 1989b; Bustard 2000 to 2002). Redside shiners were also present in four of the smaller lakes in the Morrison Watershed (Table 8).

Table 8. Summary of other fish species information collected at 10 lakes in the Morrison Watershed[14].

Lake	Waterbody Identifier	Fish Species	
Morrison	00221BABL	CSU/LSU/LW/MW/NSC/PCC	
Hearne Hill	00371BABL		Only rainbow trout
Haul	00172BABL	LW/PCC	
Tahlo	00171BABL	CSU/LW/MW/NSC	
Fission	00068BABL	LSU/RSC/NSC	
Guitar	00128BABL	LKC	Also cutthroat
M-21 (Tahlo)	00029BABL		Short gillnet set - trout only
Unnamed	00338BABL	CAS/LKC/LSU/NSU	
Unnamed	00412BABL	CAS/RSC	Angling /minnow traps
Unnamed	00376BABL	No fish	Minnow trapped only

Fish Codes:			
CAS	Prickly Sculpin	MW	Mountain whitefish
CSU	Coarsescale sucker	NSC	Northern pike minnow
LKC	Lake chub	PCC	Peamouth chub
LNC	Longnose dace	RSC	Redside shiner
LSU	Longnose sucker	WSU	White sucker
LW	Lake whitefish		

[14] Data source for this information is lake survey files, WLAP, Smithers. Additional Tahlo and Morrison lakes information from Bustard (2002). See Figure 1 for location of lakes.

Three species of suckers have been reported in the watershed (Table 8). Longnose suckers have been sampled in Morrison, Tahlo, Fission and 00338BABL. Largescale suckers have been reported in Tahlo and Morrison lakes and Morrison Creek, and white suckers have been identified in 00338BABL.

Prickly sculpins have been reported in Morrison and Tahlo lakes, 00338BABL, and 00412BAB (Table 8). They have been sampled in lower Tahlo and Morrison creek and we suspect they are present in stream sections closely associated with these lakes.

Lake chub were present in Guitar Lake and 00338BABL. Peamouth chub are known to be present in Morrison and Haul lakes and stream sections near these lakes. Size information from historical information collected in Morrison Lake is presented in Appendix 1.

Northern pike minnows were present in Morrison, Tahlo and Fission lakes (Table 8), as well as Tahlo, Haul and Morrison creeks (Bustard 2002). They were common in the net catches in Morrison Lake, comprising 9% of the catch (Table 6 and Appendix 1).

3.0 STATUS OF FISH INFORMATION SPECIFIC TO THE BOOKER MINERALS IMMEDIATE PROJECT AREA

Based on a review of the existing baseline fisheries information, the following areas to focus fish studies have been identified:

Creeks 07100, 20000 and 23700

There is no existing fish sampling information describing use of these small creeks draining the west side of Hearne Hill. Fish Reconnaissance Inventory Information mapping (1:20,000) infers fish presence in these creeks. These creeks are particularly sensitive in that they are drain directly into the most critical spawning sections of Morrison Creek, the highest value habitat in the watershed.

Creek 25500

Similar comments to above except this creek drains into the outlet area of Morrison Lake, near the old sockeye hatchery location.

Creek 29000

At present this is a key stream in terms of potential impacts from the mine development.

Three sample sites located in Creek 29000 have been located upstream from a 10 m falls – all suggesting no fish presence in the upper section of this key creek. However, the headwater lake has only been sampled using minnow traps, and needs more detailed

assessment work including gillnetting. Also the small pond below the lake needs to be sampled (gillnet and minnow traps)

The lower section of this creek from the falls to the lake needs to be evaluated, particularly the potential of fish use of the lower section for spawning. As well, fish rearing use and the amount of habitat in the lower creek needs detailed description for presentation in an impact assessment.

Creek 44800

One fish sample site at the lower end of this creek indicates rainbow trout use of this system (fry and parr). Sampling in the headwater lake (Degisi and Schell 1997) is thorough and provides excellent background information for this lake. Sampling in a headwater pond by Triton (1999) also indicates rainbow present at the headwaters of this major tributary to Creek 44800.

