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The Sockeye Salmon *(Oncorhynchus nerka)* of Morrison and Tahlo Lakes British Columbia, and Their Importance to the Salmon Fisheries of the Skeena Watershed

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Executive Summary:

Numerous sockeye studies of Babine Lake and Morrison River in the past century have produced an extensive literature on some of the largest sockeye producing watersheds in Canada, and provided the context for the Babine Lake Development Project (BLDP), which has been the most successful sockeye enhancement project in Canada. At the inception of the BLDP three rivers in the Babine watershed were studied for development of sockeye spawning channels: Fulton River, Pinkut Creek, and Morrison River. While Morrison River was not selected for development at that time, the future potential for the development of the Morrison watershed for additional sockeye production is still available.

The Tahlo/Morrison sockeye conservation unit (CU) is the second largest sockeye CU in the Skeena Watershed. The sockeye production of the Tahlo/Morison conservation unit contributes between 3% and 9% of the total combined escapement to Babine and Tahlo/Morrison (Babine Fence Count). DNA analysis of the Tyee Test Fishery for 2000-2010 suggests that the Tahlo/Morrison CU produces 7.5% of the total Skeena sockeye. Recorded escapements to Tahlo/Morrison are as high as 67,000. Since the escapement estimates are visual, they should probably be expanded at least two fold. Tahlo/Morrison spawners produce about one million fry that rear in Morrison Lake and Morrison Arm of Babine Lake. In 1994, nearly 500,000 fry were observed in Morrison Lake alone. Sockeye salmon are the most important sustenance item for the First Nations of the Skeena Watershed. Tahlo/Morrison contributions to Gitxsan and Gitanyow food, social, and ceremonial fisheries of the Skeena River make up between 3.2% and 8.8% of the total depending on the calculation methodology used.

The critical habitats of Tahlo/Morrison sockeye are the spawning and rearing areas. All of the subpopulations of the Tahlo/Morrison conservation unit have critical habitat in the zone of impact from the proposed Morrison Mine. Tahlo/Morrison sockeye spawn in Morrison River or upstream in Morrison Lake or Tahlo Creek. Morrison Lake and Tahlo Creek spawners rear in Morrison Lake. Tahlo/Morrison sockeye fry utilize all portions of Morrison Lake and Morrison Arm at various times of the day and parts of the year. This includes deep waters of Morrison Lake where sockeye sized salmonids were observed in 2011.

Introduction:

Salmon are an integral part of life in British Columbia. Sockeye salmon *(Oncorhynchus nerka)* in particular are the most highly valued species by Skeena Watershed First Nations for food, social, and ceremonial purposes. They have been the most sought after species in the commercial fishing industry since the nineteenth century. Recreational fishing targeting sockeye is rapidly expanding in British Columbia and in the Skeena Watershed. The health of sockeye salmon runs of the Skeena River are largely due to the contributions of the many sockeye nursery lakes found within the Skeena Watershed (Gottesfeld and Rabnett 2008). Morrison Lake and Lake Babine are two of the larger lakes within the Skeena Watershed, which collectively contribute over 88% of the sockeye salmon returns to the Skeena River system (years 1985-2007, PSC NBTC 2010). The purpose of this literature review is to provide a compilation of the published sockeye salmon fish literature on Morrison and Tahlo Lakes with references where appropriate to the much more extensive literature on Babine Lake. The focus of the report will be on sockeye salmon (*Oncorhynchus nerka*), and sockeye salmon habitat.

Overview of Morrison Lake Sockeye Salmon Biology

Numerous studies of the Babine Lake and Morrison River over the past century have made them the best studied sockeye producing watersheds in Canada. Much of this biological work was done from the 1930s through the 1970s. The focus was on the extent of sockeye spawning, the limits to sockeye production and the development of enhancement facilities (Fisheries Research Board and Dept of Fisheries 1965, Foerster1968, Ginetz 1977, McDonald and Hume 1984, Levy and Hall 1985). The numerous fisheries studies led to the successful Babine Lake Development Project (BLDP), which began construction in 1965 (Heskin 1967). The BLDP is clearly the most successful sockeye enhancement project in Canada. Three rivers in the Babine watershed were initially studied for the development of sockeye spawning channels including the Fulton River, Pinkut Creek, and Morrison River (Brett 1952). Fulton River and Pinkut Creek were ultimately selected for development, while Morrison River was dropped because of its smaller spawning population and remote location (Heskin 1967,McIntyre *et al.* 1983). There is future potential for the development of the Morrison watershed for additional sockeye production (Hume and MacLellan 2000).

The significance of Morrison river for sockeye spawning was first recognized in the 1930s, and it was one of the focal points of early visits to the Babine Lake (MacKay 1931, Brett 1952, McMahon 1948). This was in part because Morrison River was the site of the second salmon hatchery in northern BC established in 1906 (PBS Archives 1936, Marine and Fisheries, 1910), and operated for several decades (Department of Marine Fisheries Annual Report 1925). The last recorded sockeye egg take for the Morrison hatchery was probably in 1935 (PBS Archives n.d.)

There have been several studies of the fish and ecology of Morrison Lake, but few if any of Tahlo Lake (McMahon 1948, Shortreed et al 1998, 2001). Morrison Lake is a moderately oligotrophic lake in North Central British Columbia in the sub-boreal spruce zone at 743 m. elevation. Its surface area is 13 km^2, with an average depth of 21m (Shortreed et al 1998, 2001). Despite extensive logging activities in the area, Morrison Lake represents good physical habitat for sockeye salmon with: (i) a mean epilimnetic summer water temperature of 13.5º (ii) a mean thermocline depth of 6.2 m and (iii) a mean euphotic zone depth of 4.2 m (Shortreed et al. 1998). The seasonal average pH was

7.13 (Shortreed *et al.* 2001) and the total alkalinity 26.4 mg $CaCO_3$/L. Shortreed *et al.* report nitrate levels as 34 µg N/L at spring overturn, 10 µg N/L for the season average with a minimum of 1.3 µg N/L. Presumably the decline in epilimnetic nitrogen during the season reflects a nitrogen limitation on plankton growth. Phosphorus levels start at 8.5 µg/L at spring overturn and have a seasonal average of 6.9 µg/L. Fish production in Morrison Lake may be nutrient limited. Similar data for Babine Lake is presented by Stockner and Shortreed 1976.

The known fish species in Tahlo and Morrison Lakes are listed in Table 1. Whereas there are a reasonably high number of fish species in the Morrison watershed, few are limnetic (open-water) lake feeders. Shortreed et al (1998) found that sockeye comprise 72% of the open water fish in Morrison Lake, and that the total fish population is 692,172. The overall fish density was about 424 fish/ hectare in 1994 or about 1 fish per 2 square meters, which is considered medium to high density for a Skeena Lake.

