Conserving Skeena Fish Populations and their Habitat

Allen S. Gottesfeld, Ken A. Rabnett, and Peter E. Hall

November, 2002

Skeena Fisheries Commission
Box 229, Hazelton, BC
250 842-5670

The authors' opinions do not necessarily reflect the policies of the Skeena Fisheries Commission. Comments, corrections, omissions, and information updates are welcome and may be forwarded to the authors.

Cover: Coho at Stephens Creek, Kispiox Watershed September 2001.
Photo Credit: A. S. Gottesfeld
Back Cover: Skeena Watershed Map, Scale 1:2,000,000
Cartography by Gordon Wilson, Gitxsan Watershed A uthorities GIS Dept.

Skeena Stage I

Watershed-based Fish Sustainability Plan

Conserving Skeena Fish Populations

and

Their Habitat

Allen S. Gottesfeld, Ken A. Rabnett, and Peter E. Hall

Skeena Fisheries Commission

Table of Contents

Table of Figures

Table of Tables

Abstract

This report constitutes the Skeena Watershed Fish Sustainability Process Stage I document. *Conserving Skeena Fish Populations and Their Habitat* describes the planning process that includes prioritizing and selecting sub-basins to review. A biophysical profile of the Skeena Watershed is given which includes an overview of the status of salmon and fresh-water fishes. The initial selection of watersheds was evaluated on historic escapement information, which is used as an indicator of habitat quality, and is further refined by consideration of stocks at risk, habitat issues, development pressures, aboriginal values and interests, community interests, sustainability and availability of conservation and restoration efforts, and government priorities. Profiles were developed for eleven sub-watersheds: the Lakelse, Kispiox, Morice, Babine, Bear, Zymoetz, Kitsumkalum, Gitnadoix, Kitwanga, Ecstall and Skeena West. The sub-watershed profiles describe the environmental setting, fisheries values and resources, development activities, and management issues. The watershed strategic overview contributes to knowledge of environmental issues and cumulative effects, external and anthropogenic factors, Skeena fish and community values, ranking of productive sub-basins, and provides a strategic overview matrix. The Kispiox, Lakelse, and Morice watersheds are identified as Stage II candidates.

The Skeena WFSP Process

Context

An abundance of fish was once taken for granted in the Skeena River system. First Nations across the watershed relied heavily on the salmon that they both managed and used for thousands of years. Over the course of the last century, in the Skeena and its tributaries, fish populations have suffered severe consequences from over fishing, habitat alteration and more recently to an unknown degree, climatic change. Many populations of the six salmon species living in the Skeena basin, declined in the early part of the twentieth century, some have continued to decline in past few decades. Population declines are a concern for many chinook, coho, chum, steelhead, and sockeye stocks while some pink salmon populations and enhanced Babine Lake sockeye have reached record levels of abundance in the past decade.

Salmon populations in the Skeena Watershed face environmental challenges from high rates of logging, highway and other transportation development, and to a minor extent from mining, farming and urban development. Portions of the Skeena will also witness changes in stream habitats due to human caused climatic change.

The Skeena Watershed Fish Sustainability Plan (WFSP) will build on lessons of the past and is designed to help all fish conservation interests in the watershed work more effectively in the future. Fish conservation interests need to make a concerted effort to bring fish populations back and ensure they have the conditions they need to survive. We need to do it for the fish and for ourselves – both current and future generations.

The focus of this report is on the watersheds, their physical qualities, their freshwater ecology, and the history of salmon escapement and human occupation. Of course, there is more involved in the life cycle of salmon than the freshwater habitat; there is the other half of salmon life cycle, the part that occurs in the ocean. Discussion of the marine part of the salmon cycle would include: early ocean survival of post-smolts, ocean growth conditions, and the effect of the various ocean fisheries, past and present. Although there are references to these factors throughout the report, detailed consideration would require a separate volume.

Scope

WFSP is a planning process proposed in 2001 by the BC Ministry of Fisheries, BC Ministry of Water, Land & Air Protection, and Fisheries and Oceans Canada. "Its overall goal is to ensure effective long-term conservation of fish and fish habitat – including spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly". (BC Ministry of Environment Lands and Parks, and Fisheries and Oceans Canada. 2001).

The Watershed-based Fish Sustainability Planning process is different from other fish and habitat management initiatives in that it incorporates four fresh key points. The WFSP:

- Reflects a joint federal-provincial government mandate
- Encourages partnerships between governments and other parties with an interest in fish conservation
- Coordinates other ongoing fish and habitat conservation initiatives
- Introduces a consistent approach to planning

The WFSP process focuses on sustainability. The intention is to sponsor projects that create or maintain environments and fish populations which carry on by themselves. "In most cases it is simpler to prevent damage to fish populations and habitats in the first place than it is to restore them once damage has occurred". For this reason WFSP places a strong emphasis on the protection of fish, fish habitat, and natural ecosystem processes. It promotes restoration of priority fish populations and/or habitat that have been adversely affected by past activities. It promotes enhancement only to supplement these other approaches" (BC Ministry of Environment Lands and Parks, and Fisheries and Oceans Canada. 2001).

The WFSP takes a "Fish First" approach. WFSP places a stronger emphasis on the needs of fish than on other interests. This means that management efforts will be directed to sites that have important fish populations and valuable fish habitat.

Planning takes place in the natural landscape units – watersheds. Streams carry water and sediments downstream and affect distant natural processes. Protection of riverine fish resources require concern for activities upstream and upslope. Similarly, maintenance of commercial and sports fishing opportunities requires conservation of upstream water quality in spawning and rearing areas.

The WFSP is based on the standard WFSP four-stage planning sequence. This planning sequence is comprehensively described in the Watershed-based Fish Sustainability Planning – Participants Guidebook (BC Ministry of Environment Lands and Parks, and Fisheries and Oceans Canada. 2001).

- Stage I – Produces a biophysical and sociopolitical profile of a region and identifies watersheds within the region that are the highest priorities for further planning.
- Stage II – Produces a biophysical and sociopolitical profile of each of the priority watershed planning units identified in Stage I and identifies objectives, strategies, and targets that must be met to achieve fish sustainability within these watersheds.
- Stage III – Produces a detailed fish sustainability action plan that spells out how these objectives, strategies and targets will be met and by whom.
- Stage IV – Implementation and monitoring of the effectiveness.

Stage I of this planning sequence addresses and identifies priorities at the greater Skeena Watershed level. Stages II to IV address priorities within smaller tributary watersheds. Governments, First Nations, and fish conservation and stewardship groups can use this planning sequence to identify those fish populations and habitats that most urgently require attention, and particularly, those that are most likely to benefit from such attention.

Skeena WFSP Planning Process

The Skeena Watershed-based Fish Sustainability Plan will necessarily be complex, reflecting the condition of fish populations and habitats, the issues to be addressed, the vision of Skeena basin participants, and the resources and knowledge participants bring to the planning process. The Skeena Watershed-based Fish Sustainability Plan will be a continuing process that may carry on for as long as fish sustainability issues remain to be addressed.

Stage I: Establishing Skeena Watershed Priorities

In developing this plan, the focus of Stage I was the collection and analysis of information about the Skeena region in order to identify regional watershed priorities. The Skeena Fisheries Commission established a watershed taskforce to carry out the planning and technical tasks of the Skeena WFS Plan.

The Skeena Watershed Taskforce was charged with six key tasks that include:

1. Compiling and analyzing information about fish populations, fish habitats and other biological aspects of the watershed, which will be collated into a broad biophysical watershed profile
2. Identifying watershed-significant fish populations and habitats
3. Documenting historic activities and trends in fish populations and fishing exploitation rates
4. Providing information and criteria to classify watersheds
5. Consulting with other fish conservation interests and preparing a strategic overview of social, cultural, economic, and political values in the Skeena Watershed
6. Producing a list of prioritized candidate watersheds for Stage II of the WFSP.

Biophysical Profile: The Skeena Watershed

Climate, Hydrology and Vegetation

The Skeena Watershed is the second largest watershed in British Columbia (54,432 km^2). It is located in the northwestern portion of BC with its mouth at 54° N, just south of the Alaska panhandle. The Skeena River extends through the Coast Ranges to drain, at its eastern extremity, part of the Nechako Plateau. As a consequence, different portions of the watershed experience different climatic and hydrological conditions.

In this report we use the term "watershed" in a specific sense, as that area above the mouth of a stream, which produces the flow observed at the mouth. It thus extends to the drainage divide of adjacent watersheds. In this hydrological sense, a watershed is narrowest at its mouth where only the width of the channel is included. Thus in the Skeena Watershed a few streams which are adjacent to the Skeena River, but not tributary to it, such as Kloyia Creek near Prince Rupert are excluded from our analysis. Note that these streams are included in the DFO Statistical Area 4. This strict definition of watersheds is used throughout the report, except in the case of the West Skeena "Watershed:" which is an area of productive fish habitat located in the multichannel reach of the Skeena River below Terrace.

The Skeena Watershed is composed of a series of northwest trending mountain ranges separated by broad valleys. The coastal Kitimat Ranges are mostly composed of granite and granitoid rocks. Low-grade metamorphic rocks make up the bulk of the Hazelton Mountains in the central part of the watershed. The Skeena Mountains and Babine Range are composed primarily of Mesozoic sedimentary and volcanic rocks. Because of the difference in bedrock composition, coastal drainages produce mostly sand as rock breakdown products, while interior drainages produce abundant clay and silt as well as sand.

All of the Skeena Watershed was intensely glaciated during the last ice age 28,000 to 11,000 years ago (Clague 1984). Valleys crossing the Coast Mountains were intensely scoured. Interior valleys accumulated up to tens of meters of glacial till. During the deglaciation phase, 11,000 to 10,000 years ago, large volumes of gravel accumulated in the Skeena Valley and major tributaries. Down-cutting by the Skeena River in the few thousand years after glaciation left remnants of these gravels as large terraces. Glacial lakes in several valleys accumulated fine sediments. During deglaciation, depressed coastal areas were flooded and marine conditions extended as far inland as the mouth of the Zymoetz River. Ice margin lakes formed in several areas including the Upper Babine Watershed (Hastings *et al*. 1999), the Sustut Valley, portions of the Bulkley Valley, and the Skeena Valley near Kitwanga with fine sediments being deposited in these basins. These varied Ice Age deposits are the source of most sediment movement in the modern rivers of the Skeena Watershed. Salmonids apparently invaded the Skeena basin during deglaciation, taking advantage of short lived connections between watersheds, and have been an important part of the freshwater fauna ever since (McPhail and Carveth 1993b).

The climate of the Skeena Watershed varies greatly. On the coast there is abundant precipitation with cool summers and mild winters with average temperatures near 0°. Usually, precipitation reaches a maximum in the fall and early winter, generally in October and November (Environment Canada 1993) with intense cyclonic storms from the North Pacific moving across the coast every day or two. Rainfall amounts of 50 to 100 mm in a day occur annually. The interior has a more boreal climate with relatively low precipitation, warm summers and prolonged cold winters with average temperatures less than -10° for two or three months. Precipitation amounts are fairly uniform throughout the year. Summer convective storms are common but rarely deliver more than 20 mm of rainfall in a day.

Figure 1.
SKEENA WATERSHED
Scale 1: 2,000,000

Precipitation decreases regularly from the coast to the interior. The coastal drainages of the Skeena Watershed receive at least 2500 mm of precipitation per year, with higher amounts in the mountains. The Kitimat-Kitsumkalum trough (Terrace and vicinity) receives half or less of this amount. East of the coastal mountains, the Smithers area receives about 600 mm, while further east on the Nechako plateau annual precipitation is less than 500 mm. With these variations in precipitation and winter climate, the hydrological pattern differs greatly on the coast from the interior.

Coastal drainages have one or more brief fall or winter floods most years (Figure 2). Nearly all large floods are caused by intense rainfall that are often rain-on-snow events. Interior drainages, such as the Bulkley River above Houston, or the Babine River, usually have a single dominant flood, which occurs annually at the peak of snowmelt in May or June and lasts for several weeks (Figure 3). In intermediate areas such as the Kispiox, Kitwanga, and Zymoetz Rivers, a mix of fall rain floods and spring snowmelt floods is found. Throughout the watershed, prolonged freezing conditions yield low flows in the late winter. In the interior, higher summer temperatures and abundant evapotranspiration by forests contribute to low flows during the summer and early fall.

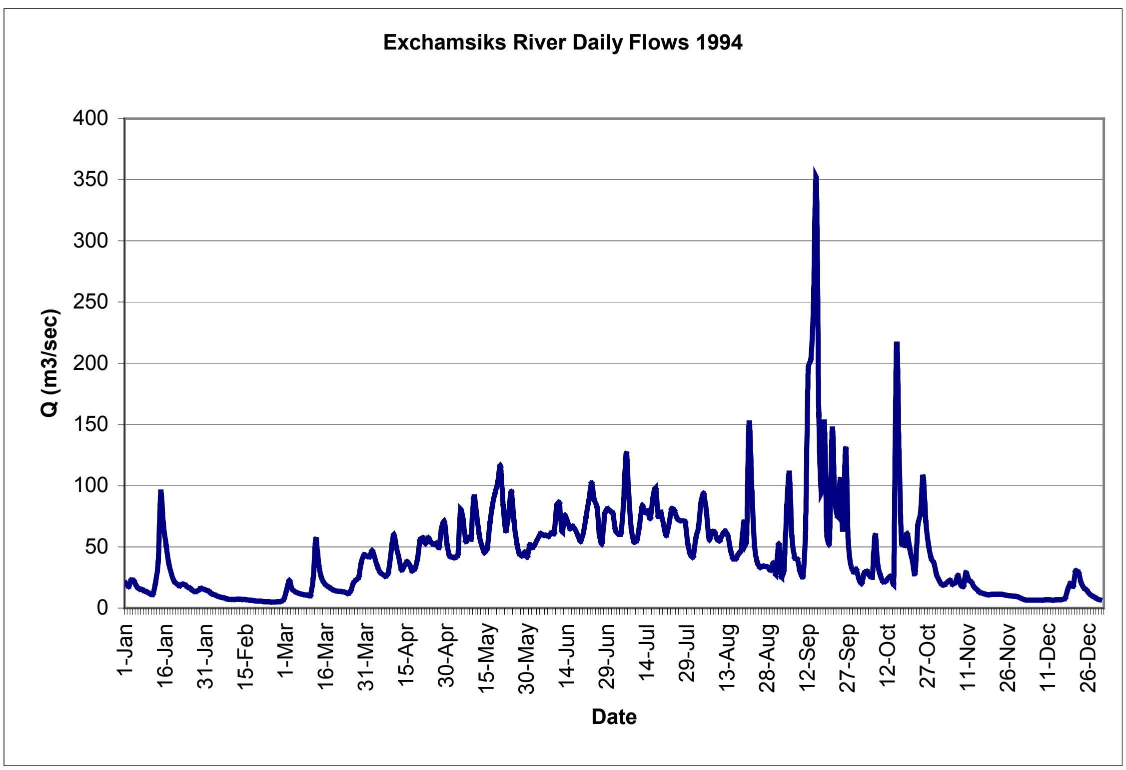


Figure 2. Annual hydrograph for Exchamsiks River.
Snowmelt contributes to higher flows from April to August; August to January have short peak flows from intense rainstorms.

Coho, chinook, pink, sockeye and chum are fall spawners. In coastal watersheds, intense floods may destroy much of the egg production. To some extent coho avoid this problem by spawning late, in November and December in coastal waters. Coho can also take advantage of the fall flood pattern by using the high flows to access small headwaters areas, which may often be inaccessible due to shallow water depths and beaver dams.

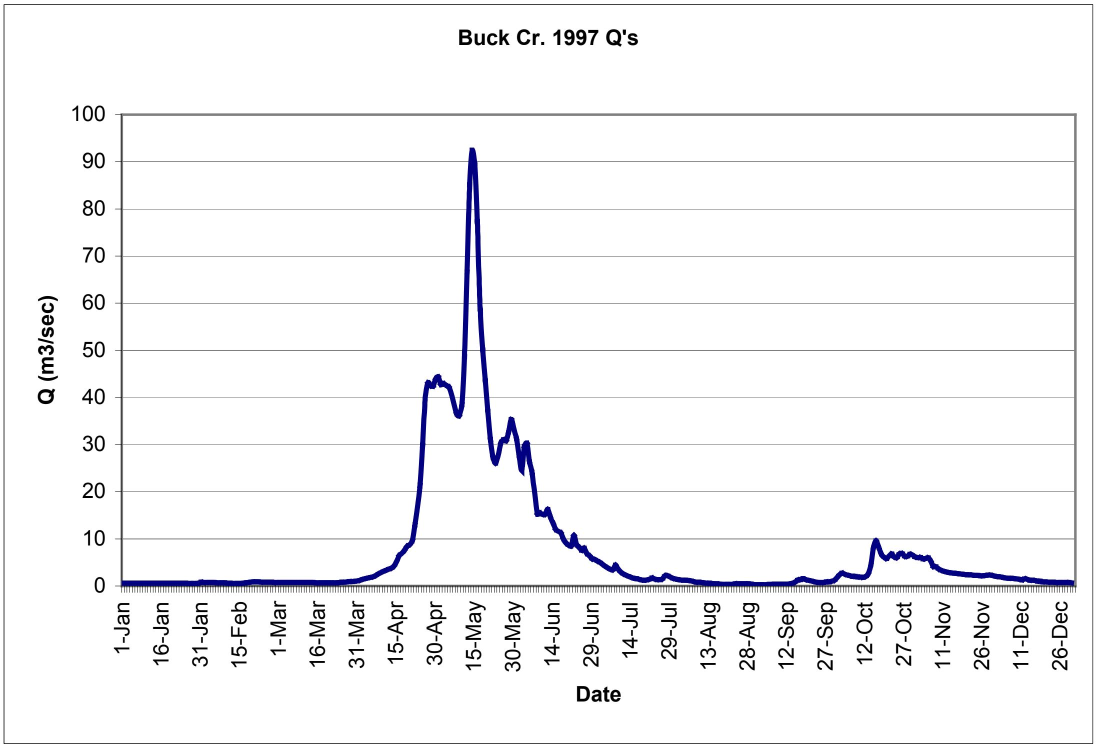


Figure 3. Annual hydrograph for Buck Creek near Houston.
Note that flood flows are restricted to the April to June snowmelt period, and the late summer low flows that recover with fall rains.

In the interior, salmon spawning redds (nests) are generally undisturbed by flood events. Late summer and early fall low flow conditions may restrict salmon access to potential spawning beds, especially in dry years. This is a particularly serious problem in the upper Bulkley drainage (Figure 4). Winter low flows may leave spawning gravels partially dewatered. Extremely low temperatures, especially early in the winter promote the formation of anchor ice on the streambed, which may restrict intergravel flow, or even result in freezing of gravel patches containing developing eggs and alevins. In the spring, high water flows from snowmelt aid the migration of salmon fry and smolts to the sea, by providing higher flow velocities. These floods also provide some degree of protection from predators by hiding the presence of fry and smolts in the generally muddy waters.

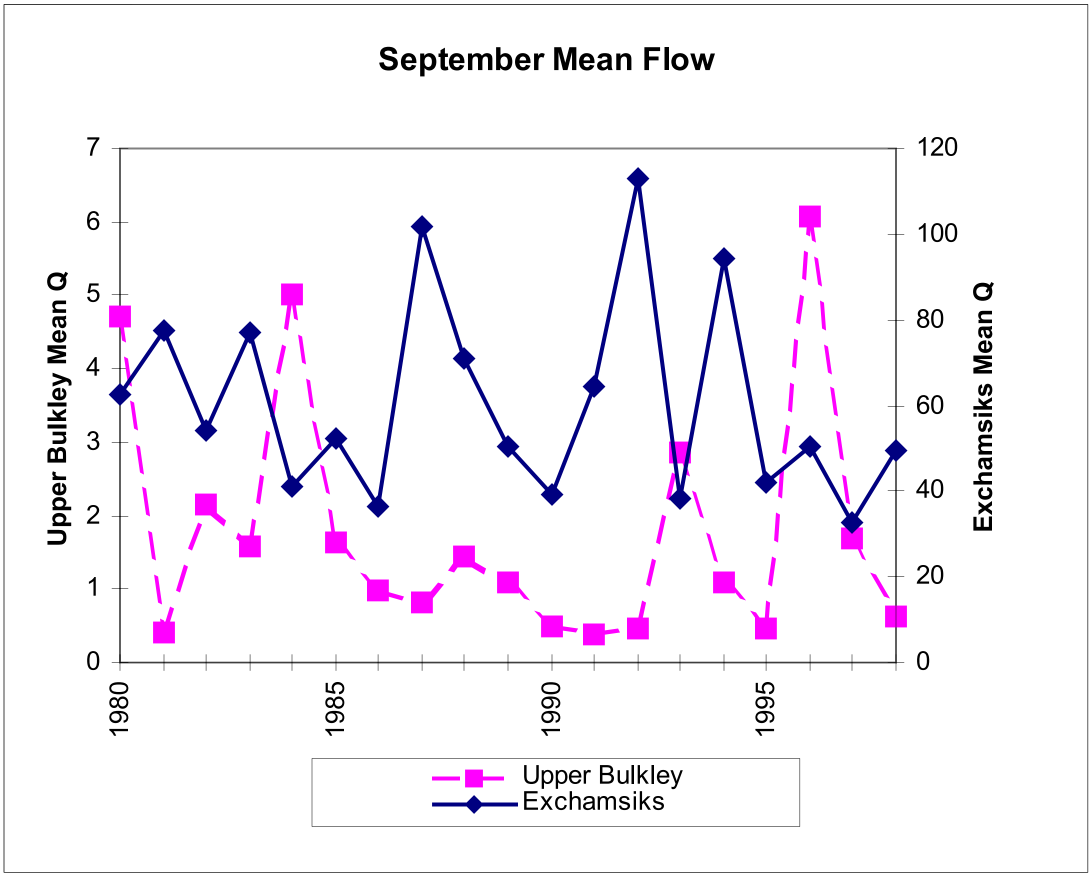


Figure 4. Upper Bulkley and Exchamsiks Rivers – September mean flow. The eastern region of the Skeena Watershed experiences frequent summer drought leading to extreme low flows. In the Upper Bulkley River, flows of less than 1m^3/sec probably prevent upstream migration by salmon.

Average annual flows, and especially late summer flows, have declined in the interior (eastern) part of the Skeena since the 1930's (Figure 5). The coastal portions of the Skeena have had near normal water discharge.

The decrease in late summer and early fall flows is a particularly strong trend in the most interior portions, the Babine River and the Bulkley River east of Houston. In the upper Bulkley, 7 of the past 13 years have had average September flows of less than 1m^3/sec, and 9 out of the 13 years have had average September flows equal to or less than 1.1m^3/sec. These September low flows decrease the ability of coho and sockeye adults to reach spawning areas and utilize spawning gravels. The migration of coho adults into spawning streams is also severely impaired and some streams are dewatered. Intensified summer drought in the interior of B.C. may be a result of global climate change. Canadian Institute for Climate Studies research predicts a continuing decline in summer precipitation in the interior portion of the Skeena for the next 70 years (Price *et al.* 2001). Finer scale modeling shows a decrease also in September precipitation (Boer *et al.* 2000).

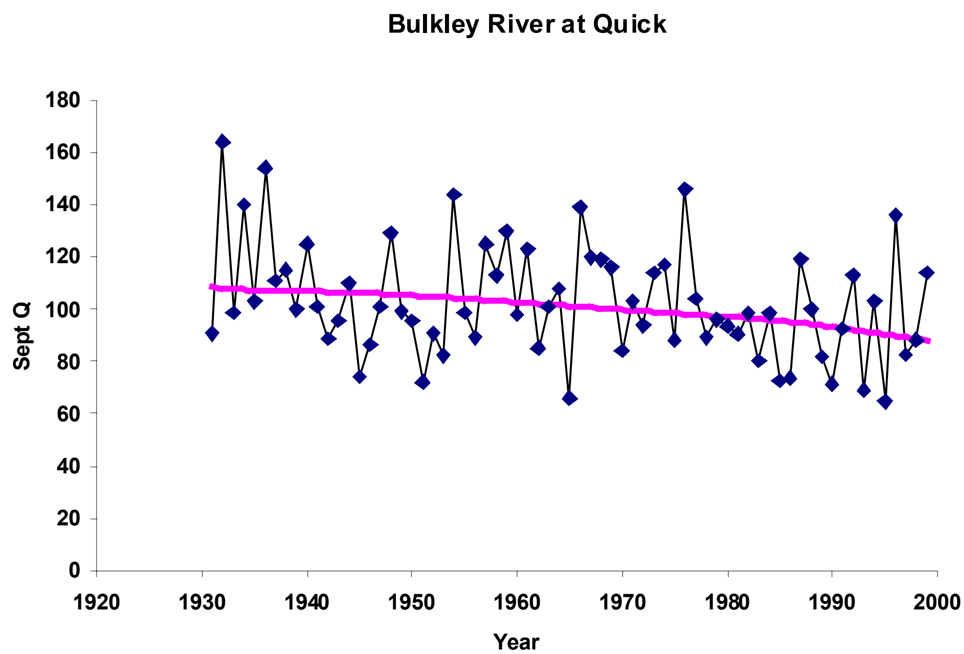


Figure 5. Average September flows, Bulkley River.
The general decline in late summer water discharge is shown by the fitted LOESS smoothed curve (f = 0.8). Flows are m^3/sec.

The Skeena Watershed is densely forested throughout. In the coastal portions, rainforests of large-size Sitka spruce, hemlock and red cedar cover all slopes, even cliffs. In the central Skeena Watershed, hemlock forests dominate although spruce and red cedar is found on moist sites as far east as the lower Bulkley Valley. In the interior, hybrid Engelmann and white spruce stands dominate, but large, low-elevation areas are composed of mixed forests and trembling aspen (poplar) forests. Some south facing slopes are parkland with grass understory. Early successional stage lodgepole pine stand areas are common, especially on gravelly soils and dry sites. Subalpine forest, that generally is above 800m, is primarily subalpine fir and Engelmann spruce although it is replaced by mountain hemlock on the coast.

Riparian vegetation is important for fish habitat. In smaller streams, overhanging vegetation shades streams and keeps them cooler in the summer and warmer in the winter (Beschta *et al.* 1987). In these streams, leaf and twig litter and insects provide the bulk of the food energy input (Swanson *et al.* 1982). In all parts of the watershed, trees are large enough that when they fall into streams, they produce stable structural features. In small streams these are critical for providing fish habitat and controlling the storage and movement of sediment. In intermediate sized streams, log accumulations are the principal structural features. Log debris seems less important for fish habitat in the largest streams (Sedell and Swanson 1984), such as the main-channel of the Skeena and its principal tributaries, because transport tends to leave logs on gravel bars and obstructions above normal flow levels (Gottesfeld 1996).

Skeena Watershed Fish Populations

The Skeena Watershed has populations of six salmon species (including steelhead), rainbow trout, cutthroat, and three char species (Dolly Varden, bull trout, and lake trout). The salmon, trout and char are best known. In general salmon populations are healthy, with relatively few threatened populations and no known recently extinct populations. (Morrell 2000). The threatened populations are of high concern and strong efforts should be undertaken to prevent their loss. They are discussed more fully in the species discussions which follow.

There are about 26 non-salmon/trout fish species in the Skeena. One species, the giant pygmy whitefish (*Prosopium coulteri*), is currently ranked as 'highest risk' by the Conservation Data Centre (Haas 1998)) and is provincially red-listed. No species are classified in the CDC 'moderate' to 'high risk' range, but few non-salmonid species have been collected.

The richest source of data on the status of salmon stocks is the Area 4 SEDS database maintained by DFO. This data set consists of annual spawning ground observations of about 196 census areas collected since 1950. The census areas vary in size from whole river systems, such as the Kitwanga River, to short reaches of productive systems such as on the upper Babine River or Club Creek in the upper Kispiox Watershed.

The SEDS database is most reliable for the larger and more consistent spawning stocks. The bulk of salmon spawning areas appear to be represented; however, very small and infrequently used spawning areas may be overlooked. For example, in years of large pink salmon runs, spawning occur at numerous sites that are not utilized under most conditions and may even appear to be unsuitable. These sites are mostly not in the SEDS database.

Spawning area counts are made with different techniques, including: aerial counts, ground counts, counts from boats, swimming counts, counting weirs and mark and recapture experiments. Most counts are simple estimates made from one or more ground visits or aerial surveys. Because of this variety in technique and varying natural conditions (visibility etc) the data vary in quality in often-unknown ways. However this data set is the best available and far exceeds the quality of data available for steelhead, trout and other non-anadromous species. In general, the number of stocks counted increased from 1950 to 1990 and declined after 1992.

The vast majority of spawning escapement data for the Skeena Watershed, used in this report, was obtained from DFO's SEDS database. The data quality varies from observer to observer and place to place. While appreciating the great value of the data records, they can only be utilized as indicators of general trends and at best reflect relative abundance, rather than actual values. Coho are probably the most poorly estimated fish.

Data for steelhead is more dispersed. Since steelhead spawn in the spring at high water conditions, direct counts are usually not possible. Catches in the Tyee test fishery give aggregate abundance indices for the whole Skeena River. More detailed data sources are discussed in the steelhead section. In general, enough is known to infer the order of importance of spawning streams. Data on the population size and status of non-anadromous fish species of the Skeena is scarce and of little use for determining population trends through time.

Stream Selection Procedure

In undertaking this Skeena Watershed conservation program of fish and fish habitat protection, enhancement, or restoration, the selection of priority areas for attention is necessary. Not all areas can be treated in a watershed, nor do they need the treatment. The process of prioritizing and selecting sub-basins is an important predictor of the outcome.

In recent years there have been several techniques used for identifying streams and/or stream reaches for habitat protection and restoration. These techniques reflect different purposes and priorities. The varying approaches:

- Focus on streams with severe impacts from urbanization and industrial pollution/degradation
- Select streams with logging impacts such as the Watershed Restoration Program
- Focus on streams with salmon population at high risk of extinction
- Focus on streams with high aboriginal values/interests
- Focus on streams with high value sports fisheries
- Focus on streams with high productivity for commercial fisheries
- Focus on streams with high quality habitat

The nature of the Skeena Watershed, with its low population density and low level of industrial development, leads to urban development and pollution effects that are not large problems. Nearly two decades ago, Paish and Associates (1983) came to the same conclusion in their strategic overview looking at critical watersheds and development issues and threats.

The Watershed Restoration Program, a provincial program that was part of Forest Renewal BC from the mid 1990's to 2001, was directed to evaluation and restoration of logging impacts on the watershed level. Many projects were carried out, but there has been little effectiveness monitoring of the projects. Focusing on restoration of habitat potential might better be done by evaluating the potential of streams for spawning and rearing and addressing the limiting factors on a watershed basis, rather than by focussing only on logging-damaged stream reaches. For example, in streams where sediment oversupply is the problem, it might be better to control natural erosion sources than logging-related sources.

As shown in detail in the following sections, the Skeena Watershed does not have many fish populations at risk of extinction.

These considerations suggest that a stream selection procedure predominantly based on identifying urban and industrial impacts, or streams with logging impacts, or streams with endangered salmon populations, is not appropriate for the Skeena Watershed. Instead we have focused on identifying significant fish populations and fish habitat so that the critical habitat areas can be protected. This procedure is consistent with the WFSP Guidebook for participants.

Maintaining and improving the overall productivity of Skeena Watershed streams and protecting critical habitat is likely to be best achieved by identifying the critical habitat and strengthening protection of these areas. Continuation of the WFSP process will result in identification of some areas where past productive capacity has been impaired. These areas will become candidates for habitat restoration activities. Carrying out this program of protection and restoration will result in benefits to streams and fish populations with high value to aboriginal groups, sports fishers and the commercial fishing industry.

After the initial selection of watersheds based on historic escapement information, the watersheds were evaluated with various other criteria including, stocks at risk, habitat issues, aboriginal values and interests, development pressures, community interests, sustainability and attainability of conservation and restoration efforts, and government priorities. The emphasis on the SEDS database for initial selection reflects a bias toward quantitative information and historic records.

However, it is likely that a selection based on a set of the other values would have yielded essentially the same list of watersheds, since the identification of important fish populations and fish habitat is the nub of the process. Due to the scant information available regarding abundance and preferred habitats of freshwater non-anadromous fish in the watershed, these fish did not greatly affect the stream selection process.

Because of the abundance of information and more than fifty years of data, the SEDS database has been selected by recent authors for evaluation of the status of salmon populations. Williams et al. (1994) produced a report that shows the location of salmon producing streams in B.C. Their analysis is based on the SEDS database for the years 1983 through 1992. They divide salmon escapements into five categories in a logarithmic series similar to enumeration categories used in the 1930s to 1950s in the Skeena Watershed. Slaney *et al.* (1996) report on salmon and anadromous trout populations for all BC and Yukon streams. Their study used the SEDS database from 1953 to 1992. Because of the scope of Slaney *et al*'s report, there was little possibility to examine the detailed data for individual streams.

Morrell (2000) used a procedure similar to Slaney et al. to review the conservation status of Skeena streams. He found relatively few populations at risk of extinction but many "of some concern", a category that includes populations with incomplete recent escapement data, and those whose numbers are now <25% of historic levels, as well as populations of less than a few hundred spawners.

For this report, we reviewed the SEDS database information taking into account recent improvements in knowledge of genetics of salmon populations. It is likely that some species such as pink salmon have a generalized genetic structure reflecting substantial amounts of straying and hence genetic mixing. For such species, the presence or abundance in marginal habitats should not be an important consideration. In years of high abundance, straying serves to populate or repopulate these streams. In population genetics terminology, the bulk of the genetic variability is at the level of major watersheds.

Other species, such as sockeye salmon, have a population structure in which the lake system in the important genetic unit. Lake system sockeye populations are differentiated such that the bulk of the genetic variability is at the lake system level. In species with this type of genetic structure it is important to maintain spawners in all of the lake systems since once a lake population is extirpated it cannot be replaced. The result of considering the population genetics of the different fish species was that some small populations of coho and pink salmon with spotty spawning records near major spawning streams are not described in this report as populations at risk of extinction.

This Skeena Watershed process focuses on streams with evidence of current or past high productivity, in that this is the easiest method to identify high quality habitat. In the case of the Skeena Watershed, it may be that much of the superior habitat does not have significant existing impacts. In this case, the appropriate response is to identify the critical habitat areas and increase the level of protection of these areas. In some of the Skeena watershed sub-basins there are significant impacts, damage or threats to high quality habitat. These watersheds need restoration studies and effective action to conserve the fish populations.

Although there are many salmon spawning areas represented in the SEDS database, the bulk of the salmon production is from a much smaller set of localities. These localities are not randomly distributed within the watershed but are sites of high habitat quality. If these tributary streams are examined more closely it is likely that even within the productive systems, small portions of the stream produce the bulk of fry. These areas have favourable temperature patterns, moderated stream flows, high quality gravel and low to extremely low amounts of fine sediment movement. In many parts of the Skeena Watershed, vast areas of low spawning productivity surround small areas of productive spawning habitat.

High quality rearing habitat is also uncommon and widely dispersed. For stream-rearing salmon, such as most coho and chinook populations, the fry may disperse widely from the spawning beds and redistribute according to their habitat preference and the habitat capacity. Small dispersed areas of quality rearing habitat may produce the bulk of the watershed's smolts. Especially favourable areas have quality rearing habitat in proximity to quality spawning areas.

Lake-rearing populations, such as most sockeye, are dependent on the lacustrine productive capacity. Lake productivity varies enormously from low productivity in cold subalpine lakes and lakes fed by glacier-sourced rivers, to relatively warm mesotrophic lakes in wide lowland areas. The most productive sockeye systems have both areas of excellent spawning habitat, and high lake productivity.

When spawning populations are ranked by abundance, relatively few sites account for the vast majority of the total spawners. For example, sockeye escapement to the Babine River in the

1990's accounts for 95% of all sockeye escapement to the Skeena Watershed. Other species exhibit this trend to a lesser extent. Only nine localities (not watersheds) accounted for 92% of the chum salmon spawners in the 1990's, ten sites accounted for 95% of the total chinook escapement in the 1950's and ten spawning sites accounted for 95% of the pink escapement in the 1970's. Of all the salmon species, coho have the most dispersed production. In the 1970's the top 29 localities accounted for only 78% of the total Area 4 escapement.

The most productive streams for each salmon species were selected by examination of the SEDS database. The database was examined by plotting the average spawner abundance of salmon for each of the decades from the 1950's to the 1990's. We reviewed the escapement data available for the leading salmon producing watersheds for each species to note the overall pattern of change, to identify the effects of missing or unreliable data, and to consider additional streams that have escapements similar to the most productive streams.

Examination of this escapement data and its trends resulted in identification of six to eight critical spawning streams for each of the salmon species. If more than one census unit was within a watershed, they were combined. Each identified selected watershed was among the top five producers for one of the decades analyzed. These watersheds each received more than 5% of the total Area 4 spawners, except in the case of sockeye where the concentration of Babine Watershed spawners meant that lower ranking watersheds might receive only ½% of the total. These areas and their exact selection criteria are discussed under each species section. The list of areas is similar for all of the salmon and steelhead species. Rivers with superb spawning conditions for one species tend to host high populations of spawners of several other species. The total list of streams with critical spawning habitat includes eleven streams. These eleven watersheds are described independently in the following sections.

Estimates of the extent of salmon habitat are shown in the eleven watershed maps that follow. These estimates were made by selecting stream segments in the 1:50,000 scale BC Watershed Atlas, which has gradients of less than 2%. A gradient of <2% provides the best fit for identifying areas with known coho juvenile presence, based on field sampling. Since coho are a widely dispersed upstream rearing species, their presence is a reasonable marker of anadromous fish accessibility. After this preliminary selection, we then eliminated headwater areas where there are known barriers to migration. We added stream reaches where we knew of the presence of salmon or received comments from reviewers familiar with local conditions. For stream segments with which we were not familiar, we evaluated non-continuous low gradient reaches by whether the intervening reach had gradients so steep that passage is not likely, or that there are no records of anadromous fish in that reach in the FISS database.

The Status of Salmon Species in the Skeena Watershed

The following six sections review the habitat and status of the six Pacific salmon species in the Skeena. For each species, the nature of their habitat and life history is described, endangered stocks are reviewed, the genetic structure of the population is described where available and major stocks are identified.

Sockeye in the Skeena Watershed

Sockeye salmon are the most valuable commercial fish of the Skeena Watershed and have consequently received much research and management attention. Important sources of information are found in Brett 1952, Larkin and McDonald 1968, Smith *et al.* 1987, Rutherford *et al.* 1999, Shortreed 1998, and Wood *et al.* 1997. Annual sockeye total run size before harvests averages several million fish. The vast majority of Skeena sockeye return as 4 and 5 year old fish, although 3 year old males (jacks) are common in some years.

Skeena sockeye adults usually spawn in streams either tributary to lakes or near the outlet of lakes with fry typically rearing in the adjacent lake. Sockeye fry spend one or two years rearing in lakes. Most productive sockeye stocks, such as those of Babine Lake, Lakelse Lake, and Alastair Lake (located in the Gitnadoix Watershed), spend one year as lake residents. These lakes are biologically productive with abundant plankton populations, the main food source for sockeye fry. Sockeye derived from colder subalpine lakes such as Morice Lake and Bear Lake spend two years rearing in the lake.

The total Skeena in-season sockeye escapement is estimated by an annual test fishery at Tyee in the Skeena Estuary, while total sockeye escapement at the spawning grounds is represented with SEDS database estimates. Escapement data for Skeena tributaries are of variable quality. The most reliable tributary counts are the fish weir counts on the Babine River. By comparison, less intensive spawning ground counts on other streams, and especially lakes, may under-represent the true escapement. This is suggested by the apparently larger proportion of non-Babine sockeye in the Tyee test fishery (McKinnell and Rutherford 1999) than expected from counts on smaller spawning populations.

Sockeye return to the Skeena River mostly in July and August. Sockeye numbers overall have increased in the past 50 years because of the success of large spawning channels constructed on Babine Lake in the 1960's. Most wild sockeye stocks have declined since the 1970's probably in response to increased exploitation rates supported by the success of the Babine Lake enhancement (Figure 6).

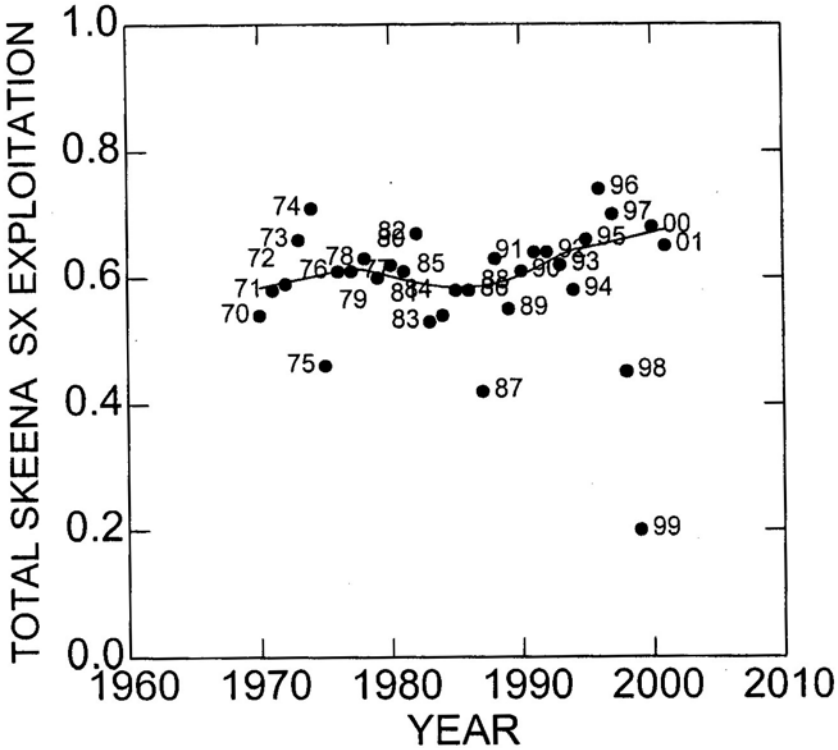


Figure 6. Proportion of sockeye harvested in all fisheries 1970-2001. The line is a LOWESS smoothed regression. From Cox-Rodgers 2001.

The commercial value of sockeye salmon led to a high exploitation rate in a series of fisheries in Alaska, on the BC coast and in-river. Early twentieth century harvests were high but declined from 1920 to the 1950's. Harvest rates in the 1940's were estimated at 50% (Anonymous 1964). Annual harvest rates rose to exceed 60% after 1970 and have since exceeded 70% four times (Rutherford *et al.* 1999.) These relatively high exploitation rates may have led to the decline of less productive wild sockeye stocks.

Research advances over the past ten years have identified genetic markers in sockeye that can separate sockeye from different spawning areas and provide a tool to help understand their population structure (Wood *et al.* 1994, Varnavskaya *et al.* 1994, Beacham and Wood 1999). This information has important conservation implications. Sockeye salmon appear to be highly specific to individual lakes and each lake system is genetically distinct. Different spawning areas in a single lake system have sockeye that are similar genetically to one another and have modest amounts of genetic interchange between different spawning streams (Varnavskaya *et al.* 1994, Wood and Foote 1996, Withler *et al.* 2000). To use the words of the US, each lake complex is an evolutionary significant unit and hence is an important fisheries management unit (Waples 1995). In contrast, river dwelling sockeye are relatively similar genetically (Wood 1995, Beacham and Wood 1999). This pattern is quite unlike that of coho where populations seem to vary by degree along river systems. Consequently the preservation of even small sockeye populations is important to preserve of species diversity.

Most sockeye populations are sufficiently stable that there are no short term concerns about survival of the stocks. The recovery of the Babine Lake sockeye stocks after the partial blockage of the Babine River by a landslide in 1951, which was cleared in 1953, and the partial recovery of the Zymoetz River sockeye stocks after blockage in 1891 and in the 1960's is encouraging.

The decline of several sockeye stocks is a serious conservation concern. The following sockeye populations are seriously depressed and at risk of extirpation:

- Kitwancool Lake
- Bulkley Lake and Maxan Lake
- Cedar River and Clear Creek

The Kitwancool Lake sockeye have declined from historic escapement in the 20,000 range in the 1940's to several hundred fish. The Gitanyow Fisheries Authority (GFA) has been conducting research on this stock for several years. At this point it is not clear whether the problem lies in recruitment, spawning habitat or rearing capacity, or a combination of these factors (Cleveland 2001). Part of the problem is that Kitwancool Lake sockeye enter the Skeena River along with the much larger Babine Lake stocks and are harvested along with them. On genetic grounds, maintaining a population size of at least several hundred fish is required for long-term survival (Waples 1990).

Bulkley Lake and Maxan Lake sockeye are one or two small stocks in the headwaters of the Bulkley River east of Houston. Maxan Creek is a tributary of Bulkley Lake. Spawning is in Maxan Creek below Maxan Lake and probably in Maxan Lake and Bulkley Lake. Escapements were 50-600 until 1978. The stock or stocks then appears to have collapsed and recent records shows a few or no fish returning. In 2001, several sockeye were spotted at a coho counting weir in Houston that may have been heading upstream to Bulkley Lake. Maxan Creek does not have sufficient flow to allow sockeye passage in some summers. This was reportedly the case in 2001, a relatively wet year (Joseph 2001) High water temperatures could also cause access problems. The upper Bulkley River has a variety of environmental impacts including transportation corridor problems and agriculture related erosion and nutrient problems (Remington 1996). This information strongly suggests that the Bulkley Lake sockeye are at high risk of extirpation.

Clear Creek and Cedar River are northern tributaries of Kitsumkalum Lake. These sockeye streams have had declining spawner numbers since the 1960's. Clear Creek had over 1000 spawners until the 1960's and has declined to very low numbers in the 1990's. It is not clear whether sockeye spawned in Clear Creek in the past few years. Nearby, Cedar River has had less dramatic declines from around 1500 spawners in the 1970's to several hundred in the 1990's, with a peak of 1000 escapement in 1998. Possible environmental causes of the North Kalum decline are that the watershed has been severely impacted by logging, and that Kitsumkalum Lake is apparently of low biological productivity (Shortreed *et al.* 1998) due in large part to high turbidity from glacially fed streams. Logging related erosion has strongly affected Cedar River (Triton Environmental Consultants 1996). Gilchrist (2001) concluded that although the supply of bedload sediment has increased to the creek, stream channel stability has generally not been affected and rates of channel migration have remained similar to the historical average for each reach.

A positive feature of north Kitsumkalum Lake sockeye escapement is the success of a small artificial spawning channel near the outlet of Clear Creek. This spawning channel is producing several thousand returning adults and has thus compensated for the decline of the stocks from the two nearby streams.

Morrell (2000) lists Upper Tahlo Creek, a tributary of Babine Lake above Morrison Lake, as a stock of high concern. It is not included in this list because sockeye appear to use it sporadically. It might simply be an extension of the lower Tahlo Creek spawning stock used in years of when there is enough flow to permit sockeye access above Tahlo Lake.

There is evidence in early fisheries reports in the DFO BC16 files of two sockeye stocks that are probably extinct. In Fishery Officer reports from 1929 to 1934, Seeley Lake sockeye are described as an early migrating stock arriving in the beginning of July, then spawning at the outlet of Seeley Lake near Hazelton. Since the spawning locality is at the current crossing of Highway 16, it is unlikely that recent occurrences would be overlooked. Reports by Fisheries Inspector A. R. MacDonnell in 1932 and 1934 describe sockeye returns to Canyon Lake, about 130 km north of Hazelton, and refer to runs in 1928 and 1929. There are no known recent records for this stock.

In recent decades, over 90% of the Skeena sockeye came from Babine Lake stocks (West and Mason 1987, McKinnell and Rutherford 1994). This proportion has increased from pre-1960 levels of about 80% (Brett 1952) largely due to the success of the Babine lake sockeye spawning channels built at Fulton River and Pinkut Creek in the 1960's. In total, about 30 spawning areas are utilized by sockeye that rear in Babine Lake, the largest natural lake system in B.C.

Selected Watersheds:

Because of the millions of sockeye returning to Babine Lake, other important watersheds produce a relatively low percentage of the total Skeena stock. The eight most important sockeye producing watersheds are listed below:

- Babine River
- Bear River
- Morice River
- Kispiox River
- Zymoetz River
- Lakelse River
- Kitsumkalum River
- Gitnadoix River

These watersheds were selected from the set of spawning localities in the SEDS database. For sockeye stock selection, all Babine Lake stocks were combined into a single group. All of the streams selected have a census unit that is among the top five producers for one or more of the five decades examined (1950’s through 1990’s). Each of these watersheds contribute more than 1/2% of the total Area 4 escapement in one of the sampled decades; that is they produced an average of at least 5000 returning fish. In the 1990's these eight watersheds produced over 99% of the total escapement.