Together this information implies that rainbow trout are present throughout this tributary and may represent a mix of populations associated with the headwater lake (00371BABL) and probably rainbow trout from Morrison Lake using the lower and mid-reaches. There is also some indication that sockeye beach spawning may occur along the shoreline of Morrison Lake in the vicinity of this creek with some spawning in the very lowest end of this creek during some years.

More extensive spawning and rearing studies on this tributary are a high priority, as some aspects of the mine footprint may be located in this watershed.

Creek 53400

Fish distribution in this creek has been delineated quite well during the reconnaissance inventory mapping. Seven sample sites were located above and below barriers located on the two forks of this tributary. No fish were located upstream from these barriers. Rainbow trout, presumably associated with Morrison Lake, were sampled below the barriers.

More extensive spawning and rearing studies, and habitat descriptions on this tributary are also a high priority, as some aspects of the mine footprint may be located in this watershed.

Morrison Lake

Morrison Lake is an important nursery system for sockeye salmon fry spawned in lower Tahlo Creek and for some shoreline spawning populations. Some of the baseline fisheries information available for Morrison Lake is derived from surveys conducted

more than 50 years ago. Information derived from data archived at the Pacific Biological Station provides solid baseline historical data for the lake fish populations. Based on these data and comments from local anglers, lake trout appear to be a key resident sport fish in this lake.

Since the proposed project is located on streams flowing directly into Morrison Lake, better background information for the lake will be important. More current sampling describing fish populations in the lake, particularly in the southern half of the basin, should be undertaken and coordinated with fish health and baseline metal sampling programs. Lake whitefish may be the most suitable sentinel fish species to use for the baseline fish health assessments.

Delineation of shore spawning locations for sockeye, lake trout and potentially kokanee in the vicinity of the key tributary inflows from the potential mine area is an important aspect of the fish assessment.

Morrison Creek and Tributary 10000

The status of sockeye and coho salmon stocks using Morrison Creek has been well documented and indicates they are of considerable regional significance.

Rainbow trout provide an important sport fishery in Morrison Creek and Morrison Arm. Information delineating whether populations in Morrison Lake and Babine Lake are directly linked is not available. Although Creek 10000 (a tributary to Morrison Creek) is located outside of the immediate area of the mine proposal, past studies have indicated this is a key rainbow trout tributary to Morrison Creek and presumably Babine Lake.

Further work on this tributary may identify potential compensation sites for rainbow trout, as one key section of this watershed appears to be barren due to a downstream fish barrier.

4.0 LITERATURE CITED

Brett, J.R. 1952. Skeena River sockeye escapements and distribution. J. Fish. Res. Bd. Can. 8: 453-468.

Bustard, D. 1987. Babine Lake creel survey. Prepared for Ministry of Environment, Smithers.

Bustard, D. 1989a. Assessment of rainbow trout recruitment from streams tributary to Babine Lake. Prepared for Ministry of Environment and Parks, Smithers.

Bustard, D. 1989b. Fish distribution in five streams on the west arm of Babine Lake and in the Morrison Lake area. Prepared for Houston Forest Products Ltd.

Bustard, D. 2000. Coho fry sampling results in the Morrison Watershed. Man. report prepared for the DFO, Habitat Enhancement Branch, Vancouver, B.C.

Bustard, D. 2001. Coho fry sampling results in the Morrison Watershed. Man. Report prepared for the DFO, Habitat Enhancement Branch, Vancouver, B.C.

Bustard, D. 2002. Coho fry sampling results in the Morrison Watershed. Man. Report prepared for the DFO, Habitat Enhancement Branch, Vancouver, B.C.

Bustard, D. 1990a. Sutherland River rainbow trout radio telemetry studies 1989. Prepared for Ministry of Environment, Smithers.

Bustard, D. 1990b. Assessment of coho salmon recruitment from streams tributary to Babine Lake. Prepared for Dept. of Fisheries and Oceans, Prince Rupert.