Table 1. Fish species of Morrison and Tahlo Lakes

Species		Morrison Lake	Tahlo Lake
Sockeye salmon	*Oncorhynchus nerka*	X	X
Coho salmon	*Oncorhynchus kisutch*	X	X
Lake Whitefish	*Coregonus clupeaformis*	X	X
Rocky Mountain whitefish	*Prosopium williamsoni*	X	X
Northern Pikeminnow	*Ptychocheilus oregonensis*	X	X
Peamouth chub	*Mylocheilus caurinus*	X	
Lake trout	*Salvelinus namaycush*	X	
Rainbow trout	*Oncorhynchus mykiss*	X	
Burbot	*Lota lota*	X	
Cutthroat trout	*Oncorhynchus clarkii*	X	X
White sucker	*Catostomus commersonii*	X	
Longnosed sucker	*Catostomus catostomus*	X	X
Prickly Sculpin	*Cottus asper*	X	X

Source McMahon 1998, Shortreed 2001, Hatlevik 1981, BC Ministry of Environmen FISS database

Morrison Lake is dimictic, which means that it is a holomictic lake with waters that mix from top to bottom during two mixing periods each year (Lewis 1983) when temperatures are uniform with depth. During winter, Morrison Lake is covered by ice and moderately stratified with a cold water level near the surface and water temperatures near 4º C at depth. Morrison Lake may be strongly thermally stratified during summer, with temperature-derived density differences separating the warm surface waters (the epilimnion) from the colder bottom waters (the hypolimnion). A thermocline separates the two layers in the summer. It has been recorded at 10 m by McMahon (1948) and at 6.2m by Shortreed 1998. As in Babine Lake, the depth of the thermocline is probably not uniform through time (Levy and Hall 1985). Observations of variable depths of thermoclines such as those of Shortreed *et al.* 2000 for Babine Lake may be due to seiches traveling the lake length. Seiches are observed on many BC lakes as rapid at-a-station changes in the thermocline depth. It is likely that the layered summer structure of Morrison Lake water is occasionally disrupted by strong winds blowing along the lake.

Summer stratification creates a hypolimnion with low oxygen levels that may exclude fish In many lakes in the temperate zone. The oligotrophic nature of Babine Lake results in oxygen use that is slow enough that an anoxic layer does not develop (Levy and Hall 1985). This is probably also the situation at Morrison Lake. In late September 2011 there was a thermocline at 9-16 m in Morrison Lake but hypolimnic oxygen levels were suitable for fish (>7 mg/L) (SFC field notes 2011). Periods of mixing on the lake at the seasonal scale or more frequently will cool the surface waters and raise the prevailing oxygen level of deeper waters. If oxygen levels are ever limiting in Morrison Lake this would expand the zone of high fish use. Evaluation of the seasonal pattern of oxygenation and fish usage over one or more years should be undertaken before siting an effluent discharge point.

Morrison and Tahlo Lake Sockeye Biology

Adult Pre-spawning Migration and Behaviour

Morrison Lake sockeye typically arrive at the Babine counting fence after the enhanced Pinkut Creek stock and early wild populations and before the large enhanced run from Fulton River and other southern lake streams. They are thus classified as one of the few middle timed Babine migration stocks (Smith and Jordon 1973). Their timing overlaps with both the early and late portions of the Babine sockeye returns, which in turn makes them susceptible to the heavy fishing pressures placed on the enhanced stocks (Gottesfeld and Rabnett 2008). In general the middle timed stocks have declined since the completion of the Babine Lake Development Project. This could make the Morrison sockeye particularly vulnerable to environmental stresses on the population.

Morrison and Tahlo sockeye spend about a month in Babine Lake before they ascend Morrison River (Levy and Hall 1985). Observations on the timing of sockeye returns to Morrison River and Tahlo Creek were reported by Diversified Ova Tech 1996a and 1996b. Earlier observations are summarized in Hancock et al 1983. Sockeye arrive at the lower section of Morrison River in the beginning of August, peak in early September and continue to arrive in decreasing numbers until the end of September. Sockeye destined for Tahlo Creek tend to arrive earlier in the season than Babine and Morrison stocks (Diversified Ova Tech 1996a, 1996b), but they occupy their spawning beds and spawn at the same time. It appears that Tahlo sockeye hold in Morrison Lake for several weeks to a month while their gametes mature.

In other northern British Columbia sockeye populations such as Kitwanga River, Slamgeesh (Damshilgwet Creek), and Swan Lake, sockeye spend a month or more holding in lakes (Skeena Fisheries Commission unpublished data). The fish are typically deep enough (>5m) that they cannot be observed from the surface or by radiotelemetry. There are no observations of the depth of adult sockeye holding in Morrison Lake.

In Lake Washington near Seattle, sockeye spend about three months holding prior to spawning. Thermal measurements suggest that their holding behaviour was at depths of 18 to 30m (Newell 2005) in a lake that reaches 60m depth. The thermocline at Lake Washington is generally at 10-20m. Oxygen levels do not seem limiting at depth (>7 ppm). This may well be the situation at Morrison Lake which also has a maximum depth of 60m. Summer hydroacoustic surveys might locate the holding locations and depth of maturing Tahlo sockeye.

Escapement and Spawning

Tahlo/Morrison sockeye stocks includes sockeye from a variety of sources including:

Sockeye that spawn in Morrison River and rear in the Morrison Arm of Lake Babine.
Sockeye that spawn in Morrison Lake and rear in Morrison Lake or downstream in Morison Arm.
Sockeye that spawn in Tahlo Creek and rear in Morrison Lake
Sockeye that spawn in Upper Tahlo Creek and rear in Tahlo Lake or downstream in Morrison Lake

Adult sockeye escapements to Morrison River have ranged up to 46,000 in 2004 (DFO North Coast BC16 escapement database 2011). The maximum escapement to Tahlo Creek was 30,000 in 2003. The maximum known escapement to upper Tahlo Creek is 2,500 in 1959, but data exists only for 12 of the possible 61 years. The annual data set for escapement to the three census units of Tahlo/Morrison is given in Appendix 1.

The spawning capacity of Morrison River has been estimated by measuring the area of apparently suitable spawning gravel. Based on calculations presented in Fisheries Research Board and Department of Fisheries 1965, the capacity is 48,000, assuming 1.0 spawning females/square meter. The sockeye spawning capacities of Morrison Lake and Upper and Lower Tahlo Creek are unknown.

Sockeye spawning activity in the Morrison River occurs throughout the length of Morrison River (Shortreed et al. 2001), and is especially concentrated in the 2-3 km above the present road bridge (Diversified Ova 1996a, 1996b). Earlier maps of the spawning sites along Morrison River show concentrations further upstream in the few kilometers below Morrison Lake in 1933, and throughout the length of Morrison River in 1975 and 1980 (DFO BC 16 reports 1933, 1975, Hancock *et al.* 1983).

In Tahlo Creek, spawning activity is concentrated in the lower few kilometers of the creek (Diversified Ova 1996a, 1996b). Hancock *et al.* (1983) show spawning throughout the length of Tahlo Creek and recommend the removal of beaver dams. Diversified Ova (1996a, 1996b) report clearing beaver dams from Tahlo Creek. Blockage by beavers has been a recurrent problem on Tahlo Creek, especially upper Tahlo Creek, and may restrict the population size. The current status of the sockeye subpopulation in upper Tahlo Creek is unknown but is presumed to be smaller than the historic high of 2,500 (Fisheries and Oceans Canada 2011). Sockeye are recorded as present in 2007, 2009, and 2010, but the stock has not been counted since 1993. Sockeye spawners do not appear to use Haul Creek, a Morrison tributary parallel to Tahlo Creek (Brett 1951).

Lake spawners are present in Morrison Lake (Hatlevik 1981, Rescan 2008, Dickson 2010, SFC field observations 2011) where they have been reported at shallow depths where they are visible from the surface. In general where there are lake spawning populations of sockeye, visual estimates are an ineffective means of enumerating spawning adults. In some Skeena lakes, sockeye spawn at considerable depths (e.g. Morice Lake and Kitwanga Lake) and are thus severely underrepresented in visual population estimates. The problem is acute in lakes with abundant lake spawner adults such as Bear Lake and Motase Lake in the upper Skeena and Bowser Lake in the Nass. This phenomenon poses such a great problem to establishing reliable and credible population estimates of sockeye, that lake spawning populations of sockeye are in general no longer evaluated by visual counts, but rather hydroacoustic surveys of juvenile fish are conducted and the results extrapolated to adult counts. Hydroacoustic surveys of Morrison Lake are needed to assess its true sockeye population, and an evaluation of the depth of spawning adults may be also be possible with hydroacoustic techniques or the use of a remotely operated underwater vehicle (ROV).