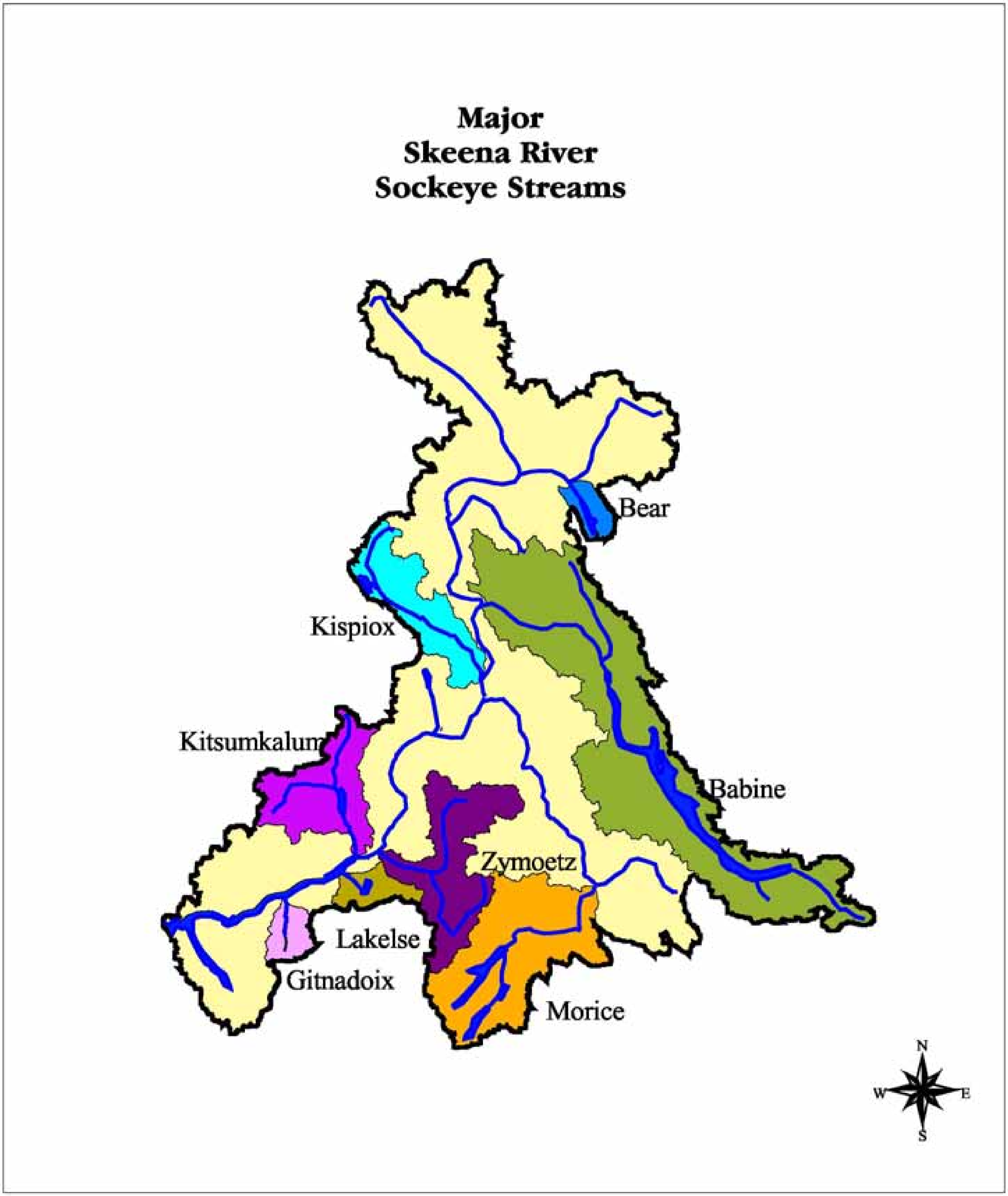


Figure 7. Productive sockeye watersheds in the Skeena region.

Coho in the Skeena Watershed

Coho salmon are widely dispersed throughout the Skeena Watershed. They are the most widespread of the salmon species and show the least amount of concentration into few productive stocks. Coho usually spend one to two winters in freshwater before migration to the ocean. They typically return as two or three year olds after spending one winter in the ocean (Holtby *et al.* 1994). Some males (jacks) return to spawn after only a few months at sea. Coho jacks are only present in the coastal portion of the Skeena from Kitwanga downstream. Coho typically spawn in small headwater streams.

Coho rearing typically takes place in streams, ponds, and lakes. In ponds and lakes juveniles inhabit the near-shore littoral zone (Irvine and Johnston 1992). In streams they prefer habitat with structural complexity including stones, logs and overhanging vegetation. River sidechannels and small streams often provide these conditions. Coho are dependent on low gradient streams (<2%) for rearing habitat (Nass *et al.* 1995) and they frequently occupy small upstream habitats. To get there, the adults have to migrate into small streams to spawn. Coho often move into these small spawning streams when heavy fall rains increase water flows that allow them to get over obstacles such as beaver dams.

Coho migrate into the Skeena River between late July and the end of September as recorded by the Tyee test fishery. The annual peak of the migration is in late August. In general the fish destined for upstream tributaries arrive first. This is because they spawn earlier in coldwater tributaries and have longer river travel times. The early arrivals pass through the various coastal fisheries along with the large sockeye run destined for Fulton River, a tributary of Babine Lake. The timing of the coho run is nearly coincident with that of the pink salmon runs. Coho are usually the last salmon to spawn in the fall. Spawning occurs from the end of September through December with late spawning being especially common in coastal areas.

The vast majority of coho return to their natal stream. However when compared to other species like sockeye and chinook, coho typically have a higher amount of straying. Several recent accounts suggest that typical straying rates are less than 1% (Sandercook 1991). Coho that do not return to their natal stream, most likely stray to nearby similar streams. Coho appear to wander freely within their spawning stream taking advantage of fall floods to pass barriers such as beaver dams to occupy new upstream areas. In years of low flows they may stray to other nearby streams or spawn further downstream. The regional pattern in the genetic structure of coho reflects this pattern of straying of adult fish (Beacham *et al.* 2001). Coho straying rates of less than 1% are sufficient to ensure gene flow between nearby streams (Wood and Holtby 1999).

The Skeena and Nass Watersheds coho constitute a genetically distinct regional group of populations (Small *et al.* 1998). Within the Skeena Watershed, variation appears to be roughly proportional to the distance apart of spawning streams. Wood and Holtby (1999) suggest that the effective size of subpopulations is approximately 100 to 400 km. Important evolutionary units are then at the major tributary level of separation. This suggests that there are several functional subpopulations in the Skeena. Typical units would be the coastal tributaries, the lower Skeena around Terrace, the Kispiox River and its tributaries, and the Bulkley River. The implication of this model is that decline of coho in a single stream is not an evolutionary concern if nearby streams retain healthy populations.

Coho populations in the Skeena have been in a long decline. Commercial coho catches in the Skeena River Region from 1910 to 1930 were three to ten times larger than the current escapements (Argue *et al.* 1986). Coho escapement counts begin about 1950 and show a trend of continuing decline to the late 1990's. The declines were especially severe in upriver stocks such as the Bulkley River (Figure 8), the Babine River, and the Bear-Sustut Rivers.

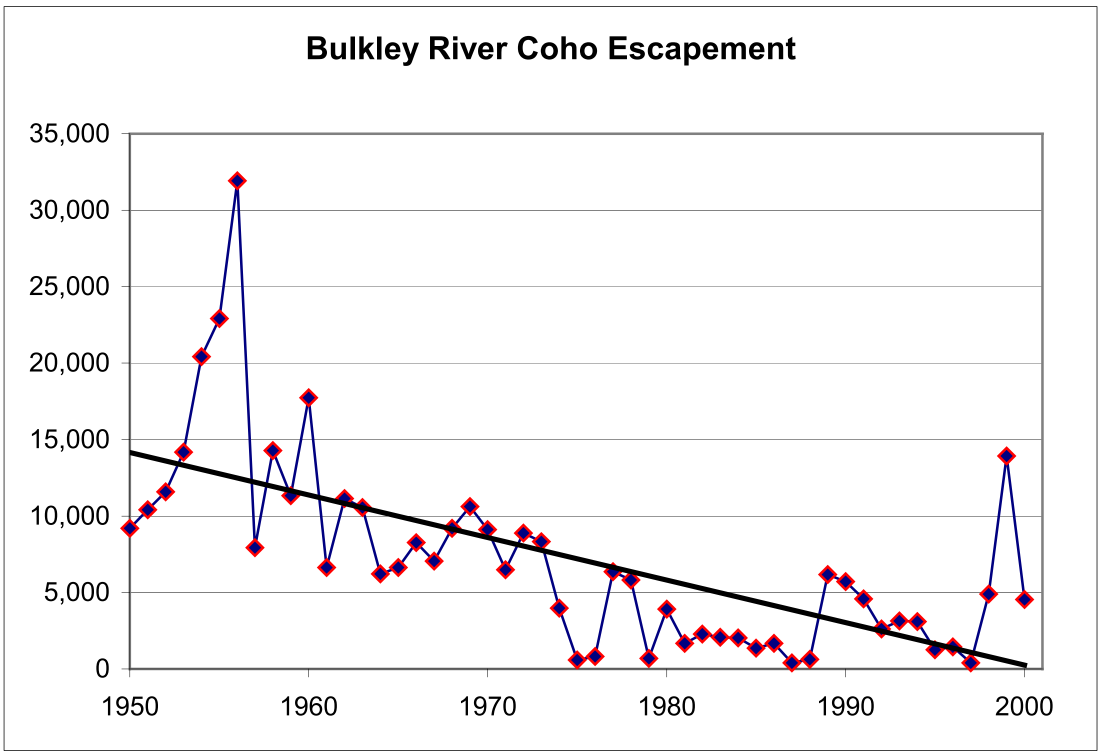


Figure 8. Spawning escapements of coho in the Bulkley River.
The line is a linear regression. Note the apparent recovery 1998-2000 coincident with severe restrictions on BC fisheries.

Likely causes of the decline in coho stocks are high rates of capture in Alaska and B.C. fisheries, a decline in ocean survival rates, and habitat damage. Skeena coho stocks are taken in a series of fisheries that include commercial fisheries in southeast Alaska and on the B.C. coast, aboriginal food fisheries on the coast and in-river, and sports fisheries on the coast and in-river.

Overall exploitation rates for three Skeena stocks are shown in Figure 9. The Lachmach River coho stock is a wild coastal stock from north of the Skeena estuary; the Toboggan Creek coho stock is in part a hatchery stock from the Bulkley Watershed north of Smithers; and the Fort Babine stock is a hatchery stock. Total exploitation rates before 1998 ranged for the most part from 60% to 80%. Few if any of the Skeena coho stocks can be expected to thrive at the upper range of this rate of exploitation. One third to one half of the total exploitation during this time period was in Alaska, where Skeena coho are harvested as an incidental catch along with a much larger Alaskan hatchery produced component. Much of the Canadian harvest is incidental catch in large sockeye and pink salmon coastal fisheries.

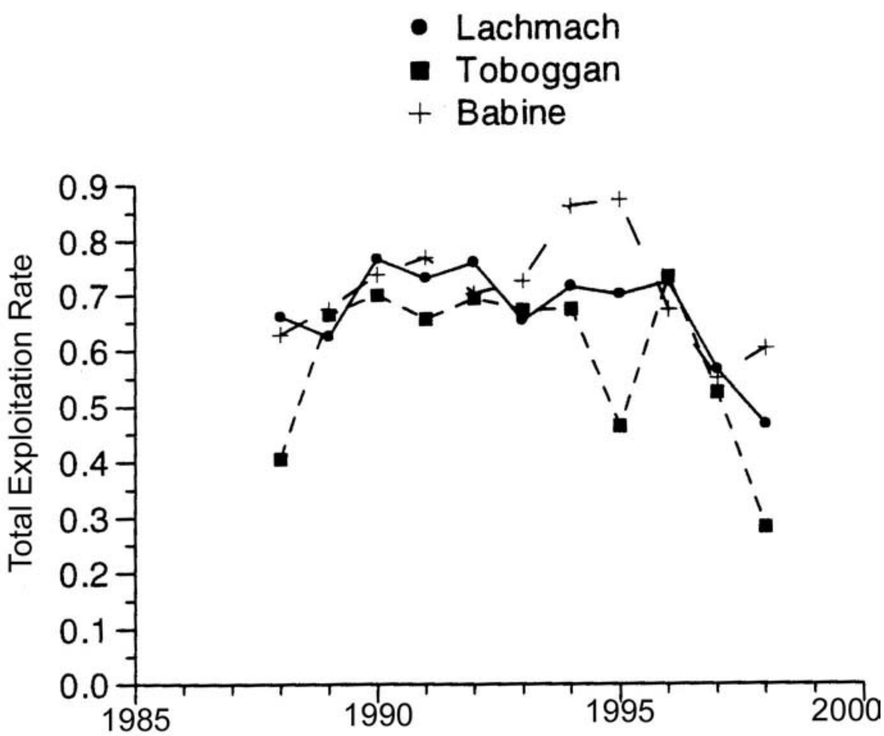


Figure 9. Total exploitation rates calculated for three Skeena index stocks (after Holtby *et al.* 1999).

The low escapements of Skeena coho in the 1980's and 1990's raised concerns about coho survival, especially survival of stocks spawning upstream of Terrace. DFO responded to this management crisis by instituting substantial changes to the commercial and sports fisheries in 1998 and 1999, directed at reducing the catch to zero. Severe restrictions on commercial fishing continued through 2001. These actions have met with some success as escapements increased in 1999, 2000 and 2001, with the added benefit of better-than-average ocean survivals.

Smolt to adult survival rates are a measure of ocean survival. The general pattern in the past decade in Oregon, Washington, and British Columbia is a decline in ocean survival. Mortality is highest in the first year at sea and probably in the first months. Ocean survival rates for Skeena coho are extremely variable (from 0.2% to 20%) and seem to have decreased in the 1980's through 1996. Survival rates for the few coho index stocks in the Skeena are shown in Figure 10. The increase in survival of 1998 smolts appears to have continued with 1999 and 2000 smolts, which returned in 2000 and 2001 (data not shown).

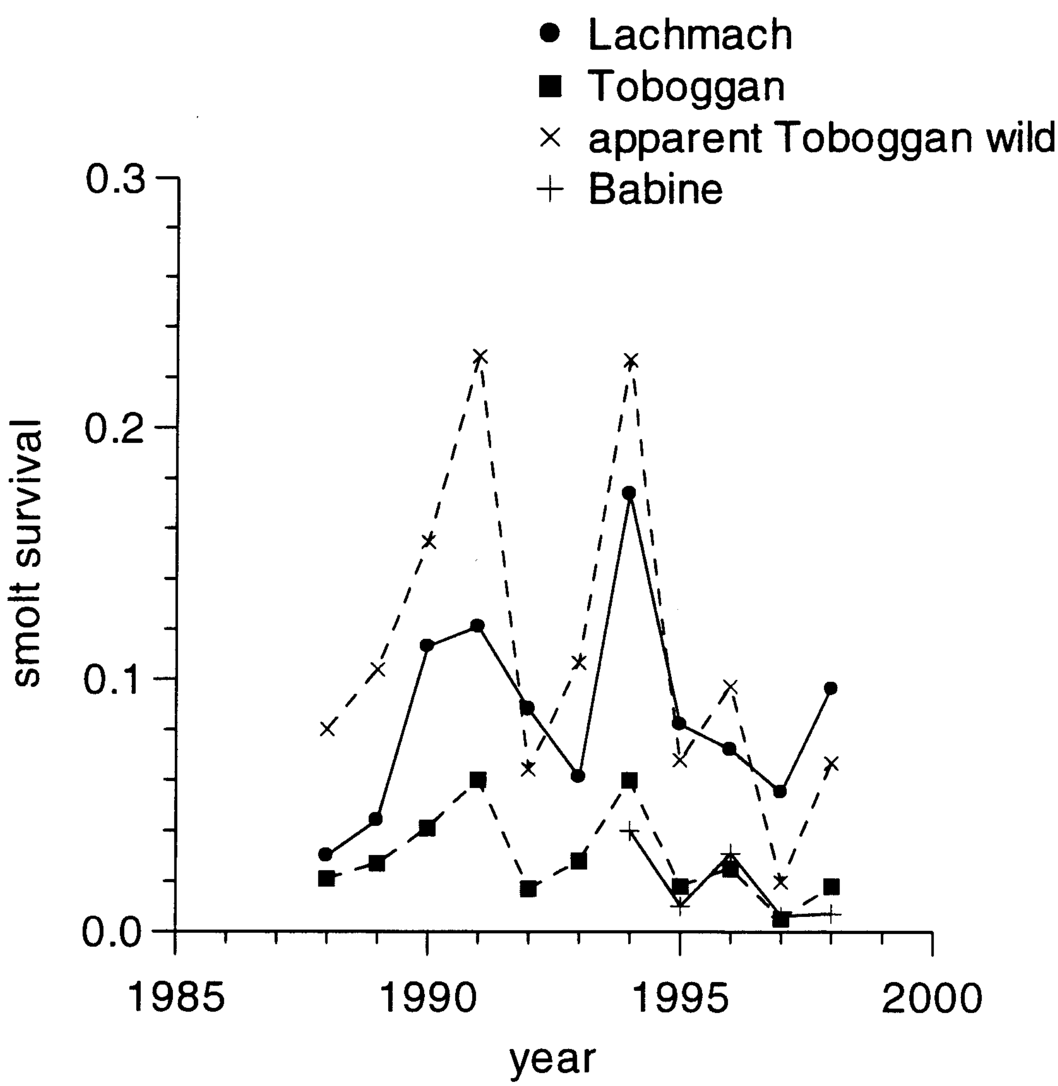


Figure 10. Survival rates of migrant smolts from several index stocks in the Skeena Watershed. (Holtby *et al.* 1999).

Coho are fish of small streams and are often dependent on off channel habitat such as beaver ponds, back channels, and seasonally flooded areas. These small stream and flood plain habitats are highly susceptible to damage from logging. Prior to the Forest Practices Code (1994) protection of small streams was often inadequate. Floodplain logging has severely impacted several portions of the Skeena Watershed including the Kitsumkalum, Lakelse, Zymoetz and West Skeena Watersheds.

In contrast, agricultural impacts are minor and localized. In the upper Bulkley area, riparian damage, fine sediment production, increased nutrient loading, and water withdrawal are associated with cattle ranching (Remington 1966). Similar impacts may occur on a few tributary streams in the Bulkley Valley. Agriculture elsewhere in the Skeena Watershed is extremely limited and therefore impacts will be small and local.

Coho enhancement has been popular for the past two decades. Small hatcheries have been functioning in the vicinity of Terrace, Hazelton, Kispiox, Smithers, Houston and Fort Babine. The effectiveness of these efforts is variable. The hatchery at Toboggan Creek north of Smithers has apparently been effective, such that most coho in the Bulkley Watershed now originate from Toboggan Creek (SEDS database). However the benefits of outplants to the Upper Bulkley and Morice River are not apparent. For the most part, the effectiveness of other projects, such as outplanting from the Chicago Creek, Kispiox, Eby Street, and Fort Babine hatcheries is unknown.

Due to the overall decline of coho in the Skeena, many individual stocks show serious declines. The selection of stocks of particular concern that follows is based primarily on evaluation of the SEDS database. These records are in large part derived from stream escapement estimates. Counts of coho spawners in streams are notoriously difficult and often underestimate true escapement numbers. The concern for individual coho stocks should be assayed against the generalized pattern of genetic differentiation and the ability of coho to reoccupy available habitat. It is clear that rebuilding coho in the Skeena region will require a sustained program of conservation efforts.

Stocks of particular concern include:

Khyex River – The record is incomplete, but it appears that escapements were in the 600 to 2000 range until about 1988. Four years of data since then show counts of 0 to 200; however, the nearby Kasiks and Ecstall Rivers seem to be doing fairly well.

Gitnadoix River and tributaries such as Kadeen Creek and Southend Creek have had great reductions in their coho runs since the early 1970's. Recent escapement records record less than 10% of early escapements, although these numbers may have resulted from high-water or other difficult counting conditions. However Dog Tag Creek, a lower tributary, seems to have a stable escapement trend and enough coho are still present for rebuilding. The Gitnadoix coho are of high First Nations interest in that an aboriginal weir fishery exploited them.

The Bulkley River system has shown serious declines in coho (Figure 8) since the 1970's. The Morice River and its tributaries were a leading coho producing river in the 1950's with an average escapement of over 10,000. The three escapement counts from the 1990's average less than 800. High quality rearing habitat is now unused. The decline in coho escapement is similar in the Upper Bulkley River. At this time, most of the production of coho in the Bulkley River (74%) comes from Toboggan Creek that is in part supplied by a hatchery located on that creek.

Fiddler Creek is the principal coho producing stream between the Zymoetz and the Kitwanga Rivers. It is about halfway between these rivers and has a flashy hydrologic regime and moderate amounts of spawning and rearing habitat for coho. It had coho escapements of 400 to 750 in the 1970's. Recent escapements have been very low. In 2001, a relatively good year, the escapement was 75. This coho population is important to the Gitxsan who harvested this stock in the past.

The Zymoetz River was one of the principal producers of coho in the 1950's to 1970's with annual escapements of about 5000. In recent years, escapement estimates have been well under 1000. The decline in coho seems especially severe in the lower portion of the river that has experienced numerous development impacts and associated channel instability.

All Babine Lake coho stocks show a serious decline since the 1970's. Juvenile density estimates are also low when compared to other portions of the Skeena (Holtby *et al.* 1999). The decline in coho is especially large in the southern tributaries of Babine Lake such as Pinkut Creek, Shass Creek, and Pierre Creek. Although recent records are of poor quality, the stocks in Shass Creek and Pierre Creek seem at high risk of extirpation. The general cause of decline in these stocks is high exploitation rates and poor smolt to adult survival. These are compounded by the increased occurrence of drought in this driest portion of the Skeena Watershed.

The Bear River system and the upper part of the Sustut River have a severe decrease in coho escapement. Juvenile density estimates are also low when compared to other portions of the Skeena (Holtby *et al.* 1999). Although escapement records are of poor quality in this remote area, it seems that the current escapements are less than 10% of the historic levels. 1990's escapement estimates suggest that the spawning population is now less than 200, a level that merits serious concern.

Selected Watersheds:

The important coho salmon spawning rivers are:

- Morice River
- Babine River
- Kispiox River
- Lakelse River
- Gitnadoix River
- Ecstall River
- Kitsumkalum River

These watersheds were selected from the combined set in the SEDS database. All of the rivers selected have a census unit that is among the top five producers of coho for one or more of the five decades examined (1950's through 1990's). In addition each of these watersheds contributed more than 5% of the total Area 4 escapement in one of the sampled decades; that is, they produced an average of at least 3000 returning fish. In the 1990's, escapement to these streams made up 67 % of the total escapement to Area 4.

The watersheds selected are well ahead of other watersheds in the Skeena and stand alone as the highly productive coho spawning and rearing habitats. The single exception is the middle Bulkley River between Moricetown and the Morice River confluence. In the 1960's this region was the fifth most important watershed in the Skeena, contributing 4% of the recorded escapement. The largest component of the coho production in the middle Bulkley in the 1960's was the section of the Bulkley River immediately below the Morice River and presumably included some fish from the larger upstream run.

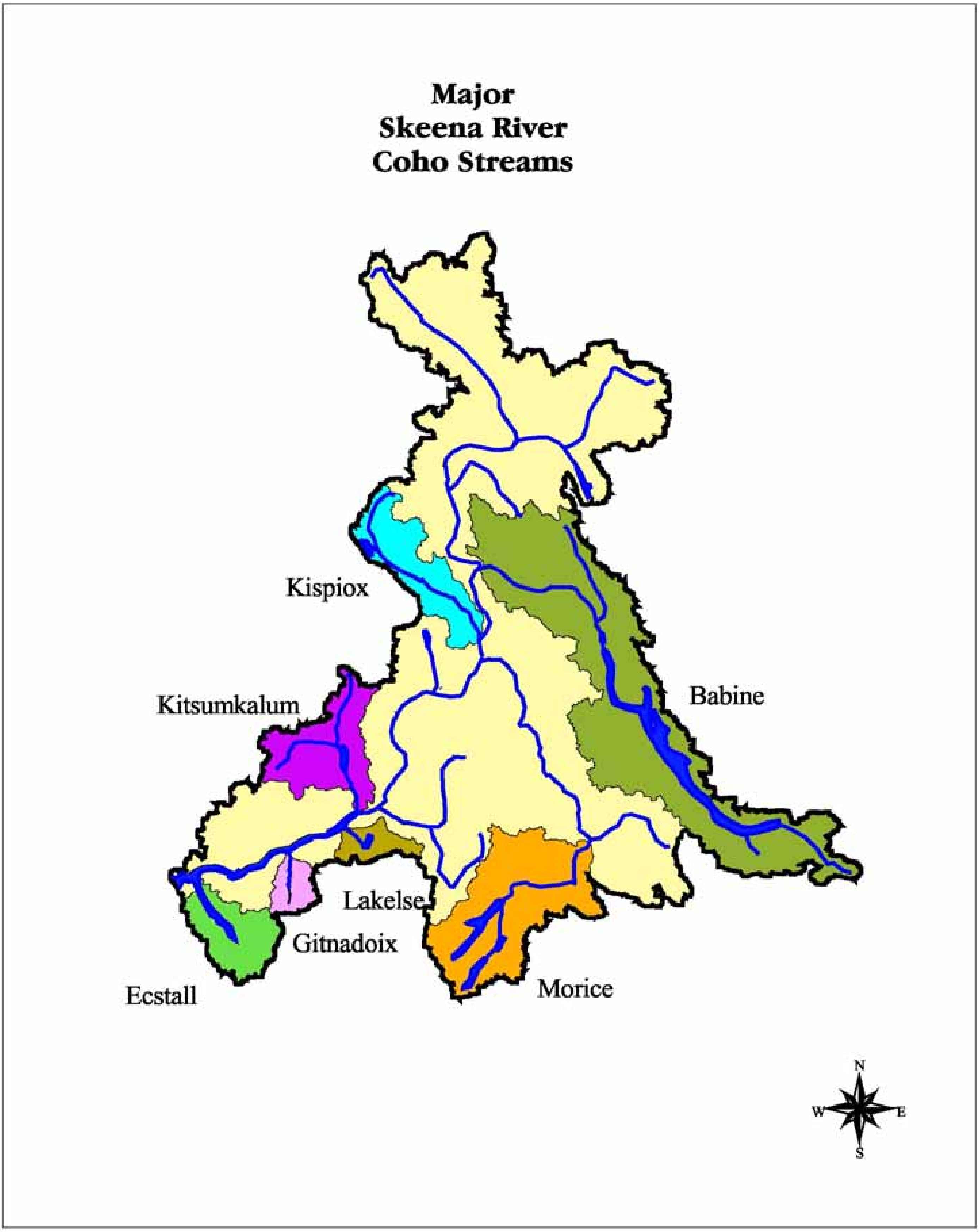


Figure 11. Productive coho watersheds in the Skeena region.

Pink Salmon in the Skeena Watershed

Pink salmon are exclusively two years old at spawning time. This means that odd and even year stocks are genetically separate. In many watersheds either the odd or even year runs are dominant. Most discussions of pink salmon stock assessment treat the odd and even years separately. The Skeena Watershed does not have a well-developed dominance. Therefore, for ease of discussion in this report the two cohorts are dealt with together.

Pink salmon arrive in the Skeena River from late July to early September, about three weeks after the sockeye. The largest spawning populations are in the coastal portion of the Skeena Watershed, although significant numbers reach headwater areas such as the Kitwanga, Kispiox, Babine and Morice Rivers. Pink salmon spawn in gravel areas in late August and September, soon after ascending the river. Pink salmon fry emerge in April and May and go to sea immediately upon hatching. They may begin to feed during their river migration, especially upstream stocks. Pink salmon return at a smaller size than other salmon due to their short life cycle. In the ocean they grow faster than other salmon species (Heard 1991).

Pink salmon tend to stray at higher rates than other salmon (Horrall 1981). Heard (1991) summarizes mark and recapture experiments that show approximately 10% straying in pink salmon. Most straying is to nearby streams. In years of large escapement many pinks wander into previously unused spawning areas and even spawn in places that appear to be unsuitable. The genetic structure of pink salmon populations reflects this pattern of straying. Only regional patterns of stock separation have been described. Beacham et al. (1985) report allozyme studies that resulted in identification of three stock groups: Fraser River, Puget Sound and B.C. non-Fraser. In general, the odd and even year lineages of pink salmon are more different genetically than stream populations over large areas (Heard 1991).

There are probably at most a few biologically definable pink salmon subpopulations that occupy the Skeena River. If so, these stocks would each occupy large portions of the watershed. There is an exceptional variability in stock recruitment from year to year, perhaps due to variation in survival of fry early in their ocean residence. These characteristics and the general robust size of spawning stocks mean that there are no identifiable stocks at risk.

Pink salmon are the one species of Pacific salmon that has been expanding in the Skeena River. Escapements in the 1980's are the highest in the escapement record (Figure 12). Total escapement doubled from the 1950's to the 1990's. The total pink salmon run size before harvest averaged over 5 million in the 1980's and 1990's.

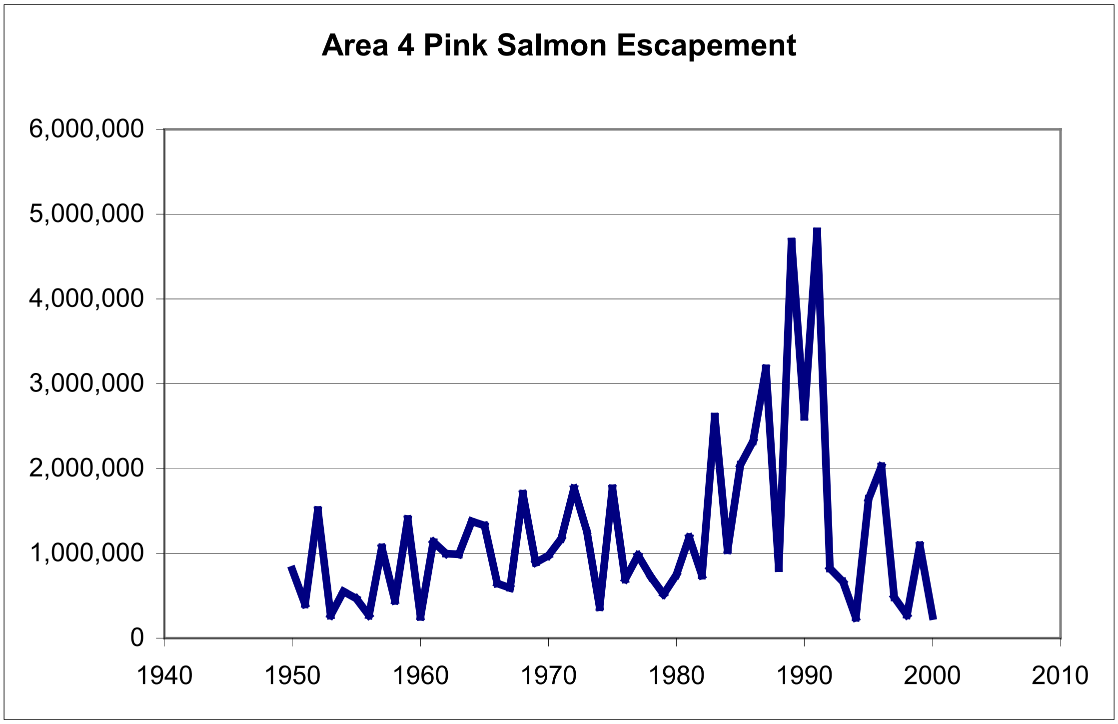


Figure 12. Pink salmon escapements in the Skeena Region.
Note the dramatic increase in escapements in the late 1980's and early 1990's.

In the 1980's pink salmon increased their range in the Morice River. The population expanded rapidly and exceeded 600,000 in 1991. The Skeena River West escapement also grew rapidly during this interval. Lakelse River continues to be the leading pink salmon producer with Lakelse River spawning occurring mostly in the few kilometres below the lake outlet. These gravels are consequently the most productive natural spawning area in B.C. Because of the generalized population structure in pink salmon, and the relatively high rate of straying there is little concern about the continued survival of small pink salmon populations. We assume that these areas are repopulated in years of high returns when straying is maximal.

Selected Watersheds:

The important pink salmon spawning rivers are:

- Morice River
- Babine River
- Kispiox River
- Kitwanga River
- Lakelse River
- Skeena River West

These watersheds were selected from the combined set in the SEDS database. All of the streams selected have a census unit that is among the top five pink salmon producers for one or more of the five decades examined (1950's through 1990's). Each of these watersheds contribute more than 8% of the total Area 4 escapement in one of the sampled decades; that is, they each produced an average of at least 100,000 returning fish. In the 1990's, escapement to these streams makes up 84% of the total escapement to Area 4.

The Bear River qualifies under the definition used above for the 1960's only. It is excluded from the selection because the decadal average is based on a single large escapement estimate (500,000) for 1989. There are no other comparable escapements for other years; the next highest enumeration is 35,000 in 1959.

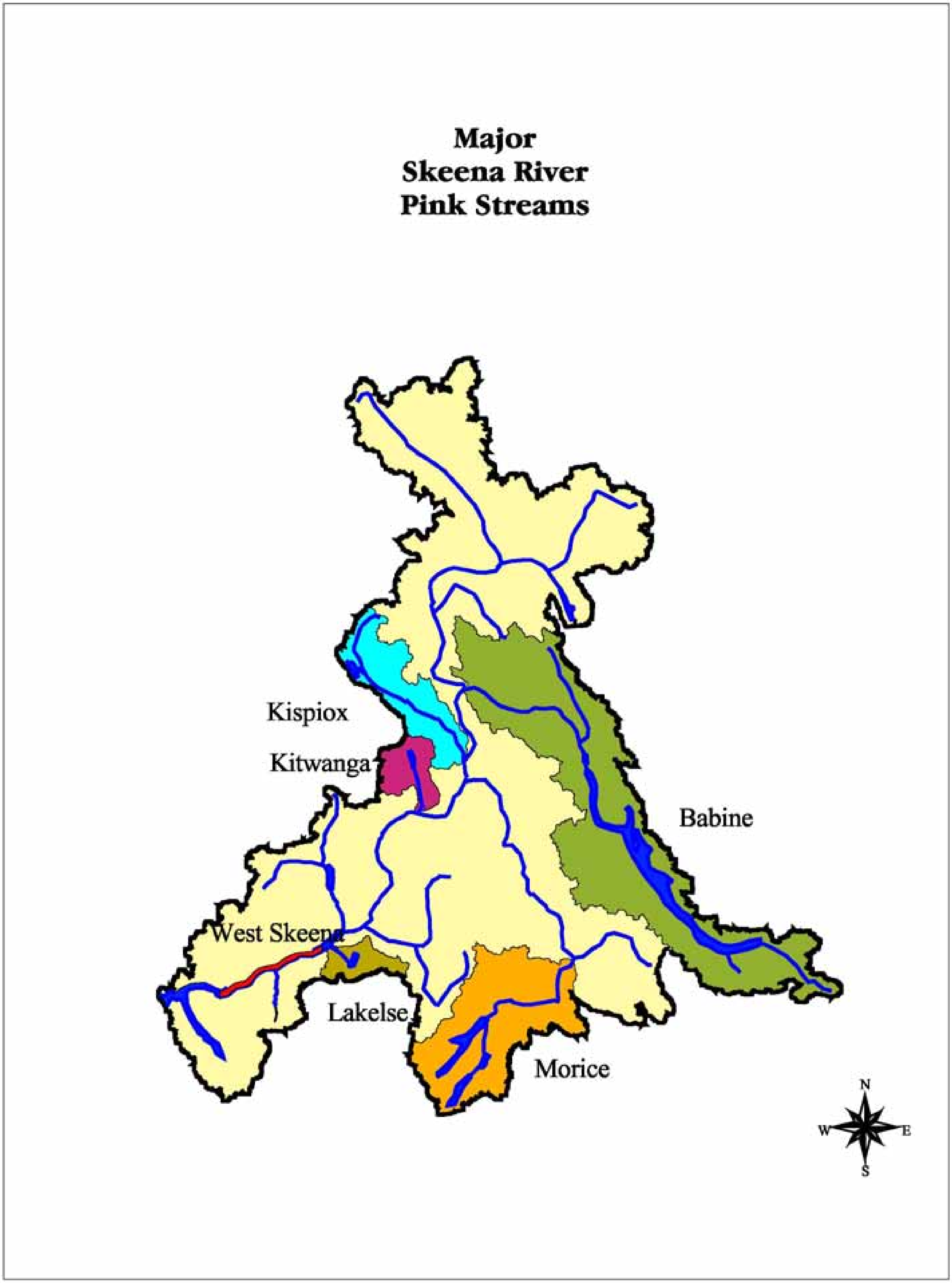


Figure 13. Productive pink salmon watersheds in the Skeena region.

Chinook in the Skeena Watershed

Chinook are the largest species of salmon in the Skeena Watershed. In general they are fish of larger streams and spawn in faster moving water with coarser gravel than other salmon. Typical chinook stocks are relatively small (Healey 1991). The largest Skeena chinook stocks, Bear River and Morice River, have average escapements under 20,000 in their most productive decade. Most stocks have average escapements of fewer than 500 chinook.

Chinook are the first salmon species to return to freshwater resulting in their popular name of "springs". Early stocks arrive in May and June; late stocks in June and July. The early stocks are usually upriver (headwaters) stocks such as Upper Bulkley, Bear River, and Upper Kitsumkalum. Late stocks tend to be more coastal and/or tend to spawn downstream of lakes.

Most chinook spawning occurs in August and September. When spawning occurs at high densities as in the Morice, Bear, and Babine Rivers, spawning dunes are created by the merger of adjacent redds. Fry emerge from the gravel early in the spring. After hatching many fry move or are displaced downstream. Chinook fry are territorial and as they grow, individual territories expand with the excluded fish displaced downstream.

In the Skeena, chinook fry spend one year in freshwater. A small number of mostly coastal fish go to sea shortly after hatching. Overall in the Skeena, only a few percent of chinook go to sea in their first summer (Peacock *et al*. 1997). In the Kitsumkalum River, generally less than 10% leave before the first winter. The rest of the smolts migrate to sea during spring high flows in May and June, when turbid water and faster flows serve to reduce predation. Chinook return after one to five years at sea, though most return after three seasons. Chinook with longer ocean residence times are larger as adults.

Chinook originating from Oregon through Alaska are widely mixed along the Pacific coast. Coastal fisheries therefore intercept fish originating in many rivers. This classic mixed-stock fishery has been difficult to manage without serious impacts on less productive stocks. Since the 1950's, chinook stocks have generally declined; this led to management actions that progressively decreased the commercial and sports catches. Restriction of North Coast chinook fisheries began in the mid 1970's. Restrictions on river sports fishing began in 1975 (Ginetz 1976). The 1985 Canada U.S. Pacific Salmon Treaty, and its subsequent amendments restricting the coastal commercial fishery in B.C., has provisions to stop the decline of chinook.

In the last few years the marine sports fishing component, although small, has increased. Sports fishing in the Lower Skeena is an important constituent of the overall chinook exploitation. Chinook salmon are also an important part of aboriginal fisheries being next in importance to sockeye. Significant harvests are taken in the Skeena River above and below Hazelton, and at Moricetown. In the past there was a large chinook fishery at Bear River.

Information on chinook stocks prior to 1950 is available only from catch data. Catches from 1899 to 1930 in the Skeena River fishery averaged over 100,000 chinook with peak catches exceeding 200,000 (Ginetz 1976, Riddell and Snyder 1989). Chinook catches declined steadily from 1930 to the 1970's. Escapement data based on spawning ground counts (Figure 14) has been collected since 1950. Total Skeena River escapement was about 50,000 in the 1950's, declining to about 25,000 from 1965 to 1985. Chinook escapement has been recovering in the past 15 years and is now approaching levels of fifty years ago. It is likely that the increase in escapement from 1985 to the present is due to the restriction on chinook harvest in Alaska that took effect with the Pacific Salmon Treaty. It should be noted that the recent recovery of Skeena chinook escapement to 1950's levels, is in the absence of a large commercial fishery in B.C

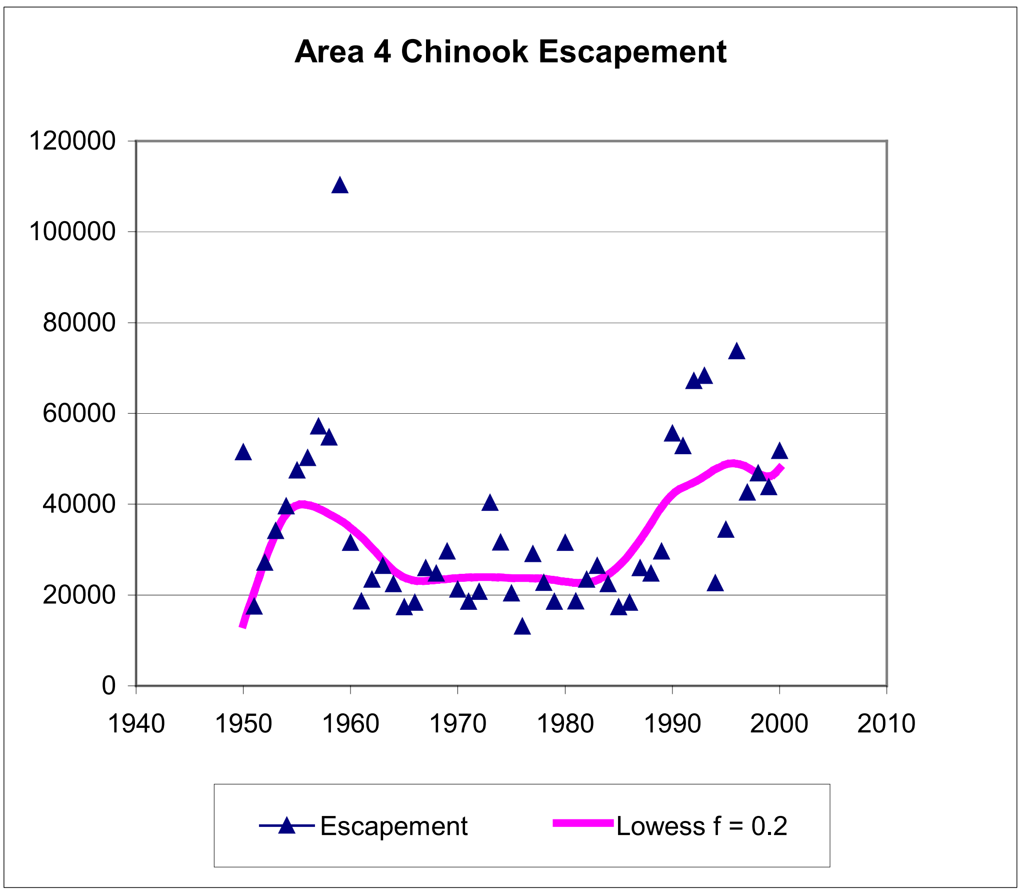


Figure 14. Skeena River chinook salmon escapements 1950 – 2000.

Overall exploitation rates in all fisheries, in the mid 1980's to mid 1990's, was 10%-25% for the early Upper Bulkley Stock and 35% to 65% for the mid-season lower Kitsumkalum Stock (Peacock *et al.* 97). Hankin and Healy (1986) suggest a maximum sustained yield exploitation rate for chinook of 40%. If this is an appropriate level, then pre-1985 harvests were too high to sustain a productive chinook population. The Kitsumkalum exploitation rates for the mid 80s to mid 90s are at about the limit proposed by Hankin and Healy; the Upper Bulkley stocks are well below it. Nevertheless, it is likely that the long term depression in chinook production and the recent increase in stock productivity is due not only to changes in exploitation rate, but also to changes in ocean survival.

The genetic structure of chinook stocks is discussed by Beacham *et al.*(1996). Their paper focuses on the separation of regional stocks and defines Vancouver Island, Fraser and North Coast aggregates, though individual stocks are also separable. Chinook from Skeena tributary rivers such as the Kitwanga River and the Bulkley River are clearly separable. Even within a watershed like the Kitsumkalum, early run chinook from above Kitsumkalum Lake are quite distinct from the late run, lower Kitsumkalum stock. Early run chinook which spawn in the upper Bulkley River are distinct from the more numerous late run which spawn mostly in the Morice River. More recent unpublished work confirms these separations. If we assume that individual spawning stocks are genetically distinct, then the conservation units are narrowly drawn and we must be concerned about preservation of the smaller stocks as well as the more productive larger stocks.

Chinook enhancement via hatchery production began in 1978 at Fulton River. It developed rapidly in the 1980's and 1990's with the spread of small hatcheries to Terrace, Kispiox, Toboggan Creek, Emerson Creek and Fort Babine (Peacock *et al.* 1997). Between 1978 and 1995 about 9 million fry and smolts were released. The coded wire tagged fry and smolts from this hatchery have contributed to the understanding of ocean survival rates and interception in various coastal fisheries. Estimated survivals to adult stage are variable: 0.0 to 0.9% for fry, 0.4 to 0.6 % for smolts, and 0.0 to 5.5% for yearlings (Peacock *et al.* 1997).

Stocks of particular concern:

As previously discussed, the overall chinook escapement to the Skeena Watershed may be a fifth or less of the escapement a hundred years ago. The problem with many chinook stocks is that at times of poor overall returns to the Skeena system, the smaller stocks may be eliminated. When stock numbers fall below several hundred, there is a significant chance of loss of genetic diversity, which adversely affects the chances of long-term survival (Franklin 1980, Waples 1990).

Deep Creek is on the northern edge of Terrace. Some of its flow has been diverted to the Terrace water supply system for about 40 years, although in recent years Terrace has used well water supplies, with only occasional use of Deep Creek water. The chinook in Deep Creek are a small stock with escapement in the hundreds in the 1970's, in the tens in the 1980's and near zero in the past decade. Spawning chinook have been noted in the past few years, but they might be escapees from the Deep Creek Hatchery. The run timing is apparently similar to the adjacent lower Kitsumkalum River and this stock may be part of the larger lower Kitsumkalum run.

The Upper Bulkley had low chinook escapements from the 1960's to the 1980's. There has been substantial recovery since 1988. There were record high runs in 2000 and 2001, years of high summer flows. The Upper Bulkley stock is an early run stock that is genetically distinct from the larger and later Morice run (Beacham *et al.* 1996). The trend to lower stream flows in late summer probably has contributed to the decline of this stock. Commercial fishing exploitation rates have been modest for at least the last fifteen years, which may have contributed to the recovery of this population. The exploitation in the food fishery by the Wet'suwet'en First Nation at Moricetown is probably modest because of the early migration timing. The Upper Bulkley stock is enhanced and serves as an index stock for management. Hatchery releases took place from 1985 to at least 1993.

The Zymagotitz (Zymacord) River has a very small chinook stock. It is difficult to enumerate this stream. As far as the field counts can be trusted, there were about 100 spawners at the peak in the 1970's. Escapement estimates for the 1990's have declined to about 25. The Zymagotitz tributary Erlandsen Creek has had escapements of about 20 fish, but had a record high escapement of 140 in 2001. The low escapement numbers for the Zymagotitz stocks are reason for concern about long-term survival.

The Gitnadoix River chinook stock has declined from about 400 in the 1960's to an average of less than 40 in the 1990's. The overall escapement has been poor for the past 20 years. Since this watershed is undeveloped and is now a Provincial Park we can assume that there are no anthropogenic environmental changes. In the past two decades the Gitnadoix tributary, Magar Creek, has been supporting increasing numbers of chinook. Two escapements in the past four years have been 300.

The Shegunia River mouth is located across the Skeena from the Kispiox River. It supported an important Gitxsan traditional chinook fishery. Escapement data are poor, but numbers seem to be depressed since the 1950's. Hatchery reared fry and smolts from this stock were released from 1986 to 1994. Increases from this outplanting may have contributed to a short-term increase in escapement but long-term recovery is not apparent. Logging in the drainage that took place from the 1970's to 1990's may be a contributing factor. The watershed has a high sediment producing regime. The Salmon River Road has provided angler access to a critical holding area since the 1950's.

Babine River chinook escapement has been poor since the 1960's. It has not recovered in the past two decades as many other stocks have, despite supplementation by hatchery production. The peak of this run is in late July and early August, coinciding with the sockeye and pink salmon fisheries. Although population levels are depressed, this stock has adequate escapement for maintenance.

Lakelse River and Coldwater Creek are a small stock with peak escapements of about 400 in the 1970's and 1980's. The adult spawning population has declined strongly since 1990. The average count for the 1990's is about 100. Coldwater Creek is a tributary of the Lakelse River adjacent to the chinook spawning area below Lakelse Lake. In the 1980's and early 1990's the escapement of chinook to Coldwater Creek exceeded that of Lakelse River. Counts are not available for either locality for the last two seasons that saw strong stock recovery in many other parts of the Skeena Watershed. This is an early chinook run, with spawning mostly occurring in mid-July and August. Hatchery releases of fish raised in the Deep Creek hatchery were made from 1986 to 1991, although they do not seem to have helped. The population size of this stock, based on available data, appears alarmingly small. It is possible that the Lakelse and Coldwater chinook enumerations are the same fish changing their spawning destinations based on habitat conditions. If this were true, then the total watershed chinook count would appear relatively stable. This situation exists with the Gitnadoix River and Magar Creek chinook as well.

The Ecstall River system includes two census areas for chinook: Johnston Creek and Ecstall River. This river was one of the top five producers in the 1950 to 1970's. It has since declined severely. Sports fishing impacts were noted in the 1970's and may have contributed to the decline. The commercial fisheries exploitation rate for this stock may be exceptionally high, restricting the ability of the Ecstall River chinook to recover. In the 1990's escapement averaged 650, about one seventh of the 1950's and 1960's escapement, and one third of the 1970's escapement. Although population levels are severely depressed, this stock has adequate escapement for maintenance.

The Suskwa River has a small chinook stock. Peak escapements during the last fifty years were several hundred. Recorded escapement values in the period from 1988 to 1992 ranged from 0 to 60. No records are available after that date. This watershed had heavy logging impacts in the 1970's, and continues to have large-scale landslide activity. The present level of chinook escapement does not suggest a stable population level, or long-term survival of this population.

Selected Watersheds:

The important chinook salmon spawning rivers are:

- Morice River
- Babine River
- Bear River
- Kispiox River
- Kitwanga River
- Kitsumkalum River
- Ecstall River

These watersheds were selected from the combined set in the SEDS database. Various tributaries within the watersheds were combined to evaluate the proportion of the total Area 4 escapement. All of the streams selected have a census unit that is among the top five producers of chinook salmon for one or more of the five decades examined (1950's through 1990's). Each of these watersheds contribute more than 5% of the total Area 4 escapement in one of the sampled decades, that is, they produced an average of at least 1500 returning fish. In the 1990's these watersheds accounted for 93% of the total Area 4 escapement.