Bustard, D. and C. Schell. 2002. Conserving Morice Watershed Fish Populations and Their Habitat Stage II Biophysical Profile. Prepared for Community Futures Development Corporation of Nadina, www.cfdcnadina.ca/html/environment.html

Degisi, Joseph S. and C. Schell. 1997. A Reconnaissance of Unnamed Lake, Watershed Code: 480-5988-448-02. Prepared for Ministry of Sustainable Resource Management, Victoria, BC.

Diversified Ova Tech. 1996. Report on the 1996 Morrison Creek fence operation. Prepared for Fisheries and Oceans Canada, Vancouver.

Diversified Ova Tech. 1999. Report on the 1998 Morrison Creek coho enumeration project. Prepared for Fisheries and Oceans Canada, Vancouver.

Environment Canada. 1979. Historical streamflow summary – British Columbia. Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa.

Fish Wizard. 2004. http://pisces.env.gov.bc.ca

FISS. Fisheries Information Summary System. www.bcfisheries.gov.bc.ca/fishinv/fiss.html

FOC. 2003. SEDS (Salmon Escapement Data System). Pacific Biological Station, Nanaimo, B.C.

Foote, C.J. 1987. An experimental examination of behavioural isolation between sockeye and kokanee, the anadromous and non-anadromous forms of *Oncorhynchus nerka.* PH.D. University of B.C.

Graham, C.C. 1976. Biophysical stream survey of several streams in the Babine-Nilkitkwa Area. Fisheries and Marine Service Data Report.

Griffith, J.S. 1968. Growth and feeding of rainbow trout (*Salmo gairdneri*) and lake trout (*Salvelinus namaycush*) from Babine Lake, British Columbia. Honours thesis, Zoology, Univ. of Victoria.

Groot, C. 1972. Migration of yearling sockeye salmon (*Oncorhynchus nerka*) as determined by time-lapse photography of sonar observations. J. Fish. Res. Board Can.29:1431-1444.

Gottesfeld, A.S., K. Rabnett, and P.E. Hall. 2002. Conserving Skeena Fish Populations and Their Habitat. Skeena Stage 1 Watershed–based Fish Sustainability Plan. Skeena Fisheries Commission.

Hamilton, S. 1988. Results of a three year monitoring program of log handling activities on Babine Lake 1983-1985. Prepared by Dept. of Fisheries and Oceans Habitat Management Unit, Prince Rupert.

Hancock, M.J., A.J. Leaney-East, and D.E. Marshall. 1983. Catalogue of salmon streams and spawning escapements of Statistical Area 4 (Upper Skeena River). Can. Data Report of Fisheries and Aquatic Sciences No. 394.

Hatlevik, S.P. 1981. A Fisheries Inventory of Some Streams within the Morrison Lake-Hatchery Arm Portion of Babine Lake. Skeena Fisheries Report No. 80-5.

Lake Babine Nation. 2003. 2002 Babine Lake tributary juvenile coho assessment program. Prepared for Fisheries and Oceans Canada Stock Assessment Prince Rupert.

Levy, D.A. and K.J. Hall. 1985. A Review of the Limnology and Sockeye Salmon Ecology of Babine Lake. Westwater Technical Report No. 27. Prepared for the Westwater Research Centre, UBC in cooperation with B.C Ministry of Forests Forest Service, Prince Rupert Forest Region.

Levy, D.A., K.J. Hall, and I. Yesaki. 1985. Log transportation impacts on Babine Lake: Post-impact conditions in Houston Forest Products Operating Sites. Phase III. Westwater Research Center, U.B.C. 98 pp.

Lough, M. and D. Bustard. 1991. Nithi River rainbow trout spawning studies 1990. Prepared for Ministry of Environment, Smithers.

McDonald, P.D.M. and H.D. Smith. 1980. Mark-recapture estimation of salmon and smolt runs. Biometrics 36:401-417.