Rearing

In most sockeye bearing lakes, sockeye fry dominate open water fish assemblages numerically, to the point that they also dominate the total fish biomass of the lakes. This appears to be the case with Morrison Lake (Shortreed *et al.* 1998).

Sockeye fry in Morrison Lake are pelagic, and typically feed at night in the open near-surface waters of the lake, above the thermocline and away from the shore. Sockeye fry spend the daytime hours concentrated in deeper water. Levy and Hall (1985) summarize studies in Babine Lake that found: “The fish remain at depth (30-45m) during daylight hours and ascend to the surface at dusk where they begin to feed actively. They descend during the night to the upper level of the thermocline. Following a dawn rise to the surface and an early-morning zooplankton meal, they descend back into the hypolimnion where they resume their daytime depth.” This feeding pattern was first described by Brett 1971 (Figure 1).

The feeding pattern described by Brett (1951) is the typical summer pattern during a period with lake stratification. In the daytime the sockeye fry are at depth often close to the lake bottom (Hume pers. com. 2011). The difficulty of recognizing sockeye fry on the lake bottom makes hydroacoustic surveying for sockeye population estimates a night-time activity. When the thermal stratification of lakes declines in the fall, sockeye fry are uniformly distributed throughout the lake, even at night. Similarly, in the winter when ice cover exists and light levels are low, sockeye fry are probably more or less uniformly distributed in the lake.

A partial hydroacoustic survey of Morrison Lake undertaken by the Skeena Fisheries Commission in late September 2011 found fish targets the size of young-of-the-year sockeye fry at all depths including at the greatest depth near the site of the effluent outlet for the proposed Morrison Lake mine.

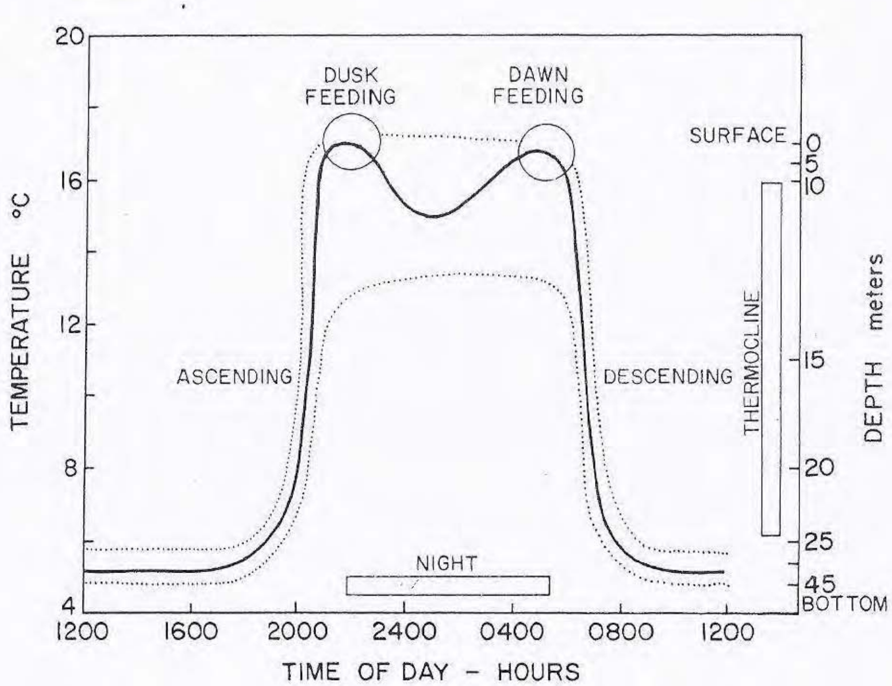

Figure 1. Pattern of diurnal movement of sockeye fry. From Brett 1971.

Morrison Lake Plankton Assemblage

Under optimal conditions the productivity of sockeye is limited by zooplankton production, which is in turn limited by the availability of nutrient chemicals for phytoplankton growth. This is the basis of the PR model assessments of productive capacity that that have been produced for British Columbia lakes by the Cultus Lake Laboratory of Fisheries and Oceans Canada (Hume and MacLellan 2000, Shortreed and Morton 2000, Shortreed *et al.* 1998, 2001, Cox-Rogers *et al.* 2004).

Shortreed *et al.* 1998 report a diverse crustacean plankton fauna in 1995 samples dominated by diaptomidae, cyclopidae, and *Heterocope* (Table 2).

Table 2. Morrison Lake Zooplankton Biomass monthly samples 1995

	mg dry wt/m3
Bosminidae	15
Cyclopidae	192
Diaptomidae	351
Daphnia	13
Heterocope	94
Epischura	4.6
Holopedium	1.6
Diaphanosoma	2.5

Source Shortreed et al 1998.

The phytoplankton reported by Shortreed *et al.*(1998) are divided into picoplankton, nanoplankton and microplankton components. Of the 10 Skeena lakes reported on in Shortreed *et al.*(1998), Morrison Lake has the highest seasonal nanoplankton and picoplankton numbers (1.53x 10^3/ml) and ranks high in chlorophyll levels and macrozooplankton biomass.

Sockeye salmon are filter feeders throughout their lives. They have very selective feeding patterns on zooplankton species such that preferred species such as *Daphnia* are often reduced to low abundances. Sockeye feeding patterns in Babine Lake and presumably Morrison Lake vary depending on time of day and light levels (Narver 1970). Sockeye fry feeding patterns also shift seasonally (Levy and Hall 1985). Zooplankton in turn, are selective feeders on phytoplankton. Abundance of the wrong species of phytoplankton leads to declines in zooplankton productivity and loss of sockeye productivity (McQueen *et al.* 2007).

The abundance and diversity of the plankton of Morrison Lake needs collection and description throughout the year so that the effects of proposed contaminant additions can be explored. Experimental work is needed on the plankton species that occur in Morrison Lake, not on species from distant regions or other continents.

Sockeye Fry Production from Morrison and Tahlo populations

McDonald and Hume (1984) suggest that 4% of the sockeye returning to Babine Lake spawn in the Morrison River system. Sockeye smolts leaving Babine Lake have been enumerated since 1959. Early sockeye smolt numbers ranged from 13 million in 1961 to 191 million in 1979 (Macdonald *et al.* 1986). The smolt counts ended in 2000. More recent numbers have been similar, ranging between 18 and 194 million (unpublished data DFO North Coast Stock Assessment). Fry count estimates have been generally two or three times larger. This suggests that assuming the Morrison River productivity is similar to the tributaries of the main basin of Babine Lake, the Tahlo/Morrison output could be between 1 to 20 million fry-stage sockeye and 0.5 million to 8 million smolt-stage sockeye.

Based on average escapements to Tahlo Creek (5,917) and Morrison River (11,860) (Fisheries and Oceans Canada 2011) and a conservative estimate of 1,000 fry produced from 4000 eggs per female (Foerster 1968) we would expect about 1.2 million fry in Morrison Arm and 600,000 fry in Morrison Lake.

Data on sockeye fry abundance is scarce, but Shortreed and Morton 2000 report between 16,000 and 600,000 fry in the Morrison Arm of Lake Babine in 1992, 1993, 1994 with high error estimates and Shortreed *et al.* 1998 report 497,000 in Morrison Lake.