Major Skeena River Chinook Streams

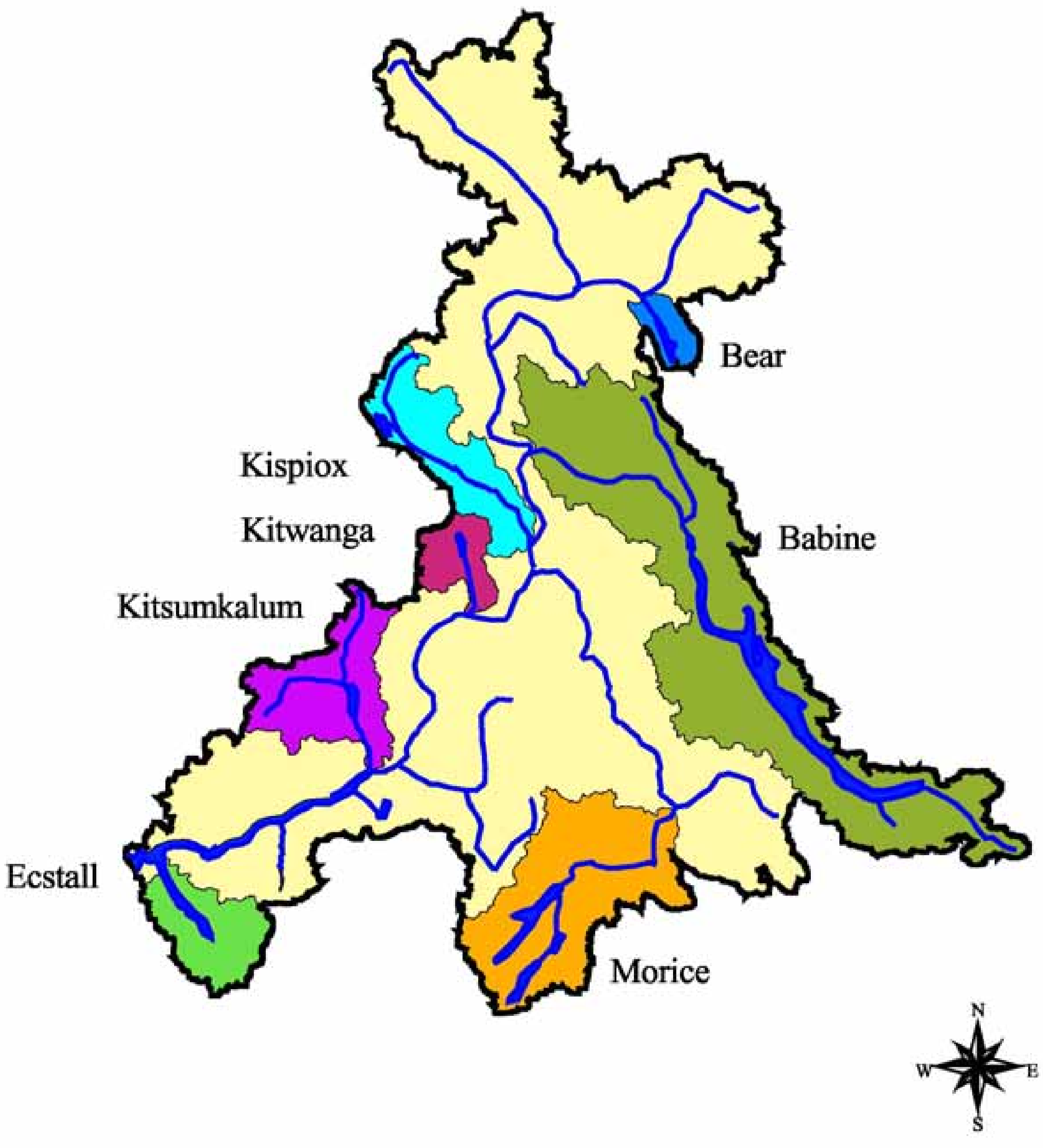


Figure 15. Productive chinook watersheds in the Skeena region.

Chum Salmon in the Skeena Watershed

Chum salmon are the least abundant of the six Pacific salmon species in the Skeena Watershed. They are much more abundant in southern BC and in Southeast Alaska where hatcheries production enhances some of the stocks. In the Skeena Watershed, chum salmon live two to five years. Three year old returning fish are most abundant, but four year old fish are generally present at spawning time (Halupka et al. 2000). Chum salmon arrive in the Skeena system from late July to early September. Their migration coincides with the much larger runs of pink salmon, and they usually spawn in places that also have spawning pink salmon. Unlike coho and sockeye, which may hold for a month or two before spawning, chums spawn soon after traveling up the Skeena River. Fry emerge early in the spring and migrate to the Skeena estuary immediately upon hatching. Chum salmon smolts typically remain in estuaries for one to several months, growing rapidly before dispersing in the ocean (Healey 1980). There is apparently a high degree of variability in the survival rate of chum early in their marine life.

Chum are most common in the coastal portion of the Skeena Watershed. The most important spawning areas are the Ecstall River and the multi-channelled reach of the Skeena River below Terrace. Other spawning areas are near the mouths of large tributary streams and in back channels along the Skeena River from Terrace to Kispiox. Significant spawning occurs in the Kitwanga and Kispiox Rivers. Smaller stocks are present in the lower portions of several other Skeena River tributaries. Chum are rare in the Bulkley River and in the Skeena River above the Kispiox River confluence.

There is an extraordinary variability in year to year chum salmon returns. Annual escapement estimates (SEDS Database) have varied one hundred fold over the past fifty years (Figure 16).

Field observations suggest that chum are highly specialized in their selection of spawning sites. Several of the Skeena River spawning sites used every year are less than a few hundred meters long. Chum continue to use these patches of gravel even when channel reorganization separates them from their former source of flow. At Andesite Creek and Coyote Creek, former tributary mouth spawners are still using the same patch of gravel after avulsions moved the stream mouths some distance away.

There are no genetic studies aimed at separating stocks of chum at the river tributary level. Beacham et al. (1987) used electrophoretic analysis to distinguish five large scale population assemblages in chum salmon: the Queen Charlotte Islands, the north and central coast, the west coast Vancouver Island, the south coast and the Fraser River system. Kondzela et al. (1994) used similar techniques to divide Southeast Alaska and northern British Columbia stocks into six groups.

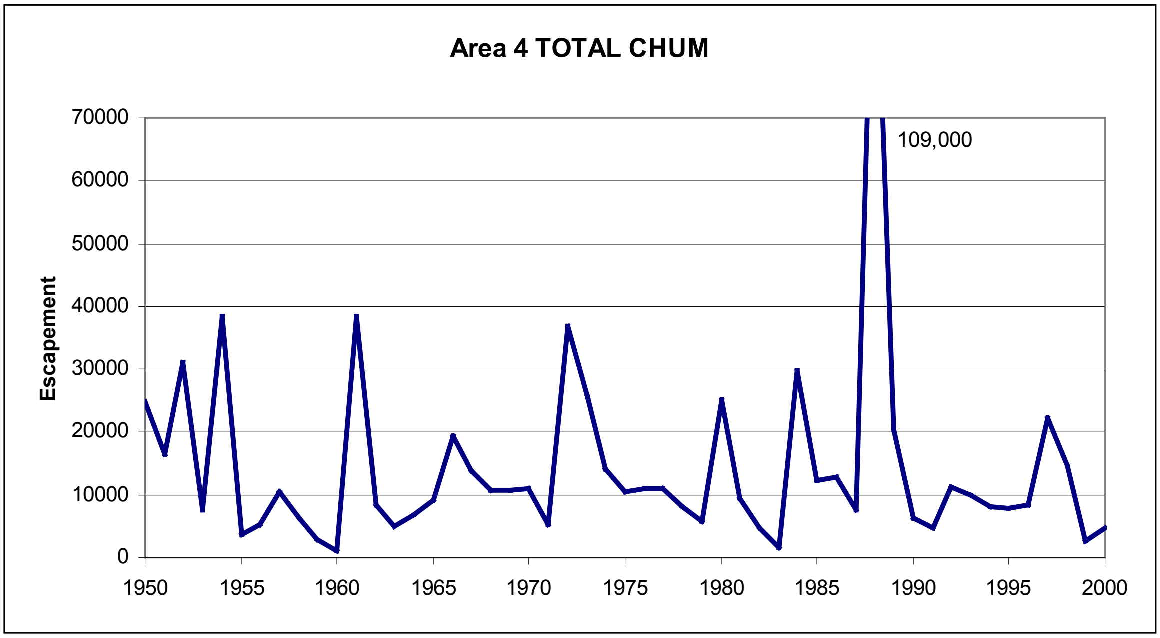


Figure 16. Total chum escapement in the Skeena region (Area 4) based on spawning grounds surveys.

Chum salmon stocks were apparently much larger early in the twentieth century. The commercial catch of chum salmon in the Skeena Area between 1916 and 1928 was over 200,000 per year (Argue et al. 1986). This suggests an escapement about ten times larger than that of the recent past. Chum salmon escapements have been low for the last 50 years. With the exception of the spectacular high escapement in 1988, the average escapements have been declining over this period. Even with the 1988 data, a smoothed trend line (LOWESS smoothing, Figure 17) shows a decreasing escapement.

The decline in chum salmon stocks is basin wide, suggesting that much of the problem is in the marine realm. Similar declines have taken place in the mid-coast region and in southeast Alaska non-enhanced stocks. This suggests that a major component of the decline in chum salmon is decreased ocean survival.

Skeena River chum salmon are taken as incidental catches in the sockeye and pink salmon fisheries of Area 3, 4, and 5 and to a lesser extent in the Noyes Island and Cape Fox fisheries in Alaska. They are also taken in small numbers in First Nations food fisheries. Charles and Henderson (1985) calculate an overall exploitation rate of between 50% and 83% for the years between 1970 and 1982. This relatively high exploitation rate has probably also contributed to the decline of the Skeena stocks.

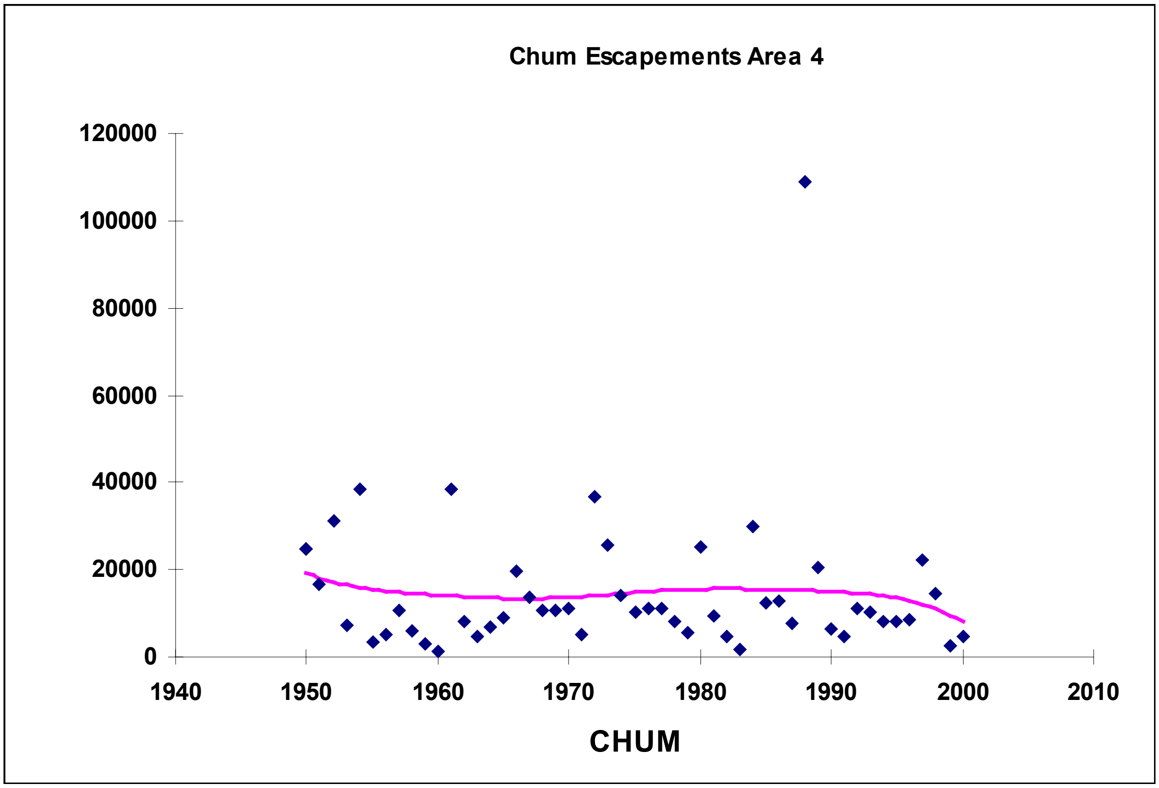


Figure 17. Chum escapements in Area 4.
The curve is a LOWESS smooth that shows a gradual decline of Chum salmon in the past 50 years.

The average overall escapement to Area 4 in the 1990's was only 10,000 to 14,000 chum salmon. The Ecstall and the West Skeena areas contain the only strong stocks, accounting for over 9000 of this total. In the 1990's, 29 censused stocks had escapements below 200, of which, 26 had average escapements of below 100. In general, one can conclude that chum are probably the Skeena Watershed salmon species in greatest danger of significant loss of spawning stocks and genetic diversity.

On the Skeena River, several areas regularly used in the past, such as the back-channel near Thornhill above Terrace, no longer support spawning fish (Kofoed 2001). On the other hand several field workers suggest that the main stem Skeena populations below Terrace are under-reported because of turbid water conditions at spawning time (Kofoed 2001, Bustard 2002, Culp 2002).

Of special note is the extremely low levels or loss of the once large Lakelse River chum stock. The formerly large Kispiox River stock has also declined dramatically, but there are still chum present. Other stocks with very poor recorded returns are Kleanza Creek, Fiddler Creek, Deep Creek, Zymoetz River and Zymacord River.

Selected Watersheds:

The important chum salmon spawning rivers are:

- Kispiox River
- Kitwanga River
- Kitsumkalum River
- Lakelse River
- Gitnadoix River
- Ecstall River
- Skeena River West

These watersheds were selected from the combined set in the SEDS database. Where more than one census area is within a watershed, such as several tributaries individually counted, the spawning escapements are summed for the watershed. All of the streams selected are among the top five producers for one or more of the five decades examined (1950's through 1990's). Each of these watersheds contribute more than 5% of the total Area 4 escapement in one of the sampled decades that is they produced an average of at least 690 returning fish. In the 90's these watersheds accounted for 93% of the total Area 4 escapement.

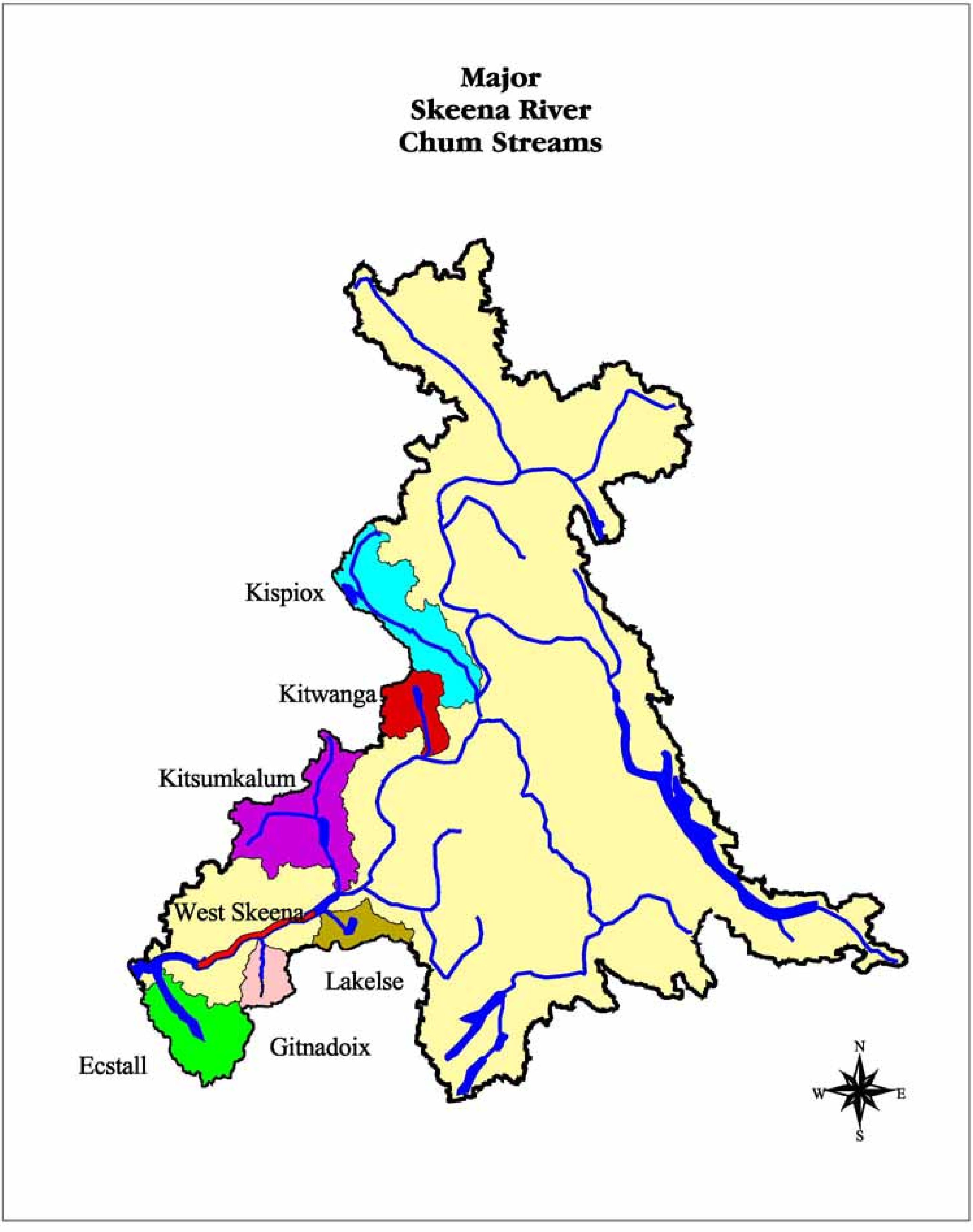


Figure 18. Productive chum salmon watersheds in the Skeena region.

Steelhead in the Skeena Watershed

Typically, Skeena Watershed streams support both sea-going and resident populations of *Oncorhynchus mykiss*. The anadromous populations are known as steelhead. There are both summer run and winter run populations of steelhead in the Skeena. The summer run steelhead return in July and August; the winter run steelhead return from November to March. Summer run steelhead are more numerous and found throughout the watershed, winter run steelhead are limited to the coastal portions of the Skeena, from the Terrace area downstream. Spawning in both groups takes place in the spring, generally in April and May, but may extend until late June in the Zymoetz and Kitsumkalum systems. The summer run steelhead spend the fall and winter in rivers or lakes, usually not far from their spawning areas. The gonads mature during this residence. Winter run steelhead move onto the spawning beds soon after migration, and therefore migrate in a sexually mature state.

Steelhead fry emerge in July and August and spend between one and four winters in fresh water. Most steelhead in the Skeena Watershed spend three years in fresh water; however, steelhead from the Morice River and Sustut River mostly have a fresh water residence time of four years (Whately and Chudyk 1979, Cox-Rodgers 1985). Steelhead smolts migrate to sea in the spring during the annual snowmelt flood. Steelhead spend one to three years in the ocean before returning to freshwater. The most common value is two years, although most Morice River steelhead return after one year in the ocean, and significant proportions of Babine and Kispiox fish return after three years (Cox-Rodgers 1985).

Unlike other Pacific salmon species, steelhead can spawn more than once. Shortly after spawning, kelts migrate back to the ocean and can return after a year at sea. Spawning more than once is uncommon in steelhead. Usually less than 10% of spawning fish are repeat spawners. Among the steelhead returning to the Kitwanga River in 2001, 7% were repeat spawners (Cleveland 2002b). It is likely that repeat spawning rates are higher for the Zymoetz and Kispiox River, 22% and 14% respectively, are reported by Cox-Rodgers (1985). The Babine River has a rate of repeat spawning rate of 2% (Whately and Chudyk 1979, Cox-Rodgers 1985).

Overall, the Tyee Test Fishery best estimates escapement to the Skeena Watershed. This site provides a useful estimate for the summer run portion of the steelhead. Little data is available to estimate the winter run component. The summer run steelhead arrive relatively late in the Skeena along with coho salmon and continue through the fall. In the lower Skeena, steelhead continue to arrive throughout the winter. In the Tyee test fishery the earliest part of the steelhead run overlaps the much larger sockeye run. Most of the steelhead arrivals take place while pink salmon are entering the Skeena. The timing of the summer run is shown in Figure 19. The index values are approximately equal to the daily percentage of the total summer run.

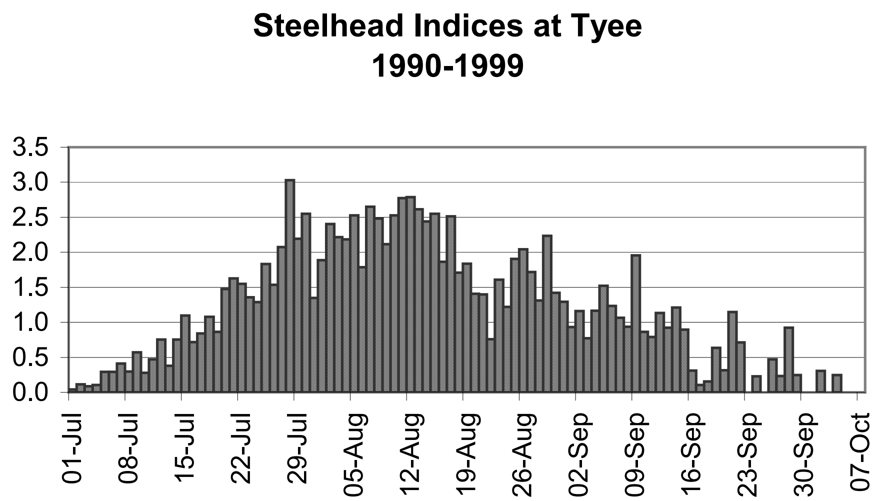


Figure 19. Timing of summer run steelhead entry into the Skeena River.

Estimates of the total summer run escapement based on the Tyee index data are available starting in 1956. The estimated total annual abundance is shown in Figure 20. Data are shown for the period of July 1 to August 27 to simplify the year to year comparison. Steelhead declined from about 1985 to 1992. The low escapements in these years led to changes in the timing of the Area 4 commercial fisheries to decrease the impact on steelhead, and to the beginning of mandatory catch and release in the sports fishery. The total closure of the Area 4 fishery in 1998, and improving ocean survival, contributed to the high escapement of that year. Spense and Hooton (1991) suggest a minimum escapement target of 26,500 for summer run steelhead, assuming no upriver harvest. Allowing for aboriginal food fisheries, the minimum escapement should be set at least 28,000. Figure 20 shows that only 9 of the last 45 years have met this criterion.

There are few good data to record steelhead escapements at individual streams. This is in large part because they spawn in spring at high water conditions when counts are usually not possible and they are typically spread out at many sites within a stream. It is clear that the Bulkley-Morice is the most important spawning stream. Based on population estimates for the Bulkley River (Mitchell 2001, Saimoto, 2002) and test fishery data from the Tyee Test Fishery using the WLAP index conversion values, he Bulkley-Morice likely accounts for at least half of the total escapement in recent years. If the WLAP values underestimate the total steelhead escapement, then the proportion of steelhead spawning in the Morice River would be somewhat lower. The Babine, Bear, Kitwanga, Kispiox, and Zymoetz Rivers also contribute sizable numbers (Heath et al. 2002, Whately and Chudyk 1976). It is likely that the six identified watersheds produce at least 80% of the Skeena Watershed steelhead.

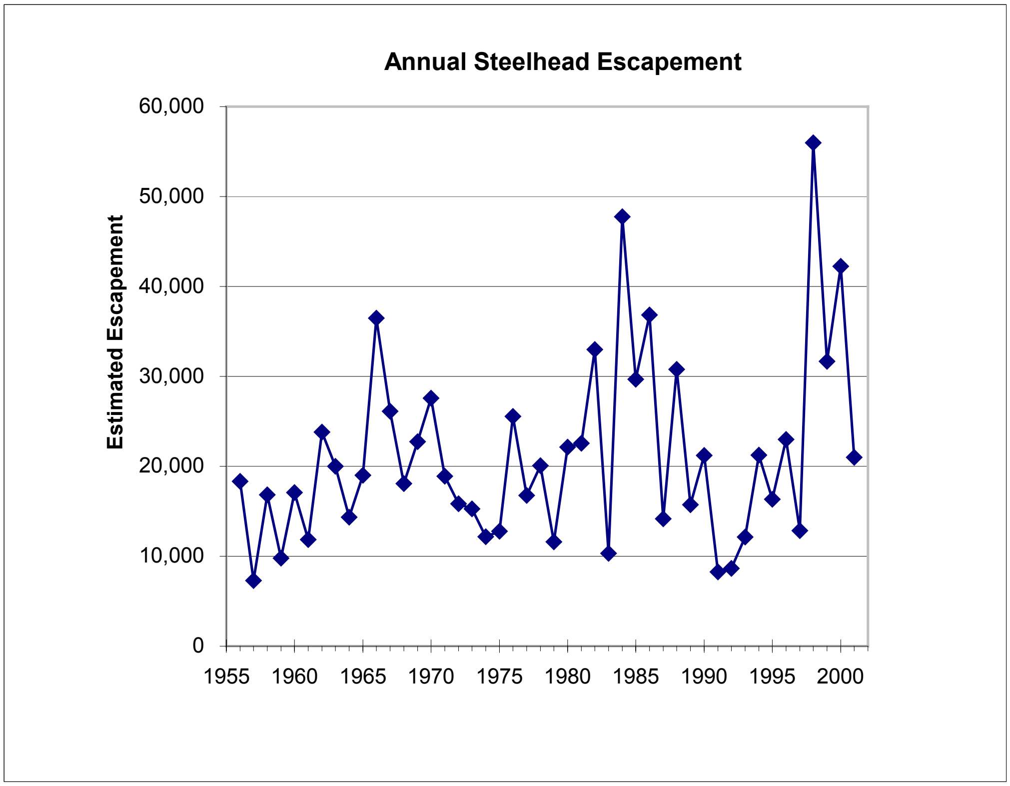


Figure 20. Skeena steelhead escapement estimated at the Tyee Test Fishery. Escapement values are based on the cumulative escapement index and WLAP index conversion values.

Low levels of straying are characteristic of steelhead (Quinn 1993, Heath et al. 2001) and where straying occurs, it is likely to streams close to the natal stream. This pattern results in a moderate degree of genetic separation of steelhead. Heath et al. (2001) analysed the genetics of steelhead stocks in the Skeena and Nass Rivers. They found significant differences between stocks from the various tributary watersheds of these two rivers. Steelhead from the Morice, Babine, Kispiox, Sustut, and Zymoetz Rivers are genetically distinct and differences increase proportional to the geographic separation of the watersheds. A low level of within population variance (heterozygosity) in the Zymoetz River stock was noted. The decline of within stock diversity has occurred since 1960 (Heath et al. 2002). This may reflect decreased population size in the recent past due to the effects of logging disturbance, landslide blockage in the Zymoetz Watershed, or over-fishing of the steelhead stock.

Changes to steelhead populations in tributary watersheds in the Skeena are hard to identify due to a shortage of relevant information. The most useful source of data is the Steelhead Harvest Analysis (Ministry of Water, Lands and Air Protection 1991) that reports the result of questionnaires mailed to steelhead anglers each year since 1968. While the reliability of CPUE data and mail surveys in sports fisheries is debatable, generally the pattern of catch reported for the major steelhead streams, the Morice, Kispiox, and Babine Rivers shows an increase in fishing effort and catch over the past 35 years. On these rivers the pattern of total catch, including released fish, resembles the Tyee estimates for summer run steelhead. In the more coastal systems dominated by winter steelhead the pattern of sports fishing catches is different. The Lakelse River steelhead sports fishing catch has been declining since 1988. Year 2000 catches are estimated at about one quarter of the 1988 to 1990 catch. The Gitnadoix River, which has only winter run steelhead, shows a similar pattern, but with a marked improvement in 1999 and 2000.

Selected Watersheds:

The important steelhead salmon spawning rivers are:

- Bulkley-Morice Rivers
- Sustut-Bear Rivers
- Kispiox River
- Zymoetz River
- Lakelse River
- Babine River
- Kitwanga River

This list is derived from discussions with WLAP fisheries staff and literature review. The order is an approximate ranking. These watersheds probably account for at least 80% of the total Skeena steelhead production.

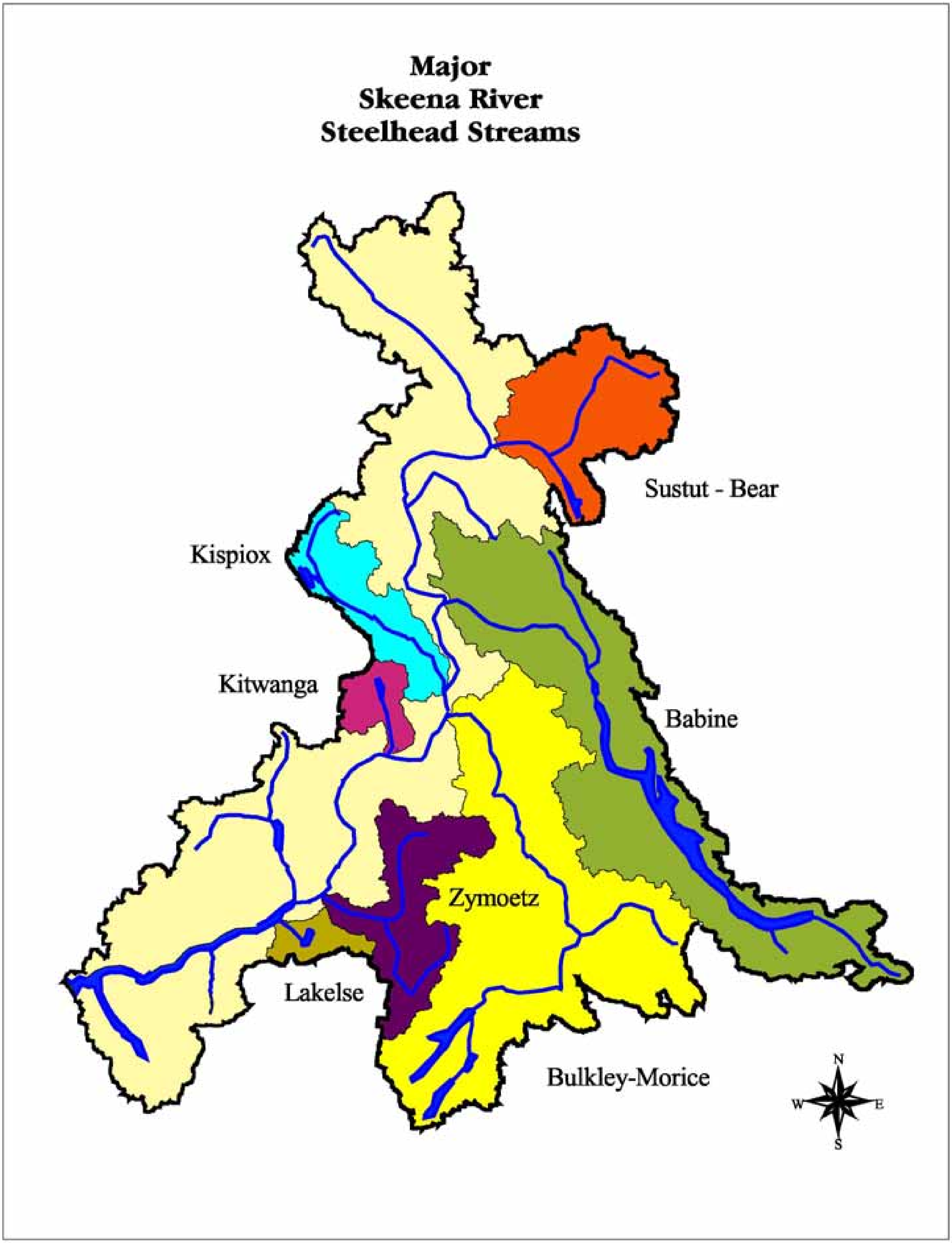


Figure 21. Productive steelhead watersheds in the Skeena region.

Resident Freshwater Fish of the Skeena Watershed

In comparison to salmon, information is sparse on resident (non-anadromous) freshwater fishes in both fluvial (rivers) and lacustrine (lake) habitats of the Skeena Watershed; indeed, much of the watershed is poorly known and may contain populations of special interest or status than are now unknown. Ecological and life history information that permits good conservation planning is simply not available. There are 28 known species of freshwater fish in the Skeena system (McPhail and Carveth 1993a), of these 18 regularly enter the sea, and are widespread along the north coast.

Freshwater species and populations inhabiting the Skeena system include rainbow trout (*Oncorhynchus mykiss*), cutthroat trout (*Oncorhynchus clarki clarki*), kokanee (*Oncorhynchus nerka*), bull trout (*Salvelinus confluentus*), Dolly Varden char (*Salvelinus malma*), lake trout (*Salvelinus namaycush*), river lamprey (*Lampetra ayresi*), pacific lamprey (*Lampetra tridentata*), western brook lamprey (*Lampetra richardsoni*), green sturgeon (*Acipencer medirostris*), white sturgeon (*Acipencer transmontanus*), American shad (*Alosa sapidissima*), lake whitefish (*Coregonus clupeaformis*), pygmy whitefish (*Prosopium coulteri*), mountain whitefish (*Prosopium williamsoni*), longfin smelt (*Spirinchus thaleichthys*), eulachon (*Thaleichthys pacificus*), peamouth chub (*Mylocheilus caurinus*), northern pike minnow (*Ptychocheilus oregonesis*), longnose dace (*Rhinichthys cataractae*), redside shiner (*Richardsonius balteatus*), longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commmersoni*), largescale sucker (*Catostomus macrocheilus*), burbot (*Lota lota*), threespine stickleback (*Gasterosteus aculeatus*), coastrange sculpin (*Cottus aleuticus*), and prickly sculpin (*Cottus asper*).

The lower reaches of the Skeena River are dominated by species that are part of the salt tolerant fauna typical of most coastal rivers, and presumably colonized the Skeena River from the coast. Some of the fish populations in the upper reaches of the watershed, such as lake trout, white sucker, and lake whitefish most likely entered the Skeena from the east by way of water connections between the Skeena, Fraser and Peace Rivers which functioned briefly at the end of the Ice Age (McPhail and Carveth 1993b). Landlocked fish populations, many with interesting and special characteristics are known to exist within the Skeena Watershed. The only known introduced fish species to the Skeena system is the American shad (*Alosa sapidissima*) that was introduced from the Atlantic to the Sacramento River in the 1870's and likely reached the Skeena by the turn of the century (Hart 1973). Within the Skeena Watershed, shad have not been reported in recent years (McPhail and Carveth 1993b).

Responsibility and jurisdiction for non-anadromous fish species and seagoing populations of predominately fresh water fish such as steelhead (rainbow trout), cutthroat trout and Dolly Varden trout, has been with the Provincial Government for many years. The focus of Provincial Government management efforts in the past on a narrow range of game fish, has recently given way to interest in the characteristics and conservation of all species. Defining conservation levels requires understanding fish values, the status of the fish resources, and the habitat attributes. What and where are critical areas for fish? What are the capability and constraints for fish production? How does the fish habitat function and how can it be maintained?

The following section briefly reviews the habitat and status of selected trout and char species in the Skeena Watershed.

Lake Trout

Lake trout (*Salvelinus namaycush*), actually a char, are known to exist in 22 lakes in the Skeena watershed (Fisheries Information Summary System (FISS 2002). Lake trout is a cold-water fish, usually frequenting deep lakes with distribution limited to the upper Skeena tributaries. They have been occasionally observed in streams tributary to lakes.

Within the Babine Watershed, lake trout have been recorded in Babine Lake, Morrison Lake and Creek, Chapman Lake, Doris Lake, Fulton Lake, Augier Lake, Nilkitkwa Lake, Pinkut Lake, Taltapin Lake, Tanglechain Lake, and several unnamed lakes. Within the Sustut River drainage, lake trout have been observed at Bear Lake, Asitka Lake, Johanson Lake and at least one unnamed lake. Lake trout locations recorded within the Bulkley system include Bulkley River, Atna Lake, Maxan Lake, McBride Lake, Morice Lake, Nanika Lake, Owen Lake, and one unnamed lake. Within the Kispiox drainage, lake trout have been documented in Kispiox River, Swan Lake, and Stephens Creek (FISS 2002).

The lake trout life cycle takes place entirely within lakes, with spawning occurring in late summer or early fall in relatively shallow areas. Eggs are usually deposited on large rubble substrate and incubate for 4 to 5 months over the winter and early spring. Fry emerge and usually remain at inshore nursery areas adjacent to the spawning beds to feed on insects and crustaceans, for a period ranging from several weeks to several months. Diets change as the juveniles grow and the fish move into deeper waters offshore. Lake trout are the top aquatic predator in most lakes where they are found (Martin and Oliver 1980). On average, maturity first occurs at age 11 with mature adults leaving offshore waters and return inshore to spawn.

The lake trout may prey on kokanee and whitefish while in deep water, and while in shallow water, usually in the spring and fall, may eat aquatic insects and shore dwelling minnows (Griffiths 1968). Lake trout are capable of reaching ages in excess of 50 years and achieving weights over 20 kg. Due primarily to their large size, and palatable flesh, they are a prized sport fish by many anglers and are vulnerable to overexploitation. They are also taken in First Nations fisheries at Babine Lake and Bear Lake. DeLeeuw *et al.* (1991) reported reduced abundances of lake trout in road accessible lakes as a result of increased angler effort. Fourteen of the 22 lakes in the Skeena watershed are known to be road accessible and are therefore, likely suffering from reduced abundances.

Rainbow Trout

Rainbow trout have recently undergone a name change from *Salmo gairdneri* to *Oncorhynchus mykiss* (Smith and Stearly 1989), which recognizes their closer relationship to the Pacific salmon than to the Atlantic salmon and trouts. Anadromous forms of rainbow trout are commonly referred to as steelhead, or steelhead trout. They are an important and popular sport fish and are likely the species most frequently caught by anglers in the watershed. It is generally thought that Skeena Watershed populations of rainbow trout exhibit three different life history strategies with considerable variation depending on geographic location and habitat: populations that live their entire lives in small streams, those that spawn in small streams and migrate to rivers to rear and mature, and those that spawn in small streams and move into lakes to rear and mature.

Most commonly in the Skeena Watershed, rainbow are lake residents, but they enter streams in the spring to spawn. Females construct redds in fine gravel into which the eggs are deposited. Young emerge from the gravel in the summer and usually migrate into rearing areas of streams or lakes in the first year. Normally, the fish remain in the rearing lake, or in some populations in a river, until they reach maturity in 2 to 4 years, before moving back to natal streams for spawning. Scott and Crossman (1973) reported that survival after spawning is usually low and the number of repeat spawners is often less than 10% of the total spawning population.

Rainbow trout exhibit a wide range of growth rates dependent on habitat, food type and availability, and life history strategy. Generally the growth of rainbow trout is slower in streams than in lakes and greatest in marine environments (Carlander 1969). The fish show seasonal movement to access suitable habitat for feeding and overwintering. Generally, the type of food eaten reflects the size of rainbows and the season, with principal prey being zooplankton, benthic invertebrates, terrestrial insects, and fish. Small rainbows may eat zooplankton, crustaceans and small insects, while larger trout may take leeches, larger insects, molluscs, and a variety of juvenile fish (Griffiths 1968). Griffiths documented growth and feeding habits, primarily by stomach analysis of rainbow trout in Babine Lake.

Within the Skeena Watershed, Babine and Nilkitkwa Lakes host rainbow sport fisheries of considerable size and abundance, which are thoroughly described by Bustard (1987). Bustard (1990) described the importance of the Sutherland River as the natal stream for Babine Lake rainbow trout. Morice River is also renowned by anglers for rainbow trout.

Hatchery raised rainbow trout are the predominant species used for stocking lakes in the Skeena Watershed. The majority of hatchery-produced fish are put into lakes that either cannot support rainbow trout or have insufficient natural production to satisfy sport fishing demands.

Cutthroat Trout

Cutthroat trout in the Skeena Watershed are coastal cutthroat trout (*O. clarki clarki*), which are blue listed by the BC Conservation Data Centre (CDC) as a species of concern. It is not, however, an identified wildlife species under the Forest Practices Code, nor is it listed by COSEWIC (Committee on the Status of Endangered Wildlife in Canada). Lacustrine populations of cutthroat trout exist throughout the Skeena Watershed, but are rare in Skeena tributaries upstream of the Babine/Skeena confluence and are not documented in the uppermost tributaries that include the Slamgeesh, Kluatantan and Sustut Rivers.

Cutthroat trout are very adaptable to their environment resulting in considerable variation in life histories. Anadromous life forms of cutthroat exist in the Skeena and are both poorly studied and understood. For the purposes of regulations, populations upstream of Cedarvale (20 km below Kitwanga), are not considered to be anadromous. There are adfluvial populations that spawn in tributary streams and migrate to lakes to grow to maturity and fluvial populations that move between mainstems and headwater streams, as well as resident populations that remain in headwater tributaries for their entire lives.

Cutthroat trout exhibit considerable variation in spawning time; which normally occurs from mid-May to mid-June (Bilton and Shepard 1955, Hatlevik *et al* 1981, Imbleau 1978, Hart 1973). The fish usually spawn in small streams with gravel substrate that are tributary to rivers and lakes. Redds are constructed by the females. Emergent fry spend variable lengths of time in their natal streams while migratory populations may spend as little as a few months to as long as 4 years in their original streams (Liknes and Graham 1988). Once in rearing areas the river and tributary dwelling populations may make minor migrations to access preferred food and appropriate winter habitats. Cutthroat trout in lakes generally grow faster than those in streams and Carlander (1969) suggests the smaller the stream, the slower the growth.

Cutthroat trout are opportunistic feeders that consume a variety of freshwater invertebrates and may feed heavily on other fishes, crustaceans and freshwater insects. Moore and Gregory (1988) studied cutthroat habitat preferences in tributary streams and found that fry abundance was proportional to the area of lateral habitat, meaning stream margins, backwaters and isolated pools. Cutthroat living in association with other trout species generally alter their feeding behaviour to minimize competition with other species.

Cutthroat trout are targeted by sport fisheries in limited instances in the Skeena River drainage. Lakelse River, Kasiks River and tributaries to the lower Skeena River are notable fisheries. Cutthroat trout are targeted in a winter ice fishery in Kitwanga Lake. Imbleau (1978), Bilton and Shepard (1955), Hatlevik *et al* (1981), and deLeeuw (1991) describe the Lakelse River cutthroat trout sport fishery.

Dolly Varden Char

Dolly Varden char (*Salvelinus malma*) are blue listed by the BC CDC as a species of concern, but not listed by COSEWIC or defined as identified wildlife by the Forest Practices Code. Dolly Varden are common in the Skeena Watershed. Small resident Dolly Varden are widely distributed in the upper reaches of small streams throughout the watershed, whereas anadromous populations, which are comprised of larger fish, exist primarily in close proximity to the coast. Dolly Varden char also exist in lacustrine-adfluvial populations. Beyond knowledge of distribution and general life history, Dolly Varden char have not received extensive management or biological study in the Skeena Watershed.

Spawning takes place in streams in the autumn with maturity usually reached in the fifth year. Regular seaward migrations may take place in spring with return migrations in the fall. Hart (1973) suggests that in the Skeena Watershed, coastal populations may spend 3 years in fresh water and 2-3 years in the ocean, with males tending to stay longer at sea. Generally food consists of fishes, including herring, sticklebacks, juvenile salmon, salmon eggs, molluscs, insects and crustaceans (Hart 1973).

Cedarvale constitutes the regulatory upper limit of Dolly Varden anadromy; the remaining populations are fluvial or adfluvial residents. Dolly Varden char are only targeted as sport fish in the lower Skeena and its coastal tributaries, due primarily to their small size in upper watershed drainages. A rare, monoculture Dolly Varden population exists in Netalzul Meadow Lake, a small lake within the Suskwa River watershed (FISS 2002).

Bull Trout

Bull trout (*Salvelinus confluentus*), is actually a char that are blue listed as a species of concern by the BC CDC, as well as by COSEWIC due primarily to their limited global distribution and their threatened status in its southern (U.S.) range. They are also listed as an *identified wildlife* species under the FPC. Bull trout are common within the Skeena River and its tributaries, and are suspected to be found throughout the drainage. The Annual Environmental Trends published by BC WLAP, lists the Bulkley Watershed as the only Skeena drainage identified as a conservation concern.

Studies on bull trout in the Skeena Watershed are limited to the Morice Watershed (Bahr 2002) and the Shelagyote River (Giroux 2002). Even with differences in life history traits and morphometry, confusion between bull trout and Dolly Varden is common, and much of the available information on distribution is suspect (Hass 1998). Seaward populations are poorly studied, though bull trout are thought to have a low tolerance for salt water. However, records of their occurrence exist for Kalum River, Zymoetz River and lower Skeena tributaries including the Ecstall River (FISS 2002). Gitnadoix River has also been reported through anecdotal sources to contain bull trout. Bull trout occurrence is considered common in Skeena tributaries upstream of Cedarvale. Both bull trout and Dolly Varden char occur in many Skeena tributaries. In these situations they appear to have divergent live history patterns (Bahr 2002), but hybridization occurs in some streams.

Fluvial and adfluvial populations spawn in small tributary streams and over-winter in larger rivers or lakes. Maturity is generally reached at 5 years of age, though precocious males may mature by age 3 (Shepard *et al* 1984). Recent observations by Giroux (2002) and Bahr (2002) show that upper Skeena bull trout typically spawn in gravel and cobble pockets in streams during late summer and early fall. Usually eggs in the gravel hatch before the end of January, with fry emerging in late spring. After hatching, bull trout fry rear in low velocity backwaters and side channels and avoid riffles and runs (McPhail and Murray 1979). Juveniles tend to utilize a variety of stream and lake habitats and are most abundant where water temperatures are 12^0C or less. Their intra-watershed distribution patterns indicate they are sensitive to water temperatures, preferring cold natal streams.

Bull trout are a long-lived repeat spawning fish that can exceed 20 years of age and 10 kg in weight; however, in general terms, most bull trout captured by anglers range between 45 and 60 cm in length, and are 8-17 years old. Bull trout are a popular sport fish and are frequently harvested by sport anglers as by-catch during recreational fisheries targeted on summer-run steelhead, chinook, sockeye and coho. As adults, they are an aggressive piscivorous fish and vulnerable to overharvest by anglers. Limiting angler access and critical habitat identification and protection remain as the most significant issues for the protection of bull trout in the Skeena River drainage.

Kokanee

Kokanee salmon (*Oncorhynchus nerka*) are a landlocked form of anadromous sockeye salmon and the only Pacific salmon species in North America to form natural populations living their entire life cycle in freshwater. Kokanee are generally believed to have evolved independently from anadromous populations of sockeye salmon within many lake systems. In the Skeena system, kokanee have been observed in the Babine, Sustut, Lakelse, Zymoetz, Kispiox, Kitwanga, Morice and Bulkley Watersheds (Table 1). There is little recent information concerning kokanee distribution (Foote *et al* 1989), and kokanee may be found in other Skeena lakes. Kokanee usually mature at smaller sizes than sockeye, and where the two forms occur together, they exhibit other morphological differences such as in gill raker number, male secondary sexual characteristics and colouration (Nelson 1968). Within the Skeena Watershed, the geographic distribution of kokanee is believed to be a result of landform or drainage changes that have isolated anadromous populations of sockeye salmon (Ricker 1940, Foerster 1968).

Juvenile kokanee and sockeye are difficult to distinguish and most of the understanding concerning kokanee developmental biology, fry behaviour and juvenile ecology is based on sockeye focused studies (Foerster 1968). Kokanee eggs are deposited in gravels of nursery lake inlet streams or on lake beach gravels. Eggs develop over fall and winter, and fry emerge in the spring. As juveniles, they move offshore, feeding primarily on zooplankton, although they also feed on benthic invertebrate food sources. Juvenile kokanee growth and survival rates are relatively variable and are determined by lake productivity and the intensity of feeding competition. Adults usually mature sexually at age 2 to 4 and migrate to spawning grounds in the early fall to deposit their eggs. As with sockeye salmon, kokanee die after spawning.

Kokanee are an important sport fish mostly caught by trolling in many of the larger lakes within the Skeena system. The deep red flesh is frequently considered by many to be the tastiest and finest eating fish in the watershed.

Watershed	Lake/Stream	Watershed Code
Babine	Augier Lake	480-927700
Babine	Babine Lake	480
Babine	Morrison Lake	480-598800
Babine	Tahlo Lake	480-598800-99100
Babine	Nilkitkwa Lake	480
Babine	Taltapin Lake	480-927700
Sustut	Bear Lake	490-267900
Sustut	Sustut Lake	490
Lakelse	Clearwater Lakes	420-759000
Lakelse	Onion Lake	420-759000-59100
Zymoetz	Burnie Lakes	440-256900-59700
Kispiox	Swan Lake	470-657200
Kispiox	Stephens Lake	470-657200
Bulkley	Goosly Lake	460-636000
Bulkley	Toboggan Lake	460-242900-51500
Morice	Morice Lake	460-600600
Kitwanga	Kitwancool Lake	400-364900
Other Skeena	Khtada Lake	400-059300
Other Skeena	Kleanza Lake	400-231800
Other Skeena	Slamgeesh Lake	400-705300-42200

Table 1. Lakes in the Skeena Watershed with kokanee salmon populations. (Data from FISS 2002, and Godfrey 1955).

Whitefish

There are three or possibly four species of whitefish, salmonids in the subfamily Coregoninae, in the Skeena Watershed. These are the Rocky Mountain whitefish (*Prosopium williamsoni*), pygmy whitefish (*Prosopium coulteri*), and lake whitefish (*Coregonus clupeaformis*). The fourth whitefish, the giant pygmy whitefish (*Prosopium* spp.) is probably not separable from the more common pygmy whitefish (Rankin 1999).

Rocky Mountain whitefish is one of the six species in the genus *Prosopium*. Rocky Mountain whitefish, also commonly called mountain whitefish, are the most widely distributed of the Skeena Watershed fishes, with occurrence in streams and lakes throughout the Skeena system (Godfrey 1955). They have been found, generally in fair abundance, in the 20 plus sockeye rearing lakes in the system that vary from deep, cold and opaque bodies of water to small, shallow and warm ponds. Godfrey reported that abundance appears to be highest in higher nutrient status lakes, such as Lakelse Lake.