McMahon, V.H. 1948. A comparative limnological study of Lakelse and Morrison lakes, B.C. with a view to assessing the suitability of Morrison Lake for the propagation of sockeye salmon. MS. Thesis. University of BC.

Ministry of Sustainable Resource Management (MSRM). 2004. Morice land and resource management plan. Public Review Draft.

Morell, M. 2000. Status of salmon spawning stocks of the Skeena River system. Unpublished report prepared for the Northwest Institute for Bioregional Research.

Pritchard, A.L. 1953a. Sockeye salmon migration in Babine River and Lake as indicated by tagging at the Babine fence in 1946. Fish. Res. Board Can. MS Rep. 532.

Pritchard, A.L. 1953b. Sockeye salmon migration in Babine River and Lake as indicated by tagging at the Babine fence in 1947. Fish. Res. Board Can. MS Rep. 536.

Scott, W.B. and E.J. Crossman. 1973. Freshwater Fishes of Canada. Bull. 184. Fisheries Research Bd. of Canada, Ottawa.

SKR Consultants Ltd. 2001. Reconnaissance (1:20000) Fish and Fish Habitat Inventory at Three Sub-basins in the Morrison Creek Watershed. Prepared for Houston Forest Products Co.

SKR Consultants Ltd. 2000. Reconnaissance (1:20000) Fish and Fish Habitat Inventory at Six Sub-basins in the Morrison Creek Watershed. Prepared for Houston Forest Products Co.

Shortreed, K.S., J.M.B. Hume, K.F. Morton, and S.G. MacLellan. 1998. Trophic status and rearing capacity of smaller sockeye nursery lakes in the Skeena River System. Can. Tech. Rep. of Fisheries and Aquatic Sciences 2240.

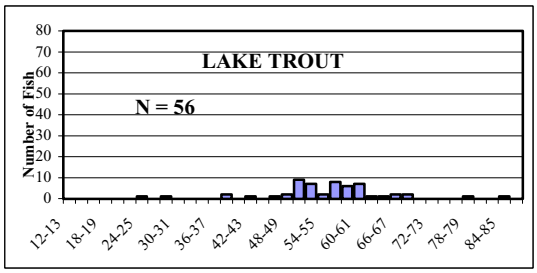
Shortreed, K.S., K.F. Morton, K. Malange and J.M.B. Hume. 2001. Factors limiting sockeye production in selected B.C. Nursery Lakes. Canadian Stock Assessment Secretariat Research Document 2001/098.

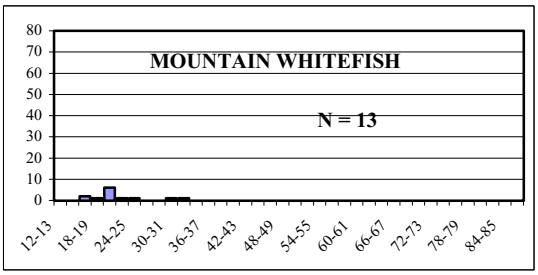
Smith, H.D. and F.P. Jordan. 1973. Timing of Babine Lake sockeye salmon stocks in the north-coast commercial fishery as shown by several taggings at the Babine counting fence and rates of travel through the Skeena and Babine Rivers. Fish. Res. Board Can. Tech. Rep. 418:31 p.

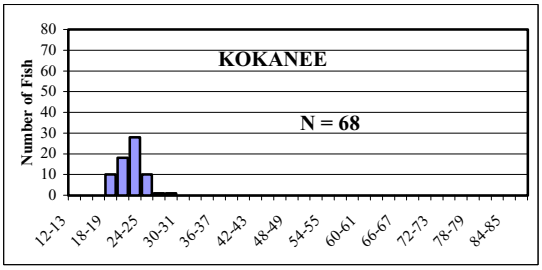
Triton Environmental Consultants. 1999. Reconnaissance (1:20000) Fish and Fish Habitat Inventory in the Babine Lake Watershed. Prepared for Northwood Pulp and Timber Ltd.