The theoretical production calculations and the existing data suggest that Tahlo/Morrison produces one half to one million juvenile sockeye. It is therefore clear that 90-99% of the fish that might be affected by the proposed Morrison Mine are sockeye. More studies of the sockeye production of the Tahlo/Morrison sockeye Conservation Unit are needed. The Skeena Fisheries Commission has begun in this direction with a hydroacoustic survey at Morrison Lake in September 2011. Very preliminary estimates from this survey suggest that the sockeye fry estimate will be consistent with the results discussed above.

Morrison Sockeye Smolts

Skeena sockeye fry spend one or two years feeding and growing in lakes before undertaking their migration to sea. The majority of Babine sockeye (95%) collected as returning adults at the Babine counting weir were one year old when they left as smolts (Rutherford et al. 1999). The Morrison and Tahlo Lake sockeye apparently are almost all one year juvenile residents. Morrison River sockeye ages reported in Rutherford *et al.* 1999 show a single two-winter smolt in a sample of 1,110, and no two-winter smolts from Tahlo Creek in a sample of 330. Skeena Fisheries Commission studies (unpublished) of sockeye ages in Gitxsan fisheries on the Skeena River below Kitwanga in 2007 and 2008 (N= 28,475) record no two-winter sockeye from Morrison Lake and 3 two-winter sockeye from Tahlo Lake. Thus the Morrison Lake sockeye derived from Tahlo Creek and Morrison Lake spawners are residents of Morrison Lake from shortly after emergence in May until May of the following year when they leave as smolts. Sockeye emerging in Morrison River rear in Morrison Arm for one year.

As sockeye fry prepare to undertake their migration to the sea they turn into silvered smolts and undergo a series of physiological transitions. Morrison Lake sockeye smolts weigh 5 to 6g (Macdonald *et al.* 1986), about the middle of the size range for Skeena sockeye smolts. Tahlo/Morrison sockeye have late timing in the smolt migration at the mouth of Babine Lake. They pass the counting trap at the north end of Nilkitkwa Lake in the last week of May and the first two weeks of June (Macdonald *et al.* 1986). To reach the Babine River, they must first migrate south through Morrison Arm and then turn northwest to exit Babine Lake. The Tahlo/Morrison sockeye smolts show this type of directional movement (Johnson and Groot 1963, Groot 1965). This migration pattern is apparently genetically controlled (Simpson 1979), and if so, it represents a powerful isolating mechanism separating Tahlo/Morrison sockeye from Babine stocks.

The dispersal of Morrison River sockeye fry in May and June from their natal sites to rearing areas was studied by Levy *et al.* (1990) in Morrison Arm. The sockeye fry spend about a month in littoral areas, initially right along the lake margins then at increasing depths further from the beaches. Some sockeye fry continue to use the littoral zone well into the summer (Levy and Hall 1985). Levy *et al.* (1990) found that sockeye fry rearing in the critical rearing area of the Morrison alluvial fan portion of Morrison Arm are impacted by log storage and log accumulation.

The Wild Salmon Policy and Conservation Units

The following definitions may be helpful to keep in mind regarding the discussion and development of the Department of Fisheries and Oceans Wild Salmon Policy:

Conservation status: The state of a species or in the context of the Wild Salmon Policy, a Conservation Unit, relative to reference points or benchmarks related to extinction risk (Holtby and Ciruna 2007).

Conservation Unit (CU): A group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to recolonize naturally within an acceptable timeframe (Holtby and Ciruna 2007).

Fish habitat: Spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly to carry out their life processes (Holtby and Ciruna 2007).

Minimum viable population (MVP). The smallest possible size at which a biological population can exist without facing extinction from natural disasters or demographic, environmental, or genetic stochasticity (Shaffer 1981; Holtby and Ciruna 2007).

Salmon Population: A group of interbreeding salmon that is sufficiently isolated (i.e. reduced genetic exchange) from other populations such that persistent adaptations to the local habitat can develop over time (DFO-WSP 2005).

Sustainable Use: The use of biological resources in a way and at a rate that does not lead to their long term decline, thereby maintaining the potential for future generations to meet their needs and aspirations (DFO-WSP 2005).

History and Intent of the Wild Salmon Policy

The goal of the Wild Salmon Policy (WSP) is to restore and maintain healthy and diverse salmon populations and their habitats for the benefit and enjoyment of all Canadians in perpetuity by:

Safeguarding the genetic diversity of wild salmon populations,

Maintaining habitat and ecosystem integrity, and

Managing fisheries for sustainable benefits.

Conservation of wild salmon and their habitat is the highest priority for resource management decision-making (DFO-WSP 2005). Implementation of the WSP will involve an open and inclusive process aimed at making decisions about salmon stewardship that consider social, economic, and biological consequences while honouring Canada's obligations to First Nations.

Wild salmon will be maintained by identifying and managing Conservation Units (CUs) that reflect their geographic and genetic diversity. A conservation unit is a group of wild salmon sufficiently isolated from other groups such that, if lost, is very unlikely to recolonize naturally within an acceptable timeframe (e.g., a human lifetime or a specified number of salmon generations). The status of CUs will be monitored, assessed against selected benchmarks, and reported publicly (DFO-WSP 2005).

Measures for habitat protection and salmon enhancement will focus on sustaining wild salmon. An integrated approach to habitat management – involving assessment of habitat condition, identification of indicators and benchmarks, and monitoring of status – will be adopted that links fish production with watershed and coastal planning and stewardship initiatives (DFO-WSP 2005).

Ecosystem considerations will be incorporated into salmon management. Indicators will be developed to assess the status of freshwater ecosystems. Information from ocean climate studies of marine survival and of the biological condition of salmon will be integrated into the annual assessments of salmon abundance that guide salmon harvest planning (DFO-WSP 2005).

The Wild Salmon Policy will foster a healthy, diverse, and abundant salmon resource for future generations of Canadians. It will support sustainable fisheries to meet the needs of First Nations and contribute to the current and future prosperity of Canadians (DFO-WSP 2005).

Conservation Units are developed along the lines of establishing the genetic identity of a given salmonid population which fully supports the first priority of conservation under the Department of Fisheries and Oceans Wild Salmon Policy: to safeguard genetic diversity (Holtby and Ciruna 2007).

Populations Included in the Tahlo/Morrison Lake Conservation Unit:

The sockeye salmon populations that comprise the Tahlo/Morrison Conservation Unit complex are comprised of two lakes: Morrison Lake and Tahlo Lake (DFO 2009; Holtby and Ciruna 2007). Conservation units are established by determining that a high degree of genetic similarity is often observed between lakes that are in close physical proximity to each other as well as being hydrologically coupled (Holtby and Ciruna 2007). This is the case for the sockeye populations of the two lakes that comprise the Tahlo/Morrison Lake Conservation unit/complex.

Many sites in the Tahlo/Morrison Lake complex have been sampled by DFO personnel to acquire sockeye DNA data. The sockeye within the Tahlo/Morrison Lake complex have been found to be very similar genetically (DFO 2009, Beacham et al. 2005; Holtby and Ciruna 2007). Tahlo/Morrison sockeye arrive at the counting fence with intermediate timing between the early runs such as Pinkut Creek and the late run such as Fulton River. The Babine Lake conservation unit is connected hydrologically to Morrison Lake via the Morrison River but is classified as a separate conservation unit from the Tahlo/Morrison Unit (DFO 2009, Holtby and Ciruna 2007). Within the Tahlo/Morrison Conservation Unit the Morrison Lake spawners, and the Morrison River – Tahlo Creek stream spawners form two readily distinguishable subpopulations based on the nature of the spawning site, hydrology and water temperature. Among the stream spawners, the Tahlo Creek spawners tend to arrive earlier than the Morrison River spawners.