Mountain whitefish use a wide range of habitats for spawning and do not construct redds. Mainstream river resident and lake dwelling populations move into tributary streams in the late fall to spawn (Northcote and Ennis 1994), however, McPhail and Lindsey (1970) report some cases of spawning occurring within lakes. Clearly, the habitat used for spawning should be determined for local populations. Mountain whitefish are generally nocturnal spawners (McPhail and Lindsey 1970). The eggs hatch in early spring usually at the time of ice break-up. Underyearlings generally leave near-shore habitat during the summer. There appears to be relatively little specific information in regards to yearling and subadult feeding, migration and habitat. Adults occupy shallow portions of lakes and feed on aquatic insects and some small clams and snails (Godfrey 1955).

Although this whitefish has attracted moderate attention from anglers, there are surprising gaps in knowledge of it life history and biology. As well, there appears to be little attention given to its fishery management and protection and conservation of its habitat. Information gaps exist in relation to stock recognition and impacts from forestry or other causes of water quality and habitat change. Significant winter sport fisheries for mountain whitefish have developed in BC, particularly in the Similkimeen River, Elk River, and Okanogan and Kootenay Lakes (Northcote and Ennis 1994).

Pygmy whitefish (*Prosopium coulteri*) are commonly misidentified as juvenile Rocky Mountain whitefish. Pygmy whitefish are found in the Peace, Fraser, and Skeena systems, and are thought to have spread into BC after the last ice age, from a refugium in the Columbia River basin (Lindsey and Franzin 1972). This fish prefers deep-water habitats (McCart 1965) with a variable diet showing the fish to be opportunistic benthic feeders. Piscivorous fishes such as trout and char prey upon pygmy whitefish. Two morphological types have been described by McCart (1970); all known pygmy whitefish populations in the Skeena system are categorized as the 'low-raker" form (Rankin 1999). There is no direct evidence of spawning locations or timing, though available evidence suggests that it takes place in October to November depending on location (Scott and Crossman 1973). Much pygmy whitefish basic life history and ecological attributes are unknown.

Lake whitefish (*Coregonus clupeaformis*) also called the common whitefish is rated by Scott and Crossman (1973) as the most important commercial freshwater fish species in Canada. Godfrey (1955) reported that lake whitefish has been found in only four lakes in the Skeena drainage, all of which have oligotrophic characteristics and are relatively deep, cold bodies of water. These are Babine, Morrison, Bear, and Azuklotz Lakes. In general, lake whitefish are pelagic and restricted to cool, well-oxygenated regions of lakes in close association with the bottom. Spawning occurs usually during October through December with eggs incubating over the winter and fry emerging in April or May. Lake whitefish fry remain in shallow inshore waters where they feed on planktonic and benthic organisms, then move into deeper waters as water temperature increases and gradually adopt the benthic feeding habits typical of adult whitefish. Age of maturity varies widely, but is typically 4 to 9 years. The main predators of lake whitefish are lake trout and burbot adults (Scott and Crossman 1973).

Giant pygmy whitefish (*Prosopium* spp.) have been reported from two lakes in the Skeena Watershed. Giant pygmy whitefish occur in Tyhee Lake, and may possibly occur in Touhy Lake both within the Bulkley River drainage. The Tyhee Lake population has been red listed as a threatened species due to the rare occurrence of the giant pygmy whitefish and the eutrophication of the lake. Rankin (1999) concludes that the Tyhee Lake giant pygmy whitefish show a distinct size at age curve and are clearly larger than pygmy whitefish, but the fish are not phylogenetically distinct from other pygmy whitefish and should remain *Prosopium coulteri*. Research is currently proceeding on the Touhy Lake population.

Enhancement of Salmon Production and Habitat

Habitat enhancement has been ongoing since the native peoples first inhabited the watershed. Since the turn of the twentieth century, DFO has taken the lead role. Habitat enhancement includes major projects such as spawning channels, as well as relatively small, ongoing activities such as stream clearance projects. Many of the salmon caught that are the progeny of Skeena River stocks are produced with human assistance in hatcheries and artificial spawning channels. Other Skeena River salmon stocks benefit from fishways built around barriers to their upstream migration, improvements to spawning beds, and occasionally, fertilization of the lakes where they spend the first period of their lives. Enhanced stocks now account for about one out of every two salmon caught, these are mostly sockeye from the Fulton River and Pinkut Creek spawning channels.

Fish enhancement projects have been in operation sporadically since establishment of the first sockeye hatchery at Lakelse in 1901, which operated until 1937. Morrison River hatchery operated from 1907 to 1936, when most BC hatchery operations shut down in the mid-depression. The early 1960's saw a resurgence of hatchery production within the watershed. The Nanika River hatchery, in operation from 1960 to 1965, was most likely not successful due to the use of transplant stock from Pinkut Creek. Kleanza Creek pink hatchery operated for several years until it was destroyed by fire in 1960. Scully Creek and Williams Creek, tributaries to Lakelse Lake, were the sites of hatcheries from 1962 to 1967.

Sockeye salmon studies in the late 1950's and early 1960's concluded that sockeye salmon production from Babine Lake was limited by the availability of suitable spawning habitat, and secondly, that the main basin of the lake was underutilized and could support additional sockeye fry. These results led directly to the Babine Lake Development Project (BLDP). Construction of this approximately 10 million dollar project, consisting of artificial spawning channels and dams to provide for water flow regulation, was located at Pinkut Creek and Fulton River, tributaries of Babine Lake.

The first channel was completed on the Fulton River in 1965; the second on Pinkut Creek in 1968; a third channel was completed on the Fulton River in 1971 (Ginetz 1977). Sedimentation problems in the Pinkut Creek enhanced channel led to a major rehabilitation program in 1976. Fulton River spawning channel has capacity for approximately 160,000 sockeye, while Pinkut spawning channel holds 63,0000 sockeye. At Pinkut Creek since 1973, an annual average of approximately 37,000 adult sockeye have been airlifted over the falls to allow utilization of a 6 km spawning area on the upper creek. In addition to the spawning channels, a small-scale hatchery at Fulton River has been in operation on a discontinuous basis since the late 1970's.

In 1977, Fisheries and Oceans Canada announced the Salmon Enhancement Program, commonly called SEP, with the primary goal of doubling salmon production. Within the Skeena watershed, five hatcheries under the Community Economic Development Program were established: Fort Babine, Kispiox, Kitsumkalum, Deep Creek, and Toboggan Creek. In addition, several minor hatcheries were established. These are classified as Public Involvement Program projects, partially or fully funded by SEP, and include Chicago Creek and Eby Street. Numerous small projects such as incubation boxes, bioengineering investigations, biophysical studies, and habitat inventories have been conducted throughout the watershed under the auspices of SEP.

A pilot hatchery project was initiated at Kispiox in 1977; however, water quantity and quality problems were not resolved until 1983, when three wells were developed that supplied stable quality and constant water temperature, at which time the present, small hatchery was constructed. It is located close to the Kispiox-Skeena confluence and was initially operated by the Kispiox Band. This Community Economic Development project under the Salmon Enhancement Program was designed to increase the severely depressed Kispiox River chinook and coho stocks (DFO and MoE 1984). The hatchery continued to operate until 1995, when it was closed due to SEP program review budget cuts. Re-opened in 1997, under the auspices of the Gitxsan Watershed Authorities, with funding from a variety of sources, the hatchery allows for a flexible fish culture program.

Since 1983, the Fort Babine Hatchery, a Community Economic Development Project (CEDP), has enhanced the Babine coho and chinook populations. Chinook brood stock is obtained from adults held at the counting fence, while coho brood stock are seined in the Babine River upstream of the fence. These fish are incubated, and reared with an approximate and variable release strategy of 50/50% fry and smolts. On an annual basis, enhanced coho typically number 150,000 to 200,000, while 80,000-100,000 chinook are raised.

In the Terrace area, a pilot facility was operated on Dry Creek from 1981 to 1982, to investigate the incubating and rearing of chinook salmon on that creek; however, the project was found to be unfeasible. Since 1984, Deep Creek Hatchery has been operated by the Terrace Salmon Enhancement Society (TSES), and was established as a chinook facility to augment chinook populations in the Zymoetz, Lakelse, and Kitsumkalum systems (Tredger 1983). Since the late 1980's, the hatchery has only supported Kitsumkalum River chinook. Other small enhancement facilities are a small groundwater facility for the incubation and rearing of coho and chum, operated by the Kitsumkalum Band, since the late 1980's, and a spawning channel for sockeye at the northeast end of Kalum Lake that enhances the Clear Creek and Cedar River stocks.

Toboggan Creek Hatchery is located on Toboggan Creek, a Bulkley River tributary, west of Smithers, BC. This facility was built in 1984 and designed to raise steelhead fry, and chinook and coho smolts. Adult coho returns have measurably increased Toboggan Creek stocks. Upper Bulkley and Morice River coho were also enhanced with local stocks raised at this hatchery. Streams other than Toboggan Creek have not been effectively evaluated with respect to increases in stock strength.

Through the Fish and Wildlife Branch (FWB), the Provincial Government focused their SEP efforts on Skeena River summer-run steelhead. FWB sought to determine baseline biological data on juvenile steelhead distribution, densities, and survival rates of fry and parr (BC-Canada 1984). FWB reared and released steelhead, cutthroat trout, rainbow trout and brook trout in many lakes, and to a lesser extent, in streams within the Skeena Watershed. Hatchery steelhead fry were released primarily in the Suskwa River, Bulkley River, Kalum River, Kispiox River, Zymoetz River, and the Morice River.

The first major habitat enhancement project occurred in 1907. It involved blasting the 1891 rockslide in the lower Zymoetz River. In 1951, fishways were constructed at Moricetown Falls on the Bulkley River, and in 1958, rocks were blasted away in Hagwilget Canyon. The 1951 Babine Slide was cleared effectively by 1952. In the late 1970's, the Fish and Wildlife Branch initiated a series of habitat modifications that included blasting the Harold Price Falls and straightening the lower reach of Serb Creek. Morice Lake was one of the few lakes in the watershed fertilized; it was aerial fertilized in 1981 and 1985.

In the mid-1990's, the Watershed Restoration Program (WRP) was established by the BC Government to accelerate the natural restoration of watersheds impacted by logging. The majority of the work in the first seven years of the program was comprised of instream/riparian assessments and upslope/road assessment and deactivation. In the eastern portion of the Skeena Watershed, a major impact of logging activities is the restriction of fish access to upstream waters, often the result of road crossings that were originally constructed as, or have become, barriers to fish migration.

In the western portion of the watershed with its naturally unstable slopes and high-energy stream systems, impacts are more complex. Identified potential restoration activities include road deactivation to prevent erosion and landslides, off-channel habitat and riparian zone restoration to stabilize channels and diversify habitat, and stabilization of highly mobile stream channels and gravel bars often associated with logged alluvial fans (MoF 2001). Modification of degraded or marginal fish habitat has been a major component of WRP. Millions of dollars have been spent in the watershed on such efforts; however, few attempts have been made to evaluate the response of fish populations to habitat manipulations. Without such studies, it is difficult to assess the effectiveness of various habitat modifications.

The Salmon Enhancement Program has committed substantial resources to education and public involvement activities. The education material is highly regarded among educators, partly because of the support they receive from Community Advisors and hatchery staff and also because students and community members have an opportunity to learn "hands on" about salmon and salmon habitat (Donas 2002). The public involvement program coordinated by Community Advisors and supplemented by Watershed Stewardship Coordinators and Habitat Stewards has supported scores of small enhancement projects – mostly incubation boxes for coho and chum, stream rehabilitation projects, and fish fence counts. The benefits of these projects are difficult to assess, but the public appears to consider them worthwhile.

Presently, the Skeena Watershed has considerable enhancement capability for sockeye, chinook, and coho that was established both before and after the SEP. The Babine Lake Development Project (BLDP), the largest spawning channel complex in the world, dramatically increased overall sockeye production, though a concurrent increase in the sockeye catch has also occurred. A serious concern about large-scale enhancement of Babine sockeye is the indirect effects on stocks of wild salmon as suggested by West and Mason (1987). This large-scale enhancement supports high catch rates in interception fisheries in Alaska and the mixed-stock fisheries close to the mouth of the Skeena River (Area 4). These fisheries have impacted many of the wild sockeye and other salmon stocks whose run timing is coincident with enhanced Babine stocks. The impacts on wild stocks range from moderate to severe depletion.

Compounding this problem is the fact that there is not much reliable information available on the status of wild stocks within the watershed. In general, there is widespread agreement that exploitation rates are too high for wild stocks and many wild stocks are well below desired optimum and/or productive capacity levels. Given the Skeena Watershed's fishery history and the relatively recent, last 100 years of DFO and fishing industry interests, many different solutions are presentable. One solution to our present depressed wild stocks – enhanced stock dilemma, is based on moving the enhanced Babine sockeye fishery inland to the Babine Watershed, thus relaxing fishing pressure on wild stocks.

Enhancement of salmon stocks can damage wild stocks; this has been a longstanding concern not only here in the Skeena system, but in other countries with large-scale salmon enhancement programs. In recent years, the impact of adult hatchery fish spawning naturally in streams occupied by wild fish has become an issue of considerable interest with respect to their impact on the biological health of wild populations (Waples 1991, Busack and Currens 1995, Campton 1995). Various perspectives challenge conventional views about the value of fish hatcheries and augmenting fish stocks.

Walters (1988) strongly suggests three policy options for responding to problems in regard to hatchery productivity declines coupled with wild stock declines. The first is to maintain the status quo and observe over time definite benefits or consequences of enhancement. Secondly, Walters suggests declaring the hatchery experience a failure, cutting back hatchery production while using stringent regulation to rebuild natural stocks to a more productive level. Thirdly, if fixed catch quotas were placed on mixed stock fishing areas while abundance in these areas increased due to enhancement, exploitation rates on natural stocks would decrease.

Hilborn (1992) argued that hatchery programs that attempt to add additional fish to existing healthy wild stocks are ill advised and highly dangerous. Hilborn states that large-scale salmonid hatchery programs have largely failed to provide the anticipated benefits. Rather than benefiting the salmon populations, these programs may pose the greatest single threat to the long-term maintenance of salmonids.

Chilcote (2002) found that the level of hatchery fish in the spawning population significantly influenced the productivity of 12 naturally reproducing populations of Oregon steelhead. The reproductive presence of hatchery fish depressed overall population productivity and reduced the number of naturally produced recruits. These results suggest that supplementation of depressed wild populations with hatchery spawners is an ineffective conservation strategy. The implication arising from Chilcote's study for Skeena Watershed sockeye stocks is the view that the most effective conservation role for hatcheries is one of impact avoidance, not direct intervention. Chilcote's suggests that limiting the proportion of hatchery fish in naturally spawning populations to less than 10% is an appropriate strategy to achieve this conservation goal.

Summary of Selected Salmon Streams

The watersheds discussed in the earlier sections and shown in the preceding lists and maps produce the bulk of the salmon in the Skeena Watershed. The selected five to nine watersheds contain the critical spawning and rearing habitat for each species. There is much duplication in the lists of most productive watersheds for the six salmon species; only eleven watersheds are represented in total.

Species	N watersheds	%
Coho	9	67%
Chinook	7	93%
Sockeye	9	99%
Pink	6	84%
Chum	5	95%
Steelhead	7	80% ?

Table 2. Proportion of total Area 4 1990's escapement in the selected watersheds.

Eleven watersheds occur in the lists of leading producing watersheds for the six salmon species. These are:

- Babine River
- Bear River
- Morice River
- Kispiox River
- Kitwanga River
- Zymoetz River
- Lakelse River
- Kitsumkalum River
- Skeena River West
- Gitnadoix River
- Ecstall River

These watersheds are discussed individually in the following sections.

We recognise that other parts of the Skeena region also support fish populations, some of which have regional significance. However the funding available for this project did not permit description of all of the parts of the Skeena Watershed. We anticipate producing a future report that will deal with the rest of the Skeena.

Lakelse Watershed

Environmental Setting

Location

The Lakelse Watershed is located in northwest British Columbia, 20 km south of Terrace. The watershed is bounded to the east and west by the steep mountain slopes of the Kitimat Ranges, to the north by the Skeena River floodplain, while an ancient ice contact terrace establishes the southern boundary

Hydrology

The Lakelse River drains Lakelse Lake at the southwest corner, in a northwesterly direction for approximately 15 km to reach the Skeena River left bank, about 17 km downstream of Terrace. The Lakelse River is a fifth order system that drains a watershed area of 589 km^2. Elevation ranges from approximately 62 to 1845 m. Rainfall records based on a 30 year observation period, 1950-1980, show an annual average precipitation of 1313 mm per year, 70% falling as rain and 30% as snow. Rainfall is greatest during September, October and November, while snowfall is greatest during December and January. Cleugh *et al* (1978) estimate that the greatest discharge occurs in the summer months, with maximum discharge in June. Lakelse Lake's mean annual discharge into Lakelse River is 20 m^3/second (Kerby 1984). MOELP Water Management Branch recently (1995) installed a manual gauge on the Lakelse River; however, there is insufficient data for analysis at this time.

Lakelse Lake is the predominant feature of the upper watershed. It covers an area of 14.5 km^2 (14,516 ha), with the majority of tributary streams feeding directly into the lake. Williams, Hatchery and Schulbuckhand (Scully) Creeks are major tributary streams and the biggest of the thirteen tributaries feeding Lakelse Lake. It is thought that Lakelse Lake is the warmest lake in northern BC. It has a maximum depth of 32m (at the north end opposite Furlong Bay), but a large portion (42%) of the lake is littoral. This extensive littoral zone affects temperature, dissolved oxygen, aquatic plants, and overall productivity of the lake (Cleugh *et al* 1978).

Temperature profiles indicate the absence of a stable thermocline, which is probably a consequence of relative shallowness combined with strong prevailing southwesterly winds (Abelson 1976). Due to the shallowness of the lake and large volumes of water from tributary streams, Lakelse Lake flushes on the average of once every 58 days (Kerby 1984, Remington 1996). A number of hot springs with temperatures up to 85 ^oC occur on the eastern shore of Lakelse Lake.

Tributary drainages are characteristically of two types: either a meandering channel at a low gradient, or a steeply graded channel within a narrow confined "V"-shaped valley, becoming braided or meandering on lower gradient fans. The majority of steeply graded creeks originate in the mountains to the east or west of Lakelse Lake, while the creeks north and south of the lake are meandering in nature. The steeply graded creeks are fed from the large area of the alpine mountain slopes, which make up approximately 19% of the total watershed area.

Water Quality

In 1982, MOELP Waste Management Branch initiated a 5 year monitoring program on major drainages of the Skeena River Watershed. Data was collected monthly from seven stations located on the upper Bulkley River, Morice River, Bulkley River at Quick, Telkwa River, Kispiox River, Skeena River at Usk, and Lakelse River (Wilkes and Lloyd 1990). The Lakelse River station is located near the mouth of the Lakelse River. The Lakelse River is exceptional in that it has a very low TSS (total suspended solids) as a result of being lake-headed (mean = 9.1 mg/L, range = 1.79 mg/L). Turbidity, an indicator of suspended sediments is also low. The Lakelse River is moderately coloured (mean = 16.7 TCU), which is attributable to natural organic substances and is not harmful to human health. Lakelse pH was near neutral (mean = 7.1) with a range of 6.7 to 7.6. Alkalinity is low (mean = 21.1 mg $CaCO_3$/L) and very near the water quality criterion, indicating the waterbody would be sensitive to acidic inputs. Nutrients are generally low, with metal concentrations often less than detection limits.

Water quality objectives were prepared for Lakelse Lake by MoELP (McKean 1986). The accompanying assessment stated that the impact of forestry on water quality has been a concern in the Lakelse Watershed, in particular, the siltation of spawning and rearing streams. There had, however, been no data collected to quantify the degree of siltation attributable to logging. A specific objective for turbidity was established for tributary streams to the lake to protect spawning areas possibly affected by logging. Monitoring recommendations include intensive turbidity sampling one year prior to and following a logging operation.

Lakelse Lake is considered to be oligotrophic because of its low phosphorous concentrations, the low oxygen depletion rates of its bottom waters, and low chlorophyll *a* concentrations. These attributes, together with the lake's high water quality, determine the recreational and fisheries importance of the lake. Physics (light, climate and thermal regime) and chemistry levels (nitrogen and phosphorous) suggest that increased nutrient loading would quickly increase lake productivity and phytoplankton biomass in Lakelse Lake. Further, already low Nitrogen:Phosphorous ratios indicate that increases in phosphorous loading without concomitant increases in nitrogen loading could result in the development of undesirable blue-green algal blooms or eutrophication (Remington 1996).

There are concerns regarding the protection of drinking and recreational waters, particularly associated with the rural residential developments that are served by septic systems, most of which are located in soils with moderate suitability for septic tank tile fields. McKean (1986) reported about 30% of the residential development, or 72 houses, are located on poor landforms. Of these, 60 houses are located adjacent to the lakeshore. In 1988 – 1992, monitoring of the water quality was carried out. Preparation of a biological and water quality database entailed monthly monitoring (May to September) of drinking water intakes for fecal coliforms and turbidity. The results show that most water quality objectives were met.

Monthly limnological surveys were carried out by DFO on Lakelse Lake during 1994 as part of a survey of selected Skeena sockeye nursery lakes (Shortreed *et al* 1998). Results noted that littoral production might be an important component in sockeye growth. At an average size of 6 g, Lakelse fall sockeye fry were the largest in the Skeena study and among the largest found in British Columbia. Sockeye fry biomass was 51% of the PR model's prediction of maximum production, and recent escapements have averaged 15% of predicted optimum escapements. It was suggested that increased fry recruitment through enlarging escapements or fry stocking would be the best ways to enhance this population. In 2000, an aquatic weed, *Elodea canadensis*, was located and identified to be colonizing waters in the lake. As this weed has the potential to severely change fish habitat, a management plan is currently being developed (Maxwell 2002).

Geography

The Lakelse Watershed is situated within the Kitimat-Kitsumkalum trough, a broad north-south trending depression, in the Kitimat Mountain Range, south of Terrace. The deep-seated nature of the eastern boundary fault along the Kalum-Kitimat trough is demonstrated by hot springs activity. The bedrock geology of the Lakelse Watershed is described as Late Cretaceous to Early Tertiary, consisting of plutonic rocks that form part of the Coastal Mountain Belt. At the eastern most end of the watershed the bedrock geology changes to early and middle Jurassic volcanic and local sedimentary rocks of the Hazelton Group.

For a short period of time at the end of the last Ice Age, between 10,000 and 10,600 years ago, the Lakelse Valley was occupied by the sea (Clague 1984, Gottesfeld 1985). The maximum sea level was about 700 m. Due to postglacial erosion and burial beneath alluvium, glaciomarine sediments presently have a patchy surface distribution in the Kitsumkalum-Kitimat trough. The largest area of relic sea floor occurs between the Skeena River and Lakelse Lake. The area is bounded on the north by alluvium of the Skeena River floodplain; it is bordered on the east and west both by alluvium (Williams Creek and White Creek fans) and by the walls of the Kitsumkalum-Kitimat trough. To the south, the relic sea floor is partially obscured by organic deposits but borders against the steep ice-contact face of the large deltaic platform south of Lakelse Lake. The west margin of the deltaic platform north of Lakelse Lake is a relict foreset slope built into the sea by meltwater streams. The foreslope became inactive when the glacier flowing down Skeena Valley retreated back from the arcuate ice-contact face at the northeast (proximal) edge of the delta. Shortly thereafter, rapid isostatic rebound uplifted much of the glaciomarine terrain in this area above sea level. The continuity of this large area of glaciomarine deposits is broken by drift-veneered bedrock knobs and ridges such as Mount Herman, and by a large ice-contact delta north of Lakelse Lake (Clague 1984).

Certain portions of the low-lying landscape in the Kitsumkalum-Kitimat trough are riddled with earthflow landslide scars. These landslide scars include the two slides that occurred in May and June 1962, with the failures occurring in marine clay overlain in part by alluvial fan sediments (Clague 1978). The May slide between Furlong and Granite Creeks buried 540 m of the old road and the new highway, moving over a distance of 2.4 km on very nearly level ground (Evans 1982). The June slide buried 1.6 km of the old road and the new highway. The most significant example of unstable glaciomarine deposits occurred in December 1993 or January 1994. when 23 ha of glaciomarine sediment – located on nearly level ground - flowed and slid rapidly into Mink Creek, a tributary of the Lakelse River. Currently, instability problems are noticeable along Schulbuckhand Creek, where numerous failures are occurring along the mouth of this tributary.

The predominant biogeoclimatic zone in the Lakelse Watershed is Coastal Western Hemlock (CWH) that merges into Mountain Hemlock (MH) at approximately 550-650 m. The historic, natural vegetation of the watershed was dominated by old-growth conifer stands (rainforests) of western hemlock, western red cedar, and amabilis fir. Sitka spruce is common, but never dominant, and occurs mainly on alluvial soils. Seral stands were uncommon before clearcut logging began on a major scale, except for some south facing slopes, where lodgepole pine, birch and aspen were well established. Red alder and cottonwood occur mainly on floodplains and landslide scars where disturbance exposes mineral soil (Banner *et al*, 1993). The Mountain Hemlock zone is distinguished by the presence of mountain hemlock and the lack of red cedar.

Stream Channel

The Lakelse River mainstem is nearly 20 km long, with a very low gradient (0-1%) and no obstructions to anadromous fish species over its entire length. Major inlet streams are Herman, Coldwater, Mink and White Creeks. Stream banks are vegetated and stable, though minor amounts of rip-rap have been placed to increase stability. Sediment loading is high at times; however, this is associated with the Mink Creek earthflow. Bedload movement is minimal with stream flow levels buffered by the lake. Channel morphology in this 40-120M wide mainstem is meandering, occasionally confined with many exposed sandbars at low flows. The channel stability in this high fisheries value river is rated high.

Reach 1 of Hatchery Creek has banks that are highly unstable, while the banks of reach 2 are stable. The high degree of bedload movement, originating in reach 2 and deposited in reach 1, has caused aggradation to the point that some sections of the creek do not have surface flow during low flow stages. The source of the bedload is natural; however, construction of dikes along the creek does not allow it to be distributed in an alluvial fan (Gordon *et al* 1996).

Schulbuckhand Creek, flowing into the southeast end of Lakelse Lake, has received restoration works in reach 1. In reach 2, large quantities of bedload are being deposited from upstream failures and the flow is sometimes subsurface. Logging and the "Cat Fire" above the Scully Creek fan apex has exacerbated problems associated with levels of sediment and bedload mobilization (Reese-Hansen 2002).

Coldwater Creek flows northeast into the Lakelse River three kilometres downstream of Lakelse Lake and has several notable tributary streams. Reach 2 acts as a depositional area with associated bank instability, while reach 3 has moderate bedload movement resulting from high contributions from its tributaries.

Mink Creek flows into the Lakelse River from the east about 8 km from Lakelse Lake. It had a massive earthflow (43 ha) of glaciomarine silt and clays in the early 1990's (Geertsema and Schwab 1995). This has led to bank instability, very-high sediment loading, and a significantly unstable channel and a sediment wedge moving down the Lakelse River.

White Creek, flowing north into the Lakelse River, 9 km below Lakelse Lake, has an unstable channel, with changes related to three major logging related impacts in reaches 2 and 3. Powerline Creek has been extensively logged with the result of unstable banks and channel (Gordon *et al* 1996).

Williams Creek and its three main tributaries, Sockeye, Myron and Llewellyn Creeks, comprise approximately 25% of the total stream length in the Lakelse Watershed. The alluvial fan of Williams Creek, particularly reach 2, has a somewhat unstable channel receiving large amounts of sediments from the unconfined reach 3 and the large amounts of bank erosion in reach 4. The recent avulsion (2001) of Williams Creek into Sockeye Creek has left three km of creek bed dry at times of low flow (Culp 2002).

Furlong Creek, Granite Creek, Clearwater Creek, Andalas Creek, Ena Creek, North Ena Creek, Eel Creek, Herman Creek, Powerline Creek, Junction Creek, and Killutsal Creek, as well as their tributaries, have essentially undisturbed or stable channels.

Access

Access for vehicles and pedestrians is relatively easy in the Lakelse Watershed due to advanced state of timber harvesting, anglers using access trails, and settlement. Small scale commercial harvesting of wood resources took place in the 1910 to 1950 period. With the conclusion of the Second World War, there was a great demand for lumber, and small mills selectively logged the valuable timber stands. Highway 25, completed in 1957, and the old Lakelse Road pass through the eastern portion of the watershed. Access to the western portion includes the CNR branch line, also built in 1955, and the road to the west of it. The majority of roads in the watershed were built in the 1964 – 1972 period when logging was most active. Approximately 300 km of logging related roads provide access to most parts of the Lakelse Watershed.

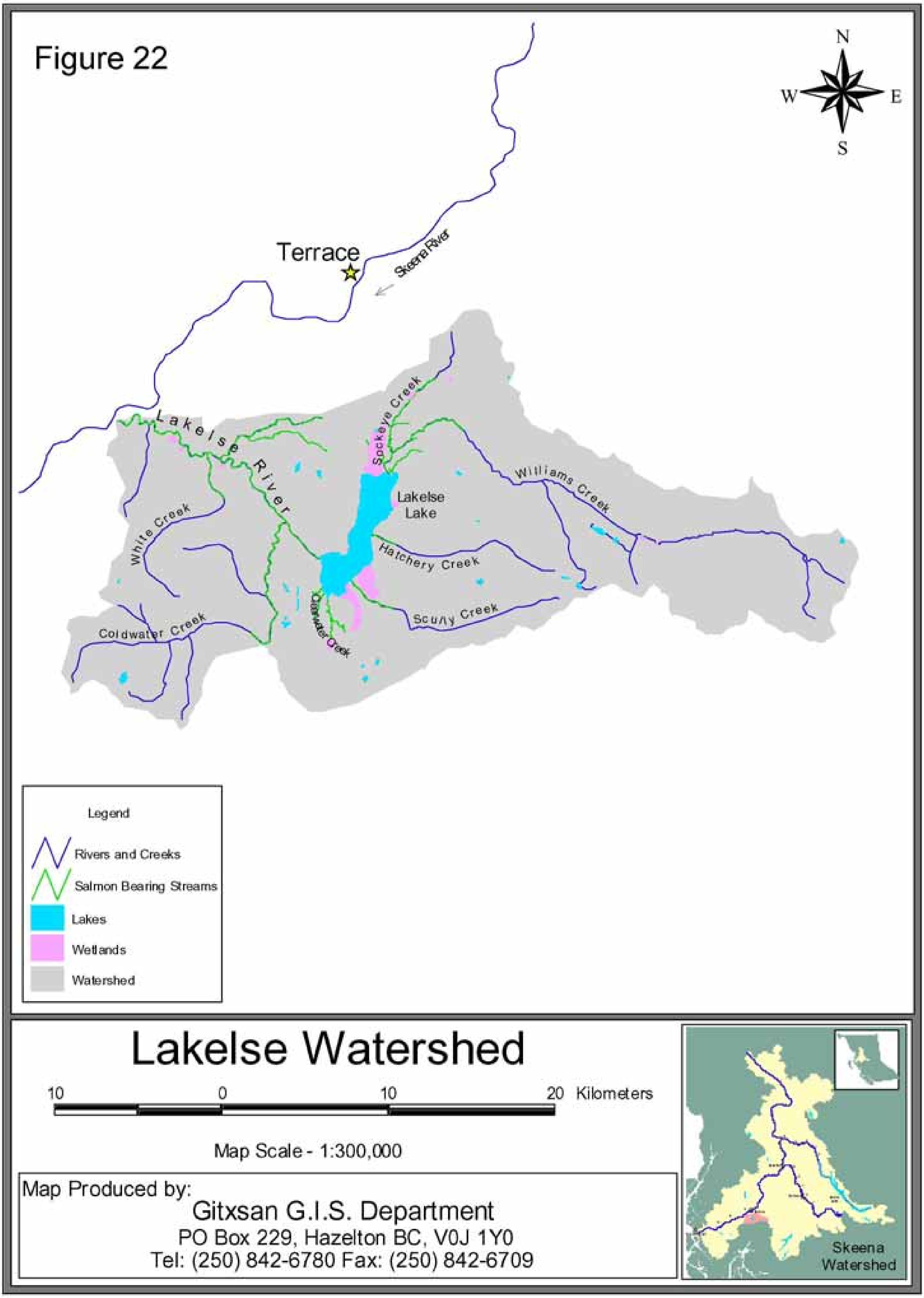


Figure 22
N
W
E
S
Terrace
Skeena River
Lakelse River
Sockeye Creek
Lakelse Lake
Williams Creek
White Creek
Hatchery Creek
Coldwater Creek
Scully Creek
Coldwater Creek
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Lakelse Watershed
10 0 10 20 Kilometers
Map Scale - 1:300,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values and Resources

The Lakelse Watershed possesses very high fisheries values and is a major producer of sockeye, coho and pink salmon, which are fished both commercially and recreationally, making it one of the premier watersheds of the Skeena system. Steelhead and spring cutthroat support a major sport fishery. Resident species present in the system include rainbow trout, Dolly Varden, mountain whitefish, and the following coarse fish: prickly sculpin, largescale suckers, redside shiners, northern pikeminnow, peamouth chub, and threespine stickleback. There are no fish species known to be at risk within the watershed.

All available spawning escapement data for the Lakelse Watershed was obtained from DFO's SEDS database. The data quality varies from observer to observer and place to place. While appreciating the great value of the data records, they can only be utilized as indicators of general trends and at best reflect relative abundance, rather than actual values. Coho are probably the most poorly estimated fish.

Chinook

The chinook salmon population is relatively low in the Lakelse Watershed is one of the smaller Skeena populations. The decadal mean since 1950 is 183 chinook spawners with a range from 91 in the 1990's, to 293 in the 1970's. Chinook enter the Lakelse system in mid August through early September. Chinook spawning principally occurs below the lake outlet, with limited spawning in the Lakelse River mainstem in a patchwork of small areas (MoE 1979, Pinsent and Chudyk 1973). Historically, chinook have spawned in low numbers (20-30) in Coldwater Creek, White Creek, Sockeye Creek and Williams Creek. (Smith and Lucop 1966, DFO 2001, Kofoed 2001).

Pink

The Lakelse River is one of the major pink salmon producing rivers in the Skeena system, with pink escapement exceeding 1.5 million fish in some years. The mid-season pink run typically averages 50% of Area 4 production (DFO 1985). Pink salmon escapement and catch were comparatively high from the early 1980's through to the mid-1990's.

The Lakelse pink salmon run enters the Lakelse River in late August, peaks early to mid-September, and ends mid-September to mid October. The odd-year pink salmon usually enter and spawn over a longer time period than even-year pinks. The mid 1980's saw different timing, as was characteristic of many Lakelse salmon runs. Pink salmon spawn virtually throughout the mainstem, with extremely heavy spawning taking place between Coldwater and Herman Creeks. This area often has the latest spawning timing in the Lakelse Watershed. Wisley (1919) reported that on September 22, 1919, the Lakelse River, from the lake outlet to Coldwater Creek, was literally filled with a mass of spawning humpbacks. This was a common observation throughout the 1920's. The lower reaches of White Creek, Mink Creek, Coldwater Creek, Herman Creek, Scully Creek, Hatchery Creek, and Granite Creek are also occasionally utilized for spawning.

Chum

The chum salmon run into the Lakelse River is modest. Escapement data is scant, though current escapements are less than 5% of adult chum returns in the 1970's. Run timing typically starts in late August, and peaks in mid September; usually all chum are in by mid October. Hancock *et al* (1983) show patches of chum spawning grounds scattered sporadically from below Mink Creek upstream to the lake outlet. Chum have been observed spawning at 6.0 km in Coldwater Creek.

Sockeye

Sockeye are significant in Lakelse Lake, which for its area supports one of the largest sockeye runs in the Skeena. Sockeye spawning population abundance was moderate in the 1950's, increased through the 1960's, severely declined in the 1970's, regained strength in the 1980's, and in the 1990's has been moderately depressed.

The Lakelse sockeye salmon run usually enters the system in June, holding in Lakelse Lake and does not start ascending the streams until August (Sword 1904, Whitwell 1906, Bams and Coburn 1962). Spawning occurs in the lower reaches of many Lakelse Lake tributaries, including: Andalas Creek, Clearwater Creek, Hatchery Creek, Granite Creek, , Sockeye Creek and Blackwater Creek; however, Williams Creek and Schulbuckhand Creek are the two important spawning streams. The major spawning stream, Williams Creek, has excellent beds of medium coarse gravel, while Sockeye Creek also provides good gravel. Sockeye rear in Lakelse Lake for one year before migrating to saltwater in late May and June. Adults return after 2 or 3 years at sea (Rutherford et al. 1999).

Comprehensive propagation and migrant survival studies of Lakelse sockeye were instituted as a component of the Skeena River Investigations (Brett 1952). Sockeye studies on Lakelse Lake in the early 1960's followed the loss, by fire, of the pink hatchery facilities at Kleanza Creek. This prompted construction of a hatchery, fish fence, and ancillary facilities at Schulbuckhand Creek. Fish fences, holding ponds and spawning facilities were also built on Williams Creek. Tow netting, trap netting and lake-pond studies were used in an effort to observe and better understand sockeye behaviour.

Coho

The Lakelse coho aggregate stock remains one of the most productive coho stocks in the Skeena drainage. Coho escapement in the 1950's annually averaged 21,000 fish, with an increase in the 1960's to 34,000 annual spawners. The coho escapement declined severely by the mid-1970's to an annual average of 8,000 fish and the decadal mean has stayed depressed at that level into the present.

Lakelse system coho enter the Lakelse River in early to mid September through to early or mid October; by early December the run has tapered off. Most of the spawning, approximately 75%, occurs in the Lakelse River below the lake outlet. Spawning has also been noted to occur in the lower reaches of: White Creek, Mink Creek, Coldwater Creek, Herman Creek, Ena Creek, Andalas Creek, Clearwater Creek, Schulbuckhand Creek, Refuge Creek, Hatchery Creek, Granite Creek, Furlong Creek, Blackwater Creek, Williams Creek, and Sockeye Creek (Hancock *et al* 1983, DFO 1991c). Coho use has been nil in the once productive Mink Creek since the large earthflow in the early 1990's (Culp, J. 2002).

Dams and Bustard (1996) noted that in 1995, spawning in Clearwater Creek peaked during the last week of October and the first week in November, with completion by the middle of December. The spawning peak on Sockeye Creek occurred in mid November to early December, with spawners still present in the last week of December. Coho juveniles are widespread throughout the accessible portions of the Lakelse system.

Steelhead

Information concerning Lakelse steelhead escapement and population trends is not available. Steelhead trout enter the Lakelse Watershed in two distinct runs: a spring run from March until May, and typically a winter run from October until January, the latter being one of a few substantial winter run steelhead populations in the Skeena River system. Anecdotal information suggests that a summer run of steelhead enter the river in September. Spawning takes place in a patchwork of small areas spread throughout the Lakelse River mainstem (Pinsent and Chudyk 1973). The major spawning area is in the river section immediately downstream of the lake outlet (DFO 1991c). The Lakelse River Project documented steelhead spawning at various sites in the main stream, from the lake outlet to the Skeena confluence (Whelpley 1983, 1984).

This investigation also observed steelhead spawning in the lower reach of Herman Creek, White Creek and Williams Creek, with evidence of spawning in Coldwater Creek (Gordon 1996). Culp (2002) considers Coldwater Creek as one of the most important steelhead spawning streams in the Lakelse system. Local anglers (Brown and Webb, *cited in* Grieve and Webb 1997) and Whelpley (1984) note that winter run steelhead generally use the upper river to spawn, while spring run steelhead utilize the lower river. Tagging records of 347 steelhead collected over a thirty year period showed that a majority of these fish spent three years in fresh water and two or three years in saltwater. These records indicated that repeat spawners accounted for 15.6%.

Juvenile steelhead utilize the low gradient streams throughout the watershed for rearing. Juvenile steelhead or rainbow trout have been observed in the lower and mid reaches of White Creek, Clearwater Creek, Junction Creek, Coldwater Creek, Johnstone Creek, Eel Creek, Ena Lake, and Williams Creek. Lakelse Lake is most likely the most important rearing and overwintering habitat in the watershed. Although steelhead do not generally overwinter in the Lakelse River or its tributaries, they have been known to do so in the lake (Tetreau 1982, Whelpley 1983, 1984). As well, there is First Nations anecdotal information that describes the netting of steelhead off the inlets of Andalas and Clearwater Creeks. It is likely that Lakelse system steelhead overwinter in the Skeena River, both upstream and downstream of Lakelse River (Grieve and Webb 1997).

.

Fisheries

First Nations Traditional Use

First Nations traditional occupation and use of the Lakelse Watershed is extensive and conservatively estimated to be from at least 5,000 years ago. Pre-historically, the Lakelse River Watershed was territory held by Gilutsau (Barbeau 1917), considered part of the Kitselas people. Haisla territories to the south occupied the flatlands south of Lakelse Lake. Gilutsau, also called Killutsal, was an important settlement on the east bank of the Lakelse River at the Lakelse-Skeena confluence (Dawson 1881). Most of the occupants of this village moved to Port Simpson prior to 1900, and the village was largely abandoned at this time. Significant trail infrastructure provided connection to Lakgeas, a burial site along the Lakelse River, and a summer village site located near the outlet of Lakelse Lake (Kerby 1984).

Local First Nations territories sustained home places and resources for many thousands of years, with traditional use features covering the landscape. Subsistence activities were tightly interwoven with the social structure, the local landscapes, and the broader regional environment. Detailed knowledge and understanding of the environment, the characteristic of each resource, and the seasonal variation in abundance and availability, were necessary to the chiefs and House members for making decisions about what, where, and when different resources were to be harvested. Over time, Gilutsau ancestors developed systems of access, tenure, and resource management. A strong and adaptive semi-nomadic economy, pre-occupied with food gathering, was based around the summer salmon food fishery and mid-winter feasting, with dispersal into smaller family groups during the rest of the year to fish, hunt and gather on the House territories.

Recreational Fisheries

The Lakelse River supports a strong recreational steelhead, coho, cutthroat and rainbow trout fishery. The cutthroat trout sport fishery is described by Bilton and Shepard (1955), Imbleau (1978), Hatlevik *et al* (1981), and deLeeuw (1991). In addition, due to a substantial winter steelhead run and easy access, there is generally an easily exploitable eight months of steelhead fishing. A large and popular coho fishery takes place in September particularly on the lower half of the river. Proximity to Terrace and Kitimat and high aesthetic values also contribute to this popular high value angler destination. The recreational importance, use patterns and economic values and opportunities were surveyed and documented by Sinclair (1974). Lakelse River steelhead was comprehensively reviewed by Grieve and Webb (1999).

The Lakelse River is designated a Class II water with specific regulations applicable to the river and its tributaries, including use of a single barb-less hook, a bait ban, and on a seasonal basis, catch and release and fly fishing only. The fall and winter fishery (October to January) is principally located from the CN Bridge crossing upstream to Herman Creek, with access from Beam Station Road. There is also fishing throughout the entire Lakelse mainstem with the easiest access points receiving most of the angling pressure, though there are favourite seasonal hot spots, as well.

Enhancement Activities

The Coldwater Creek-Lakelse River confluence was the site of the first hatchery in the Skeena system, which was constructed in 1901 and operated until 1920. Fish were trapped for egg take at the mouth of Sockeye River (presently Williams Creek) and taken to the hatchery, which had capacity for 4,000,000 fry. Coldwater Creek was dammed for a water supply, with the dam failing on a regular basis (1902, 1903, 1904, 1905 x 3) and flooding the hatchery (Sword 1903, Whitwell 1906). Due to cold water and flooding, the hatchery moved in 1920, to Granite Creek. This hatchery operated until the fall flood of 1935, when due to flood damage and the lack of funding during the Depression, the Government closed it. Escapement of sockeye salmon to Lakelse Lake averaged 175,000 fish during operation of the hatchery (Kerby 1984). From 1960 to 1962, counting fences were operated on the lower Lakelse River, Scully Creek and Williams Creek by the Federal Government. Fish eggs from these fences were raised at an experimental hatchery operated on Scully Creek.

Since the early 1900's, remedial work has periodically been implemented on lower Williams Creek to improve fish passage by countering aggradation effects on the alluvial fan. Sockeye Creek received channel improvements as well as logging debris cleanup in the mid-sixties. Scully and Williams Creeks were the sites of hatcheries from 1962 till an unknown date, possibly 1967 (Hancock *et al* 1983). Various studies for enhancement opportunities were undertaken under the auspices of SEP, particularly reconnaissance for sites with good groundwater flow (Brown 1980). In the 1980's, a small volunteer facility at Howe Creek in Terrace, called Eby Street Hatchery, began enhancing many of the small streams flowing into the east shore of Lakelse Lake. This group consistently produced coho fry from broodstock collected on Clearwater Creek for at least eight years. In the late 1980's, Deep Creek Hatchery conducted chinook enhancement on Coldwater Creek. Presently, there is one small project for coho, on Schulbuckhand Creek.

Development Activities

Principal development activities in the Lakelse Watershed are settlement and housing development, forest development activities, and transportation and utilities.

Forest Resource Development

The conclusion of the Second World War brought a great demand for lumber, and small mills selectively logged portions of the most valuable timber stands. The Whitebottom area of the Lakelse Watershed was awarded to Columbia Cellulose (TFL #1) in 1948. In 1960, the area south of Lakelse Lake was awarded to Eurocan Pulp and Paper Co. as TFL #41.

The majority of roads in the watershed were built in the 1964 to 1972 period when logging was most active. This resulted in few patches of accessible, viably commercial mature timber being left standing. Over this period, the following areas were intensively logged: Herman Creek, along Beam Station Road, in the lower Coldwater and White Creeks drainages, and north of Lakelse Lake in Sockeye Creek and Blackwater Creek watersheds. South of Lakelse Lake, logging development occurred in the Andalas Creek area, the Ena Lake area of Coldwater Creek, the south end of the lake, parts of Clearwater Creek Watershed, and at Onion Lake Flats.

The Lakelse WRP Project (Triton 1996b) stated that of the 64 stream reaches rated for impacts to riparian habitats, 25% were rated as having very high impacts, 31% as having high impacts, 22% were given moderate impact ratings, 6% low impact ratings, and 16% had no riparian impacts. Results of the fisheries assessment noted a total of 63 reaches assessed, with 43 reaches being rated as very highly impacted (68%), and eight reaches as highly impacted (13%). Ten reaches were rated as moderate (16%); no reaches were rated with low impacts, while only two reaches had nil impact (3%).

In 1992, the Thunderbird Integrated Resource Management Plan was established with the recognition that future timber harvesting activities would be constrained due to past practices and the high fisheries, wildlife and recreation values in a portion of the Lakelse Watershed. This plan has since been subsumed into the higher level Kalum LRMP with specific directions related to land use in the watershed. The Lakelse River Corridor (one km width from each bank) has been designated a Special Resource Management Zone (SRMZ) with a conservation orientation to maintain the natural integrity of this highly productive and unique river (MoF 2001). Lakelse River, Williams Creek, Hatchery Creek, Scully Creek, Furlong Creek, and Coldwater Creek are to be evaluated by the Coastal Watershed Assessment Procedure (CWAP). Lakelse Lake, Ena, End and Clearwater Lakes are to be managed for water quality, fisheries, wildlife, recreation and other uses. Hatchery Creek will be an established Community Watershed. Mount Herman and the Lakelse Lake wetlands at the south end of the lake are approved Protected Areas.

The Lakelse Watershed is located in and administered by Ministry of Forests, Kalum Forest District. The large-scale industrial logging of all timber along many of the streams has had profound impacts on stream structures and has lowered the productive capacity of the sub-watersheds (Gordon *et al 19*96).

Mineral Resource Development

There is no known mineral resource development in the Lakelse Watershed, though there are active claims west of the Lakelse River.

.

Transportation and Utilities

A network of transportation and utility systems traverses the Lakelse Watershed. Linear development includes Highway 25, a major north-south transportation route connecting Terrace and Highway 16 with Kitimat and tidewater to the south. Alongside the highway, built in 1957, are PNG's natural gas pipeline and a BC Hydro major transmission line. The transmission line forks north of Lakelse Lake with a branch transmission line heading down the south side of the Skeena River. Secondary roads through the watershed include two main north-south and two main east-west, with many secondary roads providing access to the two Provincial Parks, forest development activities, and residential developments. Both commercial and private floatplanes utilize Lakelse Lake as a base. Known impacts from linear development within the watershed include degradation of riparian habitat, a reduction in stream channel complexity at stream crossings, channelization, bank erosion and degradation. Current activities are directed towards deactivation of roads and a more aware attitude to fish, fish habitat and riparian zones.

Population and Settlement

The Lakelse Watershed supports a relatively high number of seasonal and full-time residences providing a variety of rural and high quality lifestyles. Lakelse Lake is believed to be the most heavily utilized recreational lake in the region (MoE no date). Mount Layton Hotsprings Resort, a family orientated facility, operates hot and cold pools, water slides, a restaurant and a motel on the east shore of Lakelse Lake. Mount Layton Hotsprings Resort has proposed an eighteen hole golf course and a convention centre. There are two Lakelse Provincial Parks located on the east side of the lake, and at the northeast corner, which are popular stopping off points for local and non-local water-based recreation, picnics, and camping. The east and west sides of the lake have many homes. These developments, with their associated septic systems and occasional stream diversions, may have fish and fish habitat impacts.

Property owners have also expressed interest in lowering the lake outlet to facilitate property drainage during spring and fall floods. This proposal would directly threaten critical spawning habitat at the lake outlet. Fertilizer use on residential lawns and future developments may also be of concern. There is concern associated with any housing development at or near Lakelse Lake because of the contribution of phosphorus to the watershed. The lake has been described as a phosphorous limited system that is literally in danger of becoming mesotrophic, or even eutrophic (Remington 1996). Federal, Provincial and First Nation governments, as well as community organizations, each representing differing values and interpretations, are working together to effect plans and regulations regarding settlement, water quality issues, recreation facilities and other developments. The developments surrounding the lake appear to be closely monitored, and this will most likely continue for the foreseeable future.