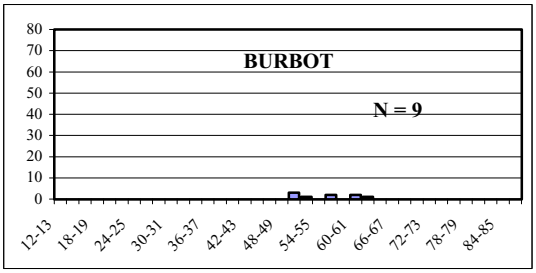
Triton Environmental Consultants. 2003. Reconnaissance (1:20000) Fish and Fish Habitat Inventory in the Tochcha Lake Watershed and Select Tributaries to Babine Lake. Prepared for Canadian Forest Products Ltd.

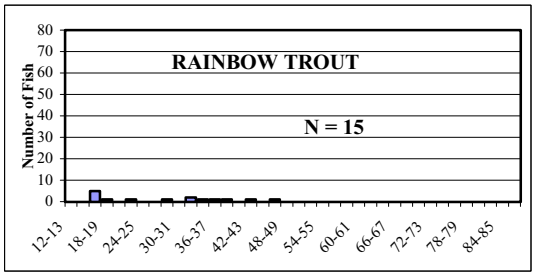
Appendix 1 Figure 1. Length-frequency distributions of fish species captured from gill netting in Morrison Lake from 1945 to 1948.

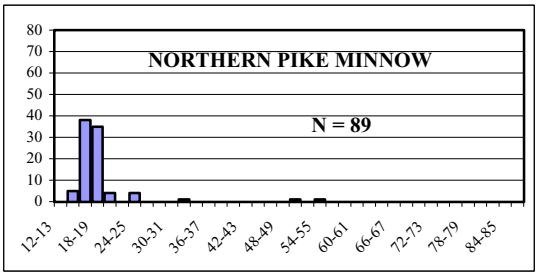


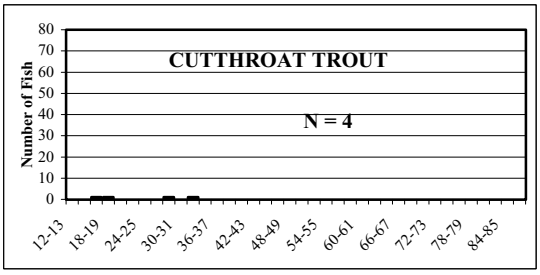


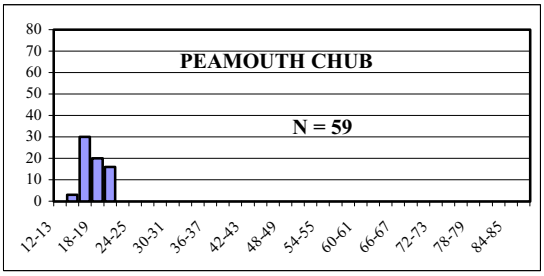


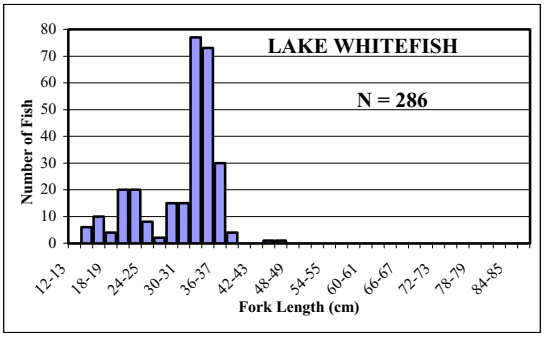


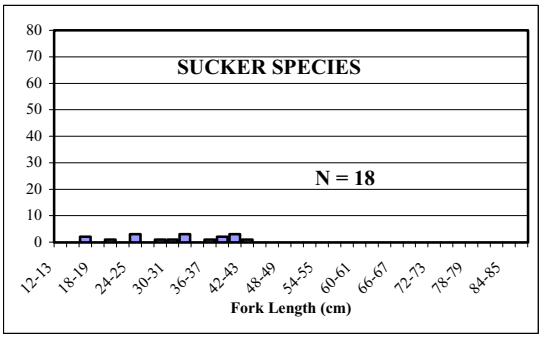












Appendix 1 Table 1. Summary of length-frequency for fish species gillnetted in Morrison Lake from 1945 to 1948.