Critical Habitat of the Tahlo/Morrison Conservation Unit

Under DFO's Wild Salmon Policy the Tahlo/Morrison sockeye Conservation Unit is classified under the Middle Skeena (MSK) freshwater adaptive zone (FAZ) and has five (5) spawning sites spread across the two lakes (Holtby and Ciruna 2007). It has the second largest spawning population of Skeena sockeye populations. The survival of sockeye in this conservation unit requires the preservation of critical habitat which consists of specialized spawning habitat and specialized rearing habitat.

Spawning areas

The defined spawning areas are critical habitats that determine the production of this unit. They have gravels that can be excavated by female sockeye and very likely have a hyper-loose packing arrangement that facilitates excavation by female sockeye and high permeability that results in good egg to fry survival rates (Gottesfeld *et al.* 2008, Hassan *et al.*2008). The high rates of water flow through these gravels are dependent on special hypabyssal flow conditions (Stanford *et al.* 2004). These special conditions make it hard to replace or expand spawning areas.

Rearing areas

The rearing areas are Morrison Lake and Morrison Arm. There may also be rearing capacity in Tahlo Lake. Successful rearing is dependent on having a stable oligotrophic lake with high micro-crustacean zooplankton productivity. Improving sockeye production by altering sockeye rearing habitats through lake fertilization has been tried in many lakes in British Columbia with few successes (Hyatt et al 2004).

Specific Critical Habitat for Tahlo and Morrison Sockeye Subpopulations

The critical habitats of the sockeye that spawn in Morrison River are the gravels of the river that eggs are laid in and Morrison Arm where the first year of life occurs. The shallow waters of Morrison Arm near the mouth of the Morrison River are particularly sensitive since the first month of growth occurs there (Levy and Hall 1985, Levy *et al.* 1990). This is the period of the highest rate of sockeye mortality (Foerster 1968). Waters derived from Morrison Lake dominate the hydrology of this area.

The critical habitats for sockeye that spawn in Tahlo Creek are the gravels of Tahlo Creek that eggs are laid in and Morrison Lake where the first year of life occurs. The sockeye fry rear in Morrison Lake and use all of the areas of the lake at least for part of the year.

The critical habitat for sockeye that spawn in Morrison Lake is the gravels along the shore of Morrison Lake, especially the gravels near the narrow portion of the lake below the proposed tailings pond (stream 44800 of Rescan 2008). Rearing is in Morrison Lake where the first year of life takes place. The sockeye fry probably use all of the areas of the lake at least for part of the year. Some presumed sockeye fry have been observed in the area of the proposed effluent diffuser.

A particular difficulty in planning a large mine and mill in the Tahlo/Morrison Conservation Unit is that all of the constituent subpopulations have critical spawning and/or rearing habitat adjacent to the proposed mine, mill, and tailings complex where impacts might be expected.

Morrison River Enhancement Potential

Research conducted by Hume and MacLellan 2000 in the Morrison Arm of Lake Babine indicated sockeye fry densities did not exceed 600 fish/ha in 3 years of surveys, leading to the conclusion that Morrison Arm has considerable room for more sockeye fry (Hume and MacLellan 2000). Using the photosynthetic rate (PR) models based on primary production of Hume et al. (1996) and Shortreed et al. (1999) to predict the juvenile sockeye rearing capacity of a lake nursery area, Hume and MacLellan predicted an escapement of 42,000 spawning sockeye would produce 2.3 million smolts (~2,000 smolts/ha) from Morrison Arm (Hume and MacLellan 2000). Hume and MacLellan applied this proportion to the PR model estimate replicating the methods of Shortreed et al. (1998) resulting in an escapement prediction of 21,000 sockeye to reach the rearing capacity of Morrison Arm (Hume and MacLellan 2000). Thus by Hume and MacLellan's reasoning only 50% of Morrison Arm's sockeye rearing capacity is being realized (Hume and MacLellan 2000). Similar reasoning can also be applied to ascertaining the sockeye rearing capacity of Morrison Lake.

A recent review of the productive status of Skeena sockeye lakes (Cox-Rogers et al 2004) shows Morrison Lake as having the second largest potential for increased production of sockeye in the Skeena watershed (Table 5). At that time, Morrison Lake was operating at only 20% of its productive capacity (Cox-Rogers et al. 2004). The full potential of Morrison Lake's sockeye rearing capacity has not yet been realized because of low escapements and low fry recruitment to the system (Cox-Rogers et al. 2004). In order for Morrison Lake's sockeye rearing potential to be fully realized, more information needs to be collected on escapement rates, limnetic fish abundance and growth rates, and an up-to-date limnological assessment of the current situation in Morrison Lake needs to be acquired (Cox-Rogers et al. 2004).

Spawning channels can contribute to sockeye populations only if the population is limited by available spawning area. This is unlikely for Morrison and Tahlo sockeye where the populations appear to be recruitment-limited (Cox-Rogers *et al.* 2004, Shortreed *et al.* 2001), which is to say that expansion of the sockeye populations is best accomplished by decreasing the exploitation in various fisheries. The potential for a spawning channel for sockeye in the Morrison River is limited by irregular stream flows (Cox-Rogers et al. 2004; Wood et al. 1997). There is a role for a spawning channel if it would result in improved egg to fry survival.

The easiest and most effective activity for increasing sockeye spawning area would be to improve access to the upper part of the Morrison Watershed by the regular removal of large beaver dams that occasionally block Morrison River occasionally and often block Tahlo Creek below and above Tahlo Lake. Dam removal of larger structures was accomplished in the past when sockeye surveys were conducted on foot and may have in part produced the larger escapements of 1950-1975.

In the early 1990s Green Plan funds were used to re-evaluate the feasibility of enhancing Morrison River sockeye salmon, both to increase fry recruitment to Morrison Arm, and to increase the productivity of the run to ensure its conservation while permitting increased harvest rates on Pinkut-Fulton sockeye salmon with the same run-timing (Wood et al. 1997). The surveys confirmed that fry densities are typically lower in Morrison Arm than in the main basin of Babine Lake (Shortreed et al. 2000a), and that unused and apparently suitable spawning habitat exists in the Morrison River and its tributaries. Shortreed et al. (2000a) and Cox-Rogers et al 2004 suggest that wild spawning escapements to the Morrison River system currently limit sockeye fry recruitment to Morrison Arm.

No decision regarding enhancement has been made for the Morrison system, with the most recent activities focused on improving opportunities for wild spawning through beaver dam control (Wood et al. 1997). At the current densities or even at several times the current densities Morrison Lake productivity is not limited by available plankton production determined by nutrients; therefore fertilization of the lake would not increase production. It is possible for Tahlo/Morrison sockeye production to be increased by hatchery rearing of fry and out plants to Morrison Arm (Cox-Rogers et al. 2004). However many such efforts in the past few decades have failed to reach their objectives, such that hatchery supplementation is generally considered a poor choice (Naish et al 2008, McClure et al 2008). The trend in recent studies of wild population conservation and enhancement is to emphasize the importance of preserving the productive capacity of the original habitat.

Morrison Sockeye contributions to Skeena Sockeye Runs

Salmon are an important commercial resource in British Columbia. As salmon return from the North Pacific to the coast and swim to upstream spawning areas they are subject to a series of commercial, First Nations and recreational fisheries. In the Skeena watershed, salmon fishing typically removes about 60% of the initial stock. As fish return to their spawning areas, the total number of returning salmon may be assessed at various stages, providing a series of estimates as the sockeye stocks decrease following the sequence of fisheries. Commonly used measures taken at sequential stages in the returns are:

(a) Total returns (from the North Pacific),

(b) Returns to Canada,

(c) Returns to the Skeena River,

(d) Returns to Babine Lake (terminal returns) and

(e) Spawning escapements.