Lakelse Watershed Management Issues

The Lakelse Watershed possesses valuable common property resources that are primarily and inextricably linked to recreational activities. The Lakelse Watershed possesses very high fisheries values and is a major producer of sockeye, coho and pink salmon, which are fished both commercially and recreationally, making it one of the premier watersheds of the Skeena system. Steelhead and spring cutthroat support a major sport fishery. Resident fish species present in the system include rainbow trout, Dolly Varden, mountain whitefish, and coarse fish. There are no fish species known to be at risk within the watershed.

The very high fishery values stem from the superb spawning and rearing habitat. Though the Lakelse Watershed was impacted by large scale industrial logging, particularly in the mid 1960's to mid 1980's, some of the post-logging impacts to fish and fish habitat have been mitigated by time. Lasting impacts of timber harvesting are primarily disturbance of tributary riparian zones, alteration of stream structures, and an increased bedload mobilization leading to channel destabilization and aggradation on steep gradient stream fans. Many tributary riparian zones have seen an expansion of beaver habitat that may provide rearing habitat, but access to this habitat is problematic.

Transportation and utilities impacts are moderately significant with highways, railroad, power transmission lines, and natural gas pipelines. The severity of impacts related to settlement and development adjacent to and on the lakeshore, create conflict with water quality and fish conservation values, posing difficult questions that need to be addressed in a localized, detailed fashion. The priority in managing and conserving fish habitat in the Lakelse Watershed, particularly the sensitive lake habitat, is to ensure protection of the environmental quality of the lake's water and the fisheries resource. Proper land management practices must be promoted and monitored to maintain and where possible, restore the integrity of streams and the Lake.

Kispiox Watershed

Environmental Setting

Location

The Kispiox River is a large tributary of the Skeena River. It flows 140 km southeast from its headwaters to the confluence with the Skeena River (right bank) at Kispiox Village, approximately 12 km north of Hazelton. The watershed is bounded in the north and the east by the Southern Skeena Mountains, to the south, predominantly by the Kispiox Range, and to the west, by the low relief Nass Basin.

Hydrology

The Kispiox is a fifth order stream with a catchment area of 2,088 km^2. Elevation ranges from approximately 200 m at the mouth to 2090 m on Kispiox Mountain and 1850 m in the Skeena Mountains. This major tributary contributes about 9% of the Skeena River flows (Remington 1996). Kispiox River peak discharges typically occur in May and June due to spring snowmelt, then decrease through July and August. In September, fall rain and run off from early snow melt once again increases stream flows through to October. Stream flows decrease through November and December when precipitation falls as snow, with low discharges recorded January through March. The Hydrometric Station (08EB004), located downstream from the McCully Creek confluence, recorded a monthly mean discharge of 128 m^3/s for June, while low flows in February average 7.8 m^3/s over a thirty-year observation (1963-1993). Summer low flows are typically 4 to 8 times greater than winter stream flows and are principally sustained by high elevation snowmelt draining from the Skeena Mountains, while winter low flows are derived from groundwater, lakes and unfrozen wetlands (Wilford 1985).

Climatic information from the Murder Creek weather station (AES 1993), located in the lower Kispiox, shows mean annual precipitation of 631 mm over a 20-year period, of which, rainfall accounts for 71%. Total annual precipitation (TAP) is much greater in the upper watershed, particularly at higher elevations; Stockner and Shortreed (1979) reported 1500 mm TAP at Swan Lake. The Skeena Mountains, to the north, and the Nass Basin, which broaches the northwest and western perimeter of the watershed, exert the major hydrological influences. The low elevation watershed divide to the Nass drainage in the west, allows coastal weather systems to enter the watershed, leading to heavy snow packs in the mountains and the upper half of the drainage.

The watershed as a whole has a moderately high response from water input due to the steepness of the upper Kispiox and most major tributaries. In general, the streams flowing from the west into the upper Kispiox River arise from a myriad of lakes and bogs; hence, they are relatively stable in flow, temperature, and water quality characteristics. The Kispiox Range to the southwest is principally drained by Date and McCully Creeks, which both transport large amounts of bedload and suspended sediment originating from natural sources and have active alluvial fans at their confluences with the Kispiox River (Weiland 2000a). Tributaries to the upper Kispiox from the northeast, principally the East Kispiox River, Sweetin River, and to a lesser extent the Nangeese River, drain glacial headwaters and transport moderate amounts of sediment from natural sources. Through the summer season these streams generally have glacially turbid, unstable flows. The wide variations in water flows in the Kispiox mainstem may be primarily attributed to these mountainous areas.

Pinsent and Chudyk (1973) noted water temperature variation on May 31st; Stephens Creek was 8.0 °C at the Kispiox River confluence, while the mainstem was 2.5 °C, a difference of 5.5 °C. This difference was attributed to Stephens Creek originating in Swan Lake and Stephens Lake, while high elevation snow and glacial melt are the main contributors to the Kispiox mainstream.

Swan and Stephens Lakes, the two most important high fish value lakes in the watershed, are located close to the Nass drainage divide in the upper watershed. These two clear water lakes have ice cover for up to six months of the year, receive approximately 1500 mm of total annual precipitation and lie at an elevation of 520 m (Stockner and Shortreed 1979). Stephens Lake is small (surface area = 1.9 km^2), relatively shallow with a mean depth of 11m, and located 3 km downstream of Swan Lake. The results of limnological sampling (Stockner and Shortreed 1979), showed a pronounced thermal stratification with a strong thermocline at a depth of 4.8 m, with maximum surface temperatures not exceeding 18°C. Average euphotic zone depth was 13.1 m. Although there was no data on phosphorous levels and photosynthetic rates, the lake appears to be oligotrophic and is most likely nutrient-limited (Shortreed *et al.* 2001). Although its importance as a salmonid nursery area is unknown, macrozooplankton biomass is relatively high, as is *Daphnia* abundance (Rankin and Ashton 1980). Simpson *et al.* (1981) reported mean sockeye fry weight of 3.1 g, for Stephens Lake, which is moderate to high in relation to other sockeye lakes in the Skeena system.

Swan Lake discharges through Club and Stephens Lakes into the Kispiox River. Its physical environment is excellent for juvenile sockeye, with a 15.3 m euphotic zone depth, a stable cool epilimnion, and a large hypolimnion (Shortreed *et al.* 2001). *Daphnia* was abundant relative to other northern lakes (Rankin and Ashton 1980); however, despite a good physical environment, an abundant food supply, and low planktivore densities, Swan Lake fall fry averaged only 1.0 g (Simpson *et al.* 1981). Given the apparently good rearing conditions, it is unclear why Swan Lake sockeye fry do not exhibit higher growth rates. Shortreed *et al.* (2001) suggested that the productive capacity of most BC sockeye nursery lakes has been, and continues to be, degraded by the harvesting of a substantial proportion of returning adults in various fisheries, thus preventing them from contributing their nutrients to their natal streams and lakes. It is possible that the majority of sockeye fry in the Swan-Club-Stephens system rear in Stephens Lake.

Water Quality

In 1982, the MELP Waste Management Branch initiated a five-year water quality monitoring program with a station (Site 0400205) on the Kispiox River close to the Skeena confluence. The program concluded that Kispiox River is a soft water river, with neutral to slightly alkaline pH and clear, slightly tea coloured waters for most of the year. This coloration is due to natural organic substances, such as humic acids, contributed by swamps and wetlands in the drainage. Alkalinity and calcium concentrations are in a range that would provide moderate buffering from acidic inputs. Total suspended solid loadings are much higher during freshets than the remainder of the year. Nutrient concentrations are low. Mean total levels of metals are generally very close to MELP criteria for the protection of aquatic life at the hardness levels present (Wilkes and Lloyd 1990).

Community watersheds are located on Dale and Quinmas Creeks, supplying domestic water for Kispiox Village. Licensed water withdrawals within the Kispiox Watershed are mainly from small tributaries presenting minor impacts on instream flows for fisheries. The effects of clearcut logging on increased peak flows in the Kispiox River has been a persistent issue raised by the public. Keeping logging debris out of small creeks, particularly in winter logged areas, was reported to be a major difficulty (Remington 1996). Loedel and Beaudry (1993) noted that their investigation of interception and throughfall water at Date Creek was initiated by concerns from waters licensees, native peoples, and others that clearcutting may increase peak flows; decrease low flows, and/or alter the timing of these flows.

The Kispiox WRP Overview (Jyrkkanen *et al.* 1995) concluded that erosion, obstructions, sedimentation, gravel aggradation and altered water yield are the primary sources of impacts to the aquatic resources of the Kispiox valley. Concerns about turbidity and poor water quality from tributaries and the impact on sports fishing were also noted. Nortec (1997) implemented a Level II stream and fish habitat assessment in 1997 in which their report reiterates that water quality was impacted from forest development activities. Weiland (2000b) conducted a reconnaissance sediment source mapping survey, which identified natural sources and activity in the watershed. This study reported that presently, it appeared that natural sources supply by far the most sediment in the Kispiox River and the mountainous sub-basins, and currently that sediment transport in the watershed appeared to be in an overall steady-state equilibrium.

Geography

Three physiographic units are present in the Kispiox Watershed; the Nass Basin, the Kispiox Range, and to the north and northeast, the Skeena Mountains. The Nass Basin is an area of low relief, which generally falls below 700m and forms the valley floor. The Kispiox Range, which bounds the watershed to the southwest, is largely drained by Date and McCully Creeks. The southern Skeena Mountains form the headwaters of the major Kispiox River tributaries: the Sweetin and East Kispiox Rivers.

Folded and faulted Bowser Basin marine sediments characterize the underlying bedrock in the Kispiox Watershed; minor amounts of an intrusive granitic stock appear in the Kispiox Range. The ice that covered and flowed down the Kispiox Valley during the last glacial period strongly glaciated the mountain slopes and the basin, leaving a legacy of drumlin fields, hundreds of small lakes and a generally linear drainage pattern. Thick blankets of glacial till cover the main valley and mountain valleys and extend up the valley sidewalls. The surface expression conforms generally to the underlying bedrock surface, with bedrock exposure along deeply incised streams and on steep-sided hillocks (Weiland 2000b).

The coastal/interior transition climate is reflected in the major ecological zones. Vegetation in the wide, gently sloping valley below approximately 750m is represented by the Interior Cedar Hemlock (ICH) biogeoclimatic zone, which is dominated by forest stands of hemlock, spruce, subalpine fir and, in the southern half, red cedar. Before industrial logging, the majority of forest stands were mature hemlock and fir. These stands have been replaced with plantations of spruce and pine, with a major portion of the valley bottom replaced by deciduous forests. With increasing elevation, the ICH zone passes into a forest dominated by mature and overmature subalpine fir, representing the Engelmann spruce-subalpine fir (ESSF) biogeoclimatic zone (Pojar *et al.* 1988). Meidinger and Pojar (1991) comprehensively describe the above ecological zones.

Stream Channels

From the Skeena River upstream to Sweetin River, the Kispiox River is divided into three distinct reaches and the channel presents a regular profile, with a gradient of 0.3 % slope or less (MoE 1979). These lower three reaches are composed of a mix of pools, riffles and runs, which offers holding, rearing and spawning habitat. Bedrock outcrops are infrequent and bank erosion is common. Minor amounts of sediment are received from tributaries. Low summer flows may compromise off-channel habitat rearing capacity.

Reach Four, from Sweetin River upstream to Gitangwalk Canyon, is frequently confined by bedrock, which becomes more evident in reach five that starts at the bottom end of Gitangwalk Canyon. Gitangwalk Canyon is approximately 1 km in length with an average gradient of 0.6%. The lower end of the canyon presents a 200+ m long cascade with two 1-2 meter drops that restrict pink and chum salmon access to the upper reaches of the river. In some years of low water flows, late running sockeye have been unable to ascend these falls and have been observed spawning just below. Adjacent to this section of the river is the ancient village site of Gitangwalk and the river crossing location of the grease trail (Rabnett *et al.* 2001). Wadley and Gibson (1998) noted that DFO carried out blasting in the cascade-falls section to facilitate fish passage. Above Gitangwalk Canyon, the river has gravel banks and a lower gradient. Reach 7 and 8 both have 0.4% slope. Another falls, about 3 meters in height, is found past the confluence of the East Kispiox River. Generally, the Kispiox River mainstem channel is stable with few direct impacts known to be caused by development activities.

Tributaries to the main stream have received relatively low impact; however, sediment deposition at their mouths has caused concerns for fish passage at low flows, channel avulsions at high flows, and sub-surface flows in several tributaries (Triton 2001). Murder and McCully Creeks have avulsions in their lower reaches due to agricultural clearing of the floodplain riparian zone, with downstream sediment deposition contributing to channel instability (Wadley and Gibson 1998). Weiland (2000b) noted that several tributaries have very low gradient channels in their lower reaches, with low sediment transport capability.

Another major impact to fish in the system is beaver dams that limit fish access to spawning areas at low flows; however, the beaver ponds provide excellent rearing habitat (Riley and Lemieux 1998). Nortec (1997) described twelve creeks where channel changes, bank erosion and decreases in riparian suitability for conifers were due to beavers and their dams.

In their inventory of Kispiox River tributaries, Taylor and Seredick (1968) described three types of fish habitat problems: upstream migration of young fish is hindered by extensive beaver dams; upstream migration of young fish and some adults is hindered by some culvert crossings (Cullen, Ironside, Corral, and Skunsnat) at both critical and non-critical times of the year; and some types of spawning and rearing areas have been reduced.

Access

Access within the Kispiox main stream for anadromous fish returning to their natal spawning beds is unobstructed up to the Williams Creek confluence, except for the barrier at Gitangwalk. The upper Kispiox, including the mainstem and tributaries upstream of the confluence of the Nangeese River, which encompasses a third of the watershed, remains unroaded and contains little forestry development. Most of this area has been designated as the Swan Lake Kispiox River Provincial Park. The park management direction is to ensure that users have a limited impact on the natural ecosystem and respect the conservation focus of the park. Access to this area is by canoe and portage from the Brown Bear lake recreation site or by foot trail (6 km) from the end of the Kispiox Main road. Swan Lake and the other nearby large lakes are accessible by floatplane, but floatplane and motorboat use is restricted to special circumstances by park regulations. From the Nangeese River downstream, the river is floatable with several launch sites easily accessible.

The east side of the river hosts the major road, the approximately 85 km long Kispiox Trail, which heads northwest from Kispiox Village. The road branches twice to accommodate two crossings of the Kispiox River and provides access to the west side. Both west side roads, the Helen Lake Forest Service Road (FSR) and Mitten Main FSR, converge 58 km upstream to provide access northwest out of the drainage and into the Nass Watershed. The Kuldo FSR located at 45.5 km on the Kispiox Trail swings north providing access to the Upper Skeena and Shedin drainages. There are numerous branch access roads, in various states of deactivation and repair that accommodate forest development activities within the majority of tributary basins. It is unknown how many kilometres of main and secondary road exist in the watershed.

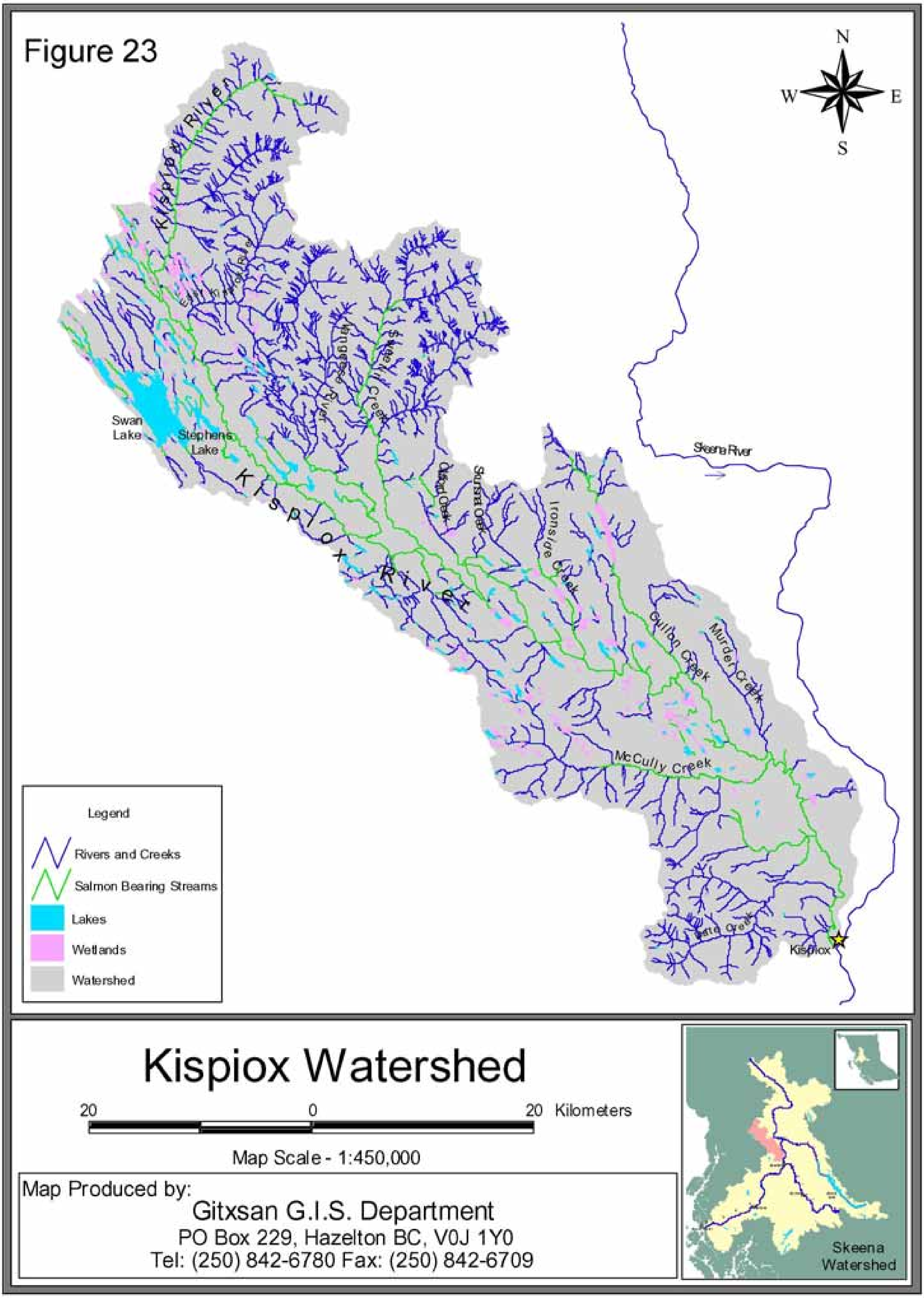


Figure 23
N
W
E
S
Kispiox River
Swan Lake
Stephens Lake
Skeena River
Ironside Creek
Cullon Creek
Murder Creek
McCully Creek
Kispiox
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Kispiox Watershed
20
0
20 Kilometers
Map Scale - 1:450,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values and Resources

The Kispiox River Watershed is composed of approximately 100 km of mainstem and 300 km of tributary streams that are considered high value fish habitat, and that provide a migration corridor and support spawning and rearing (Nortec 1997). The numerous salmonids utilizing this habitat include: sockeye, coho, pink, chum, chinook, and steelhead salmon; rainbow, lake and cutthroat trout, Dolly Varden, bull trout char, and mountain whitefish. Lamprey and several coarse fish (*Cottidae* and *Cyprinidae*) are also found in the watershed. This fish community contributes to the ecology, nutrient regime and structural diversity of the drainage and provides strong cultural, economic and symbolic linkages, particularly for First Nation peoples, as well as supporting recreational and commercial fisheries. The Gitxsan Watershed Authorities have recorded sockeye and coho escapements within the Kispiox Watershed since 1992. These data compliment the SEDS data enabling a clear 1990's decadal picture.

Chinook

Kispiox River chinook salmon are one of the large and important stocks in the Skeena Watershed. Since the 1950's, there has been a long-term population decline due in part to the mixed-stock fishery and incidental interception, and a targeted sports fishery. This has slowly turned around with escapement numbers recovering to near 1950's levels in the last five years. Chinook escapement has varied widely in the past, from about 400 in many years of the 1970's and 1980's to 15,000 in 1957 and 1992 (SEDS). The ten-year mean escapement for the 1950's was 12.560, for the 1980's 2,801, and for the 1990's was 5,493.

Typically, chinook salmon enter the Kispiox system in June and July and disperse to their spawning areas where they spawn from late July through August. The bulk of the spawning is concentrated in the mainstem. Critical chinook spawning areas include: portions of reach three upstream and downstream of Murder Creek (DFO 1991a, Wadley and Gibson 1998); sections of reach three, particularly south of Elizabeth Lake (DFO 1991a), and dispersed areas throughout the mainstem, often just downstream of tributary outlets that provide sources of fresh sediment and increased hyporheic (shallow intragravel) flow.

A variety of bedrock pools in reach three support holding areas for mature chinook, coho and steelhead (Wadley and Gibson 1998). Reach four contains moderate to heavy spawning in suitable sections with good holding pools. Reach five is essentially Gitwangak Canyon with no known reports of chinook spawning. Reach six, located above the canyon upstream to the mouth of Stephens Creek, has excellent spawning beds in the upper section. Dispersed, heavily used spawning areas exist in reach seven, especially in the upper portion. Reach eight and nine, which are above Williams Creek, have no record of spawning (DFO 1991a, MoE 1979).

Tributaries with noted chinook spawning in their lower reaches include: Date Creek, McQueen Creek, Cullen Creek, Sweetin River, Nangeese River, Stephens Creek particularly near the mouth, Lower Club Creek, and lower Williams Creek (DFO 1991a, Hancock *et al.* 1983, Smith and Lucop 1966). Stuart (1981) conducted a biophysical assessment of the Kispiox mainstem and thirteen of the major tributaries, reporting that chinook fry were present only in Date Creek and in the Kispiox mainstem. Chinook rearing occurs virtually throughout the high value habitat located in the watershed, with migrants for the most part migrating at age one down to the Skeena and into the estuary and then into saltwater.

Pink

The Kispiox River is one of the major pink salmon producing areas of the Skeena River system. Kispiox River pink salmon are distinguished by their early run timing, with no dominant cohort year. Pink escapement fluctuate widely from cycle to cycle. Relative to recent pink salmon escapements in the Skeena, Kispiox River pinks have not experienced a dramatic increase in escapement. The ten-year mean escapement for the period of 1990-1999 shows 33,500 for the even year mean, and 56,800 for the odd year mean (DFO 2001). Typically, pink salmon enter the system in mid to late August and disperse to spawn throughout the mainstem and its lower tributaries. Gitangwalk Canyon is a barrier to pink upstream movement and is consequently the upriver limit of pink spawning.

The area of heaviest spawning occurs from Seventeen Mile Bridge upstream to Cullon Creek (Smith and Lucop 1966). Wadley and Gibson (1998) report moderate mainstem pink spawning in areas of suitable substrate upstream from McQueen Creek; heavy pink spawning from McCully Creek up to Cullon Creek; and dispersed patchy spawning in reach 4. Pink salmon also utilize the lower reaches of the following tributaries: Date Creek, McQueen Creek, McCully Creek, Murder Creek, Cullon Creek, Ironside Creek, Twin Creek, Corral Creek, Skunsnat Creek, Clifford Creek, Sweetin River and the Nangeese River. Upon emerging from the gravel in spring, pink salmon fry migrate immediately to the saltwater.

Chum

Kispiox River chum are the farthest upstream of any large chum population spawning in the Skeena system, but the escapement has been severely depressed since the late 1950's. The ten year mean escapement for the 1950's decade was 4,083; for the 1960's, 553; for the 1970's, 1,108; the period from 1980-1989 recorded 131 chum, while the ten year mean escapement for the period from 1990-1999 was 400 spawners. Surveys in 1994 and 1999 (DFO 2001) observed spawning chum.

Generally chum move into the Kispiox system in August, spawning in selected sections of the mainstem, principally reach one and two. Chum spawners have also been observed scattered along the mainstem close to the mouths of Date Creek, McCully Creek, McQueen Creek, Murder Creek, Elizabeth Creek, Steep Canyon Creek, Sweetin River and Nangeese River, in the lower parts of Date Creek and Nangeese River, and occasionally as well in the lowest reaches of the other tributaries. Migration downstream to the saltwater begins immediately following fry emergence in the spring.

Sockeye

The Kispiox River Watershed is among the eight most important sockeye producing watersheds in the Skeena system. Kispiox River sockeye are a unique population with spawning taking place primarily in streams tributary to the Swan, Club and Stephens Lakes. From the DFO BC16 and SEDS records, the population size seems stable, although variable from year to year.

Sockeye adults typically enter Stephens Creek in August and the beginning of September (Sterritt and Gottesfeld 2002) and migrate upstream to spawn in Club Creek and other Swan Lake tributaries. A small number of sockeye also spawn in the lower reaches of Stephens Creek. Once through Stephens Creek the sockeye will hold in either Stephens Lake or Swan Lake until ready to spawn. The major spawning grounds are located on upper and lower Club Creeks (FRB 1948). The sockeye spawning in Club Creek may be unique in the Skeena in that the spawning substrate is primarily boulder size. Other spawning areas are found on four creeks tributary to Swan Lake, of which Falls Creek is the most important. Some sockeye also spawn in Swan Lake and possibly Stephens Lake. Spawning takes place in September (Sterritt and Gottesfeld 2002). Following emergence from the spawning beds, most juvenile sockeye (>95%, Rutherford *et al.* 1999) spend 1 year in Swan, Club or Stephens Lakes before migrating to the sea.

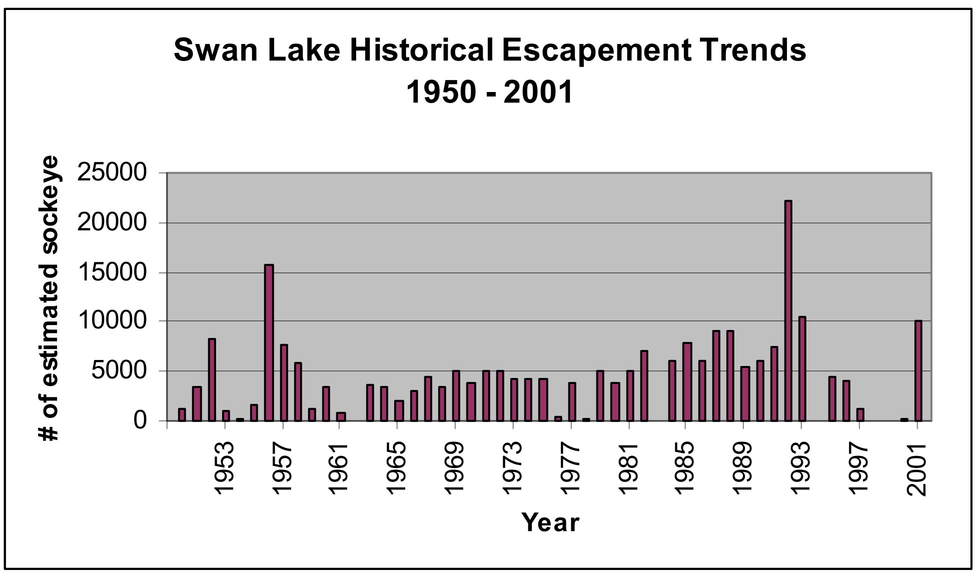


Figure 24. Historical escapement estimates for Swan and Stephens Lake sockeye.

Figure 23 shows the historical escapement estimates for the Swan Lake system. Estimates prior to 1992 were based primarily on Club Creek (Upper and Lower) counts. In 1992 the GWWA included Jackson and Barnes Creeks, and in 2001 the GWA enumerated all known spawner areas in the Swan Lake system, including Club Creek. A counting weir was set up in 2001 to obtain accurate escapement for the Swan Lake Watershed; 10,109 sockeye were enumerated.

Small numbers of sockeye regularly spawn in downstream sections of Ironside, Clifford, and Skunsnat Creeks and in the Nangeese River (GWA, unpublished data). Since there are no lakes accessible to sockeye from these sites, with the possible exception of Skunsnat Creek, we presume that these fish are river type sockeye. River type sockeye are rare in the Skeena Watershed, although this life history type is common in Asia and makes up a significant part of the total escapement of sockeye to the Stikine River, and to a lesser extent, the Nass River.

Coho

Coho salmon are widely distributed throughout the Kispiox River system. The greatest abundance is within the Kispiox mainstem where escapements as high as 35,000 (1958) have been recorded. Coho escapement within the watershed has decreased by an order of magnitude over the last few decades (Plate *et al,* 1999). Recent coho synoptic and stock assessment studies have been conducted by the Gitxsan Watershed Authority (Plate *et al,* 1999, GWA 2000, GWA 2001, Wilson and Gottesfeld 2001, Sterritt 2001). The Kispiox Watershed coho escapement declined steadily from the 1950's until the last few years, when widespread fishing restrictions and improved ocean survival led to a marked rebound.

Generally, coho return to the Kispiox system to spawn throughout September, with spawning occurring from late September through December, usually dependent on water flow and levels. Coho spawning grounds are concentrated in the upper half of the mainstem; however, select areas adjacent to creek mouths in the lower portion are also used. The Nangeese River and the Stephens Watershed have large escapements. Approximately twenty other streams support smaller spawning groups. Recent (1999-2001) escapement of the Kispiox coho aggregate stock is in the range of 2,300 (1990) to 6,400 (2001, GWA unpublished data).

The majority of tributaries support coho rearing, while mainstem rearing principally occurs in side-channels. Comprehensive mark and recapture sampling, as well as smolt out-migration fence counts conducted by the GWA, have resulted in delineation of wild smolt and enhanced smolt habitat distribution, density, and migration timing. These studies (Plate *et al,* 1999, GWA 2000, GWA 2001, Sterritt 2001) also identified under utilized stream sections that are suitable for future coho hatchery releases.

Steelhead

The world-renowned Kispiox River steelhead population is distinct from other Skeena River stocks due to the large average size of the returning adults. Though uncertainties exist as to steelhead escapement levels, given the large estimated population size (Tautz *et al.* 1992), as well as the continuing high sports fishery catches, the steelhead population appears to be relatively stable. Ward *et al.* (1993) calculated commercial harvest rates of Kispiox River steelhead for the period of 1986 to 1991, with the mean being 41.2% incidental harvest in the Area 4 commercial fishery. It was estimated that 4,027 steelhead returned in 1994 (Koski *et al.* 1995), and 2,514 in 1995 (Alexander and English 1996).

Steelhead migrating up the Skeena River enter the Kispiox system in late August and September and overwinter in deep pools, mainly in the lower Kispiox River below Cullon Creek, and in the mainstem Skeena below the confluence (Lough 1980, 1983). Steelhead have been observed spawning from mid May through to mid June, primarily in mainstem side channels, though Stephens Creek and the Club Creek system are most likely the most concentrated spawning grounds (Chudyk 1972b). Lough (1983) reported a small concentration of fish spawning in the mainstem between Date and McQueen Creeks. As well, two steelhead left the Kispiox and spawned in Skeena River side channels, while one steelhead moved over to the Shegunia River to spawn. In 1979, a radio tagging study showed 80% of the radio tagged steelhead spawned in tributaries including Cullon Creek, Ironside Creek, Skunsnat Creek, and the Nangeese River (Lough 1980).

Other tributaries known to support steelhead spawners include the lower reaches of Date Creek, Williams Creek and Sweetin River (DFO 1991a, Baxter 1997a). In late May, kelts leave the river. In a detailed study of Kispiox River steelhead during 1975, Whately (1977) found that 12.1% of steelhead adults were repeat spawners (S1+) and 0.6% second time repeat spawners (S1S1+). Most of the repeat spawners were females, because males experience a higher mortality during spawning.

Steelhead juveniles remain in the Kispiox system for 1+ to 4+ years; with scale sample analysis of upstream migrating adults showing an average age of three years in the river before moving to the ocean; Whately (1977) estimated that Kispiox steelhead smolt at age 3 or 4. Fry densities are generally lower in the mainstem than in sampled tributary sites; however, parr densities in both rearing areas are largely similar. Cullen Creek has the highest fry densities by a factor of five, in relation to other monitored or sampled sites (Stuart 1981, Tredger 1983a). Recent mark and recapture sampling was conducted by the GWA (Gottesfeld *et al,* 2000) with generally low densities reported (0.01-0.31/m^2). Results suggest that the Kispiox Watershed as a whole is underutilized. It is likely juvenile recruitment is low due to incidental catch from high exploitation rates in the mixed-stock fishery.

Fisheries

First Nations Traditional Use

For the Gitxsan, salmon are a most important cultural icon and an important food source. Traditionally, sockeye followed by coho have been the most important species to First Nations groups harvesting Kispiox River fish stocks. Kispiox Village, also called Ans'payaxw, is one of seven main Gitxsan villages spread along the Skeena River and its tributaries. Gitangwalk and Lax Didax, both abandoned in the early 1900's, were important villages strategically located to intercept the upstream migration of the sockeye and coho salmon to the Upper Kispiox River spawning areas.

Many seasonal fish camps positioned along the mainstem were used to harvest fish. Rabnett *et al.* (2001) described the sixteen traditional fisheries presently known that ascend upstream from Kispiox Village at the Skeena River confluence. The "grease trail," which runs from Kispiox Village to the Nass, passed along the eastern side of the Kispiox River and provided access to the above fish harvesting sites, as well as many other resource gathering localities.

Table 3. Traditional fishing sites and fishing villages on the Kispiox River.

Fishing Site Name	Site Location	Site UTM (NAD 27)
Anspayaxw	Mouth of Kispiox River	582550, 6134000
Agwi'tin	Kispiox River R & L banks	582900, 6137370
Xsi Ankalamsit	Kispiox River R & L banks	581420, 6143600
Xsa Gailexan Xsa Angexlast	Kispiox River R. bank	581280, 6143180
Antkilakx	Kispiox River L. bank	580060, 6147010
Tsihl 'niit'in	Kispiox River R. Bank	597310, 6150515
Xsa An Seegit	Kispiox River L. Bank	576940, 6151080
Wiluuskeexwt	Kispiox River R. Bank	unknown
Miinhlgwoogoot	Kispiox River L. Bank	unknown
An'Uxwsdigehlxw	Kispiox River R & L banks	unknown
Katgaidem	Kispiox River L. Bank	569250,6158270
Xsi Luukailgan	Kispiox River R & L banks	569890,6158140
Wiluuwak	Kispiox River L. Bank	560410,6159460
Nadak	Kispiox River R. Bank	588190,6160100
Sgansnat	Kispiox River L. Bank	549800,6168050
Luu'Andilgan	Kispiox River L. Bank	543400,6168740
Gitangwalk	Kispiox River L. Bank	539150,6170590
Lax Didax	Stephens Cr.	527610,6179830

The abundant and predictable sockeye salmon stocks provided the Gitxsan with the opportunity to harvest and preserve a large amount of high quality food in a relatively short time of intensive effort. The sockeye run was the major focus, as it provided the majority of high-quality dried fish needed to sustain the Gitxsan over the year, and to produce a trade item. Following the passage of the bulk of the sockeye, coho appeared and were available well into the autumn, providing both fresh and dried fish. Chinook, steelhead and a variety of other fish were taken and processed in their respective habitats.

Recreational Fisheries

The Kispiox Watershed attracts a large sports fishery that includes local residents and non-residents. Adult steelhead that return to the Kispiox River are among the largest steelhead in the world, and the river is an international destination for anglers. Generally, angler access to fishing sites is easy.

Local anglers fish trout and char in the many lakes of the Kispiox Watershed. River angling effort is directed primarily to steelhead, coho and chinook from mid summer to late October. Since 1969, various creel surveys (Pinsent 1970, Remington *et al.* 1974, Whately 1977, Lewynsky and Olmstead 1990, Tallman 1997) have estimated or determined the angling effort, catch per unit effort (CPUE), gear fished, rate of release and use of guide services. There are currently two licensed guides who operate on the river, and an additional guide who has not operated since 1993, with a total allocated quota of 493 angler days (Baxter 1997a). Seldom are quotas fully utilized, because water conditions, and thus fishing conditions, can deteriorate rapidly due to seasonal heavy rains in the Kispiox River Watershed.

The Kispiox River is designated Class II Waters, September 1 to October 31, and a Steelhead Stamp is mandatory. The annual catch quota is one steelhead a year from the Skeena Watershed, with no fishing in any stream from January 1 to June 15 (MELP 2000). Tallman (1997) reported that in the fall of 1996, according to those anglers interviewed, all steelhead caught were released, 62% of the anglers were of foreign residence, fly fishing was the predominant method used (80%), and compliance with required regulations was fairly high (over 90%). A sports harvest of Kispiox steelhead most likely occurs in the Skeena River bar fishery, downstream from Terrace. Total estimate of the angled fish is unknown for the Kispiox Watershed.

Enhancement Activities

A pilot hatchery project in Kispiox was initiated in 1977. Water quantity and quality problems were not resolved until 1983, when three wells were developed that supplied stable quality and constant water temperature, at which time the Kispiox Hatchery was constructed.

Located close to the Kispiox-Skeena confluence and initially operated by the Kispiox Band, this Community Economic Development project under the Salmon Enhancement Program was designed to enhance the depressed Kispiox River chinook and coho stocks (FOC and MoE 1984). The hatchery continued to operate until 1995, when it was closed due to SEP program budget cuts. Re-opened in 1997, under the auspices of the GWA, with funding from a variety of sources, the hatchery allows for a flexible fish culture program. This small community facility continues to work with coho, releasing coho fry and smolts to local creeks within the upper tributaries of the watershed.

A summary of the total chinook and coho fry and smolts released by the Kispiox Band and the GWA from 1984 to 2001 is provided in Table 4. The total fry and smolts released from the Kispiox Hatchery since 1984 are 893,684 coho and 1,086,252 chinook.

Table 2. Kispiox Hatchery Fry Release Summary (1984-2001)

		Year Released																	
		Kispiox Band													Gitxsan Watershed Authorities				
Stream	Species	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996*	1997**	1998	1999	2000	2001
Nangeese River	coho	22068	28196	12663	14937	27488		51223		20500							85674	58716	
	chinook				40100														
Clfford Creek	coho	5210		10000	8767	10000		2904		20486							9020	39551	
	chinook																		
Skunsnat Creek	coho	4790	12807		8765	10000		19672		19990							29611	52037	48308
	chinook																		
McCully Creek	coho	5662			16245														
	chinook		7094	14676															
Cullon Creek	coho	6265															5381		24506
	chinook		10306		4622														
Pentz Lake	coho	10000	10006																
	chinook																		
McQueen Creek	coho	3333			30656		31166				22105								
	chinook																		
Murder Creek	coho	3333		8000		30604			1276		22429								
	chinook																		
Hodder Creek	coho					10000													
	chinook																		
Salmon Creek	coho			15000															
	chinook																		
Sweetin River	coho																		
	chinook				40632	65161													
Kispiox R. - 10 mile	coho	3334																	
	chinook		10630		26135	16930													
Kispiox R. - 41 km	coho																		
	chinook		9262		8100	15026													
Kispiox River - Marty Allen's	coho																		
	chinook		9560		39300														
Date Creek	coho																		
	chinook		6139	14676	16848			1385											
Other	coho			1000															
	chinook	115	47357		85962	144304	123489	123828		98615			106000						
Total	coho	63995	51009	46663	79370	88092	31166	73799	1276	60976	44534	0	0				129686	150304	72814
	chinook	115	100348	29352	261699	241421	123489	125213	0	98615	0	0	106000				0	0	0

*Hatchery shut down in 1995 - no releases for 1996

** Broodstock taken in 1997 and 1998 but no releases until 1999

Development Activities

The principal development activities are logging, residential areas, linear development, and recreational activities, which are described in the following section.

Forest Resource Development

The Kispiox River Watershed is located within the Ministry of Forests, Kispiox Forest District. With completion of the railroad to the Skeena in 1912, forest development activity began with agricultural clearing by settlers, and by 1920 the pattern of land use and settlement was well established. Small-scale lumbering led to small bush mills when the post-WW II demand for lumber skyrocketed. In the early 1950's, Columbia Cellulose was granted TFL # 1, which initiated the centralization of license holding and milling capacity in the Skeena Watershed that is observed today.

In 1958, only 23 km of road were present on the Kispiox River, with logging operations concentrating on easily available, high quality timber. In 1959, some 70 km of road bordered the river, while by 1966, approximately 90 km of road accessed the east side of the river (Taylor and Seredick 1968). Over the years up to the present, industrial forest activities within the watershed have waxed and waned, as the cut was concentrated on other watersheds (Gitsegukla and Suskwa), and as distance off the highway increased. The 1980's and the early 1990's saw the volume and rate of development expand dramatically, particularly across the northern, low elevation portion of the watershed, from Murder Creek through to the Nangeese River. The early 1980's also saw completion of the Mitten Main connecting the Kispiox Valley to Highway 37; this road facilitated development on the western flank of the river and transport of logs to the saltwater Port of Stewart. The 1990's also saw logging development in Date and McCully Creeks, though to a lesser extent than in the northeastern Kispiox.

For the last five years, a common problem throughout the Interior Cedar Hemlock (ICH) zone has been the escalation of *Dothistroma* needle blight affecting pine stands regenerating in cutblocks (Ministry of Forests 2002). This disease is endemic throughout pine forests worldwide, and when active, causes pine trees to lose all their needles, thereby killing the trees. The spread of *Dothistroma* has been facilitated by the last five cool, moist summers that are due to the changing climate. Stands that have suffered the most are where pockets of cold, moist air can be stagnant, i.e. valley bottoms and depressions between ridges. About 90% of all pine plantations in the Kispiox and Cranberry Timber Supply Areas (TSA) are affected to some degree, with 2% of stands having greater than 10% mortality currently. The disease will continue to persist unless there are hot, dry summers for a decade.

The extensive forest development activities described above raised concerns about damage to fish habitat and fish populations among First Nation peoples, local residents, and government fisheries agencies. Since 1995, the Watershed Restoration Program (WRP) has been involved in assessing the logging related disturbance in relation to fish, fish habitat, and upslope sediment producing areas. Watershed health, particularly hydrological recovery, has benefited from road deactivation, as well as riparian, in-stream, and off-channel site works. A large contribution of the WRP has been to increase the awareness in the forest sector of best management practices regarding water quality, fish and fish habitat. Currently, very little information exists that delimits cumulative effects on fish and fish habitat.

The 2000-2005 Kispiox Watershed Restoration Plan (Triton 2001) summarizes WRP investment to date ($1.1 million) and outlines the watershed goals, presenting a four-year plan focusing on in-stream and riparian rehabilitation components. The budgeted investment totals approximately $1.3 million dollars and is presented in order of priority for restoration activities. Proposed works include riparian and instream assessments and treatments to take place in thirteen of the sixteen sub-basins to rehabilitate impacted conditions, restore fish passage with culvert replacements and reduce risk through road deactivation.

Future trends regarding forest development activities are uncertain. Skeena Cellulose Incorporated (SCI), which holds the majority of the allocated cut in the Kispiox Watershed has terminated its forest development activities due to a series of financial difficulties. This also affects the Small Business Program cuts, as SCI was the predominant buyer of the Small Business Program timber. Adding to this uncertain future are high softwood tariffs, high stumpage rates, and BC Government forestry legislation and policies that are predicted to change. The watershed continues to be managed under the direction of the Kispiox Land and Resources Management Plan, which provides a framework of land use management zoning, objectives and strategies (Ministry of Forests 2001a).

Mineral Resource Development

Mining development in the Kispiox Valley is limited to exploration of a few mining claims for coal and vein metallic mineralization in the southern part of the Kispiox Watershed. There is no production known from these claims.

Transportation and Utilities

The east side of the Kispiox River hosts the major road, the Kispiox Trail, which heads northwest from Kispiox Village, branching twice to accommodate two crossings of the river and provide access to the west side. The two west side roads meet and provide a route out of the drainage and into the Nass Watershed. Close to Cullen Creek, the Kuldo FSR swings north to provide access to the Skeena and Shedin drainages. There are numerous branch access roads, in various states of deactivation and repair, to accommodate forest development activities within most of the tributary basins. Most roads, both major and secondary, are gravel surface.

The Kispiox River lends itself to riverboat travel in limited sections; however, the Kispiox River is closed to motorized transportation. Rafting is by far the most popular method of on-river travel, with many parties descending the river spring through fall.

Utility corridors, consisting of BC Hydro transmission lines and Telus phone cable servicing residential developments, exist up the east side of the valley for approximately 40 km, and, to a limited extent, on the west side of the river. These corridors usually parallel access roads; however, the river is crossed twice to service residents.

Population and Settlement

The Kispiox valley has been home to Gitxsan people for thousands of years. Euro-Canadian settlers arrived following completion of the railroad in 1914, attracted by the agricultural possibilities. This population base remained relatively stable until the early 1970's, when rural living and hobby farming became a more popular lifestyle. Currently, approximately 650 people reside in Kispiox Village (SNDS 1998), and an additional 250 people reside on valley bottom lands, mostly north of Kispiox Village and adjacent or close to the Kispiox River. Historically, and up to the recent past, many Gitxsan people derived their income from the fishing and forestry sectors; however, severe job losses have curtailed this income. There are currently an estimated 18-23 relatively small ranches in the Kispiox, with approximately 460 breeding cows that graze on Crown land. Most residents derive their income from service sector employment in the Hazelton area. Land parcels are typically large (greater than 60 ha), with Agriculture Land Reserve restrictions regulating the majority of holdings. Population trends project growth for Kispiox Village and a stable rural resident community in the rest of the valley. Recreational and tourism-based incomes are projected to grow over the next decade.

Kispiox Watershed Management Issues

The Kispiox Watershed has highly productive habitat for all six Pacific salmon species as well as being one of the top five salmon producers for each of the species. The Kispiox River Watershed is composed of approximately 100 km of mainstem and 300 km of tributary streams that are considered high value fish habitat, and that provide a migration corridor and support spawning and rearing (Nortec 1997). The salmonids utilizing this habitat include: sockeye, coho, pink, chum, chinook, and steelhead salmon; rainbow, lake, and cutthroat trout; Dolly Varden, bull trout char, and mountain whitefish. Lamprey and a variety of coarse fish (Cottidae and Cyprinidae) are also found in the watershed.

This fish community contributes to the ecology, nutrient regime and structural diversity of the drainage and provides strong cultural, economic and symbolic linkages, particularly for First Nation peoples, as well as supporting recreational and commercial fisheries. The very high fishery values are rooted in the outstanding spawning and rearing habitat. The Kispiox River is probably the most famous steelhead river in the world today. When the water is low and clear, the river is an angler's dream with easy wading, many pools and stretches of swift water.

The Kispiox Watershed has been impacted to a certain extent by large-scale industrial forestry activities, particularly from the mid 1970's through to the late 1990's; however, it is difficult to define post-logging impacts. There is concern regarding timber harvesting impacts to mainstem and tributary riparian zones and valley-bottoms, and to low-gradient fans from bedload aggradation, and washload (fine sediment) aggradation at tributary mouths. Changes in snowmelt timing and spring flood volumes are likely in the heavily logged tributaries.

The severity of agriculture impacts is relatively minor when compared to the impacts associated with timber extraction. Murder and McCully Creeks have avulsions in their lower reaches due to agricultural clearing of the floodplain riparian zone, with downstream sediment deposition contributing to channel instability.

Kispiox Watershed land use issues include agriculture, rural residential development, recreation and tourism, and forestry activities with a high, unsustainable rate of cut. These activities need to take into consideration fish habitat conservation at both the site specific and watershed levels. Maintaining adequate escapement of salmon through the Alaskan and Canadian mixed stock commercial fishery is critical to sustaining fish populations in the watershed. Knowledge of run timings, an inventory of critical rearing habitats, and a fisheries management regime directed toward preserving Kispiox Watershed salmon stocks will do much to ensure fish conservation goals.

Morice Watershed

Environmental Setting

Location

The Morice Watershed is located in west-central British Columbia south of Houston. The watershed is bounded to the west by the Telkwa River and Burnie River drainages, and to the east and south mainly by Nechako River tributaries. To the north the watershed is bounded by the Bulkley River drainage.

Hydrology

The Morice Watershed is part of the Bulkley River drainage basin, which is fed by streams originating in both the Interior Plateau and the glacier fields of the Coast Mountains. From the outlet of Morice Lake, the Morice River flows northeastward 80 km to join the Bulkley River near Houston, BC. The Bulkley River flows 150 km northwestward to enter the Skeena River at Hazelton, BC. Although the Morice is the larger tributary at the fork of the Bulkley River near Houston, the Bulkley River name is used for the tributary that flows eastward along the travel route to the interior.

The Morice River is a sixth order stream that drains a catchment area of 4,349 km^2 and comprises the southwestern portion of the Bulkley River Watershed. Elevations range from approximately 2740 m at the western border to 560 m at the Bulkley confluence. Morice Lake (762 m) is the largest lake in the system and is the origin of the Morice River. Major tributaries include: Atna River, Nanika River, Thautil River, Lamprey Creek, Owen Creek, and Houston Tommy Creek.

Annual discharge peaks at 250 to 550 m^3/s during the early summer snowmelt season and after the occasional fall frontal storms; however, much of the flow is buffered by storage in Morice Lake. Late winter low-flow conditions have discharges of 15 to 25 m^3/s (Gottesfeld and Gottesfeld 1990). Hydrometric stations are located on the Nanika River at the outlet of Kidprice Lake (Station 08ED001), on the Morice River at the outlet of Morice Lake (Station 08ED002), and just upstream of the Bulkley River confluence (08ED003 – discontinued). The contribution of high elevation snowmelt and ice melt runoff is important in maintaining adequate summer water levels in the main stems and side channels of Morice and Nanika Rivers. Rainstorms in the fall and decreasing evapotranspiration yield moderate flows. The Morice River, on average, contributes more than 90% of the flows to the Bulkley River at their confluence, and up to 99% of flows at certain times (Nijman 1986). There is a steep precipitation gradient from west to east, as well as from the high alpine to the forested, valley bottom country in the drainage. Annual total precipitation ranges from 1700 mm in the Coast Mountains to under 500 mm along the lower Morice River.