Species		Fork Length (cm)	Weight (kg)
Lake Trout			
	Mean	55.9	2.29
	Range	24.8-83.8	0.34-8.64
	Std Dev.	8.98	1.35
	N	56	29
Kokanee			
	Mean	21.9	0.17
	Range	18.4-27.9	0.11-0.34
	Std Dev.	2.09	0.07
	N	68	37
Rainbow Trout			
	Mean	27.5	0.54
	Range	15.9-46.4	0.23-0.91
	Std Dev.	10.79	0.28
	N	15	4
Cutthroat Trout			
	Mean	24.1	nm
	Range	17.1-33.0	
	Std Dev.	7.65	
	N	4	
Lake Whitefish			
	Mean	30.3	0.45
	Range	14.6-45.7	0.03-1.36
	Std Dev.	6.10	0.25
	N	286	90

Species		Fork Length (cm)	Weight (kg)
Mountain Whitefish			
	Mean	21.6	0.11
	Range	15.9-32.4	0.11
	Std Dev.	4.88	0.00
	N	13	2
Burbot			
	Mean	55.4	1.18
	Range	49.5-62.2	0.91-1.59
	Std Dev.	5.08	0.30
	N	9	5
Northern Pike Minnow			
	Mean	18.6	0.18
	Range	14.6-54.6	0.09-1.93
	Std Dev.	5.71	0.32
	N	89	32
Peamouth Chub			
	Mean	17.4	0.11
	Range	14.0-20.3	0.06-0.11
	Std Dev.	1.40	0.01
	N	59	21
Suckers			
	Mean	31.2	0.57
	Range	15.9-43.2	0.23-1.14
	Std Dev.	8.49	0.39
	N	18	4

This data is derived from archived files stored at the Pacific Biological Station in Nanaimo and represents a combination of information collected during the four years of field surveys on Morrison Lake.

Appendix 1 Table 2. Rainbow and cutthroat trout and kokanee scale aging information from 1945 to 1947 Morrison Lake fish samples.

Location	Fish ID	Species	FL (cm)	Sex	Age
Morrison Lake	M4754	CT	17	F	2+
Morrison Lake	M4770	CT	29	F	5+
Morrison Lake	M4755	CT	33	F	4+
Morrison Lake	M47110	KO	16	F	2+
Morrison Lake	M47175	KO	18	F	2+
Morrison Lake	M47151	KO	19	F	2+
Morrison Lake	M47152	KO	19	F	2+
Morrison Lake	M47176	KO	19	F	2+
Morrison Lake	M47181	KO	19	M	2+
Morrison Lake	M47171	KO	20	F	2+
Morrison Lake	M47174	KO	20	M	2+
Morrison Lake	M47182	KO	20	M	2+
Morrison Lake	M47164	KO	20	F	2+
Morrison Lake	M47178	KO	20	F	2+
Morrison Lake	M47109	KO	21	M	2+
Morrison Lake	M47150	KO	21	F	2+
Morrison Lake	M47169	KO	21	M	2+
Morrison Lake	M47172	KO	21	M	2+
Morrison Lake	M47173	KO	21	F	2+
Morrison Lake	M47111	KO	22	M	2+
Morrison Lake	M47180	KO	23	F	2+
Morrison Lake	M47170	KO	23	M	3+
Morrison Lake	M47179	KO	23	F	3+
Morrison Lake	M47108	KO	24	M	3+
Morrison Lake	M47132	KO	24	F	3+
Morrison Lake	M47177	KO	24	M	3+
Morrison Lake	M4768	KO	25	M	3+
Morrison Lake	M47131	KO	25	F	3+
Morrison Lake	M4765	KO	25	M	3+
Morrison Lake	M4766	KO	25	F	3+
Morrison Lake	M4767	KO	25	M	3+
Morrison Lake	M4769	KO	25	F	3+
Morrison Lake	M47107	KO	26	M	3+
Morrison Lake	M4751	RB	17	IM	3+
Morrison Lake	M47256	RB	18	F	2+
Morrison Lake	M47153	RB	22	F	2+
Morrison Lake	M4752	RB	33	F	5+
Morrison Lake	M47313	RB	36	F	5+
Morrison River	M471	RB	43	M	4+
Morrison Lake	M4753	RB	46	F	5+
TOTAL:		**40**			