The initial measure (total returns) is often more than twice the escapement (Wood et al 1998) based on fence counts. Evaluation of the proportions of contributions to the final escapement requires using similar measures of stock size. Confusing and misleading conclusions may be drawn from combining the various stages in this sequence of returns and escapement.

The Babine counting fence numbers are returns. The fence count includes First Nations and recreational fisheries at and above the fence and various unaccounted losses. First Nations fisheries range from several tens of thousands (1950-1990) to 455,756 in 2000 and 509,760 in 2001 with an average of 58,928 (DFO North Coast Stock Assessment BC16 Summary 2011). The recreational fishery is generally much smaller, accounting for less than several tens of thousands of fish in the few years of known exploitation rates. The Babine Sub-area total is calculated by excluding these known removals from the Babine fence count. The DFO and the Canadian delegation in the Pacific Salmon Treaty use the Babine Sub-area total, rather than the Babine Fence counts (Gazey & English 1996) for Babine sockeye accounting.

Furthermore, where visual counts are used, they typically underestimate the escapement, generally by a factor of two or three times in the Skeena Watershed. The problem of undercounting sockeye escapement at Babine Lake tributaries by using visual estimates has been recognized since at least 1946. Brett (1952) provides data that compares fence counts to visual counts and shows the correction factor to be 2.17 for the 1946 Babine Fence count and 2.04 for the 1947 Babine Fence count. Wood *et al.* 1995, 1997b expand the counts of visually enumerated sockeye with a "parsimonious" model. The expansion value for visually enumerated Babine stocks used in recent modelling by the Pacific Salmon Commission (PSC 2010) and Gazey (2008) is 2.59. Expansion for counts of non-Babine escapements is generally 3.60.

There are various unaccounted losses in addition to the Babine fishery removals. The "unaccounted" component is the difference between the sum of escapement estimates and the Babine Sub-area total. The "unaccounted" component includes mortality in the lake, uncounted lake spawners, and undercounted stream escapements (visual counts). The annual unaccounted Babine sockeye range from 13,078 to 503,831 with an average of 173,055 (DFO BC 16 Summary 2011). It is very likely that there are some lake spawners in Babine Lake and there must be some loss due to parasites and disease, but even if the stream visual undercount ratios are only half of the general Skeena level it is the principal component of the "unaccounted" category. Since undercounts of streams are a significant part of the "unaccounted" component we prefer to use the escapement total for comparison with the Morrison escapement.

Estimates of the Morrison and Tahlo Lake Sockeye Contributions

Since the mid-1990s, genetic techniques have been increasingly used to evaluate fisheries and salmon returns. Microsatellite DNA techniques developed by the DFO Salmon Genetics Laboratory in Nanaimo (Beacham *et al.* 2005a, 2005b, 2006) are the most popular of such techniques in Canada. Genetic analysis produces a reliable and repeatable classification of the stocks of origin for all sockeye specimens. The Tyee Test Fishery collects daily samples of the salmon entering the Skeena watershed throughout the season. The collections since 2000 have been analyzed for microsatellite DNA and summed by week and year of collection. The results of these analyses (Table1) are discussed below.

We attempt to establish the proportions of Morrison sockeye in the total Skeena returns and Babine Lake aggregate and compare the results by three techniques:

The DNA proportions for the last decade (2000-2010)

Escapement counts for the last decade (2000-2010)

Escapement counts prior to the Babine Lake Development Project

(BLDP) 1950-1978

The proportions of Morrison River and Tahlo Creek sockeye in the microsatellite DNA analyses of the Tyee Test Fishery are given in Table 3. The average proportion of Morrison River and Tahlo Creek sockeye is 7.5%. The proportions of Morrison and Tahlo fish will be somewhat higher in the Babine aggregate as some of the other Skeena stocks are excluded. If the non-Babine stocks are excluded from the total, the average proportion of Morrison and Tahlo fish will be 8.8%.

Table 3. Morrison River and Tahlo Creek abundance in the Tyee Test Fishery

Year	N	Morrison %	SD	Tahlo %	SD	Tot Morrison & Tahlo %	SD
2000	984	1.4	(1.0)	2.8	(1.3)	4.2	(1.7)
2001	1178	2.8	(1.4)	1.4	(1.1)	4.3	(1.8)
2002	775	3.3	(1.6)	3.4	(1.4)	6.8	(2.1)
2003	902	6.4	(2.6)	3.7	(1.6)	10.0	(3.0)
2004	652	6.2	(2.8)	1.9	(1.6)	8.0	(3.2)
2005	724	1.2	(2.3)	0.1	(0.2)	1.3	(2.3)
2006	996	2.9	(1.6)	3.7	(1.7)	6.6	(2.3)
2007	585	1.8	(1.5)	0.3	(0.8)	2.1	(1.7)
2008	685	0.1	(0.2)	3.2	(1.4)	3.2	(1.4)
2009	390	24.2	(4.0)	5.9	(2.2)	30.2	(4.6)
2010	650	5.4	(3.6)	0.9	(1.3)	6.3	(3.8)
all years	**8521**	**5.1**	**(2.2)**	**2.5**	**(1.4)**	**7.5**	**(2.5)**

Source: The genetic determinations are by the DFO Salmon Genetics Laboratory, Nanaimo BC. The data was made available by Steve Cox-Rogers, DFO stock assessment Prince Rupert BC. Calculations of the summed Morrison and Tahlo contributions and their standard deviations were by Gottesfeld.

The results of the comparison of escapement counts for Morison River and Tahlo Creek to the total Babine escapement are given in Table 4. The average proportion of Morrison and Tahlo fish from 2000 through 2010 is 3.2%. In order to facilitate comparison, the same years as those for which DNA data is available are used. No correction is made for the undercounts due to use of visual counting techniques. A complete set of escapement counts to the Tahlo/Morrison Conservation Unit and Babine Lake aggregate counts is supplied as Appendix 1.

Table 4. Morrison River and Tahlo Creek Escapement vs Total Babine Escapement

Year	Morrison Escapement	Morrison %	Tahlo Escapement	Tahlo %	Tot Morrison Escapement	Tot Morrison % Fence Cnt	Babine Area Total	Babine Area Escapement	Morrison & Tahlo % Escapement
2000	15,000	1.1%	1,200	0.1%	16,200	1.2%	1,375,957	1,109,497	1.5%
2001	32,000	2.2%	7,500	0.5%	39,500	2.7%	1,474,601	1,244,332	3.2%
2002	20,000	3.4%	5,000	0.8%	25,000	4.2%	588,453	588,453	4.2%
2003	37,000	3.2%	30,000	2.6%	67,000	5.9%	1,138,509	899,088	7.5%
2004	46,000	5.2%	3,000	0.3%	49,000	5.5%	887,989	874,911	5.6%
2005	26,000	3.8%	1,300	0.2%	27,300	4.0%	676,081	647,569	4.2%
2006	10,000	0.9%	A/P		10,000	0.9%	1,133,909	894,240	1.1%
2007	10,000	1.0%	A/P		10,000	1.0%	1,000,734	877,141	1.1%
2008	A/P		N/I				840,400	667,712	
2009	8,900	1.5%	5,479	0.9%	14,379	2.3%	613,284	572,147	2.5%
2010	3600	0.6%	2780	0.5%	6,380	1.1%	595,629	521,308	1.2%
all years	**20850**	**2.3%**	**7032**	**0.7%**	**26476**	**2.9%**	**938686**	**808763**	**3.2%**

Source: 2011 BC 16 file for Area 4, DFO Stock Assessment Prince Rupert BC.