Three large headwater lakes, Morice, Nanika and Kidprice, provide most of the lake storage in the Morice and Bulkley systems. Morice Lake lies in a deep trench between the Morice Range to the west and Tahtsa Range to the east. Nanika and Kidprice Lakes occupy another trench east of the Tahtsa Range. Morice Lake is surrounded by glaciated mountains that drop steeply into the lake from an elevation of 1200 to 1500 m. The lake has a surface area of 96 km^2 draining a basin area of 1,872 km^2. Morice Lake is deep, with an average depth of 69 m, and relatively cold, with an average summer seasonal surface temperature of 10.2 C^0 (Shortreed *et al.* 1998). The two main lake tributaries are the lower Nanika River and the Atna River. The Nanika River contributes about 50% of the total water inflow into Morice Lake. Other major lake-headed tributaries within the Morice system are Owen Creek, Lamprey Creek and McBride Creek, which have their floods buffered to some extent by lake storage.

The Morice River, downstream of Morice Lake, has several large tributaries including the Thautil River and Houston Tommy Creek, which drain mountainous areas. Two lake-headed tributaries, Owen Creek and Lamprey Creeks, drain Nadina Mountain and southern plateau areas. Tributary descriptions can be found in Morris and Eccles (1975), Carswell (1979), WTO (1996) and Nortec (1998).

Water Quality

Morice River water is soft; the pH is near neutral, while mean alkalinity, a measure of pH buffering capacity, is low. Morice River water is typically very clear, although TSS readings can be high during freshets. Nutrient levels overall are extremely low, in many cases less than the detection limits (Remington 1996). Morice Lake shows a high dissolved oxygen content (90-100%) and cool water temperatures. Primary and secondary productivity in Morice Lake is limited by low nutrient inputs. The shallow north end of the lake is consistently warmer than the south end, except in winter. Nanika River is the only tributary to contribute measurable phosphorous input to Morice Lake. In the northern portion of Morice Lake, the water chemistry, the greater phytoplankton production, and the zooplankton, which feed on littoral phytoplankton, are substantially influenced by the supply of nutrients received from the Nanika River (Cleugh and Lawley 1979). The carcasses of spawned-out salmon are the nutrient source in the Nanika River. Thus the low intrinsic productivity of Morice Lake is compounded by the low numbers of sockeye returning to spawn in the Nanika system (Schug 2002).

Water quality issues in the watershed have been minor and focus on forestry and mining land use. Bustard (1986) conducted an assessment of stream protection practices in the Morice TSA. Sediment from roads, due to both construction and inadequate maintenance, was cited as the main impact from logging activities on streams in the Morice Watershed. Saimoto (1994) conducted an assessment of four tributaries of the Morice River and found that about half the sites examined had been impacted by roads or cutblocks in some manner.

The Silver Queen mining property, located immediately east of Owen Lake, is the source of elevated levels of zinc and copper in the lake. Remediation efforts, consisting of wetland treatment and contaminated drainage improvements, have been ongoing throughout the 1990's (Remington 1996).

Geography

The Hazelton Mountains within the Morice Watershed are comprised of a complex group of small ranges: the Telkwa Range, the Morice Range, and the northern portion of the Tahtsa Range. Relief is relatively high in these ranges, with rugged peaks partially covered in glacial ice. The mountainous portions of the watershed are underlain by Mesozoic sedimentary and volcanic rocks, intruded by isolated stocks and small batholiths of granitic rock from the Cretaceous age (Holland 1976). The Coast Mountains (Kitimat Range) on the western edge of the Morice Watershed are underlain by granitoid rocks of the Coast plutonic complex. The Nechako Plateau extends into the northern and eastern portions of the watershed, with elevations largely below 1500 m. Over much of the Nechako Plateau, Tertiary lava flows cover the older volcanic and sedimentary rocks of the Takla and Hazelton Groups and intrusive rocks of the Tertiary age. Glacial drift is widespread and most bedrock is obscured (Holland 1976).

The predominant biogeoclimatic zone, Sub-Boreal Spruce (SBS), covers most of the lowland coniferous forests in the watershed. Subalpine fir and hybrid spruce are the major tree species; subalpine fir stands tend to dominate older, high elevation stands and moister sections of the zone. Due to a relatively intense natural and aboriginal fire history, lodgepole pine seral stands are extensive, particularly on stream terraces and south aspect slopes. Small areas of grassland and shrub-steppe are found on warm, dry sites scattered along the Morice River, Owen Valley, and occasionally in other major tributaries. The SBS zone merges into the Engelmann Spruce-Subalpine Fir (ESSF) zone at higher elevations ranging from 900 to 1300 m, depending on local topography and climatic conditions. The ESSF zone possesses a shorter, cooler, and moister growing season, with continuous forests passing into subalpine parkland at its highest elevations. Subalpine fir is dominant, with lesser amounts of lodgepole pine and white spruce hybrids in drier or fire-influenced areas. The Coastal Western Hemlock (CWH) zone characterizes the low elevation sites along the southern sections of Morice Lake, and the Atna drainage, reflecting the close proximity of maritime moisture from the coastal Kildala and Kemano drainages. Major tree species are western hemlock, amabilis fir and subalpine fir (Banner *et al.* 1993).

Stream Channels

The Morice River mainstem is 80 km in length with a very low gradient (<0.2%) and no obstructions to anadromous fish passage over its entire length. The river channel and floodplain dynamics were the subject of several studies in the early 1990's (Gottesfeld and Gottesfeld 1990, Weiland and Schwab 1992), which described the flood plain history and elucidated the patterns and processes of channel change. Reach 1 is situated between the outlet of Morice Lake and the Thautil River and is a single thread channel with a stable channel configuration. The substrate is mainly cobble with some gravels, deep pools, rock outcrops and steep banks. A moderate amount of instream cover is provided by logjams and debris in the lower section of Reach 1 (Envirocon 1980).

Reach 2 extends from the Thautil River downstream to Fenton Creek confluence. This reach is characterized as a wandering gravel bed river with one to several channels, frequent channel changes, gravel bars, forested islands, eroding banks, log jams, and a network of seasonally flooded channel remnants over the floodplain (Weiland and Schwab 1992). The bedload of Reach 2 is coarse (over 97% is coarser than 2 mm), consisting mostly of gravel and cobbles. Cobble lithologies show that the Thautil River provides as much as 98% of Reach 2 bedload (Gottesfeld and Gottesfeld 1990). This bedload contribution is in part due to the intense coastal storms entering the watershed through the Telkwa Pass and then the Thautil River. Reach 3 of the Morice River; from Fenton Creek to the Bulkley River confluence, is a single thread channel that maintains a relatively stable channel configuration. The variable substrate is composed of silt to boulders to bedrock with low amounts of instream cover.

Of the many tributaries feeding into the Morice mainstem, only the second largest, the Thautil River, is a large producer of bedload and wash load sufficient to create turbid conditions. Mountainous valleys throughout the watershed have glacio-fluvial fans that were mostly constructed during deglaciation. These fans are now more or less active with building or down cutting zones in or adjacent to the stream channel. Fan stability is dependent on two key factors: the influences of the delivery of water, and the supply and delivery of sediments to the fan. Forest development activities influence snow accumulation, snow melt and water movement, which in turn influence erosion potential and sediment movement. Given the natural tendency of streams in British Columbia to increase their geomorphic response to disturbance as sediment progresses downstream (Church et al. 1989), it is likely that the sediment supply and movement have increased throughout the watershed.

Access

Access through the majority of the Morice River and tributary valleys is relatively easy due to the timber harvesting road network. Many of these roads lie on top of the traditional Wet'suwet'en trail infrastructure. The trail routes followed the easy ground connecting trade routes, home places and resource gathering locales. In 1929, the trail to Francois Lake was hacked out as a winter sleigh road to Owen Lake, and then was further developed into a wagon road to facilitate mineral development.

Between 1954 and 1958, the Forest Service began the half–million dollar construction of the Morice River Road that went from Houston to Owen Lake, and included the construction of the road to the Collins Lake – McBride Lake area. The most remote portion of the road, built in 1958 to Morice Lake, was not originally part of the plan, but was built for fire crew access when the 10,000 ha Clore Fire broke out (Smith 2002). The road to Morice Lake was then used for access to a hatchery on Nanika River. The building of the Morice River Road and the many subsequent smaller access roads opened a new timber supply area, with many small bush mills appearing through the area. The Morice-Nanika, Lamprey, Nado, Morice West, and the Cedric branch roads were constructed in 1961. Improvements and upgrades on the Morice-Owen Forest Service Road (FSR) occurred in 1978 and 1997, with the latter accommodating the greatly increased traffic to Huckleberry Mine site. In 1990, the Morice River West FSR was extended, crossing the Morice River and Gosnell Creek.

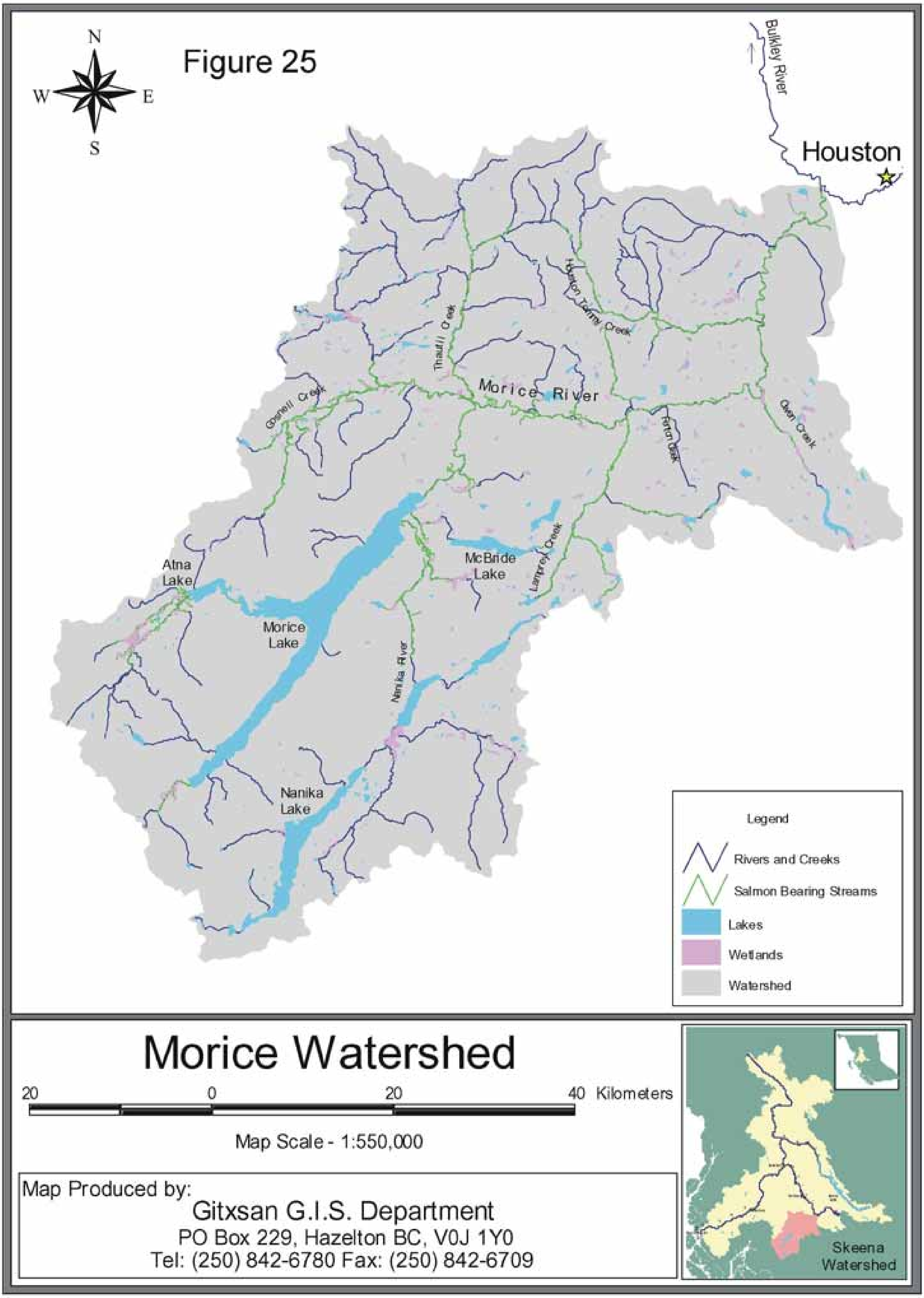


Figure 25
N
S
E
W
Bulkley River
Houston
Houston Tommy Creek
Morice River
Gosnell Creek
Owen Creek
Atna Lake
McBride Lake
Lamprey Creek
Morice Lake
Nanika River
Nanika Lake
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Morice Watershed
20 0 20 40 Kilometers
Map Scale - 1:550,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values and Resources

The Morice Watershed has high fisheries values and is a major producer of chinook, pink, sockeye, coho salmon, and steelhead trout, which are fished by the aboriginal, commercial and recreational fisheries. Rainbow and cutthroat trout, Dolly Varden and bull trout char, whitefish, lamprey, burbot, sculpins, suckers and shiners are also present in the system.

Chinook

Morice River chinook salmon are the most important single salmon stock in the watershed, contributing approximately 30% of the total Skeena system chinook escapements in the 1990's. In the recent past, this stock has constituted as much as 40% of the total Skeena River chinook escapement (Fisheries and Oceans Canada 1984). In the late 1950's, an estimated escapement of 15,000 Morice River chinook spawners was recorded. From 1960 through to the mid 1980's, an average of 5,500 spawners returned, after which chinook spawner escapement increased, reflecting sub-stock rebuilding that followed the closure of directed chinook net fisheries. From the mid-1980's to the present, Morice River chinook spawners have increased to the historic, late 1950's (15,000) returns.

Adult chinook salmon begin their migration into the Morice River system about mid-July and spawn from August to October; peak spawning was observed by Shepherd (1979) to be mid-September, with die-off by mid-October. Spawning principally occurs in the upper 2 km of the Morice River downstream of the lake outlet. Most of the riverbed at this site is characterized by a series of large gravel dunes orientated perpendicularly to the direction of flow (FOC and MoE 1984). The dunes are constructed by chinook during redd excavation. Scattered minor spawning also occurs downstream to Lamprey Creek and in the Nanika River, below Kidprice Lake.

Morice chinook spend less than one year (sub-1, 35%) or one year (sub-2, 65%) in freshwater and return mainly as four or five year olds (85% in 1973 & 1974). In comparison with other Skeena chinook stocks, the Morice River produces more six-year-olds than other systems in the Skeena (12% average versus 3% average) and less two and three-year-olds (3% versus 17%) (Shepherd 1979).

Chinook fry migrate or are displaced downstream upon emergence from the gravel between mid-April and early-July, though typically peak emergence is in late-May to early-June. Downstream smolt movement occurs between mid-April and mid-August, though it appears to peak in early June. Upstream fry movements begin in mid-July, peak in mid-August, and end in early September (Shepherd 1979). Various survey results (Smith and Berezay 1983, Envirocon 1981) indicate that chinook fry overwinter throughout most of the Morice River mainstem. However, the reach between Thautil River and Owen Creek, with abundant side channels and log debris, is considered the most productive rearing area.

Pink

The Morice pink salmon run is significant among the small producers in the Skeena system. The odd-year pink run to the Morice River has been expanding since construction of the Moricetown Canyon fishway in 1951 and the removal of key rocks by blasting at Hagwilget Canyon in 1958. The blasting at Hagwilget Canyon had the negative effect of substantially eliminating the aboriginal food fishery at Hagwilget. Pink salmon were first seen in the lower Morice River in 1953 and had reached Owen Creek by 1961 and Gosnell Creek by 1975 (Shepherd 1979). By the mid-1980's, this steady expansion of range saw pink spawners colonizing the Nanika River spawning grounds.

Adult pink salmon usually migrate upstream into the Morice system in late August to early September. Pink spawning is reported to take place through September (DFO 1991b) with over 90% of the escapement spawning in Reach 2 side channels. Small numbers of spawners have also been observed at Gosnell Creek, Nanika River, and in the mainstem downstream of the lake. Winter observations of pink redds in heavily utilized side channels indicate that dewatering of redds, and probable losses of eggs and alevins with reduced flows, occurs more often at these sites than in the deeper main channel spawning areas. Upon emergence from gravels, pink fry migrate directly to the ocean, returning to spawn as two-year old fish.

Chum

The Department of Fisheries of Canada (1964) reported that a small number of chum utilize the lower Morice River, but very little is known regarding their distribution. Kussat and Peterson (1972) noted that the chum escapement had never been enumerated, but observations indicate that the population numbers only a few hundred fish. Shepherd (1979) noted that he did not observe chum salmon in the Morice system. No Bulkley River chum localities are listed in the SEDS database. At the Moricetown Canyon Wet'suwet'en food fishery about 100 km downstream of the Morice River, no chum were observed in 1992 to 1995, and only three in 2001.

Sockeye

Historically, sockeye returning to the Morice Watershed numbered on the order of 50,000 to 70,000 fish and comprised as much as 10% of the total Skeena River escapement (Brett 1952). In 1954, the population collapsed, with the following twenty-year period, 1955-1975, seeing an average annual return of 4,000 sockeye to the watershed (FOC 1984). Average annual returns in the 1980's were 2,500 fish, while the annual average returns in the 1990's were 21,500 fish. Up until 1998, Nanika sockeye seemed to be following the trend of other wild Skeena stocks in slowly increasing escapements. However, recent returns to the Nanika appear to be decreasing (Cox-Rodgers 2000). The potential loss of this important fish resource greatly concerns the Wet'suwet'en. The Morice sockeye are among the earliest sockeye to reach the Skeena. The early commercial fishing openings were delayed in Area 4 in 2001 to avoid capture of Morice bound fish. Return of Morice River escapements to optimal levels probably requires a long-term reduction in the overall exploitation rate across all fisheries, including ocean and in-river, that impact this stock, and possibly enhancement initiatives such as lake fertilization.

Peak migration of sockeye salmon past the Alcan counting tower near Owen Creek occurred in early to mid-August (Farina 1982). The main sockeye run usually holds in Morice Lake before ascending the Nanika River, where the principal 3 km reach below Nanika Falls and two other secondary spawning grounds are utilized (DFO 1991b). The other major sockeye spawning ground is at the south end of Morice Lake, where beach spawning occurs for 3 km north of Cabin Creek. Atna River also supports a small sockeye run averaging 300 fish.

Following emergence, sockeye fry emigrate from spawning beds into Morice Lake from late-May to late-July, usually coincident with peak annual flows (Shepherd 1979). In contrast with other Skeena sockeye stocks, which spend one year in freshwater, over 85% of Nanika River sockeye spend two years in Morice Lake, and 90% return as four- (2.2) and five- (2.3) year-olds (Shepherd 1979). Due to the lack of nutrient input into Morice Lake, phytoplankton and zooplankton biomass levels are low, resulting in very slow growth rates for sockeye fry. Age-0 fall fry are the smallest in any sockeye nursery lake in BC; the large percentage of two-year old smolts in Morice Lake is also indicative of its low productivity (Shortreed *et al.* 1998). Sockeye smolts migrate out of Morice Lake from late April to August with a peak migration in May (Shepherd 1979, Smith and Berezay 1983).

Coho

The relative contribution of coho from the Morice River system to Skeena coho escapement as a whole is approximately 4%. In reviewing SEDS data (DFO 2001), a declining trend from the 1950's to the present is apparent in coho populations for the Morice system. The decline is in absolute numbers as well as relative to the overall Skeena escapement. The highest ten-year period of abundance in escapement numbers, the 1950's, shows an annual average escapement of 10,700 fish. In the 1970's, the average annual escapement was approximately 4,300 fish. The escapement dropped to 518 fish in the 1980's, and remained low in the 1990's with an escapement of 672 fish. Recently, returning coho spawners appear to have increased.

Coho enter the Morice system in mid-August through to mid-September, generally holding in the mainstem and in Morice Lake, and then, depending on water flow conditions, move with fall freshets into the tributaries to spawn. In years of below average stream flows, most coho spawners (85%) have been observed in the prime spawning grounds downstream of the lake outlet, with scattered spawning along Reach 2 side channels (Envirocon 1980). In these low flow years, often the only tributary streams with adequate flow for coho access and spawning are Gosnell Creek, the Thautil River, and Houston Tommy Creek. In most years, other preferred tributaries used for spawning include Owen and McBride Creeks and the Nanika River. Documented spawning areas occur in all tributary streams of the Morice River (Shepherd 1979); however, this is likely to depend on adequate adult escapement and fall freshets coinciding with the late October and November spawning period.

Coho fry emergence extends from April to July. Juveniles are widely distributed throughout the Morice mainstem, as well as in most of the tributaries and lakes in the system during years of suitable recruitment. Rearing in these streams occurs for one to two years. Habitat preferences are well defined and include side channels, side pools, ponds and sloughs with instream cover providing an important key habitat component (Shepherd 1979, Envirocon 1980). Overwintering coho prefer side channels, which makes them susceptible to reduced winter flows and cold temperatures that may result in dewatering and freezing of their winter habitat. This is a major constraint for coho smolt production in the Morice River, as significant mortalities have been documented (Bustard 1983).

Steelhead

The Bulkley-Morice likely accounts for at least half of the total escapement of steelhead in recent years, based on population estimates for the Bulkley River (Mitchell 2001) and test fishery data from the Tyee Test Fishery. The significant summer steelhead run of the Morice system moves into the river in mid-August and continues into the autumn (Whately *et al.* 1978). Overwintering appears to occur throughout the mainstem, particularly downstream of Gosnell Creek, with evidence that steelhead also utilize Morice Lake. With the exception of Gosnell Creek, tributaries do not support overwintering steelhead due to insufficient discharge (Envirocon 1980, Tetreau 1999).

Steelhead spawning coincides with an increase in Morice River flows resulting from snowmelt, typically in late-May to early June. Results from Envirocon (1980) sampling surveys indicate widespread spawning distribution through the mainstem and tributaries. According to SISS maps, critical spawning habitat is in the upper Morice River and scattered downstream pockets to the Thautil confluence, as well as the lower reach of Gosnell Creek (DFO 1991b). Repeat spawners among Morice River steelhead comprises 6.6% of the total returns, with females outnumbering male repeat spawners by a ratio of 2:1 (Whately *et al.* 1978).

Steelhead fry emergence in the Morice mainstem occurs primarily between mid-August and mid-September, while emergence in some tributaries may occur as early as late-July, due to earlier spawning and warm water temperatures. Tredger (1981-87), Bustard (1992 and 1993), and Beere (1993) described juvenile steelhead fry and parr distribution, densities, and size estimates from a network of index sites. Most Morice steelhead remain in freshwater for three (24%) or four (70%) winters prior to smolting, which is a longer freshwater residency time than the six other summer-run steelhead rivers studied in the Skeena system (Whately 1978). Rearing occurs throughout the mainstem and tributaries. Thautil River and Owen, Lamprey, and Gosnell Creeks account for most of the steelhead fry (85%) and parr (75%) sample catch (Envirocon 1984).

Fisheries

First Nations Traditional Use

First Nations traditional occupation and use of the Morice Watershed is extensive and estimated to have been over a period of at least 5,000 years. Historically and into the present, the Morice River Watershed territory is held by three Wet'suwet'en clans: Gilseyhyu, Laksamshu and Gitumden. Seven House territories from these clans overlay the Morice drainage, with traditional use features covering the landscape. The cultural infrastructure existing throughout the watershed is comprehensive, particularly before large-scale industrial forestry activities were initiated in the 1960's. Wet'suwet'en use and occupancy has been documented over the last century, with recent, intensive efforts in preparation for the *Delgamuukw* court case, and various studies that ground-truthed traditional use and occupancy (Naziel 1997, Rabnett 2001, Wet'suwet'en Chiefs 2001). Morrell (1985) and Rabnett *et al.* (2001) discuss salmon and steelhead stocks fished, fishing timing, and fishing methods.

Subsistence activities were tightly interwoven with the social structure, the local landscapes, and the broader regional environment. Detailed knowledge and understanding of the environment, the characteristic of each resource, and the seasonal variation in abundance and availability, were necessary to the chiefs and House members for making decisions about what, where, and when different resources were to be harvested. Over time, Wet'suwet'en ancestors developed systems of access, tenure, and resource management. A strong and adaptive semi-nomadic economy, preoccupied with food gathering, was based around the summer salmon food fishery, with dispersal into smaller family groups during the rest of the year to fish, hunt, and gather on the House territories.

The current decline of Nanika River sockeye, a large part of the aboriginal food fishery, due to the mixed-stock interception, as well as both ocean and lake productivity issues, has deeply impacted the Wet'suwet'en First Nation. The importance of the traditional fishery, which is a blend of food resource, trade capital, cultural expression, and connection to ancestral practices, cannot be overstated. For the last two years, the Native Brotherhood of BC, in association with the United Fisherman and Allied Workers Union, north coast gillnet groups, and fish processing companies have supplied the Wet'suwet'en with 8,000 sockeye (PFRCC 2001). The Wet'suwet'en have not directed a food fishery on the Nanika sockeye stocks. With this cooperation, reduced harvest rates on the Nanika sockeye stock may be addressed at the terminal fishery (river) level in a way that is more difficult to achieve in the mixed stock fishery.

Recreational Fisheries

The Morice River Watershed with its many tributaries and lakes provides valuable sport fishing opportunities to residents and non-residents. Provincially, the Morice River is one of the most significant streams for chinook and steelhead angling enthusiasts. Coho, chinook, and steelhead are seasonally fished. The sports fishery directed towards steelhead is intensive and includes the angling effort on the Bulkley River for Morice system steelhead. Further angler pressure is applied to Morice steelhead when other popular steelhead fishing rivers such as the Kispiox and Zymoetz become silty or dirty with fall storm floods.

Rainbow trout, lake trout and Dolly Varden are also actively angled, particularly in Morice and other headwater lakes. Aspects of the Morice sport fishery have been noted by Taylor (1968), while Pinsent and Chudyk (1973) discussed the steelhead resource. Angler-use surveys were conducted by Remington *et al.* (1975), Morris *et al.* (1976), Whately *et al.* (1977 and 1978), Envirocon (1980), and Sinclair (1979). Lewis (2000) provides a steelhead anglers perspective.

The Morice River is designated as Class II waters requiring both a Classified Water License and, if applicable, a Steelhead Stamp from September 1 to October 31. Seasonal fishing and gear restrictions also apply.

Enhancement Activities

Enhancement activities in the Morice Watershed have been ongoing for centuries according to Wet'suwet'en elders, particularly in regards to fish access and passage issues. In 1951, the present Moricetown Canyon fishway was constructed. Concerns regarding the low number of returning Nanika sockeye in 1955 led to the decision to remove perceived obstructions in Hagwilget Canyon. The canyon rocks were blasted in 1958, effectively eliminating the aboriginal fishery in the canyon. There was no apparent increase of sockeye populations following this action. However, intended or not, these actions facilitated the colonization of the Morice drainage with pink salmon.

As the Nanika sockeye population continued to decline with escapements of less than 1,000 fish for the three consecutive years of 1957 to 1959, a pilot hatchery was constructed on the lower reach of Nanika River. In operation from 1960 to 1965, the hatchery was not successful, most likely due to the use of transplant stock from Pinkut Creek in the Babine system. The selected stock was unsuitable with emergence three to four weeks early, differences in Pinkut adult life history (largely 1.2 and 1.3 fish), and Pinkut fry being small and thin compared to Nanika sockeye fry (Shepherd 1979). The hatchery was closed in 1966 pending evaluation of returns.

In 1969, Owen Creek was studied as a potential site for the construction of artificial spawning facilities for steelhead (Pinsent 1969). Owen Creek was deemed not suitable due to water supply problems at low flows; however, recommendations included correction of the Morice River Road crossing near the mouth of Owen Creek, which continued to create a fish access problem. This access problem was corrected with replacement of the culvert at the mouth of Owen Creek by a bridge in the late 1990s. Morice Lake was aerial fertilized in 1981 and 1985, and although the project was not comprehensively followed up, preliminary results indicated phytoplankton increased 35%, while zooplankton levels went up 60% (Shortreed, 2002). Further lake productivity studies are proposed for the 2002 field season.

Studies to assess steelhead enhancement opportunities in the Morice Watershed were undertaken from 1980 to 1983 (Tredger 1981, Harder 1983). The stocking of the Morice River system began in 1983 with 70,000 summer steelhead fry released above barriers (locations unknown) and in underutilized areas. In 1984, this program continued with an additional 62,000 fry released (FOC & MoE 1984). In 1985, 3,900 steelhead fry were released, while 21,000 were released in 1986 (FISS 2001). Post-stocking assessment indicated that the stocked juveniles were doing well. Various enhancement projects were proposed by Alcan to mitigate and compensate impacts from the potential Kemano Completion Project; however, the project never came to pass (FOC 1984, Envirocon 1984).

Development Activities

Principal land use and development activities in the Morice Watershed result from forest development, with minor mineral, transportation and utilities, and settlement concerns.

Forest Resource Development

The foundations of the permanent forest industry were laid by tie hackers, who cut small amounts of lodgepole pine for railroad ties at the lower end of the Morice Watershed from 1925 through the Depression years. Following World War II, there was a great demand for lumber; however, most of the logging was centered in the Bulkley Valley and in the Buck Creek area (Hols 1999). The Morice River Road from Houston to Morice Lake was constructed from 1954 to 1958. Logging started shortly thereafter, with sawmills located at Collins and McBride Lake and the lumber trucked to Planer Row in Houston. Three small operators cut timber off the road on Morice Mountain, and a small mill operated at Owen Flats. By the mid 1960's, Bulkley Valley Pulp and Timber bought up the small mills and attached quotas, then built a new mill in 1970, the predecessor of the current Canfor mill. In 1963, the Bulkley Valley Pulp and Timber Company obtained rights to 104,000 km^2 of timber and proposed large-scale log drives on the Morice River. The Department of Fisheries was quick to reject the idea (Dept. Fish. Can. 1964), citing serious problems on the Kitsumkalum River. Prior to 1968, logging in the Morice was mainly conducted off trails, creating herringbone patterns. By 1968, clearcut logging was dominant, utilizing the easily accessible timber stands located adjacent to the Morice River Road. Years of planning by Weldwood and Eurocan resulted in the opening of Houston Forest Products in 1978.

In 1983, the Swiss Fire burnt 18,000 ha on both sides of the Morice River, precipitating three years of intensive salvage operations. Logging operations in the 1980's were widespread, with intensive development in the Morice North area (Chisholm Lake). The 1990's saw the initial development of the Morice West area with continued widespread operations throughout the watershed. In the recent past, development has been targeting various types of beetle infestations, with timber extraction from many, small infested areas. Recent timber harvesting and current proposed Forest Development Plans (FDPs) in the Morice West area have focused on the Gosnell, Thautil East, and Shea drainages.

The Morice Watershed Restoration Program was initiated in 1994 with SKR conducting assessment work on Cedric, Lamprey, Fenton and Owen Creeks (Saimoto 1994). An overview assessment was conducted by the Wet'suwet'en Treaty Office (WTO 1996) and followed by a Level II assessment in 1997 (Nortec 1998). The British Columbia Conservation Foundation (BCCF 1999) also conducted a Level II assessment on the Nanika and Lamprey sub-basins. These assessments of logging related damage to fish habitat led to a small number of site works, which were principally implemented to alleviate fish passage problems at Fenton Creek and an unnamed creek at 28 km on the Morice West Road, as well as for some minor riparian rehabilitation (Ministry of Forests 2001b).

In summary, forest development activities within the Morice Watershed have involved progressive road development on relatively good ground in most tributary valleys, and clearcutting activities primarily focused on harvesting the medium volume, solid, high value pine stands.

The Morice Local Use Resource Plan (LRUP) was established in 1992 to resolve recreation, wildlife, and timber harvesting issues. Two zones were created from the Morice-Bulkley confluence to Morice Lake; the river zone fluctuated in width from 400 to 1000 m, which precluded forest harvesting activities, though it accommodated forest health and fire concerns. Currently, spruce bark beetles have been active in the LRUP area, and brood areas are being logged (Buirs 2002). Since early 2000, the Morice and Lakes TSAs have been developing an Innovative Forest Practices Agreement. This locally based, industry-led plan, with its own unique focus and priorities, including incorporation of forest certification standards, will be principally implemented through operational plans. IFPA coordinators are currently having discussions on ways to effectively combine the IFPA process with a LRMP (Horn 2001).

Future trends in forest development are difficult to predict with certainty, as legislation affecting both forestland use and forestland management has not been clearly presented. Furthermore, the Morice Forest District is currently preparing a new Lands and Resource Management Plan (LRMP).

Mineral Resource Development

Mineral exploration activities have been extensive in the Morice Watershed; however, economic considerations and mining circumstances have resulted in only one productive mine, the Silver Queen property. Substantial amounts of money and effort have been spent on developing this silver, lead, and zinc deposit located east of Owen Lake, but a sustainable mining operation has yet to be developed there.

Transportation and Utilities

A network of roads developed by the forest sector lies in most valley bottoms and extends onto the majority of plateaus. These gravel roads branch from the main road, the Morice-Owen Road, which connects with Highway 16 west of Houston. The forest industry and recreation enthusiasts utilize the road network. Since 1996 Huckleberry Mine, located 120 km southwest of Houston, uses the Morice-Owen Road daily to haul ore to Stewart. A BC Hydro transmission line serving the mine was constructed in 1997 and for the most part closely follows the road right-of-way.

Population and Settlement

Historically, Wet'suwet'en people resided at various village sites and home places throughout the watershed, but in the early 1950's, peoples' lifestyles changed, with residents moving to the Bulkley Valley. Less than 20 people currently reside in the watershed and few seasonal workers "camp out," with the majority traveling into and out of Houston. Located 4 km east of the Morice-Bulkley confluence, Houston is home to approximately 4,000 people (Stats Can 1996). This community is heavily dependent on the forest resource, with minor amounts of agriculture and mineral resources contributing to the economy (Horn 2001). Population growth trends are projected to be stable; however, closure or downsizing of major industrial or public sector operations would have a significant impact upon the population. The forest sector, which is based on two mills located in Houston, directly employs approximately 600 people and indirectly employs approximately 800 people (Reg. Dist. of Bulkley-Nechako 1998).

Huckleberry Mine, using Houston as its base community, directly employs 205 people and indirectly employs another 200. The majority of the Bulkley Valley bottomlands are used for agriculture, primarily livestock production. While agriculture's direct contribution is no longer particularly significant, it has given the Houston area a relatively stable base of economic activity over the years.

Morice Watershed Management Issues

Morice Watershed has excellent habitat for five of the six salmon species. The spawning and rearing habitat for steelhead, coho and chinook is extremely valuable. The river supports salmon runs that are among the top five for five species. Rainbow and cutthroat trout, Dolly Varden and bull trout, whitefish, lamprey, burbot, sculpins, suckers, and shiners are present in the system. Morice River chinook salmon is the most productive single chinook stock in the Skeena system. The major lakes within the watershed all support lake trout. Wet'suwet'en traditional use of the watershed has been long and extensive. The Morice River supports excellent angling for chinook, steelhead and rainbows trout.

Recent Nanika sockeye stock returns appear to be decreasing – likely a result of the run timing through the mixed stock fishery, poor ocean survival, poor lake productivity or a combination of the above. In the past, the watershed was one of the largest Skeena coho producers, but there has been a decline in escapement since the 1970s. The principal land use and development activity is intensive forestry, which has occurred since the late 1950s and continues at present in the headwaters. The most significant environmental problems are related to the intensive forestry. Transportation impacts are relatively minor, being related to the logging road network. Providing fish access is the principal transportation related problem.

There is a small mine that has operated sporadically over the past 80 years in the Owen Creek drainage. Current pollution problems are at a scale that can be addressed. The Morice Watershed is positioned in the transition zone from coastal to interior conditions, which makes major rainstorms infrequent and of relatively low intensity. Morice Lake serves as a buffer against large floods. The transition zone also makes it likely that summer dry periods will be of short duration, at least in the western part of the watershed. In short, the environmental problems of the Morice are manageable. An important direction for conservation activities in this watershed is the preservation of critical fish habitat.

Babine Watershed

Environmental Setting

Location

The Babine Watershed is the largest sub-basin tributary to the Skeena River. It is bounded on the east and southeast by the Nechako drainage, on the west predominantly by the Bulkley drainage, and to the north by smaller tributaries to the Skeena drainage.

Hydrology

Babine Lake is the largest natural lake in BC and is drained by the Babine River, which flows 96 km into the Skeena River left bank about 65 km north of Hazelton. The Babine Watershed is a sixth order system with a catchment area of 10,477 km^2. Elevations range from 2380 m in the Sicintine Range to 360 m at the Skeena River confluence, with Babine Lake at an elevation of 710 m. Babine River is the largest tributary of the Skeena River, contributing approximately 15% of the Skeena River's mean annual flow (Levy and Hall 1985). The watershed is often separated into the upper and lower Babine.

The upper portion of the watershed, situated on the low-relief Nechako Plateau, has an area of approximately 6,584 km^2 and is composed of Babine Lake and its drainages. Its major tributary streams include the Morrison, Fulton, Pinkut, and Sutherland Rivers. The remainder of the Babine Lake Watershed consists of relatively small creeks draining directly into Babine Lake. These creeks often dry up in late summer exhibiting sub-surface flow in parts of their lower reaches and alluvial fans.

The lower Babine Watershed, with an area of 3,892 km^2, cuts northwesterly through the Southern Skeena Mountains, draining portions of the Babine, Bait, Sicintine and Atna Ranges and their major tributaries: the Nichyeskwa, Nilkitkwa, Shelagyote and Shedin drainages. The surrounding glaciated mountains help to maintain moderate summer stream flows. In comparison with the upper watershed, the lower watershed streams are relatively steep, with greatly fluctuating flows. Originating from glaciers, these streams produce moderate amounts of natural sediment and are the primary contributors to the wide and rapid variation in water flows on the lower Babine mainstem.

Babine River peak discharges typically occur in May and June due to snowmelt, then decrease until late September, when fall rains and early snowmelt increase stream flows until the end of October. Stream flows decrease in late November and December when precipitation falls as snow, with minimum discharges recorded in January through April, prior to snowmelt.

Babine Village (Fort Babine) at the outlet of Babine Lake is the site of Station 08EC001 with a 55 year record period. Another hydrology station is located close to the counting fence at the outlet of Nilkitkwa Lake (Station 08EC0013), with 26 years of record (Environment Canada 1991). Several hydrometric stations are located on tributaries within the Babine drainage. The three stations located on the Fulton River have been discontinued; however, hydrometric stations still exist on Pinkut Creek (Station 08EC004) and on the Morrison River at the outlet of Morrison Lake.

The station at Babine Village shows annual average low flows of 7.53 m^3/s, while the monthly mean discharge record for June is 185 m^3/s. Peak discharge in tributaries is typically earlier, in May for the Morrison and Fulton River flows. Approximately 65% of the surface inflow to Babine Lake enters south of Topley Landing with 27.7% contributed from the Fulton drainage and 11 % from Pinkut Creek, as measured at Babine Village (Stockner and Shortreed 1976).

The climate of the upper watershed is typical of the central interior plateau, with cool, moist summers and a relatively deep snow pack accumulating from October to May. Total precipitation is approximately 500 mm, of which rainfall accounts for 55% (Environment Canada no date). The lower Babine Watershed climate is predominantly characterized by a shorter, cooler, and moister growing season than the upper watershed, and a longer, colder, and snowier winter. In the most western portion of the watershed occupied by the Shedin drainage, the weather is moderated throughout the seasons, due to coastal climatic influences.

Babine Lake is composed of numerous basins whose water bodies are discrete as indicated by various factors. Physical factors are seasonal thermal history, including time of formation, depth, form, and stability of the thermocline, and time of formation and break up of its ice cover. Biological factors are composition and quantity of the pelagic zooplankton and discreteness of populations of its principal pelagic zooplankton-eating fish sockeye (Johnston 1964). Babine Lake waters flow into Nilkitkwa Lake, which is also multi-basin in character; together they constitute a multi-basin system of at least 13 basins (Johnson 1964).

Water Quality

Water quality has been intensively investigated and studied in the Babine Watershed, particularly in regards to Babine Lake, with limnological and fisheries studies dating back to the 1940's. Babine Lake is the largest sockeye nursery lake in BC and currently produces about 90% of the sockeye returns to the Skeena River. The lake has a 461 km^2 surface area with a mean depth of 61 m and a water residence time of 18 years (Shortreed *et al.* 2001). The pH of Babine Lake waters is slightly basic (mean=7.65), and the alkalinity range indicates moderate pH buffering capacity (Stockner and Shortreed 1976). The lake generally has a very low level of suspended solids.

Stockner and Shortreed (1976) define Babine Lake as a dystrophic, oligotrophic lake, reflecting the water stain by input of organic matter, and the low nutrient status, particularly phosphorus, that is crucial to phytoplankton productivity. Despite its oligotrophic rating, the trophic status of Babine Lake based on the 1973 primary production measurements, which were the most complete, ranks Babine Lake as one of the most productive large lakes in BC (Stockner and Shortreed 1975). The distribution, abundance, and seasonal patterns of zooplankton occurrence strongly influence the growth and survival of juvenile sockeye during their nursery year (Foerster 1968). The most intensive zooplankton sampling has been carried out by Johnson (1964, 1965); other zooplankton investigations by Narver (1970) and McDonald (1973) described diel vertical migration patterns.

Rankin (1977) undertook a comprehensive analysis of the long-term changes in Babine Lake zooplankton associated with the three to four fold increase in sockeye fry following construction of the spawning channels. Comparisons were made between zooplankton collections obtained in the pre-enhancement years (1958-62) and the post-enhancement years (1973-74). The results indicated a decrease in zooplankton biomass, especially the large body-sized *Cyclops* (50%), *Diaptomus* (50%), and *Daphnia* (80%). Rankin (1977) attributed these changes to the selective removal of these species by the increased number of juvenile sockeye foraging in the pelagic zone of Babine Lake. Shortreed and Morton (2000) state that Daphnia biomass is low relative to other interior nursery lakes and comprises a much smaller proportion of juvenile sockeye diet. These data, and escapements approaching the PR model optimum escapement, suggest that fry production from natural spawning areas and the three spawning channels can fully utilize the lake's rearing capacity. If fry recruitment to Babine Lake were to be further increased, lake fertilization would be required to maintain current fry growth and survival rates (Shortreed *et al.* 2001).

Most Babine Lake studies have been aimed towards understanding sockeye production, but a number of studies have been undertaken of Babine Lake limnology because of the high importance to fisheries of this sockeye rearing lake, and the presence of two open pit copper mines that operated to the early and mid-1990's. A detailed review of limnology and sockeye salmon ecology of Babine Lake was prepared by Levy and Hall (1987), as one component of Westwater's three-year study (1983-85) of log transportation impacts in the lake. In regards to the two copper mines, it was concluded that the low levels of copper in the lake, coupled with the considerable complexing capacity of the water, pose no acute threat to Babine sockeye (Davis and Shand 1978, *cited in* Remington 1996). Rescan (1992a) also reviewed the historical environmental data of Babine Lake.

The Nilkitkwa River and Nichyeskwa Creek were the subject of water quality monitoring; surface erosion, slope stability, and suspended sediment studies that were completed from 1991 to 1997 (Weiland and Schwab 1991, Beaudry 1992, Weiland 1993, Maloney 1995, Weiland and Maloney 1997). Alteration of the natural sediment regime of the two streams due to forest management activities was a concern, due to the very high fisheries values. These studies inventoried and provided an understanding of water quality and the natural sediment regimes in the two drainages. Wilford *et al.* (2000) examined water quality and flow problems and geomorphology on Tsezakwa Creek following the spring flood related mortality of over 200,000 coho fry at Babine Hatchery (Donas 2000).

Geography

The Babine Watershed, as described above, is composed of the upper portion on the low-relief Nechako Plateau and the lower part that intersects and drains the southern Skeena Mountains. The bedrock geology of the Nechako Plateau is comprised of flat or gently dipping Tertiary lava flows that cover older volcanic and sedimentary rocks of the Takla and Hazelton Groups and intrusive rocks of Tertiary age. Glacial drift is widespread and a high percentage of bedrock is obscured (Holland 1976). The Nechako Plateau is generally below 1500 m elevation. It is crossed by a series of N-NW trending faults, which are the boundaries of down dropped basins that are occupied in part by lakes and by a series of faults on the northern boundary separating it from the uplifted Skeena Mountains.

The southern Skeena Mountains within the Babine Watershed are comprised of the Atna, Babine, Bait and Sicintine Ranges that abut the Nechako Plateau, presenting a striking visual appearance, rising out of the plateau. Prominent northwesterly trending valleys, that are generally wide and drift-filled, divide these ranges. Following the accretion of the Stikine Terrane onto the North American landmass, about 135 million years ago, thick sediments from volcanic activity to the west accumulated in the Nilkitkwa trough, situated along Babine Lake and extending northwards (Tipper and Richards 1976). Following this sedimentation, uplifting and volcanic and plutonic continued to 50 ma. The many glacial advances and recessions produced the legacy of the surficial landforms we experience today. As the ice melted at the end of the last glaciation, water in the Babine depression drained eastward to Prince George (Hastings et al. 1999). As the lake level fell, the Babine Watershed began to drain northward into the Skeena River.

The predominant biogeoclimatic zone, Sub-Boreal Spruce (SBS) zone, covers most of the lowland coniferous forests in the watershed. Subalpine fir and hybrid spruce are the major tree species. Subalpine fir tends to dominate older, high elevation stands and moister sections of the zone. Sutherland River, located in the southeast portion of the watershed, contains open aspen stands and grassland slopes, with Douglas fir scattered throughout. Due to the pervasive natural and aboriginal fire history, as well as more recent logging activity, lodgepole pine and deciduous seral stands are extensive, particularly along stream terraces and on southern aspect slopes. Non-forested wetlands occur in the morainal landscape depressions, while dry grass/shrub meadows, though limited, are present on dry sites with favourable warm aspects.

The SBS zone merges into the Engelmann Spruce-Subalpine Fir (ESSF) zone at upper elevations ranging from 900-1300 m, dependent on local topography and climatic conditions in the upper Nilkitkwa, Shelagyote, and Shedin drainages. The ESSF zone possesses a shorter, cooler, and moister growing season, with continuous forests passing into subalpine parkland at its highest elevations. Subalpine fir is the dominant tree species, with lesser amounts of lodgepole pine and white spruce hybrids in drier or fire-influenced areas. The low-elevation, southern section of the Shedin drainage is characterized by the transitional Interior Cedar Hemlock zone (ICH) zone, reflecting the close proximity of warmer, humid maritime moisture. Major tree species in this zone are western hemlock, amabilis fir and subalpine fir (Banner *et al.* 1993).

Stream Channels

The Babine River mainstem is 96 km in length with a very low gradient and no obstructions to anadromous fish passage over its entire length. Reach 1 on the lower mainstem has been moderately studied and documented in relation to the 1951 Babine Slide (White 1953 and 1964, Dyson 1955, Wild 1991, Moore 1993, Psutka and Rapp 1996, and Psutka 1996). In 1951, a rockslide occurred that dammed the river and obstructed the majority of returning salmon from reaching their spawning grounds in 1951 and 1952. Remedial efforts to maintain escapement were successful in late 1952 (Godfrey *et al.* 1954).

Reach 1, extending approximately 27 km from the Skeena River to 3 km upstream of the Babine Slide, carves a sinuous, confined channel with an average 0.5% gradient. For the most part the river is incised 50 to 100 m below the valley floor leaving local high slopes in bedrock and overburden that are susceptible to sliding (Psutka and Rapp 1996). Four high hazard and 21 moderate hazard unstable areas are identified and recommended for monitoring on an annual basis and following earthquakes. Channel stability in reach 1 has a high hazard rating with a very high-risk consequence. The major tributaries into reach 1, Shedin and Shenismike Creek, do not possess high value fish habitat since they have high gradients with falls located a short distance above their mouths. Shenismike Creek is particularly steep and unstable with failing banks.

Reach 2 on the Babine River extends from downstream of Thomlinson Creek to 1 km upstream of Shelagyote River. Reach 2 major tributaries include Thomlinson and Gail Creeks, as well as the Shelagyote River. Reach 3 on the mainstem extends from 1 km upstream of Shelagyote River to Nichyeskwa Creek. Both reach 2 and 3 are characterized as a single-thread, irregularly sinuous channel pattern, incised into the bedrock, with glacial till, and gravel deposits lying on the broad valley floor. These reaches possess a low average gradient of 0.4%, with the channel and banks considered stable. There is a narrow and discontinuous floodplain, especially on the inside of channel bends. Hanawald Creek, Shahnagh Creek, and the Nilkitkwa River are the major tributaries. Reach 4 on the mainstem extends upstream to Nilkitkwa Lake and is a single-thread channel with a stable channel configuration. The upper Babine River, also known as "Rainbow Alley," is a 2.8 km constriction of Babine Lake caused by the Tsezakwa Creek fan (Wilford *et al.* 2000). It has moderate flow velocities and a gravel bed that makes prime spawning habitat.

Watershed tributaries producing large volumes of sediment are mainly glacially fed and drain the mountainous, northern portion of the watershed. These include the Thomlinson, Shenismike, Gail, Nilkitkwa, Nichyeskwa and Tsezakwa drainage streams. Weiland (1993) conducted a sediment point source study on the Nilkitkwa River and Nichyeskwa Creek, which provided a better understanding of the natural sediment regimes in the two drainages. Channel stability and sediment production concerns are relatively minor in the low-relief topography of the Nechako Plateau.

Access

The Babine Watershed has relatively easy vehicular access that connects to Highway 16 at Hazelton, Smithers, and Topley. The mouth of the Babine River and Kisgagaas, an ancient Gitxsan village, can be reached from Hazelton via the Salmon River Road. Access is also afforded from this road to the north side of the river with a bridge crossing close to Sam Green Creek. Upstream of Kisgagaas Canyon, navigation is only possible by white water craft moving downstream. The Babine River can be approached within one km, east of Gail Creek, off the Suskwa Forest Service Road (FSR). A road connection has just been approved for construction to connect Hazelton with Nichyeskwa Creek and Nilkitkwa Lake via the Suskwa River Road.