Scale aging conducted in 2004 by Birkenhead Scale Analyses on samples collected by DFO in 1940's.

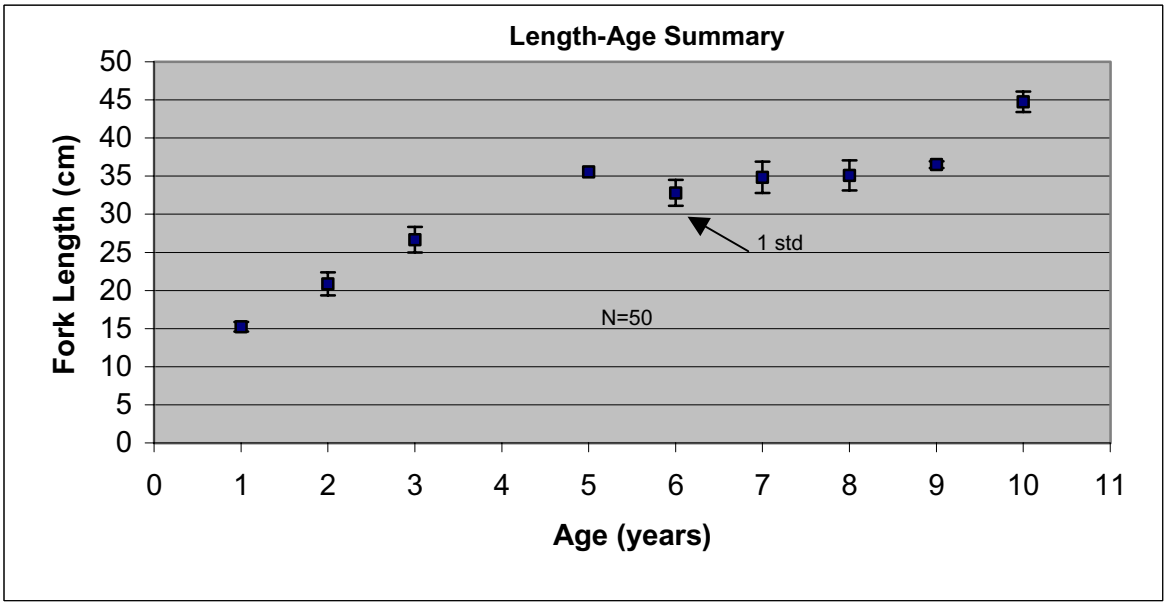
Appendix 1 Table 3. Lake whitefish scale aging information from 1945 to 1947 Morrison Lake fish samples.