The spawning channels of the Lake Babine Development Project have increased the sockeye returns to Lake Babine since the first significant returns in 1971.It is generally believed that the increase in the proportion of spawners in the enhanced streams has contributed to a decline of the wild Babine stocks (Wood *et al.* 1997a, , Cox-Rogers *et al.* 2004). This may be especially true for the spawning tributaries of Morrison River (Hume & MacLellan 2000). We have therefore prepared a separate analysis of the size of the Morrison and Tahlo escapement from 1950 through 1970 (Table 5). This might be considered to be the "natural" escapement proportion of the Morrison runs.

Table 5. Historic escapement % Morrison stocks as a proportion of Babine Aggregate Escapement

1950's	6.0%
1960-1970	5.2%
1950-1970	5.6%

Other estimates of the size of Morrison and Tahlo sockeye returns

Gazey 2008 models the escapement of Skeena stocks by making corrections for undercounts from visual estimates based on 1999 and 2000 microsatellite DNA sampling of the Skeena as a whole, using a factor of 2.69 to expand visual escapement counts. Gazey's analysis is expanded to cover the years 1982 through 2010, the years for which detailed coastal fisheries data are available from the Pacific Salmon Treaty process. The modeling of Gazey suggests that the average escapement to Morrison River (below Morrison Lake) was 46,235 with a range between 8,119 (1986) and of 173,696 (2003). According to this analysis, the proportion of Morrison sockeye in the total Babine escapement averages 4.7% and ranges from 0.9% (1982) to 15.3% (2003).

McDonald & Hume (1984) review the first decade of the Babine lake development project. They assign 4.0% of the total Babine Lake production to the Morrison Arm (of Lake Babine), apparently using data from West (1978) for 1949 -1963. The range of values in West (1978) is from 0% to 18% of the Babine Lake total. The only significant spawning streams of Morrison Arm are Morrison River (Morrison River) and its tributary Tahlo Creek.

Estimate from the Morrison Mine Draft Environmental Assessment

The estimate of the relative size of the Morrison watershed contribution to Babine stocks cited in the BCEAO Draft Assessment Report is 1%. This value obtained from the proponent (PBM) is erroneous for several reasons.

First, the ratio used by the EA is based on the returns to the Babine Weir, not the Babine Sub-area total, or the total escapement to Babine spawning areas. The Babine fence count includes significant numbers of harvested sockeye, therefore includes large errors from ignoring the First Nations fisheries and the "unaccounted" components, and thus over reports sockeye escapement to Babine Lake. The fence count interval selected for the Morrison Mine EA estimate included 6 of the 8 largest fence harvests of the last 60 years, with an average of 185,775 harvested sockeye each year. These harvested fish could hardly have gone on to populate the Morrison spawning beds. The Morrison proportion is under-reported when the total Babine Fence count is used to calculate the proportion of Morrison River spawners in the selected time interval.

Second, the Morrison escapement used is for Morrison River. The Morrison River sockeye do not rear in Morrison Lake but in Morrison Arm. The fish spawning in Tahlo Creek and perhaps upper Tahlo Creek rear in Morrison Lake. The sockeye likely to be most affected by the proposed Morrison Mine are not considered. The total Morrison contribution should include the two large populations of Morrison River and Tahlo Creek and the infrequently counted smaller populations of Upper Tahlo Creek and Morrison Lake.

Third, the time period used for deriving the low estimate for Morrison sockeye appears to have been selected to give a low estimate. The draft Environmental Assessment report states "The Proponent reports that escapements from Morrison Lake averaged 13,000 from 1950 to 1970 and 13,500 from 1993 to 2002….Numbers at the Babine fish counting fence… for the same period showed an average of 1,320,000 sockeye".

The average count at the Babine fence for 1950 to 1970 was actually 527,499 (DFO North Coast Stock Assessment BC16 database). The average count for 1993 to 2002 was close to 1,320,000 at 1,314,202. The period 1993-2002 includes 5 of the 6 highest Babine fence counts over the last 60 years. A lower average fence count would have resulted from considering all but three of the 51 possible 10-year periods.

The Babine enhanced component was especially large for the years selected because of concern about the relatively low proportions of non-enhanced sockeye, which resulted in managing for a high Babine escapement at that time. The decline in the proportion of Babine harvest in coastal fisheries was intentional and was compensated in part by initiating and/or expanding a terminal fishery at the Babine weir (DFO, 1999).

The proportion of Morrison fish in the following table (Table 6) in the Gitxsan and Gitanyow Skeena fisheries is calculated by the three techniques discussed previously.

Table 6. Proportions of Morrison & Tahlo Fish in Gitxsan & Gitanyow Fisheries

	Fishing Zone		
	Kitwanga-Haz	Hazelton-Babine	Babine R
Proportions from Skeena Test Fishery DNA 2000-2010	**8.24%**	**8.36%**	**8.81%**
Proportions from Babine escapements 2000-2010	**3.16%**	**3.19%**	**3.21%**
Proportions from Historic Babine Escapement 1950-1970	**5.47%**	**5.49%**	**5.56%**

The proportions of Babine and Morrison sockeye in the Gitxsan and Gitanyow fisheries.

The Gitxsan divide their food, social and ceremonial fisheries (FSC or Section 35) into several geographic zones which are monitored separately. The zones are the Lower Skeena, the Skeena from Kitwanga to Hazelton; the Upper Skeena, the Skeena from Hazelton to the mouth of the Babine River; and the lower few kilometers of the Bulkley River. Sockeye in these zones are harvested with fixed gill nets. The Babine zone along the lower Babine River near Gisgagaas is fished with dip nets.

The Gitanyow harvest sockeye from the Nass River and the Skeena River. A significant part of the Gitanyow food fishery, about one third, is taken in the Lower Skeena zone through arrangements with Gitxsan Chiefs. The Gitanyow also have arrangements with the Tsimshian of Lax Kw'aalams to harvest sockeye in the Skeena Estuary.

In some years First Nations commercial harvests take place in addition as demonstration fisheries or ESSR (Excess Salmon to Spawning Requirement) fisheries which are monitored separately. These fisheries all target sockeye headed for Babine Lake and Morrison Lake.

The Gitxsan/Gitanyow fisheries are the largest First Nations food fisheries in the Skeena, about twice the size of the Lake Babine Nations fisheries. The relative size of these fisheries is shown below in Table 7 which summarizes data from the DFO Post Season Reports of 2001 through 2010. The catches recorded as Gitxsan and Wet'suwet'en are almost entirely Gitxsan. Not all of the annual entries are comparable. For example, the 2006 total might include the relatively small non-Babine sockeye catch on the Bulkley River at Moricetown and some of the years might include the small catches in the lower Bulkley River and the lower Babine River. However, the magnitudes of the catches are substantially correct.

Table 7. First Nations Sockeye Catches in the Skeena above Kitwanga

YEAR	Source of Catch Data	Skeena above Kitwanga Sockeye Catch	Lake Babine Nation Sockeye Catch
2010	2010 DFO Post Season Review Report	**76,937** (Classed as mid-Skeena River)	**38,800** (Classed as Upper Skeena River)
2009	2009 DFO Post Season Review Report	**73,545** (Classed as Lower = 33,956 and Mid = 39,589)	**44,949** (Classed as Upper Skeena)
2008	2008 DFO Post Season Review Report	**66,836** (Classed as Gitksan and Wet'suwe'ten Lower and Upper Skeena)	**38,002** (Classed as Upper Skeena)
2007	2007 DFO Post Season Review Report	No FSC Catch Reported	
2006	2006 DFO Post Season Review Report	**74,568** (Classed as Gitksan = Skeena River and Wet'suwe'ten = Bulkley River)	**37,198** (Classed as Babine Lake and area)
2005	2005 DFO Post Season Review Report	**68,990**	**32,156**
2004	2004 DFO Post Season Review Report	**70,395**	Not Available/Not Reported
2003	2003 DFO Post Season Review Report	**65,069** (Classed as Gitksan/Wet'suwe'ten)	**32,000**
2002	2002 DFO Post Season Review Report	No Data Available by Nation	
2001	2001 DFO Post Season Review Report	**49,705**	**5,000**

Of the total Gitxsan catch, 50% was taken below the Bulkley River (Lower Skeena zone), 41% was taken between Hazelton and the Babine River (Upper Skeena zone), and 3% on the lower Babine River (Babine Zone). Two Gitxsan drift gill net fisheries comprising 5.5% of the total catch are not included in this table.