Traveling from Highway 16 in the Smithers area through McKendrick Pass provides access to the northwestern portion of Babine Lake. This road services Smithers Landing and Fort Babine Village, as well as forestry development throughout the north-central part of the watershed. Drainages accessed from this road include Tsezakwa, Nichyeskwa, Nilkitkwa, Shahnagh and Hanawald. The Babine River is crossed at 57 km, close to the fisheries counting fence. Several public boat launches from this road system provide access into Babine Lake, Rainbow Alley, Nilkitkwa Lake and Babine River. Further east on Highway 16, a paved road leads to the communities of Topley Landing and Granisle and ferry service across the lake.

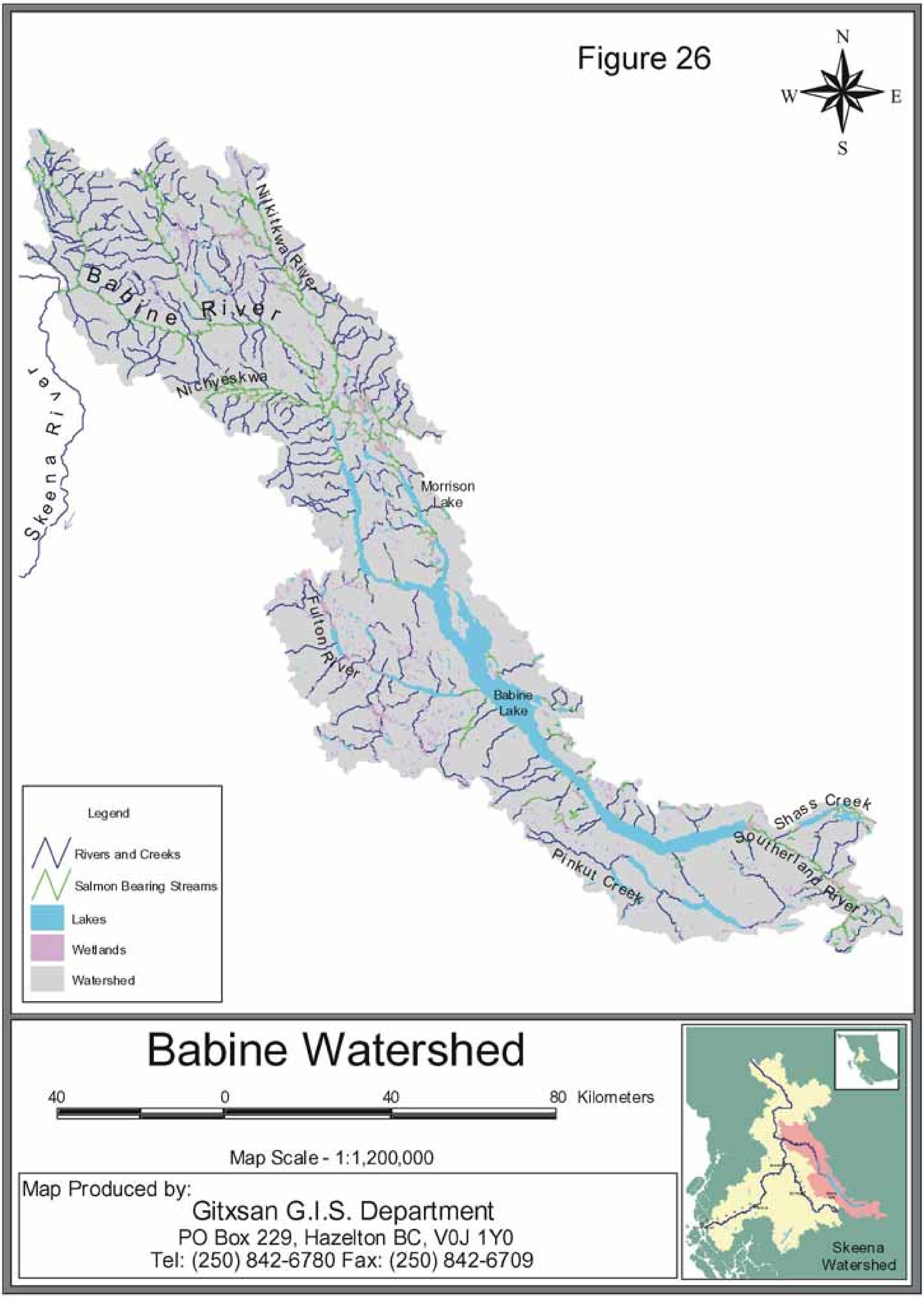


Figure 26
N
W
E
S
Babine River
Nilkitkwa River
Skeena River
Nichyeskwa
Morrison Lake
Fulton River
Babine Lake
Shass Creek
Southerland River
Pinkut Creek
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Babine Watershed
40 0 40 80 Kilometers
Map Scale - 1:1,200,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values and Resources

The Babine Watershed has high fish values and is a major producer of chinook, pink, sockeye, coho, and steelhead salmon, all of which are fished by the aboriginal, commercial and recreational fisheries. Chum salmon, rainbow and cutthroat trout, Dolly Varden, bull trout, and lake char, kokanee, lake and mountain whitefish, lamprey, burbot, sculpins, suckers and shiners are also present in the system. The Babine Watershed's rich salmon production is attributed to Babine Lake, which provides a moderating effect on water temperature, flows and clarity. Babine Lake is one of the most intensively studied lakes in Canada.

Chinook

The Babine drainage chinook are one of the important Skeena chinook populations. Relatively accurate escapement counts for the Babine River chinook run come from the weir located on the river below the outlet of the lake. The weir has operated from 1946 to the present, with the exception of 1948 and 1964. Nevertheless, there are minor difficulties arising from the weir escapement counts: firstly, the location of the weir in the middle of the principal Babine chinook spawning grounds, and secondly, as a general rule of thumb, chinook salmon are not receptive to moving through weirs (Peacock 2002).

Babine chinook annual average escapement for 1950-1959 was 8040 fish. In 1960, the Babine sub-population declined dramatically. Escapements from 1960 to 1995 were between 500 and 2500. Escapements have been improving since 1996 to a high of over 600 in 2001. The increase in chinook escapement most likely reflects the effects of the 1983 policy changes directed to reduce interception in chinook net and troll fisheries. There is concern on the part of aboriginals, the public, and fish managers regarding the present and future status of the Babine chinook.

Adult chinook salmon begin their migration into the Skeena River usually in the third and fourth weeks of July, arriving at the counting weir throughout the month of August. There is uncertainty regarding the effects of the counting fence on chinook migrations. Chinook hold for extended periods below the fence, and it is not clear whether these fish are delayed because of the fence, or if they are pausing because the fence is a convenient normal holding area for adjacent spawning areas (Peacock *et al.* 1997). Spawning takes place principally from Nichyeskwa Creek upstream to the Nilkitkwa Lake outlet, typically peaks in mid-September, and is over by mid-October (Shepherd 1975). Shepherd noted 90% of the spawning was above the fence to Nilkitkwa Lake, where spawning dunes are formed in years of high escapement.

Spawning also occurs occasionally on the Babine River downstream from Nichyeskwa Creek to the Nilkitkwa River (Shepherd 1975), and in reviewing the period from 1934-1965, Smith and Lucop (1969) reported pockets of spawning for 12 km below the fence. Minor to moderate amounts of chinook spawners utilize the lower reach of Nichyeskwa and Boucher Creeks, as well as the Fulton River. In years of high returns, chinook will often spawn on the upper Babine River (Rainbow Alley), which is the general location of Fort Babine Hatchery. This reach is characterized by excellent gravels with stable flows along the margin of the Tsezakwa Creek fan (Smith and Lucop 1969).

Results of adult sampling showed males (mean 629 mm) were significantly smaller than females (mean 742 mm); the run was dominated by three year olds (23%), 4 year olds (57%), and five year olds (13%) (Shepherd 1975). Ginetz (1976) pointed out that generally Skeena chinook have not displayed consistent returns of a particular age class, except that the majority of returning adults are usually four and five year olds. Upon emergence, fry appear to migrate both upstream and downstream to rear in the Babine mainstem and tributaries, with the majority being "stream-type" migrants that have an extended freshwater phase of up to a year or more. Though Shepherd (1975) did not present density data, results of chinook fry trapping indicated that rearing utilization was in this order of importance: Upper Babine (Rainbow Alley), Babine River above the fence, Nilkitkwa Lake, and Babine River below the fence.

Pink

The Babine pink salmon run is one of the early Skeena pink stocks and contributes approximately 4% of the total Skeena Watershed pink escapement. From 1950 to 1990, the annual average escapement into the Babine system by even-year pink adults has increased by a factor of 17. For the same time period, odd-year pink adult escapements have increased by a factor of 13. In the 1990's, the increasing even-year trend levelled off somewhat. The slight expansion of distribution in years of high abundance has seen pinks spawning in the Babine River in the 1950's and moving upstream through Babine Lake to colonize Morrison, Pinkut, Nine-mile, Twain, and Pierre Creeks, as well as the Fulton River; however, 98% of both the even and odd-year runs spawn in the Babine River. Spawning grounds other than the Babine mainstem appear to be more utilized in years of high escapement abundance.

Adult pink salmon usually migrate upstream on the Babine River, arriving August 10 and ending September 10, with odd-year pinks entering and spawning 10 days earlier than even-year pinks (Smith and Lucop 1969). The principal spawning ground is from the forestry bridge (below the fence) upstream to Nilkitkwa Lake; the high productivity of this section of river is mainly due to reliable water flows and low turbidity throughout spawning and incubation periods. Other minor spawning areas not mentioned above include the lower reach of Nichyeskwa and Boucher Creeks and selected pockets of the upper Babine River. Upon emergence from the spawning bed gravels, pink fry migrate downstream to the ocean.

Chum

Babine Watershed chum salmon have never been abundant, with spawning observed in the Babine mainstem upstream and downstream of the counting weir. Average annual escapement from 1950 to 1959 was 28 chum salmon. These returning adult numbers have steadily decreased to an average annual escapement of 3 chum salmon in the 1990's.

Sockeye

The Babine Watershed supports the largest sockeye salmon population in Canada. Babine sockeye studies and investigations began with the Fisheries Research Board of Canada in the 1940's. Extensive data has been gathered to date with references available in Levy and Hall (1985) and Wood *et al.* (1997). Tagging studies (Smith and Jordan 1973) have identified three distinct runs (early, mid, and late-timing) as sub-populations. Johnson's investigations (1956, 1958, 1961) concluded that sockeye salmon production from Babine Lake was limited by the availability of suitable spawning habitat, and these results led directly to the Babine Lake Development Project (BLDP). This approximately 10 million dollar project, consisting of artificial spawning channels and dams to provide for water flow regulation, was located at Pinkut Creek and Fulton River, tributaries of Babine Lake. In 1965, the first channel was completed on the Fulton River; the second was completed on Pinkut Creek in 1968, and in 1971, a third channel was completed on the Fulton River (Ginetz 1977).

Sockeye salmon production from Babine Lake increased significantly as a result of the BLDP program. At least 90% of Skeena sockeye salmon now originate from the Babine-Nilkitkwa system (McKinnell and Rutherford 1994) compared with less than 80% prior to 1970 (Brett 1952). The relative increase in Babine Lake sockeye is due to an increase in abundance of enhanced sockeye and a decrease in most other (wild) Skeena sockeye sub-populations. The mixture of enhanced and wild stocks in the commercial mixed-stock fishing areas has generally depressed wild stocks - some to a greater extent than others - particularly non-Babine sockeye, coho, chinook and steelhead stocks. Management concerns regarding this situation are dual in nature: ensuring the conservation and continuity of non-Babine stocks, and maximizing the catch of enhanced Babine sockeye salmon (Wood *et al.* 1998).

Accurate spawning escapement counts for Babine sockeye salmon runs come from the counting weir located on the Babine River below the outlet of Nilkitkwa Lake. It has operated from 1946 to the present (with the exception of 1948 and 1964). The fence was completely rebuilt in 1966-1967, and replaced again in 1994. Since 1966, spawning escapements to, and fry emigration out from Fulton River and Pinkut Creek spawning channels, have been counted through facilities maintained as part of the BLDP. The annual average escapement at the Nilkitkwa counting fence in the 1950's was 449,000 sockeye, with depressed years in 1951 (141,415) and 1955 (71,352) due to the Babine Slide.

Sockeye populations have steadily increased by a factor of three, with the average annual escapement during the 1990's of 1,425,613 sockeye. This total Babine sockeye population can be broken into enhanced and wild sub-populations. Average annual sockeye escapements to Fulton River and Pinkut Creek have increased from 102,628 in the 1950's to 817,260 in the 1990's with the success of the spawning channels. Total wild (un-enhanced) sub-populations originate from 25 enumerated spawning areas in the watershed. The overall escapement of wild sockeye stocks in the Babine Watershed has remained steady since the 1950's. From the 1950's through the 1990's, the average 10 year annual escapement has been as follows: in the 1950's, 258,448 sockeye; in the 1960's, 308,306 sockeye; the 1970's, 281,583 sockeye; the 1980's, 219,740 sockeye; and the 1990's, 301,423 sockeye (Spilsted *in* Wood *et al.* 1997).

Migration rates of Babine sockeye observed by Takagi and Smith (1973) indicated an average travel time of three weeks from the mouth of the Skeena to the counting fence, although differences in the median travel times were noted for the three runs; the early run took 24.5 days, the middle run 14-18 days, and the late run 21.3 days. The early run usually passes the counting fence from mid-July to mid-August and heads to the small streams located in the southern portion of Babine Lake. This is followed by a run of Morrison River, Tahlo, Grizzly and Pinkut Creeks sockeye, which typically pass the fence between August 1 and 18. A large run of Fulton River sockeye passes the fence between August 5 and 30. The last run appears at the fence after August 15 and customarily spawns in the upper and lower Babine River (Groot *et al. cited in* Levy and Hall 1985).

Smith and Jordan (1973) compared annual tagging results and noted remarkably precise adult migration timing from year to year. Because of the run timing of different stocks in the commercial fishery and a difference in their productivity, the present commercial fishery could over-exploit and possibly deplete wild stocks. In addition, Smith and Jordan suggested that it might prove impossible to preserve the Morrison River sockeye stock in view of their temporal overlap with Fulton River fish.

Principal spawning sites for the mid-timing run of enhanced sockeye, with annual median escapement for 1990 to 1999, are as follows: Fulton Channel #1 (15,416); Fulton Channel #2 (116,287); Fulton above the weir (147,195); Fulton below the weir (143,500); Pinkut Channel #1 (78,451); Pinkut above the weir (27,348); Pinkut airlift (33,146); and Pinkut below the weir (125,315) (DFO 2001).

Principal and minor spawning sites for the wild, early run of sockeye, with annual median escapement for 1990 to 1999, are as follows: Babine River below the fence (750); Babine Lake (5,000); Boucher Creek (43); Donalds Creek (53); Five-mile Creek (108); Fork Creek (N/I); Four-mile Creek (4,544); Nichyeskwa Creek (10); Nilkitkwa River (155); Nine-mile Creek (1,486); Pendleton Creek (869); Pierre Creek (19,975); Shass Creek (4,683); Six-mile Creek (452); Sockeye Creek (2,279); Sutherland River (900); Tachek Creek (2,036); Tsezakwa Creek (388); and Twain Creek (10,243) (DFO 2001).

Principal and minor spawning sites for the wild, middle run of sockeye, 1990 to 1999, are as follows: Morrison Creek (8,990); Tahlo Creek (4,317); and upper Tahlo Creek (75). Principal spawning sites for the wild, late run of sockeye, 1990 to 1999, escapement averages are as follows: the upper Babine River (Rainbow Alley) downstream to Smokehouse Island in Nilkitkwa Lake (201,000); and Babine River from the Nilkitkwa Lake outlet downstream to the counting fence (5,025) (DFO 2001).

Distribution and abundance patterns of sockeye fry have been investigated by Johnson (1956, 1958, 1961) and Scarsbrook and McDonald between 1966 and 1977 (Scarsbrook and McDonald 1975, Scarsbrook *et al.* 1978), with fry abundance estimates summarized by McDonald and Hume (1984). Fry feeding ecology, fry production characteristics, juvenile horizontal and vertical migration, parasitology, fry to smolt mortality, and smolt characteristics are comprehensively reviewed in Levy and Hall (1985) and Wood *et al.* (1997).

An average of one million sockeye smolts typically emigrate from Babine Lake every day over a 40-day period between May 5 and June 15 (MacDonald and Smith 1980). The pattern of migration is a bi-modal one, with a large peak of smolts emigrating out of the lake in mid-May, and a second one occurring at the end of June. Scale analysis of Babine Lake sockeye smolts (Dombroski 1952, 1954) indicates that the smolt emigrates are largely one-year lake fish, with less than 2% spending two years in the lake.

Coho

The Coho salmon aggregate in the Babine Watershed constitute approximately 3% of Skeena River coho escapement and are dominated by stocks that spawn in upper Babine River. Babine coho stocks are currently depressed in abundance and are among those interior Skeena coho populations that are of high conservation concern (Finnegan 2002). This coho stock is enumerated at the counting fence and used as an index of abundance in determining the status of Skeena coho (DFO 1999). The fence has been operated since 1946, but coho enumerations commenced in 1951. Decadal median trends in total annual escapement for the 1960's is 12,771; for the 1970's, 10,156; for the 1980's, 3,233, and from 1990 to 1998, 2,669 coho counted passing through the fence (DFO 2001).

This continuous decline of the Babine coho stock since the early 1970's to 1998 indicates an average shrinkage of 5% each year. The average age of a Babine coho at return is 3.3 years; consequently, for every generation, the stock size declined by an average of 16% (DFO 1999). The decline in coho stocks is attributed to a combination of Alaskan net fisheries, northern BC troll fishery, the Skeena mixed-stock net fishery, and unknown ocean survival factors. Tagging information available for Babine coho suggests that the stocks have a distinct ocean distribution off southeast Alaska. In 1998 with complete closure of the Skeena commercial fisheries, there was still an estimated exploitation rate of 60% on Babine coho, indicating an intense Alaskan net fishing impact (DFO 1999).

Coho pass through the counting fence throughout November, typically moving to the outlet of various tributaries to hold. Dependent on water flow conditions, coho will wait for the fall freshet before moving into the tributaries from late September to late November to spawn. In years of below average flow, spawners will back off and utilize either the upper or lower Babine River or Morrison Creek, with minimal spawning loss (Finnegan 2002). Principal spawning grounds in order of their production are: Babine River between the fence and Nilkitkwa Lake, the upper Babine River between Nilkitkwa and Babine Lakes, Fulton River, and Morrison River (Finnegan 2002). The remainder of coho spawning is dispersed in tributaries, which include Boucher Creek, Nichyeskwa Creek, Nine-mile Creek, Pierre Creek, Pinkut Creek, Shass Creek, Tachek Creek, Tahlo Creek, Tsezakwa Creek, and Nilkitkwa River.

Coho fry emergence extends from April to July. Juveniles are widely distributed in accessible, slow stream waters and in various upland lake systems. Assessment of juvenile coho populations sampled throughout the watershed from 1994 to 1997 indicated the majority of coho densities are under $0.30/m^2$ (Taylor 1995, 1996, 1997; Bustard 1997). Coho smolt mostly after two winters and migrate downstream to the ocean with the spring high water to return as adults 14 to 17 months later.

Steelhead

The Babine Watershed supports summer-run steelhead populations that enter the mouth of the Skeena in late June or early July, arriving in the Babine system beginning in August and continuing into autumn. Babine steelhead are notably important for their large body size and their abundance, which makes them the basis of an internationally famous sport fishery that occurs from the late summer into the fall. Variation between different spawning stocks in the Babine Watershed has been observed; for example, Shelagyote River steelhead exhibit shorter heads and varied spotting (Beere 2002). Radio-tagging studies (Beere 1991, 1996) showed steelhead overwintering throughout the mainstem.

Steelhead spawning occurs from March through May, coinciding with warming water and an increase in Babine River flows. The principal spawning ground is from the counting fence upstream to Nilkitkwa Lake; however, the largest concentration is 400 m below the lake outlet and adjacent to the Boucher Creek confluence. It is estimated that at least 40% of spawning occurs below the Babine fence with spawning documented in Secret Creek, Hanawald Creek, and Shahnagh Creek, as well as Shelagyote and Nilkitkwa Rivers (DeGisi 2000, Beere 2002). Results from radio tagging programs (Beere 1991, 1996) indicate that kelts generally migrate downstream promptly following spawning.

Steelhead fry emerge between mid-August and mid-September and are widespread throughout the middle Babine section in the smaller tributaries that offer suitable refuge. Juvenile steelhead freshwater residency varies from 2 to 6 years. Whately and Chudyk's sampling (1978) found 46% were 3.2s[1], with 4.2s comprising 26.5%, and 10% were 3.3s. DeGisi (2000) using a much larger sample subset, found 60% were 3.2s, and 32% were 4.2s, though 10% return after one year and 25% return after 3 ocean years. It is suggested that freshwater residency time relates to juvenile steelhead habitat location in the system; slower growth rates are apparent when rearing in glacial fed stream systems, compared to nutrient rich lake habitat.

Fisheries

First Nations Traditional Use

First Nations traditional use and occupancy of the Babine Watershed is extensive and well documented by oral history and early Euro-Canadian visitors. In general terms, the upper portion of the watershed, the Babine Lake drainage, was home to the Ned'u'ten, while the lower watershed was central to the Gitxsan. Although they differed linguistically, intercultural interactions were widespread resulting from the use of the same basic social structure, which had integral connections to the similar environment they inhabited. This shared social structure was composed of a matrilineal kinship society, exogamous clans divided into houses, with crests, oral histories, and a land tenure system of territories, which were managed through a public forum process called the feast. These separate aboriginal groups possessed distinctive characteristics and complexities that are important to note, but the social structure cut across major linguistic and cultural divisions (Rabnett 2000).

The very abundant and predictable sockeye salmon stocks provided the Gitxsan and Ned'u'ten with opportunity to harvest and preserve a large amount of high quality food in a relatively short time of intensive effort. The two dominant sockeye runs (early and middle) were the major focus, as they provided the majority of high-quality dried fish needed to sustain the Gitxsan and Ned'u'ten over the year, and to produce a trade item. Following the passage of the bulk of the sockeye, coho appeared and were available well into the autumn, providing both fresh and dried fish. Rainbow trout, steelhead, lake trout, Dolly Varden char, lake char, and whitefish were also fished and processed in their respective habitats.

For the Ned'u'ten, the salmon fishery at Nilkitkwa Lake formed the principal foundation of the traditional economy. Wud'at, also known as Tsa Tesli (where the lake ends), was the principal salmon season village on Babine Lake. It was located primarily on the right bank of Babine River and is, for the most part, currently overlaid by DFO's counting weir camp. Salmon fishing was conducted as a cooperative clan endeavour with the fish caught in weirs

[1] Note that with this "European" system of age notation the first number is the number of winters in fresh water, the number after the dot is the number of winters in the sea.

across Nilkitkwa Lake and the upper Babine River. On the Babine River below Nilkitkwa Lake, the Tsayu or Beaver Clan operated a weir. Upstream from the Tsayu and close to the lake outlet, the Laksamasyu harvested fish from their weir. Further south, at the inlet to Nilkitkwa Lake and upstream of Smokehouse Island in the shallower water, the Gilserhu owned a weir that did not quite span the entire width of the river, as did the other three. The fourth weir, operated by the Laksamasyu, was positioned at the outlet of Babine Lake, in the river section near the present day hatchery site (Hackler 1958).

Kobrinsky (1973) describes "large weirs spanning the Fulton River near its confluence with Babine Lake, and served the village at that site," The fisheries officer Helgerson noted weir construction downstream of Nilkitkwa Lake, when he went to eradicate them in 1906:

> The barricades were constructed of a immense quantity of material, and on scientific principles; I will endeavor to describe them. There were posts driven into the bed of the river, which is 200 feet wide, and from two to four feet deep, and running swiftly at the intervals of 6 or 8 feet.
>
> Then sloping braces well bedded into the bottom and then fastened to the top of the posts, then strong stringers all the way on top and bottom, in front of posts, then panels beautifully made of slats woven together with bark set in front of all, these were set firmly into the bottom, and reaching four feet above the water. This made a magnificent fence which not a single fish could get through.
>
> On the upper side of the dam were placed 12 big traps or fish bins. Opposite holes made in the panels for fish to enter the traps, prepared with slides to open and shut, and if the traps did not have a sufficient quantity of fish in them, when the women wanted more fish on the bank, the men would take their canoe poles, wade out in a line and strike the water, making a noise that could fill the traps in a moment, then shut down the slides, take a canoe on each side of bin, raise the false bottom, by some contrivance so as to elevate the fish, then load up canoes with gaff hooks. (Helgerson 1906).

At the turn of the century, a campaign by cannery operators who wanted a larger share of the fish and a guarantee of harvesters and plant workers – two good reasons to get Indian food fishers away from their weirs - was enforced by the Department of Marine and Fisheries (Newell 1993). The legal action prohibited weirs used by aboriginal fishers and the sale of processed fish throughout the Skeena Watershed focusing on the weirs in the Babine country. The dispute was somewhat settled with the Barricade Agreement of 1906; however, to this day, there are bitter feelings remaining with the Lake Babine Nation. Since that time, the majority of Ned'u'ten food, social and ceremonial fish needs have been procured with gillnets. Fort Babine Enterprises currently operates an Excess Salmon to Spawning Requirement (ESSR) fishery targeting sockeye jacks that are harvested from Babine River at the counting fence. Beach seines and a small seine boat are used near the Fulton River and Pinkut Creek spawning channels to harvest ESSR large sockeye (Talon Development Services 2002).

For the Gitxsan, salmon represented the most important cultural foundation as well as the substantial, singular element of diet. Kisgagaas Canyon was the heartland of many adjacent Gitxsan villages and was most likely the largest aboriginal settlement in the Skeena Watershed (Rabnett 2001). Salmon fishing also occurred in other locations on the Babine River, including Xsugwinlik'l'insxw and Gwit ts'ilasxwt, located close to the Shenismike-Babine confluence, other locations on the Babine mainstem, particularly at tributary mouths, and various locales on both the Shelagyote and Nilkitkwa Rivers.

In Kisgagaas Canyon, where strong currents concentrated salmon, lashed wooden strip or woven basket traps - some incorporating ingenious delivery chutes - were principally utilized to harvest large amounts of fish. Gear types suited to single fish harvest included specialized dip nets with a closable mouth (banna). The various traps and dip gear used depended on site location, fish quantities needed, the number of people available to fish the gear, and importantly, processing capacity (Morrell 1985, Rabnett *et al.* 2001). Ownership of fishing sites in the canyon is defined as one of the ancestral House prerogatives passed down through the generations. A weir crossed Babine River below the canyon (Brown 1823), but little is known of its exact location and history. Currently, salmon harvested for personal use and as part of the ESSR fishery are primarily dip-netted. The importance of the traditional fishery, which is a blend of food resource, trade capital, cultural expression, and connection to ancestral practices, cannot be overstated.

Recreational Fisheries

The sport fish of the Babine Watershed support large-scale recreational use from residents and seasonal visitors. Recreational angling is divided into two relatively distinct fisheries: a lake-based fishery and the Babine River sport fishery. The large, lake-based fishery, principally conducted from powerboats, runs from May until October, focusing on resident trout and char species. Anglers spent an estimated 21,000 and 15,000 angler days on Babine Lake in 1985 and 1986 respectively (Bustard 1987). Babine Lake supports one of the largest rainbow trout populations in the province with exceptional fly-fishing. Bustard (1989) noted that anecdotal information from long-time residents indicate that fish size and angling success rates have deteriorated in recent years. Char provide fine angling, and fishing for burbot, a fresh-water lingcod, is also popular. Five fishing lodges, Granisle Marina, and 10 – 12 boat launches on the lake, as well as many fish guides, supply services and infrastructure to the Babine and Nilkitkwa Lakes' recreational fishery.

The Babine River fishery is conducted from the river shore, jet boats, and the occasional drift boat and inflatable. The river sport fishery is primarily directed to steelhead, though chinook may be harvested, and a sockeye fishery is held in years of abundance. This sports fishery, dominated by non-resident anglers, has steadily increased in popularity since the early 1970's, with the projected trend indicating further increase. Resident anglers account for 40% of the angling effort which takes place mostly in the reach upstream from the Nilkitkwa River, with most fishing in sight of the forestry bridge (MELP 1997).

Three angling guides run lodges and satellite camps on Babine River, with a fourth guide having no lodge. Guided anglers typically total approximately 2000 fishers (1995-1998), who annually caught 2,439 steelhead on average from 1990 to 1998, with less than 1% retained.

In relation to the high and growing level of angling activity on the river, the recent Management Direction Statement from BC Parks (2000) outlines three areas of concern regarding the sports fishery: impacts on fish populations, impacts on grizzly bears, and maintaining a quality recreation experience. Thirteen other Provincial Parks are spread throughout the watershed, seven of them with lakeshore access. Babine River Provincial Park (14,500 ha) and the recently created Sutherland Provincial Park (12,900 ha) are the largest protected areas; the other parks within the watershed are relatively small in size.

Current regulations applicable to Babine Lake and Nilkitkwa Lake are as follows: no fishing east of a line from Gullwing Creek to the south shore of Babine Lake; Rainbow Alley open all year, though fly-fishing only from Babine Village bridge to the counting fence, June 16 to September 30. Angling regulations specific to Babine River include: bait ban; no fishing, January 1 to June 15; fly fishing only from 80 m below counting fence to Nichyeskwa Creek confluence, June 16 to September 30; and Class 1 waters apply from September 1 to October 31, with a mandatory steelhead stamp (Anonymous 2001a).

Enhancement Activities

Enhancement activities in the Babine Watershed have been ongoing for centuries according to Ned'u'ten Elders, particularly in regards to controlling beaver populations, and dealing with fish access and passage issues. In 1907, the Babine Dominion Fish Hatchery was constructed and operated from 1907 to 1936 with a 10,000,000 egg capacity. Morrison Creek sockeye generally supplied half the eggs needed; the remaining brood stock needs were acquired from Pierre Creek, Babine River, and 15 Mile or Pinkut Creek (Smith and Lucop 1969).

From the mid-1930's through to the 1950's, crews cleared streams on a regular basis to improve fish access, with emphasis applied to those streams with late summer-early autumn low water flows (DFO 1930–1960). The counting weir located on the Babine River was constructed in 1946 and has operated to the present (with the exception of 1948 and 1964). The fence was completely rebuilt in 1966-1967 and replaced again in 1994.

Sockeye salmon studies in the late 1950's and early 1960's concluded that sockeye salmon production from Babine Lake was limited by the availability of suitable spawning habitat, and secondly, that the main basin of the lake was underutilized and could support additional sockeye fry. These results led directly to the Babine Lake Development Project (BLDP). Construction of this approximately 10 million dollar project, consisting of artificial spawning channels and dams to provide for water flow regulation, was located at Pinkut Creek and Fulton River, tributaries of Babine Lake. The regulated water flows at Pinkut Creek and Fulton River spawning channels provide stable conditions for the incubation of salmon eggs after they have been deposited in the gravel.

The first channel was completed on the Fulton River in 1965, the second on Pinkut Creek in 1968; a third channel was completed on the Fulton River in 1971 (Ginetz 1977). Sedimentation problems in the Pinkut Creek enhanced channel led to a major rehabilitation program in 1976. Since 1973, an annual average of approximately 37,000 adult sockeye have been airlifted over the Pinkut Creek falls to allow utilization of a six km spawning area on upper Pinkut Creek.

High spawning sockeye densities in the enhancement channels have lead to health problems over the last three decades. Three fish diseases have caused concern (Harrison, 2002 Higgins, 2002). The viral disease, infectious hematopoietic necrosis (IHN), endemic to adult and juvenile sockeye has been identified as an important cause of losses among sockeye alevins and fry at the Fulton River facility (DFO and MoE 1985). Presently, no treatment methods have been developed to combat this disease and fish culturists must rely solely on stock management procedures and manipulation of rearing conditions to minimize losses. The protozoan parasite *Ichthyophthirius multifilis* (Ich) caused high prespawning mortality at Fulton River in 1994 and 1995 (Traxler *et al.* 1998) and continues to be a problem. Although Ich is present in wild fish populations, this disease has a history of severe outbreaks in hatcheries and fish farms (Håstein and Lindstad 1991). The infestation at Fulton River seems to be related to high temperatures and crowding below the spawning channel (Higgins and Munby 2000, Higgins 2001). Changes in the spawning gravel material and spawner density may have contributed to control. Since 1997, *Loma salmonae*, a microsporidial parasite, has caused prespawning mortality of female sockeye. In 1997, 2000 and 2001, Loma and Ich were both present, and cause prespawning mortality of 30% to 40% (Higgins 2002).

Fulton River Hatchery is small-scale and has been in operation discontinuously since the late 1970's. Babine River steelhead and chinook (>100,000) were hatched, reared, then moved to the fence and net-penned to imprint them, before release at the fence for several years in the 1970's. In the late 1980's, the hatchery incubated and reared 30,000 Fulton River coho, with no apparent adult returns (Harrison 2002). In recent (1999-2002) efforts to increase coho in the Morrison drainage, broodstock has been held at the Fulton River Hatchery, eggs fertilized and hatched and an annual average of 65,000 fry released into lower Tahlo Creek (Donas 2002)

Since 1983, the Fort Babine Hatchery, a Community Economic Development Project (CEDP), has enhanced the Babine coho and chinook populations. Brood stock is obtained from adults held at the counting fence, incubated, and reared with an approximately 50/50 release of fry and smolts. On an annual basis, enhanced coho typically number 150,000 to 200,000, while 80,000 to 100,000 chinook are raised. In the Nilkitkwa River, steelhead smolts were released close to the mouth; 29,000 smolts were planted in 1979 and 5,800 in 1980 (DFO 1991b).

Development Activities

Land use and development activities in Babine Watershed are extensive particularly in the lake drainage area. The principal land use activity is logging, which is widespread throughout the accessible timbered portion of the watershed. There are mineral resource, transportation, and settlement developments, particularly in the southern part of the drainage.

Forest Resource Development

The roots of forest development in the watershed started in the 1930's with hand loggers falling timber into or close to Babine Lake and horse loggers hauling to the lake. Logging steadily increased following WW II supplying small local mills. Extensive selective logging operations focused on the accessible, low relief, timbered ground south of Babine Lake. To a lesser extent, logging operations also occurred on the north side of the lake, with logs being boomed and towed across to sawmills on the south shore. Pendleton Bay was the hub of activity; log storage grounds and seven mills were situated 2 km north in Mill Bay, while another sawmill was 5 km north (Strimbold 2002, BCFS 1956). Logging camps and log dumps were prolific, with at least 21 operations in 1955 (BCFS 1956).

By 1960, Michell Bay, just north of Topley Landing, had a permanent sawmill. Milled wood was trucked out to the rail line at Topley, Burns Lake and Decker Lake. The 1960's saw large-scale industrial logging on the west side of the Babine Lake (Tsak to Babine River), as well as the north side of the lake, southeast of Hagen Arm, with the log booms towed down the lake to Pendleton Bay (Strimbold 2002). These 1960's cuts are characterized for the most part by their distinctive herringbone pattern.

Forest development activities in the 1970's took place mostly south and west of Babine Lake with the Pinkut River and Cross Creek drainages being heavily clearcut. The mid-Fulton and Guess Creek areas saw widespread clearcut activities, as did the west side of Nilkitkwa and upper Babine Lakes. The North Road, built in the early 1970's, linked Houston with Topley Landing and eased logging traffic. In addition, 1970's logging development adjacent to Hagen Arm, progressed northward to the east side of Morrison Arm. These logs were dumped into Nose Bay, towed across the lake, de-watered in Michell Bay, close to the mouth of the Fulton River, and then trucked to Houston (Strimbold 2002). In the early 1970's, the Babine Watershed Change Program was initiated in response to the increased logging and mining (Granisle Copper and Bell Copper) developments in the watershed. The purpose of the program was to collect and review baseline environmental data so that effects of environmental change on salmonids could be properly assessed (Smith 1973, 1975, 1976).

Forest development in the 1980's was widespread throughout the watershed, although concentrated logging of blowdown and beetle wood occurred in the upper Fulton River area. Logging was also intense in the Tanglechain-Smithers Landing area, in the Taltapin-Henrietta area, in the Fulton Lake south area, and to a certain extent in the lower Nilkitkwa. In the mid to late 1980's, logging accelerated on the north side of the lake in response to mountain pine beetle outbreaks. This led to a three-year study by Westwater Research Centre to determine the effects of log transportation on fish habitats and populations in Babine Lake (Levy and Hall 1985). Two barges currently provide transportation across the lake for the forest industry.

In the 1990's, logging trends continued with new roads and progressive clearcutting in the Morrison and the north side of Babine Lake, the bulk of Nilkitkwa drainage up to West Nilkitkwa River, and the Granisle area. In 1994, the Babine River Local Resource Use Plan was established for the Babine River downstream of the counting fence. This plan protected the river corridor from development activities, and the area was subsequently confirmed as Babine River Corridor Park in 1999 (MoF 2000). The lower Babine River, downstream from Kisgagaas, was bridged in 1997 to facilitate forest development north of the river. Logging development in the upper and lower Shedin continued into 2001, until SCI financial difficulties caused operations to shut down.

The Watershed Restoration Program (WRP) in the Babine Watershed has been applied fragmentally, most likely because the watershed lies in five administrative Forest Districts: the Kispiox, Bulkley-Cassiar, Morice, Lakes, and Vanderhoof. Few prescriptive and restorative works have been implemented to date. The overall gentle nature of the terrain, the coarse, well drained soils, and the presence of large lake and wetland complexes, appear to have mitigated the impacts of past forest development activities. One of the major impacts identified within Babine Watershed is impeded fish access - most often the result of road crossings that were originally constructed as, or have become, barriers to fish migration (Ministry of Forests 2001b). Restoration of fish access to these areas will re-establish access to many kilometres of productive upstream habitat. Because of the prevailing gentle terrain of the Nechako Plateau there are few open slope landslide failures or slumps related to logging. Logging related landslides are present in the steeper terrain of the northern portion of the watershed.

Cumulative effects of logging-related sedimentation, if any, are presently unknown. Bustard (1986) documented high sediment loads due to road-related erosion and loss of small stream habitat in the upper Fulton drainage. Bustard also noted road-related erosion compounded by poorly drained soils and potential water temperature changes in the Morrison drainage.

The Watershed Restoration Program (WRP) has identified sub-basins within the Babine Watershed for future "major works" include Taltapin, Morrison Lake, and the Babine, which includes the Nichyeskwa, the lower half of Nilkitkwa River, and the Babine River drainages within the Bulkley-Cassiar Forest District (Ministry of Forests 2001b). These targeted sub-basins total a few percent of the watershed; however, there is uncertainty as to how, or if, the WRP will continue in the future. Forest development tenures held by major licensees in the watershed are described in (Ministry of Forests 2001b).

Overall, the watershed has been extensively roaded and logged up to the present. It is assumed that the future trend will be to continue widespread logging throughout the watershed, with probable concentrated logging in the upper Morrison, Hanawald, Shahnagh, and Shelagyote drainages.

Mineral Resource Development

Prospecting and mining were an important part of Euro-Canadian history in the Babine Watershed. The watershed has received a substantial amount of primary and secondary exploration activity over the years. Relatively small mining operations, targeting gold and silver vein deposits at French Peak, Cronin Mountain, Thoen Mountain, Taltapin Lake, and Dome Mountain, have been past producers. Recent mining interest has centered more on large, low-grade deposits, which can be worked by open pit methods, such as the Bell and Granisle deposits.

The Granisle Mine was located on McDonald Island in Babine Lake and operated from 1966 to 1982, when poor economics forced the closure. This open pit mine produced principally copper with small amounts of gold. Granisle, an "instant town," was located on the west shore of the lake, with access via ferry between the town site and the mine. During winter, a bubbler system was used to maintain an ice-free ferry channel.

Bell Copper Mine, located to the northwest of the Granisle Mine, on Newman Peninsula, operated from 1970 to 1982 and was closed due to deteriorating market conditions. The mine reopened in 1985, with operations continuing until 1992, when available ore was exhausted. Production ore from this open pit mine was predominantly copper, with minor amounts of gold. Granisle was utilized as the town site, and access to the mine was via barge. The energy needs of both Granisle and Bell Copper mines were met by BC Hydro. The copper concentrate from the mines was trucked to Topley, and thence shipped by rail cars to various destinations including Vancouver and Prince Rupert for export, and to the smelter in Noranda, Quebec.

A number of studies have been undertaken because of the presence of two open pit copper mines near the shore of Babine Lake. Stockner and Shortreed (1976) investigated water quality, as did Noranda (Hallam 1975, Hatfield 1989, Rescan Environmental Services 1992) and the Environmental Protection Service (Godin *et al.* 1985, 1992). No significant changes were observed in water quality. The mines closure plans directed a relatively conservative approach to reclamation, ARD, and future monitoring. Environmental concerns regarding current toxicity and deleterious discharges are relatively minor (Stewart 2002).

Lake Babine Nation community members continue to have concerns regarding the tailing ponds of the two de-commissioned mines (Talon Development Ventures 2002). The mineral development outlook in the Babine Watershed is for continued primary and secondary development of small mining prospects. New large open pit porphyry copper mines with low grade ore will not be developed unless there is a major change in world copper supply. Any new mines are expected to be relatively small, high-grade operations. Key properties currently receiving attention include Dome Mountain, Hearne Hill, Nanika, Old Fort and Fireweed (Ethier 2002).

Transportation and Utilities

The existing transportation network in the watershed reflects seventy years of steady improvement based on the First Nations trail infrastructure. Trails were initially widened for packhorses and later improved for wagons, then further improved for vehicular traffic. Overall, the development pattern has been spurred by a single motive: the extraction of forest products. Most of the watershed is currently roaded to support forest sector activities.

All major roads providing access into the Babine Watershed originate from Highway 16. Other than the paved Granisle Highway, which accommodates traffic between Topley and Topley Landing-Granisle, the majority of roads are gravel and are the responsibility of the Forest Service or forest sector. Forest resource roads continue to be developed throughout the watershed, and future trends point toward road maintenance responsibilities being off-loaded to industry or dropped altogether.

The Augier and Grizzly Forest Service Roads (FSR), as well as the Babine Fisheries Road, access the southern shore of the lake at its eastern margin. Babine Forest Products facilitates log movement to its processing facility in Burns Lake with two seasonal barge crossings. The winter barge crosses from Augier FSR north to the Fleming FSR. The summer barge crosses from Grizzly FSR to the north shore of the lake. The North Road from Topley Landing to Houston is primarily used for one-way, southbound logging traffic. The barge crossing from Topley Landing to Nose Bay on the north shore accesses a large network of roads into the east-central Babine Watershed and Fraser drainage.

The western portion of the watershed is accessed by three main roads: the Babine Lake road, the Suskwa FSR, and the Salmon FSR, with the Kuldo FSR and Damsumlo FSR giving entry to the upper Shedin Watershed. The Babine Lake Road, which leaves Highway 16 east of Smithers, provides cut-offs to the upper Fulton Watershed (east and west), the upper Harold Price Watershed, to the Granisle Connector, and Smithers Landing. The road continues north as the Nilkitkwa FSR, accommodating access to Fort Babine Village, the Nichyeskwa drainage, and the Nilkitkwa drainage, with a western branch heading towards Shelagyote River. The Suskwa FSR, which leaves Highway 16 east of New Hazelton, furnishes access to a large area south of the Babine River. The Suskwa FSR will also provide a cut-off to the Nilkitkwa Road just south of the counting fence through the recently approved and constructed Nichyeskwa Connector. North from Hazelton, the Salmon FSR provides access to the Babine-Skeena confluence, Kisgagaas Village, and northwestern drainages of Babine River.

Utilities are limited within the watershed. Electricity is supplied from BC Hydro's provincial grid, with the main transmission line more or less paralleling Granisle Highway. This was constructed to service the two copper mines and communities close by. This line was extended northward to Smithers Landing and Fort Babine Village in 1979, and further extended eastward out of the watershed to provide service to Takla Lake communities. Telephone services are supplied to the Granisle area, and the prospect of service to Fort Babine is occasionally mentioned. Natural gas is not piped into the watershed. The future outlook in regard to utilities is continuance of the status quo, with little future development foreseen.

Population and Settlement

Historically, Ned'u'ten people resided at various village sites and seasonal home places throughout the watershed, though particularly on the lakeshore. Current population centres continue to be based on the lake shoreline. The Granisle area has the largest population at 450, the majority of whom are retired. Topley Landing has approximately 50 residents, while Tachek has approximately 100 residents. Consumer services are limited, with these communities typically doing business in Houston or Burns Lake.

Fort Babine or Babine Village, located at the outlet of Babine Lake, has a population of approximately 140 people; however, in fishing season, the number is up to 300 people. Employment opportunities include a fishing lodge, fish hatchery, road maintenance, and village services. A chronic lack of employment, education, and training opportunities has drawn people off the reserve to larger centres such as Smithers and Burns Lake.

Other full-time residents include recreational lodge service people and rural residents. In addition to the population of these year–round communities, there is a seasonal population of recreational cabin owners with approximately 110 properties. Summer season attracts many fishing enthusiasts and tourists.

Babine Watershed Management Issues

Babine Lake is the largest natural lake in BC and is drained by the Babine River, the largest tributary of the Skeena River. The Babine Watershed has high fish values and is a major producer of chinook, pink, sockeye, coho, and steelhead salmon, all of which are fished by the aboriginal, commercial and recreational fisheries. Chum salmon, rainbow and cutthroat trout, Dolly Varden, bull trout, and lake char, kokanee, lake and mountain whitefish, lamprey, burbot, sculpins, suckers and shiners are also present in the system. The Babine Watershed's rich salmon production is attributed to Babine Lake, which provides a moderating effect on water temperature, flows and clarity.

Chinook from the Babine drainage are one of the important Skeena chinook populations. The Babine Watershed supports the largest sockeye salmon population in Canada, with sockeye salmon production from Babine Lake increased significantly as a result of the Babine Lake Development Program located at Pinkut Creek and Fulton River. At least 90% of Skeena sockeye salmon now originate from the Babine-Nilkitkwa system compared with less than 80% prior to 1970. The relative increase in Babine Lake sockeye is due to an increase in abundance of enhanced sockeye and a decrease in most other wild Skeena sockeye sub-populations. Management concerns regarding this situation are dual in nature: ensuring the conservation and continuity of non-Babine stocks, and maximizing the catch of enhanced Babine sockeye salmon. Babine steelhead are notably important for their large body size and their abundance, which makes them the basis of an internationally famous sport fishery that occurs in the late summer and fall.

First Nations traditional use and occupancy of the Babine Watershed is extensive and well documented by oral history and early Euro-Canadian visitors. In general terms, the upper portion of the watershed, the Babine Lake drainage, was home to the Ned'u'ten, while the lower watershed (the Babine River) was central to the Gitxsan. The sport fish of the Babine Watershed support large-scale recreational use from residents and seasonal visitors. Land use and development activities in Babine Watershed are extensive, particularly in the Babine Lake area. The principal land use activity is logging, which is widespread throughout the accessible timbered portion of the watershed. There are mineral resource, transportation, and settlement developments, particularly in the southern part of the drainage.

A number of studies have been undertaken because of the presence of two open pit copper mines near the shore of Babine Lake. Stockner and Shortreed investigated water quality, as did Noranda and the Environmental Protection Service. No significant changes were observed in water quality. The mines' closure plans directed a relatively conservative approach to reclamation, ARD, and future monitoring. Environmental concerns regarding current toxicity and deleterious discharges are relatively minor. Transportation impacts are relatively minor, most being related to the logging road network. Providing fish access at stream crossings is the principal problem.

The environmental problems of the Babine are manageable. An important direction for conservation activities in this watershed is the preservation of the critical fish habitat. The priority in conserving fish habitat in the Babine Watershed is to ensure high water quality.

Bear Watershed

Environmental Setting

Location

The Bear Watershed is located in the northeastern headwaters of the Skeena River in central British Columbia. The Bear drainage basin is bounded to the south by the Driftwood River basin, to the north by the Sustut River drainage, to the east by the Connelly Range, and to the west by the southeastern spur of the Skeena Mountains.

Hydrology

The Bear Watershed is a fifth order system with a catchment area of approximately 452 km^2. Elevations range from Peteyaz Peak at 2241m to 690 m at the Bear-Sustut confluence. The Bear River drains 10 km northwesterly into the Sustut River, which then discharges westerly into the upper Skeena River. Maximum freshet discharges occur in mid-June corresponding with high elevation snowmelt; flows then decrease until September when fall rains and early snowmelt increase stream flows through October. Summer low flows are typically 4-8 times greater than winter stream flows and are principally sustained by high elevation snowmelt draining from the Skeena Mountains. Stream flows decrease through November and December when precipitation falls as snow. Stable winter low flows are derived from groundwater, lakes and unfrozen wetlands. There is no history of hydrometric stations in the watershed. The watershed has a sub-boreal climate with relatively low precipitation, warm summers, and long cold winters with a heavy snowpack.

The actual drainage area tributary to the watershed is relatively small. Tributaries flowing into Bear River are minor, with the exception of Patcha, Salix, and Azuklotz Creeks. Patcha Creek, the largest, is the only one that carries glacial silt.

Bear Lake is the dominant hydrological feature in the watershed, which regulates river flows and levels. The lake, lying at 779 m elevation, is 19 km long and averages 1 km in width, although it is 4.5 km in width at Tsaytut Bay. Two deep basins at either end of the lake are separated by a shallow section. Limnological data collected in 1978 and 1995 indicated the lake has a mean depth of 14.8 m, an average summer thermocline depth of 7.5 m, a mean surface temperature of 14.6 ^oC, an 8.8 m euphotic zone depth, and a substantial, cool, hypolimnion. The average photosynthetic rates and average macrozooplankton biomass in Bear Lake are among the highest in the Skeena system (Shortreed *et al.* 2001).

Geography

The Bear Watershed is comprised of two mountain masses split by a trench-like fault valley. The valley is located along a major crustal break that separates the Stikine Terrane on the west from the Cache Creek Terrane on the east. This fault zone extends for several hundred km south past Takla Lake and Stuart Lake. The mountains to the west are a part of the Skeena Mountains, and are composed of middle Jurassic Hazelton Group volcanic and sedimentary rocks. The Connelly Range to the east is comprised of upper Cretaceous Sustut Group sedimentary rocks presumably overlying Asitka Group Volcanic rocks at depth. The top of the Connelly Range has a dramatic tower on it called The Thumb, formed by a Tertiary volcanic neck. Dispersed small stocks of Tertiary age Kastberg granitic intrusions are evident surrounding Bear Lake (Lord 1948) and are responsible for the mineralization on Tsaytut Spur to the west.