Location	Fish #	FL (cm)	Sex	Age	Comments
Morrison Lake	4	15		1+	
Morrison Lake	31	15		1+	
Morrison Lake	30	15		1+	
Morrison Lake	27	16		1+	
Morrison Lake	35	16		1+	dirty scale
Morrison Lake	6	18	m	2+	vague 2nd annulus near edge
Morrison Lake	5	19		2+	
Morrison Lake	8	20		2+	
Morrison Lake	28	20		2+	
Morrison Lake	20	20	f	2+	
Morrison Lake	39	20		2+	
Morrison Lake	7	21		2+	
Morrison Lake	24	21		2+	
Morrison Lake	16	22	m	2+	
Morrison Lake	48	22	f	2+	
Morrison Lake	18	22	m	2+	
Morrison Lake	47	22	f	2+	
Morrison Lake	19	23	m	2+	stress in 2nd year
Morrison Lake	41	23	m	2+	
Morrison Lake	17	25	m	3+	
Morrison Lake	32	26		3+	
Morrison Lake	40	29		3+	1 scale only
Morrison Lake	10	36		5+	5th annulus on scale edge
Morrison Lake	34	30		6+	
Morrison River	1	32		6+	6th annulus on scale edge
Morrison Lake	9	33		6+	
Morrison Lake	42	33	f	6+	5th annulus vague
Morrison Lake	43	34	f	6+	6th annulus on scale edge
Morrison Lake	45	35	f	6+	
Morrison Lake	46	32	m	7+	
Morrison Lake	37	33		7+	
Morrison Lake	11	34	f	7+	
Morrison Lake	13	34	f	7+	
Morrison Lake	26	36		7+	7th annulus on scale edge
Morrison Lake	22	37	m	7+	
Morrison Lake	44	37		7+	
Morrison Lake	25	32		8+	8th annulus on scale edge
Morrison Lake	50	33	m	8+	
Morrison Lake	12	34	m	8+	8th annulus on scale edge
Morrison Lake	15	35	m	8+	8th annulus on scale edge
Morrison Lake	14	36	m	8+	8th annulus on scale edge
Morrison Lake	36	36	m	8+	
Morrison Lake	49	37	m	8+	only readable scale
Morrison Lake	3	38	m	8+	
Morrison Lake	21	36	f	9+	9th annulus on scale edge
Morrison Lake	33	37	m	9+	9th annulus on scale edge
Morrison Lake	23	44		10+	only 1 scale; 10th annulus on edge

Appendix 1 Table 3. Lake whitefish scale aging information from 1945 to 1947 Morrison Lake fish samples.

Location	Fish #	FL (cm)	Sex	Age	Comments
Morrison Lake	29	46		10+	starting to regenerate
Morrison Lake	2	33		n/a	regenerated; estimate 6+
Morrison Lake	38	34	f	n/a	regenerated; estimate 7+
Total - 50 samples.					

Aging conducted in 2004 by Birkenhead Scale Analyses on samples collected by DFO in 1940's.



Appendix 2 Table 1. Summary of stomach analyses of lake trout captured by gill netting in Morrison Lake from 1945 to 1948.					
	Year				
	1945	1946	1947	1948	TOTAL
# Lake Trout	3	20	23	1	47
Stomach Analysis:					
Empty		9	7		16
% of total	*0*	*45*	*30*	*0*	*34*
UID Fish	2	5	6		13
% of total	*67*	*25*	*26*	*0*	*28*
KO			2		2
% of total	*0*	*0*	*9*	*0*	*4*
LW			5		5
% of total	*0*	*0*	*22*	*0*	*11*
MW			1		1
% of total	*0*	*0*	*4*	*0*	*2*
CAS			2		2
% of total	*0*	*0*	*9*	*0*	*4*
RSC		1	1		2
% of total	*0*	*5*	*4*	*0*	*4*
PCC		1	1		2
% of total	*0*	*5*	*4*	*0*	*4*
SK	1	2			3
% of total	*33*	*10*	*0*	*0*	*6*
CO		1			1
% of total	*0*	*5*	*0*	*0*	*2*
Cyprinidae		1			1
% of total	*0*	*5*	*0*	*0*	*2*
Insect Remains		2	4	1	7
% of total	*0*	*10*	*17*	*100*	*15*
Plant Remains			9	1	10
% of total	*0*	*0*	*39*	*100*	*21*
UID = unidentified		PCC = peamouth chub			
LW = lake whitefish		SK = sockeye salmon			
ME = mountain whitefish		CO = coho salmon			
CAS = prickly sculpin		Cyprinidae = minnow family			
RSC = redside shiner		KO = kokanee			