At the coast, Babine fish make up 83% of the Skeena run (2000-2010). The proportion of the Babine fish increases further upriver where the Skeena River stocks separate, and the proportion of Morrison & Tahlo fish increases likewise. The lower Skeena stocks such as Alastair Lake, Kalum Lake and Zymoetz River are removed to adjust the Skeena total for the Kitwanga-Hazelton fisheries. The Bulkley River contributions are removed to adjust the proportions for the Hazelton-Babine River fishery. The Kispiox River sockeye totals were included in the potential catch since most of the catch is below the Kispiox River. Finally, the Kispiox and upper Skeena stocks are removed for the lower Babine River proportions, leaving only the Babine stocks.

The reductions for the years 2000 through 2010 were applied for each year based on the recorded escapements of the various stocks. Since the large majority of sockeye in all of the Skeena River fisheries are from Babine and Morrison lake stocks, this adjustment results in modest declines in the proportion of Morrison and Tahlo stocks compared to Babine Lake proportions, and modest increases in the Morrison and Tahlo proportions based on the genetic analysis of the Tyee test fishery.

Table 8 shows the results of applying the above corrections to the three techniques of estimating the proportion of Morrison & Tahlo fish. The proportions of Morrison & Tahlo fish in the Gitxsan and Gitanyow diets range from 3.2% to 8.8%. The magnitude of the differences different in the first and second estimates should be considered mostly as evidence for undercounting the wild visually counted Babine lake stocks.

Table 8. Proportions of Morrison & Tahlo Fish in Gitxsan & Gitanyow Fisheries

	Kitwanga-Haz	Hazelton-Babine	Babine R
Proportions from Skeena Test Fishery DNA 2000-2010	**8.24%**	**8.36%**	**8.81%**
Proportions from Babine escapements 2000-2010	**3.16%**	**3.19%**	**3.21%**
Proportions from Historic Babine Escapement 1950-1970	**5.47%**	**5.49%**	**5.56%**

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APPENDIX 1

Tahlo/Morrison Conservation Unit Escapements

Year	Morrison River	Tahlo Creek	Tahlo-Upper Creek	Total Tahlo/Morrison C.U.	Babine Fence Count	Babine Subarea	Babine Unaccounted	Babine Aggregate Escapement
2010	3600	2780	A/P	6380	639054	595629	74321	521308
2009	8900	5479	A/P	14379	672002	613284	41137	572147
2008	A/P	N/I	N/I	0	1083319	840400	172688	667712
2007	10000	A/P	A/P	10000	1050481	1000734	123593	877141
2006	10000	A/P	N/I	10000	1391679	1133909	239669	894240
2005	26000	1300	N/I	27300	709198	676081	28512	647569
2004	46000	3000	UNK	49000	919250	887989	13078	874911
2003	37000	30000	UNK	67000	1170359	1138509	239421	899088
2002	20000	5000	UNK	25000	595227	588453	UNK	
2001	32000	7500	N/O	39500	1984261	1474601	230269	1244332
2000	15000	1200	N/I	16200	1831613	1375957	266460	1109497
1999	15000	3500	N/O	18500	606136	582916	87423	495493
1998	8600	4500	N/I	13100	510246	499552	155318	344234
1997	23000	5000	N/I	28000	1086610	931602	182950	748652
1996	5100	1300	N/I	6400	2000591	1649072	295848	1353224
1995	3900	1287	N/R	5187	1737009	1639117	503831	1135286
1994	6000	N/I	N/I	6000	1052905	1004450	218736	785714
1993	6000	12000	75	18075	1737426	1559836	275941	1283895
1992	4800	2500	N/O	7300	1233785	1473957	N/R	
1991	13000	7500	N/O	20500	1176318	1155518	157831	997687
1990	4500	1450	N/O	5950	978646	956646	154903	801743
1989	3000	3100	N/O	6100	1132316	1110316	479165	631151
1988	12000	7000	50	19050	1408879	1383929	337166	1046763
1987	9000	3800	N/O	12800	1307852	1287756	253847	1033909
1986	2500	600	N/I	3100	701507	678007	175995	502012
1985	7000	7200	N/O	14200	2148044	2130544	471735	1658809
1984	2500	4000	N/R	6500	1052385	1031885	207857	824028
1983	4500	2500	N/R	7000	886393	866393	284404	581989
1982	3500	400	N/R	3900	1136835	1094835	334788	760047
1981	5000	700	N/R	5700	1432734	1402734	572927	829807
1980	4000	5000	N/R	9000	526259	504630	132417	372213
1979	11200	6600	N/R	17800	1160966	1139466	241989	897477
1978	1500	1500	N/R	3000	401318	390398	147874	242524
1977	9000	3600	N/R	12600	937992	928815	118604	810211
1976	3600	1400	1400	6400	580597	562440	76978	485462
1975	16000	7000	N/R	23000	820795	806899	137820	669079
1974	13755	17200	300	31255	726990	704672	109574	595098
1973	17200	9000	100	26300	797461	780446	109024	671422
1972	8000	600	N/R	8600	680145	655862	60779	595083
1971	6000	2000	N/R	8000	816000	792550	21806	770744
1970	7200	N/R	N/R	7200	662000	642352	12916	629436

Tahlo/Morrison Conservation Unit Escapements

Year	Morrison River	Tahlo Creek	Tahlo-Upper Creek	Total Tahlo/Morrison C.U.	Babine Fence Count	Babine Subarea	Babine Unaccounted	Babine Aggregate Escapement
1969	12250	10200	N/R	22450	634000	617107	145812	471295
1968	35000	11000	N/R	46000	552000	532854	65433	467421
1967	14000	1500	N/R	15500	602807	583815	149597	434218
1966	9000	2500	N/R	11500	389000	370398	70654	299744
1965	5000	3500	N/R	8500	580000	563460	133280	430180
1964	16000	10000	1000	27000	827437	807782	201418	606364
1963	32500	24600	100	57200	588000	577260	N/R	
1962	9000	4500	25	13525	547995	529873	103998	425875
1961	18000	7000	2000	27000	941711	910855	180155	730700
1960	6000	5000	N/R	11000	262719	245965	25965	220000
1959	22000	12500	2500	37000	782868	766141	148841	617300
1958	9000	10000	N/R	19000	812050	773470	204970	568500
1957	20000	9000	1500	30500	433149	433571	N/R	
1956	18000	11000	N/R	29000	355345	324763	36313	288450
1955	600	1200	N/R	1800	71352	61750	N/R	
1954	12000	12000	N/R	24000	493677	471830	26830	445000
1953	16000	10000	N/R	26000	686586	659673	137210	522463
1952	400	450	400	1250	349011	314607	101363	213244
1951	2200	1000	1200	4400	141415	122408	36585	85823
1950	9800	N/R	N/R	9800	364356	374661	N/R	