The fluvial and surficial geomorphology is strongly influenced by its recent glacial history. Ice moving southward eroded the Bear Lake valley and scoured all slopes. Thick blankets of glacial till cover the main valley and mountain valleys, extending up the valley sidewalls, though the surface expression conforms generally to the underlying bedrock surface, with bedrock exposure along deeply incised streams and on steep-sided hillocks (Holland 1976). During deglaciation, stream flow was to the south into the Takla Lake basin, the Stewart River and then the Nechako River.

The predominant biogeoclimatic zone, Sub-Boreal Spruce (SBS), covers most of the lowland coniferous forests in the watershed. Subalpine fir, lodgepole pine, and hybrid spruce are the major tree species; subalpine fir tends to dominate older, high elevation stands and moister sections of the zone. Due to the pervasive, natural and aboriginal fire history, lodgepole pine, and to a lesser extent, deciduous seral stands are extensive, particularly along stream terraces and on southern aspect slopes. Non-forested wetlands occur in the morainal landscape depressions, while dry grass/shrub meadows, though limited, are present on dry sites with favourable warm aspects (Meidinger and Pojar 1991).

The SBS zone merges into the Engelmann Spruce-Subalpine Fir (ESSF) zone at mid elevations ranging from 900-1300 m, depending on the local topography and microclimate. The ESSF possesses a shorter, cooler, and moister growing season, with continuous forests passing into subalpine parkland at higher elevations. Subalpine fir is the dominant tree, with lesser amounts of lodgepole pine and white spruce hybrids in drier or fire-influenced areas (Meidinger and Pojar 1991).

Stream Channels

The Bear River is 10 km in length exhibiting a single thread channel, with an irregular sinuous channel pattern, and is generally low gradient. However, the lower and upper 1.6 km of the river are steeper in gradient (Shepherd 1975). Pink salmon access upstream is restricted by one obstruction near the top of the river. Williams *et al.* (1985) divided the Bear River is into two reaches. The lower section of Reach 1 is steeper than the upper section (of Reach 1) and channelized, with a boulder substrate and little cover other than overhanging streamside vegetation. The upper section of Reach 1 is characterized by slow and meandering, long, wide runs punctuated by relatively deep pools, with substrate composed primarily of gravel and some cobbles. In addition to numerous beaver ponds, side channels, oxbows and pools, stream complexity is also provided by logjams, undercut banks and abundant streamside vegetation (Williams *et al.* 1985). Reach 2 has less than 1% gradient and is channelized, with predominantly boulder substrate at its upper and lower ends. The middle 1.5 km of Reach 2 consists of wide slow runs with gravel substrate and minor amounts of log debris.

Access

Watershed access is limited to either air transport or irregular BC Rail service from Fort St. James to the south.

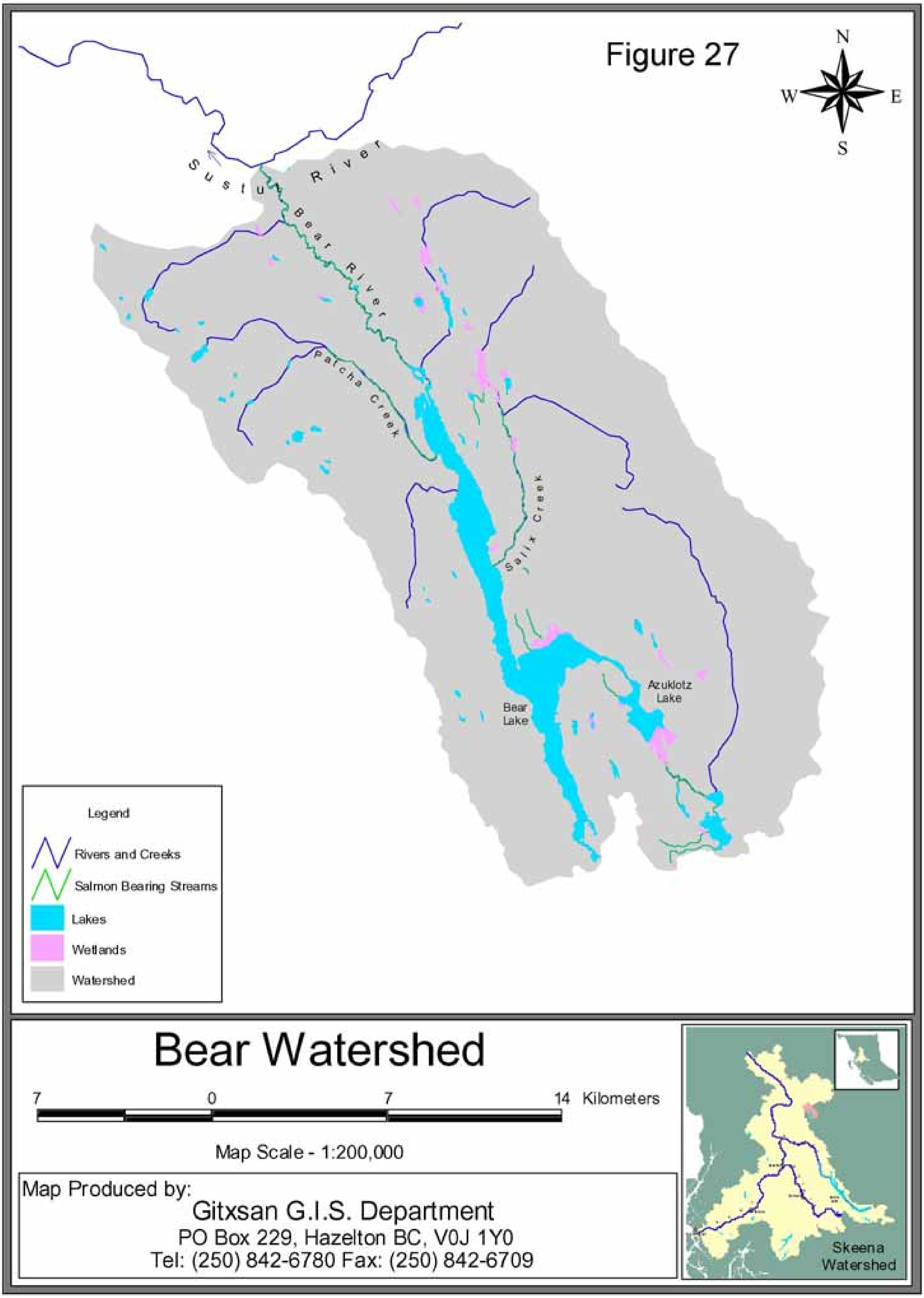


Figure 27
N
W
E
S
Sustut River
Bear River
Patcha Creek
Salix Creek
Azuklotz Lake
Bear Lake
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Bear Watershed
7 0 7 14 Kilometers
Map Scale - 1:200,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values and Resources

The Bear River Watershed is a relatively small, but biologically rich river system that has high value fish habitat. Fish species utilizing this habitat include: sockeye, kokanee, coho, pink, and chinook salmon, steelhead, and rainbow trout, Dolly Varden, bull trout and lake char, burbot, and lake and mountain whitefish. Hatlevik (1999) reported a very large bull trout population appearing in the Bear River. Adult chum and chum fry have been documented in the watershed, although at very low densities (Shirvell and Anderson 1990, Williams *et al.* 1985). The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage. It also provides strong cultural, economic and symbolic linkages, particularly for First Nation peoples, as well as supporting recreational and commercial fisheries.

Chinook

Bear River chinook salmon are one of the largest chinook populations in the Skeena system. It is estimated that as much as 85% of the Sustut chinook stock spawn in the Bear River. Bear River has exceptionally high chinook spawning densities, which are probably the maximum achievable by this species (Shervill and Anderson 1990). Four field studies have documented chinook in the Bear River: the Skeena River Salmon Investigation 1944-48 (Foskett 1948), a counting fence operation in 1972 (Kussat 1973), juvenile salmonid studies in 1984 (Williams *et al* 1985), and Shirvell and Anderson's (1990) "control" feasibility study.

In the mid 1980's, chinook escapement increased, partly in response to the Pacific Salmon Treaty management changes. Although Bear River chinook stock may not have reached the historical escapement estimates of the 1950's (average annual mean 18,750), the present trend is toward an increase in abundance, with annual mean escapements in the 1990's of 11,300 chinook (DFO 2001).

Chinook salmon enter Bear River throughout August with peak spawning in early September. Concentrated spawning occurs from 2 to 3 km downstream of the lake outlet adjacent to the airstrip, which has excellent gravel and many dunes resulting from redd construction (Shepherd 1976, Williams *et al.* 1985). The remainder of chinook spawning takes place from this locality downstream until 2 km above the Sustut confluence. Shepherd (1975) reported that Bear River chinook spawners had on the average smaller body size than fish from other similar age Skeena chinook runs, and that male fish were significantly smaller than females.

Peak emergence of chinook fry occurred during mid-June. Williams *et al.* (1985) trapped migrating fry with an inclined plane trap and found that most fry migrate downstream after July upon reaching a threshold size of 50 mm. Shervill and Anderson (1990) sampled one juvenile chinook per 1.4 m of stream in Bear River and suspected that the river is not an important chinook overwintering area. Their sampling methods utilized stream walk visual observations, daytime drift diving, electrofishing, night-time drift diving, and minnow trapping.

Pink

Bear River pink salmon account for a few percent of the Skeena system total escapement. Odd-year escapement is the dominant cohort with an annual mean escapement of 46,600 adult pink, and a range of 200 to 500,000 (in 1989). Even-year pink annual escapements have ranged from 700 to many years of no returns.

Pink salmon generally enter the Bear River in mid-August with peak spawning typically occurring in late August to early September. The principal spawning grounds are scattered in the lower and middle river, and pink salmon seldom seem to pass the falls 3.5 km below the Bear Lake outlet. Emergence from gravels is coincident with ice-break-up, with peak emergence levels in early May (Williams *et al.* 1985), followed by their seaward migration.

Chum

Adult chum and fry have been reported in the Bear River, though the numbers have only been one or two (Shirvell and Anderson 1990, Williams *et al.* 1985).

Sockeye

Historically, sockeye abundance in the Bear system was much greater than shown by the last 50 years of escapement (SEDS) data. To facilitate estimation of the sockeye salmon run to Bear Lake, a fence was constructed across the head of Bear River during 1947 and 1948. Direct counts, combined with recaptures from a fence-tagging program, demonstrated that a high proportion of the returning sockeye salmon spawned in the lake (FRB 1947, 1948). Brett (1952) estimated the number of Bear Lake spawning sockeye at 42,000, with only Azuklotz Creek supporting a >1,000 fish stream spawning population. Bear Lake sockeye spawners decreased greatly in the 1950's and have not recovered. Azuklotz Creek since 1950 has had variable escapement with no clear trends till the mid-1980's, when escapement increased to above pre-1950 escapement levels. At least some of the Azuklotz fry rearing takes place in Azuklotz Lake, which is separated from Bear Lake by a low gradient stream channel a few hundred meters long.

Sockeye adults typically return to Bear Lake in mid to late August, with peak spawning in mid-September. In the past, Bear Lake spawners used various beach and deep-water grounds scattered along the western lakeshore. Upper and lower Azuklotz Creek are now the principal spawning grounds, and Salix Creek supports minor numbers of spawners when flow conditions are high enough to permit entrance.

Fry emergence is followed by a lake residency of one year. In 1995, Shortreed's sampling (1998) found sockeye fry stomachs were 60% full and contained mostly *Daphnia* and *Heterocope*, both large and desirable food items. Although fry densities were relatively low with a mean of 132 fry/ha, mean weight was 3.9 g, which is above average for sockeye nursery lake fry in the Skeena system.

Coho

Knowledge about coho escapement numbers and spawning distribution is limited. Coho arrive in the Bear River generally throughout September and head to their spawning grounds. Scattered spawning occurs in the Bear River and in tributaries feeding Bear Lake, which include the lower reaches of Salix Creek, the un-named creek across the lake from Salix Creek, Azuklotz Creek, and the un-named tributary flowing into lower Azuklotz Creek (Finnegan 2002). There are serious conservation concerns with Bear system coho, due to very few coho adult spawners; 200 adults returned in 2001. Williams (1985) reported that peak fry emergence occurred in mid-April, with another larger peak occurring mid-June, and coho smolts migrating down Bear River in May.

Steelhead

The Bear Watershed supports one of the large summer run steelhead populations in the Skeena Watershed. The Bear River is well known for its large and abundant steelhead. Once steelhead bound for the Bear River enter the lower Skeena River, it is estimated that it takes about one month to reach the Bear River (Lough 1980, 1981). Bear River steelhead and lower Sustut River steelhead are grouped into a distinct sub-population due to run timing and unique life-histories (Baxter 1997b). Bear Lake is a known overwintering area (Chudyk 1972a), and it has been suggested that steelhead also overwinter in Sapolio Lake (Bustard 1993c) as well as in the mainstem Sustut River at the Bear confluence (Spence *et al.* 1990).

Bustard (1993c) estimated that the timing of steelhead spawning in Bear River started in mid-May, peaked in late May, and ended in early June. Chudyk (1972a) reported that 3,000 adult steelhead were spawning in the spring salmon spawning "ridge" on Bear River. Turnbull reported 700 steelhead spawners in late May 1989 in the mid-reach where chinook spawn (BC MoE files). Kelts are thought to migrate seaward immediately following spawning (Beere 2002).

Bustard (1993) estimated that in the Bear River, the timing of fry emergence was July 24 to August 5, with a peak around July 30. Williams *et al.* (1985) found that steelhead fry moved downstream into the lower Sustut River; he suggested that fry production in the Bear River was critical for seeding Sustut mainstem habitat. Steelhead smolt peak migration occurred at the beginning of May, before the onset of the freshet (Williams *et al.* 1985).

Fisheries

First Nations Traditional Use

Traditionally, Gitxsan from Kisgagaas and Wil Dahl'Ax extensively used the Bear Watershed. It is generally thought that pre-contact Bear Lake, by the nature of its location, was peripheral to Gitxsan, Tahltan, Tsetsaut, Sekanni and Carrier central territories, and may have been used, to some extent, by all of them at different times. Economically, the Gitxsan claimed exclusive trading privileges with the Carrier, Babine, and Sekanni, ascending inland as far as Bear Lake to trade (Morice 1978). According to Jenness (1943), the Gitxsan controlled pre-contact trade. Early Sekanni trade with groups to the west is indicated by the presence of iron trade goods among a group of Sekanni on the Parsnip River in 1793. These people informed Alexander McKenzie that they traded beaver skins for iron and dentalia from groups to the west. Jenness (1937) commenting on this, states that these articles were obtained from the Gitxsan at Bear Lake.

The very abundant and predictable sockeye salmon stocks provided the Gitxsan at Bear Lake with opportunity to harvest and preserve a large amount of high quality food in a relatively short time of intensive effort. The strong chinook run was the basis of a vigorous fishery as evidenced by the ten recorded fishing and processing sites described in Rabnett *et al.* (2001). The dominant sockeye run was the major focus, as it provided most of the high-quality dried fish needed to sustain the Gitxsan over the year, and to produce a trade item. Following the passage of the bulk of the sockeye, coho were available well into the autumn, providing both fresh and dried fish. Rainbow trout, steelhead, lake trout, and Dolly Varden char were also fished in the lake.

Although various fisheries occurred at Bear River and Lake, by far the most intensive fishing effort was expended at the weir immediately below Bear Lake village, also known as Wil Dahl'Ax. This productive weir, built across the shallow narrows between Bear and Sapolio Lakes, supplied the salmon needs for the Bear Lake people. Posts pounded into the river bottom, then overlaid with panels secured on the upstream side, supported a walkway across the top enabling access to barrel-type traps. These traps were fitted with a movable panel through which fish could be dipped, gaffed out, or released, depending on whether the species was desired. Patrick (2001) noted that one trap in the fence provided enough fish for everybody. The only other known weir location was at the shallows between Azuklotz and Bear Lakes; this fence also used only one trap (Patrick 2001).

Recreational Fisheries

The recreational fishery in the watershed is limited by access and the no fishing regulation applied to Bear River. Access for unguided and guided sport fishers is usually by aircraft or helicopter. A fishing lodge is located near the northwest corner of the lake that provides clients with game fish opportunities on Bear Lake and day trips to other nearby popular lakes, such as Babine Lake.

Development Activities

Development activities are proposed forest harvesting and expansion of the existing transportation infrastructure. Mineral occurrences do exist, although no properties have been developed. Bear Lake village is occupied year round in most years.

Forest Resource Development

Up to the present, there has been no logging development in the Bear Watershed. Proposed harvesting is scheduled for nine blocks northeast of Bear Lake and approximately two km east of the rail line. To the west of Bear River, extensive development is to be accessed by the proposed (2002) Sustut River crossing downstream of Birdflat Creek.

Transportation and Utilities

In 1970, construction of the BC Rail, Dease Lake Extension reached the watershed. The railway construction resulted in severe environmental impacts to fish, wildlife, and water quality, due to irregularities in design and construction practices. Portions of the roadbed were constructed relatively close to sections of the Bear River, where plastic glacial-lake deposits of stiff clay and silt underlie sand and gravel terraces. Consequently, earth slides and rotational failures into the river caused massive sediment deposition. The marginal drainage structures on tributary creek crossings, as well as deranged subsurface flows and seepage, caused more failures and sediment problems to occur over a number of years. In 1977, BC Rail and the Province abandoned construction of the line indefinitely. In the early 1990's the railroad was completed almost to the mouth of the Sustut River. In the past few years, the railroad has been used to transport logs out of the Minaret and Birdflat Creek area.

Bear Watershed Management Issues

The Bear Watershed is a relatively small, but biologically rich and diverse river system that has high value fish habitat. Fish species utilizing this habitat include sockeye, kokanee, coho, pink, and chinook salmon; steelhead, rainbow and bull trout, Dolly Varden, lake char, burbot, and lake and mountain whitefish. The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage. It also provides strong cultural, economic and symbolic linkages, particularly for First Nation peoples, as well as supporting recreational and commercial fisheries. Watershed access is limited to either air transport or irregular BC Rail service from Fort St. James to the south.

Bear River chinook salmon are one of the largest chinook populations in the Skeena system. The sockeye population is at less than historical escapements, but is apparently stable. There are serious conservation concerns with Bear system coho, due to very few coho adult spawners. The Bear Watershed supports one of the large summer run steelhead populations in the Skeena Watershed. Traditionally, Gitxsan from Kisgagaas and Wil Dahl'Ax extensively used the Bear Watershed. The recreational fishery in the watershed is limited by access and the no fishing regulation applied to Bear River.

Development activities are proposed forest harvesting and existing transportation concerns. Mineral occurrences do exist, although no properties have been developed. Up to the present, there has been no logging development in the Bear Watershed. Proposed harvesting is scheduled northeast of Bear Lake and to the west of Bear River. In 1970, construction of the BC Rail, Dease Lake Extension resulted in severe environmental impacts to fish, wildlife, and water quality, due to irregularities in design and construction practices.

An important direction for conservation activities in this watershed is the preservation of the critical fish habitat and maintaining high water quality.

Zymoetz Watershed

Environmental Setting

Location

The Zymoetz River Watershed is located in northwest British Columbia, in the south central portion of the Skeena Watershed. The Zymoetz River, locally known as the Copper River, flows generally westerly into the Skeena River left bank, approximately 8 km north-east of Terrace, BC. The headwater lakes in the north are approximately 20 km southwest of Smithers, BC.

Hydrology

The Zymoetz River is a sixth order system that drains a watershed area of approximately 3,028 km^2. It is a major tributary of the Skeena River contributing approximately 10% of the flow (Kerby 1984). The Zymoetz River mainstem arises from a chain of headwater lakes – Aldrich, Dennis and McDonell Lakes – and flows approximately 120 kilometres to the confluence with the Skeena River. The Zymoetz River drains a portion of the Bulkley Ranges of the Hazelton Mountains with approximately 20 salmon bearing streams and their tributaries. Elevation ranges from 120 m at the Skeena–Zymoetz River confluence, to 2740 m in the Howson Range. McDonell Lake is situated at 830 m.

Snowmelt controls the hydrology with a mean annual discharge for the system of 105 m^3/s. Monthly mean discharge ranges from a low in March of 25.7 m^3/s to a high in June of 358 m^3/s (WSC gauging station 08EF005, for a thirty year record period, 1963–1993). The river shows a prolonged late May/early June discharge peak due to snowmelt and in most years one or more fall floods following rainstorms. In about 40% of the years the annual peak flood is one of the fall storm events.

The headwaters of the Zymoetz Watershed include Hudson Bay Mountain (2250 m) near Smithers, the rugged and heavily glaciated Howson Range, the Burnie Lakes basin, and the northern slopes of Atna Peak at the head of the Clore River. Important tributaries are Clore River, draining 625 km^2, Kitnayakwa Creek with a drainage area of 274 km^2, and Limonite Creek draining 83 km^2. Hydrological characteristics, landforms, and stream processes vary greatly throughout the drainage due to its large size and transitional climatic nature.

Geography

Regional bedrock consists mainly of sedimentary and volcanic rocks of early Jurassic to Cretaceous age with small intrusions of late Cretaceous to early Tertiary granitic rocks (Hutchison *et al.* 1979). Red volcanic rocks of the Telkwa Formation are abundant in the central part of from the watershed, and lend a characteristic reddish colour to turbid floodwaters. Following deglaciation, as valley glaciers melted, silty-gravelly kame deposits were deposited against the lower valley sides, where they now form terraces. The long, comparatively narrow valley bottom was filled with glacio-fluvial sediments that were dissected and terraced when the river down cuts (Clague 1984).

The forested valleys and hill slopes are mainly covered by the Coastal Western Hemlock biogeoclimatic zone that changes into the Mountain Hemlock at higher elevations. The upper Zymoetz River Watershed is characterized by its broad valley that passes by transition into the Nechako Plateau and is dominated by the Sub-Boreal Spruce zone with Engelmann Spruce–Subalpine Fir at higher elevations. Engelmann Spruce–Subalpine Fir dominates forested areas in the upper Clore and Burnie Rivers.

Stream Channels

The Zymoetz River has always been a volatile system subject to extreme discharges and channel changes. The river experienced extreme fall flood events in 1935, 1936, 1945, 1951, 1961, 1962, 1964, 1966, 1974, 1978, 1987, 1988, 1991, 1992 and 1993, while snow melt extreme flood events occurred in 1936 and 1950, with a 1954 mid-winter thaw flood event (Septer and Schwab 1995).

The Zymoetz River forms a wandering gravel bed channel for about 6 km above its mouth, then is confined within the lower canyon for 3 km, and the upper canyon for 2 km. There is a 10 km stretch of unconfined river between the canyons. The river then widens out again to a multichannel wandering gravel bed river for about 20 km up to the Clore River confluence. Typical elements of wandering gravel bed configuration include a wide continuous floodplain with a mostly unconfined channel, continuous lateral bank erosion, and several flood channels. Zymoetz River above the Clore River is confined by numerous bedrock obstructions. In his assessment of Zymoetz River fluvial hazards for Pacific Northern Gas's pipeline route, Miles (1991) stated that dramatic changes in channel morphometry had occurred in the Zymoetz River. Subsequently, Weiland and Schwab (1996) conducted a study to provide geomorphologic information on the floodplain, to document the history of channel changes, and to provide management interpretations.

The study assessed historic channel changes from 1949 to 1992, noting that in the time period up to 1973, the channel was characterized as relatively stable. Large/warm autumn rainstorms and related extreme peak flows are considered the primary reason for the onset of lateral channel instability and bank erosion commencing in 1974. During the 100-year flood in 1978, bank erosion, rapid meander bend migration, and channel avulsions mobilized a large bedload volume. This large volume of highly mobile bedload will continue to pulse down-channel and destabilize the floodplain for many years to come.

The distribution of large organic debris (LOD) within the lower mainstem is similar to most coastal systems where the majority of LOD is ephemeral, and only piles deposited during extreme high waters will be retained for any length of time. Typically these piles will be left high above normal water levels and are consequently of little value to fish habitat. Approximately 70% of the LOD piles in this system are ephemeral (Pollard 1996).

Riparian habitat has been substantially reduced within the lower watershed, first by fire, and later through forest development and pipe line and electric transmission corridor clearing activities. Road construction has caused a loss of 25 to 30% of the off-channel habitat (Lewis & Buchanan 1998).

Access

Logging roads that leave Highway 16 provides access to both the upper and lower portions of the Zymoetz River Watershed. From Smithers, the McDonell Forest Service Road (FSR) accesses all the major tributaries north and south of the Zymoetz, as far west as the mid-reaches of Mulwain Creek. The Bulkley/Cassiar Forest District administers forest resource development in the upper watershed downstream to Red Canyon Creek, while the Kalum Forest District administers the lower watershed. From Terrace, access to the lower watershed is by the Copper River FSR, which is sited on the west side of the river and extends to the fossil beds approximately 50 km upstream.

In the past, the Copper River FSR provided access upstream on the Zymoetz River past Limonite Creek; however, this road has been washed out. After departing the river, the road followed the Pacific Northern Gas (PNG) gas pipeline route through the Limonite Creek drainage and then over the Telkwa Pass. Access to the middle watershed is now via the Kleanza Mainline, which crosses the headwaters of Nogold Creek and descends to the Zymoetz River 58 km upstream of the Skeena confluence. This road proceeds up the Zymoetz River to within two km of Red Canyon Creek.

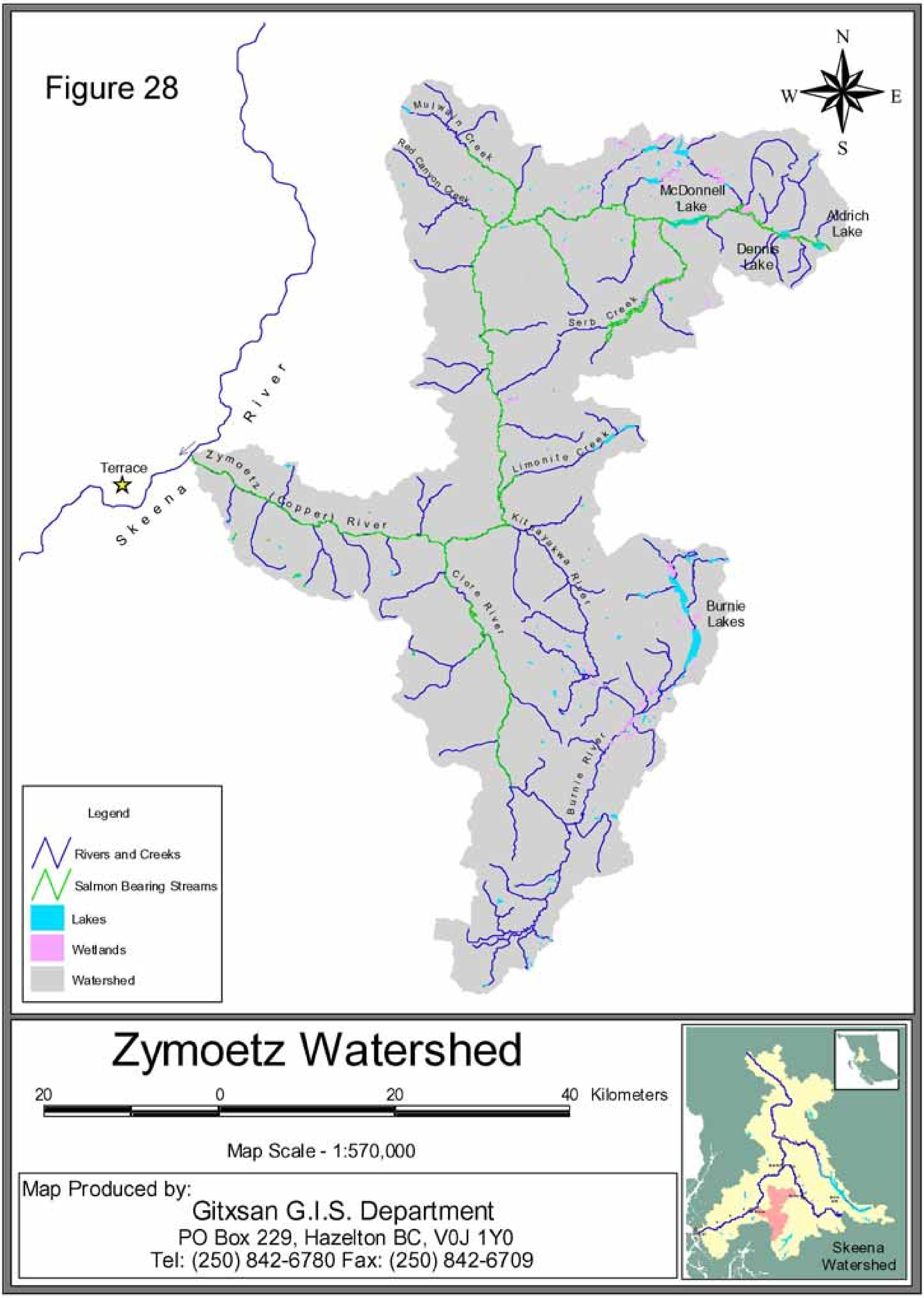


Figure 28
N
W
E
S
Mulwain Creek
Red Canyon Creek
McDonnell Lake
Aldrich Lake
Dennis Lake
Serb Creek
Skeena River
Terrace
Zymoetz (Copper) River
Limonite Creek
Kitnayakwa River
Clore River
Burnie Lakes
Burnie River
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Zymoetz Watershed
20 0 20 40 Kilometers
Map Scale - 1:570,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values & Resources

High fisheries values are prevalent throughout the Zymoetz Watershed with use by all species of Pacific salmon, steelhead, rainbow trout, burbot, cutthroat trout, Dolly Varden char, Rocky Mountain whitefish, sculpins, longnose dace, resident sockeye (kokanee), longnose sucker, bull trout, peamouth chub (DFO 1991b, DFO 1991c Triton 1999). Burbot and kokanee are present only in Burnie Lakes (BC MoE files). Cutthroat and rainbow trout, bull trout, mountain whitefish, as well as Dolly Varden char, are found throughout the river headwaters and accessible portions of most tributaries.

The Zymoetz River is relatively steep and is punctuated by two canyons, 6.4 and 19.6 km upstream of the Skeena confluence. Access by pink and chum salmon to the Zymoetz is impaired by gradient–induced barriers on the mainstem in these canyons and prevented by blockages (falls, chutes, and beaver dams) on some tributaries.

Chinook

Chinook enter the Zymoetz River in late June, with spawning occurring from the end of August to the end of September. The presence of chinook salmon is documented (DFO 1991c) in the Zymoetz River from the second canyon upstream to Limonite Creek, although no barriers exist that would definitely prevent them from migrating further up the system. Culp (2002) reports, however, that chinook salmon have been consistently observed for ten years at Corner Creek, close to Red Canyon Creek. Release of enhanced chinook at McDonell Lake has resulted in no observations of chinook adults returning there. Critical spawning habitat occurs in patches throughout the mainstem, the lower 3 km reach of Limonite Creek, and in the lower reach of Thomas Creek, a tributary of the Clore. The lower reach of Salmon Run Creek has a high concentration of chinook spawners (Kofoed 2001). The lower portion of Cole Creek has not been accessible to chinook for several years due to beaver dams (Culp 2002). Anecdotal information suggests Simpson Creek supports chinook spawners.

Information concerning historical chinook escapement is limited to the lower Zymoetz River, with estimates available from 1968 until the present. The average annual escapement was less than 300 chinook in the 1970's, increasing to an average of 700 chinook spawners in the 1980's. In the 1990's, an average of 375 adult chinook returned annually (DFO 1991c, DFO 2001).

Pink

Pink salmon escapement in the Zymoetz system has been recorded since the early 1970's, and is relatively small. The last two decades averaged approximately 2,000 pinks annually, with annual ranges from 75 to 35,000 fish. Pink salmon enter the Zymoetz River in August and spawn in September and October within the largely unconfined first reach below the canyon. Upon emergence from the gravel, pink fry migrate downstream to the ocean (DFO 1991c).

Chum

Chum salmon escapement into the Zymoetz River was recorded from 1960 to 1989. The 1960's annual average escapement was 50 chum salmon; the 1970's annual average escapement was 322 chum; and the 1980's annual average escapement was 50 chum. The highest escapement estimate was in 1978, with 750 adult chum returns. Chum salmon enter the Zymoetz River in August and spawn in September and October within the largely unconfined first reach below the canyon (DFO 1991c, DFO 2001). It is likely that habitat loss due to the Highway 16 bridge repositioning and channelization efforts below the bridge in the 1970's and early 1980's, have contributed to low chum returns.

Sockeye

Sockeye escapement records for the Zymoetz River indicate moderate fluctuations of abundance in the last fifty years. Average annual escapement in the 1950's was 2,550 sockeye, ranging from 5,000 to 750 fish. The 1960's and 1970's annual average escapements were under 1,500 fish, while the 1980's average annual escapement was 1,860 fish. The 1990's escapement data is incomplete; however, the 1990 to 1994 average annual escapement was 3,650 sockeye, with a high of 7,500 in 1993 (DFO 1991b, DFO 2001).

Sockeye enter the Zymoetz River in July, spawning primarily during the months of August and September in the upper watershed. Critical spawning areas are in the Zymoetz River mainstem, from Serb Creek to McDonell Lake, and the reaches upstream of McDonell Lake to Aldrich Lake. Upstream of McDonell Lake, the meandering low gradient reaches, as well as the lakes themselves, are stable with moderated flow and temperature regimes. This area provides important rearing and overwintering habitats. Several inlet streams to McDonell, Dennis and Aldrich Lakes, particularly lower Silvern Creek, provide excellent spawning grounds (DFO 1991b).

Coho

The Upper Zymoetz River shows a long-term decline in coho from about 1960 to 1990. Escapements in the 1950's averaged 1,861; in the 1970's, 622. The three counts made in the 1980's and 1990's averaged only 7 coho. Coho escapements in the lower portion of the Zymoetz River have declined since 1972. The 1970's average was 1,925 coho, and the 1990's average, 325. The current status of coho in this watershed is poorly known. The upper watershed experienced a recovery in coho escapement in 1990, when the escapement was 776.

The lower Zymoetz River coho enter the river in early August, and spawn throughout the months of September to December. Anecdotal information indicates that there are a distinct upper river and lower river coho run components. Critical spawning habitat in the lower Zymoetz River includes the lower 8.5 km reach of Clore River and the lower reach of Salmon Run and Thomas Creeks. Moderate concentrations of spawning occur in the lower mainstem side channels. In the upper Zymoetz River, spawning occurs in the mainstem at the outflow of McDonell Lake and in the tributaries: Coal Creek, Sandstone Creek, Willow Creek, Passby Creek, Silvern Creek, and Serb Creek. In addition, the lower ends of many of the small tributaries flowing into the upper Zymoetz mainstem between McDonell and Aldrich Lakes support coho spawners (DFO 1991b, DFO 1991c).

Coho juvenile rearing and overwintering areas are found throughout the Zymoetz River Watershed, probably occurring in all accessible low gradient habitat. Critical rearing and overwintering habitat for coho include the off channel habitats adjacent to the mainstem between McDonell and Aldrich Lakes, and in the lakes themselves (Triton 1999).

Steelhead

Steelhead trout are the most intensely documented fish species within the Zymoetz River Watershed, most likely due to the high value of the recreational steelhead fishery. Escapement estimates are not available. Since 1999, Terrace Salmonid Enhancement Society has conducted steelhead enumerations in the Zymoetz and Clore Rivers (Culp 2002).

Adult steelhead enter the system from July to November and spawn the subsequent year in late May and early June. Zymoetz River steelhead are believed to be a mixture of summer run and winter run fish, though they are predominately summer run (Tetreau 1997, *cited in* Lewis and Buchanan 1998). Local anglers report that a spring run of steelhead enters the system in March and April (J. Culp, G. Llewellyn, & B. Hill 1997, *cited in* Lewis and Buchanan 1998). This has not been clearly documented to date, but is clearly feasible considering the proximity of Kitsumkalum and Lakelse Rivers, both of which have strong spring runs of steelhead. Repeat spawners compose 16% of Zymoetz River steelhead, similar to the proportion (17.9%) found within the Kispiox River (Whately 1977).

Most summer steelhead spawn in the upper 20 km of the river, with 15% of the fish spawning at the outlet of McDonell Lake. Approximately 30% of the steelhead appear to spawn in tributary streams including Serb Creek, Willow Creek, and Coal Creek, and in the mainstem river vicinity of Coal to Sandstone Creeks (Lewis and Buchanan, 1998). Anecdotal information suggests that Clore River also has a significant run though there is little information available on it.

Steelhead overwinter in McDonell Lake and in areas of the mainstem between Limonite Creek and the Clore River; the latter also provides some overwintering habitat. Radio telemetry studies conducted on Zymoetz River steelhead in 1978 to 1979 indicate that a proportion of the steelhead may be wintering in the Skeena River and returning to the Zymoetz system in the spring.

Fisheries

First Nations Traditional Uses

First Nations traditional use of the upper Zymoetz River Watershed by Gitxsan and Wet'suwet'en people was extensive and varied with village sites, home places, and fish houses. A major aboriginal grease trail provided connection from the upper to the lower Zymoetz River and to the Skeena River, with a branch trail forking through Limonite Creek and passing down the Telkwa River. The fishery primarily utilized a weir at the outlet of McDonell Lake and spears at Six Mile Flats, close to Dennis Lake (Rabnett *et al.* 2001, Naziel 1997). Information is unknown about aboriginal fishery activities on the lower Zymoetz River; though the mouth of the river is within IR #5, and it is assumed that a fishery was operated at the mouth and possibly the first canyon.

Recreational Fisheries

The Zymoetz River is considered one of the top ten steelhead rivers in BC (Bustard 1975). Since the advent of logging, angling pressure has increased over the last 35 years, particularly in the lower and upper reaches. Angler success rates appear to be dropping from their high point in 1975, though reasons are difficult to clearly define. The upper reaches of the watershed have been designated as a special management area, and special restrictions apply. Estimated annual steelhead catch is 1,700 fish, which includes guided angling effort (Lewis and Buchanan 1998).

Creel census data was collected in five studies over the period 1974 to 1990. Almost all (94%) of the anglers were non-guided with greatest catch success from September 15-30, a reflection of when river conditions were best for angling. Angling restrictions regulate steelhead fishing times and methods in the Zymoetz River. The river is a "classified water" from September 1 to October 31, with Class 1 licensing upstream of Limonite Creek and Class 2 licensing downstream. This classification requires that a license be purchased by anglers over and above the basic angling license. For the past several years, a kill ban has been instituted for the entire Skeena River Watershed to protect steelhead runs from harvest. Overwintering protection is afforded by angling ban regulations between January 1 and June 15, from McDonell Lake downstream 3 km, between signs in Zymoetz Canyon, and above the signs at the transmission line crossing (Anonymous 2001a).

Enhancement Activities

In 1907, the Department of Marine and Fisheries blasted a rockslide (in one or the other of the lower canyons) that had obstructed migration since 1891, and sockeye showed up at McDonell Lake that fall. In 1968, a rockslide was blasted through approximately 10 km upstream from the mouth; in 1973, a fishway was blasted around a series of difficult falls located seven kilometres upstream from the confluence. In 1980, the lower reach of Serb Creek was diverted to extend and improve spawning and rearing habitat, and gravel was placed to rehabilitate the outlet of McDonell Lake. An incubation box was placed at Fossil Creek, and was utilized from 1981 to 1983. Brood stock collection and hatchery operations were undertaken from 1981 to 1985, with steelhead fry releases in 1981, 1983, and 1985 and chinook fry in 1984 and 1985. All fry releases were in the upper Zymoetz River Watershed (BC MoE).

Development Activities

The primary human activities in the Zymoetz River Watershed are recreation, forest harvesting activities, mining, and linear developments including electric transmission lines and gas pipelines. Population and settlement impacts are very light and limited to a segment of floodplain close to the river mouth.

Forest Resource Development

The lower and middle portions of the watershed are located in the Kalum Timber Supply Area (TSA), with administration from Terrace. The portion of watershed north and east of Red Canyon Creek is located in the Bulkley-Cassiar Forest District and administered from Smithers. Burnie River upstream of the Clore River is located in the Morice TSA and administered from Houston. All planning directions and efforts originate with the centralized Ministry of Sustainable Resource Management in Smithers. For the last 45 years, forest harvesting has proceeded at a fairly steady pace and continues today.

Forest harvesting began in the late 1950's under Tree Farm License #1, (TFL) with the construction of a mainline forestry road up the lower river. By 1965, the road had reached Limonite Creek. Since that time, road systems have been developed into all the major tributaries and most of the minor tributaries. In 1985, the Kleanza road was extended into the Zymoetz drainage north of Nogold Creek and in 1995 approached the TFL boundary. Currently, total area clearcut logged is just under 10,000 ha, and many second pass blocks are being logged. Harvesting and road building techniques have impacted the fish producing potential and habitat in the lower watershed (Pollard 1996).

Timber harvesting and road construction activities have been ongoing in the upper Zymoetz River Watershed from 1968 to the present. Early harvesting began in the upper reaches; however, with construction of the Copper Forest Service Road (FSR) north of McDonell Lake in approximately 1980, access and development of Hankin, Willow, Passby, Sandstone, Coal and Mulwain Creeks have been relatively rapid. Current proposed developments in areas west of Mulwain and Lee Creeks have been identified as potentially highly hazardous terrain, due to erodible soils and the presence of natural failures. Timber harvesting has not occurred in the Burnie River drainage to date, though Canfor's current Forest Development Plans (FDPs) do have major proposed developments for the area southeast of lower Burnie Lake.

The Watershed Restoration Program (WRP) was initiated in 1995 to restore the terrestrial and aquatic productivity of watersheds negatively impacted by forest development and harvesting. The upper Zymoetz Watershed received an overview fish and riparian assessment in 1999 (Triton 1999), which found that forestry-related impacts to fisheries values generally were low. A total of 131 potential impacts were identified within the study area; the majority (104 or 80%) were related to road crossings. Of the total potential impact, 15 were rated as high priority sites, 41 as moderate priority, and 75 as low priority.

The lower Zymoetz Watershed has received numerous assessments under WRP. The 1995 Fisheries Assessment Overview (Pollard 1996) identified 45 sites requiring restoration or further assessment, with the majority of impacts acute and occurring 20 to 30 years in the past. Most of these sites were regenerating naturally or were irreparable, and while the majority of sedimentation sources are natural, these sources have been accelerated by forestry operations. The most significant forestry impact on fisheries values is the restriction or loss of critical rearing and overwintering habitat because of road construction. Recommendations were made for more in-depth fisheries assessments and analysis.

Since 1996, the lower watershed has received approximately twelve studies that included detailed aquatic, riparian, and upslope site impact assessments along with several reports concerning aquatic habitat rehabilitative site works. Various rehabilitative site works have been completed, as well as approximately 50 km of road deactivated (Ottens 2002). WRP has completed an interim Restoration Plan (2002-2006) for the lower Zymoetz. The estimated cost of implementing this plan is $228K. Proposed activities will include approximately 10 ha of landslide treatments, 30 ha of riparian treatments, and access and habitat improvements to at least 10 ha of salmonid rearing areas. Six sub-basins that have been designated as high priority. It is largely unknown what the future holds with the demise of FRBC and the uncertain future of Skeena Cellulose Incorporated (SCI).

Riparian habitat, especially off-channel in the lower Zymoetz Valley, has been substantially reduced. Changes in channel morphology have been accelerated with harvesting of floodplain forests and road building. While it is difficult to quantify exactly how much change is related to forestry, the end result is a decrease in fisheries habitat.

Currently, trends for forest development activities are uncertain. SCI, the present holder of TFL # 1, with the substantial cut in the lower Zymoetz drainage, has terminated operations due to a series of financial difficulties. This also affects the upper watershed, as the SCI Smithers mill is a buyer for a portion of the Ministry of Forests Small Business cut there. The transfer of the majority of the Small Business cut eastwards, to accommodate beetle concerns on the Nechako Plateau, complicates planning for future harvest and development. SCI's future is impossible to predict, and proposed Forest Development Plans are tabled for both the upper and lower watershed.

The sub-regional Bulkley Lands and Resources Management Plan (LRMP) and the Kalum LRMP both have management intents and objectives that are intended to protect the high fisheries values, fish habitat, water quality, aesthetics of the Zymoetz Watershed, and opportunities for consumptive and non-consumptive human use of fish. The Kalum LRMP has directed a Special Management Zone for the upper Zymoetz River. This area was established to conserve its high value fish and fish habitat and a quality angling experience.

Mineral Resource Development

Approximately 50 known mineral occurrences are dispersed throughout the watershed. Mineral resource development in regards to developed prospects and past producers is primarily centered in the upper watershed. Precious and base metal, vein-style mineralization predominates, although coal and copper-molybdenum bulk tonnage is noteworthy. Many mineral prospects have been worked on from 1910 up to the present, but only the Duthie Mine advanced to production. Duthie Mine, located 12 km west of Smithers on the McDonell Lake road, operated from 1922 to its closing in the 1930's, due to poor markets. It operated again from 1950 to 1953; sporadic operations at a small scale continued into the mid 1980's. During its productive life, 47,000 tonnes of tailings flowed down to a swampy area below the mill where they were impounded in settling ponds.

Field investigations from 1982 to 1983 (Maclean 1983) found that the dyke around the old tailings was failing, causing contaminated run-off to Henderson Creek, subsequently to Glacial Creek and then Aldrich Lake. Aldrich Lake flows into the Zymoetz River. The tailings were found to have a high concentration of arsenic, iron, aluminum and lead. Metal levels were found in Glacial Creek and Aldrich Lake that exceeded water quality criteria for cadmium, copper, lead and zinc. Arsenic concentrations in the lake were found to exceed maximum allowable water drinking standards. Lake bottom sediments had elevated metals, but there was no corresponding evidence of metal contamination in fish. Subsequent covering of the tailings and diversion of leachate were carried out, and in 1987 the tailings were contained behind a berm. Sampling in 1993 found that the tailings were still generating acid rock drainage (ARD). A remediation plan and mitigation of the ARD were implemented, with work carried out in the last several years.

Transportation and Utilities

Highway 16 crosses the Zymoetz River near its mouth. In 1964, the Highway 16 Bridge was relocated from the fan apex to its present location. The span placement was threatened by the 1978 extreme high water event. Subsequently, work was carried out to stabilize the upstream banks of the fan channel approaching the bridge. This work resulted in moving the fan apex significantly downstream from its natural location, and consequently 70% of the floodplain was cut off (Pollard 1996).

Pacific Northern Gas (PNG) and BC Hydro both utilize the east-west corridor that passes through the Telkwa River, over the Telkwa Pass, then downstream on Limonite Creek and Zymoetz River to the Skeena River. Between 1967 and 1975, the natural gas pipeline was constructed, with large sections of the original pipeline built alongside the Copper River Forestry Road. The road itself was built on the floodplain, often near the channel. In several locations, the pipeline crossed the river. By 1975, the BC Hydro power line, located mid-slope along the north side of the valley, was near completion. The right-of-way encroaches on the riparian zone of the Zymoetz River in several places; however, in general, the loss of riparian habitat is not significant.

Following severe bank erosion during the 1978 flood event, rip-rap channel protection was placed in reaches 5 and 6a. In reach 6a, the road and the pipeline were routed on opposite riverbanks with the rip-rap forcing the river channel into a straight flume. The 1978 flood caused several new channel crossings to be installed for the pipeline, as well as extensive road relocation between Kitnayakwa and Limonite Creeks, where the road was destroyed. The Copper FSR was also relocated at the Clore Junction. After additional wash outs, the natural gas pipeline was relocated to a position on the southern hill slope over most of the route.

During the 1980's through to 1991, repeated road washouts required repair work and minor rerouting at the Clore Junction (km 34) and reaches 3, 5, and 6, along with rip-rap maintenance in reach 6. In 1991 and 1992, the second and third major road relocations downstream of the Clore Junction were necessary after flooding.

Zymoetz River Management Issues

High fisheries values are prevalent throughout the Zymoetz River Watershed with use by all species of Pacific salmon, burbot, cutthroat trout, Dolly Varden char, Rocky Mountain whitefish, sculpins, longnose dace, kokanee, longnose sucker, bull trout, peamouth chub and resident rainbow trout. First Nations traditional use of the upper Zymoetz River Watershed by Gitxsan, Kitselas, and Wet'suwet'en people was extensive and varied. The Zymoetz River is considered one of the top ten steelhead rivers in BC and supports a high value, recreational steelhead fishery. Since the advent of logging road access, angling pressure has increased over the last 35 years, particularly in the lower and upper reaches. Angler success rates appear to be dropping from the mid-1970's.

Sockeye escapement records for the Zymoetz River indicate moderate fluctuations of abundance in the last fifty years. The Upper Zymoetz River shows a long-term decline in coho from about 1960 to 1990. Chinook and pink spawning populations appear to be stable, while chum average escapements are highly variable. Enhancement activities have included facilitating fish passage through slide removal, as well as habitat enhancement projects under the auspices of SEP and WRP. Proposed mitigation of logging related problems is projected to cost several million dollars. In the upper Zymoetz River, brood collection and release of steelhead and chinook fry occurred.

The primary human activities in the Zymoetz River Watershed are recreation, forest harvesting activities, mining, and linear developments including electric transmission lines and gas pipelines. Population and settlement impacts are very light and limited to segments of floodplain close to the river mouth.

Most salmon bearing streams in the watershed have logging development in upland areas, and there are concerns about site specific as well as cumulative impacts to fish habitats. Land use activities have severely impacted riparian areas, particularly in the lower Zymoetz mainstem and off-channel habitats. Riparian habitat, especially off-channel habitat in the lower Zymoetz Valley, has been substantially reduced. Changes in channel morphology have been accelerated with harvesting of floodplain forests and road building and power line construction. While it is difficult to quantify exactly how much change is related to logging, the end result is a decrease in fisheries habitat.

A continuing escapement inventory of salmon stocks to spawning streams throughout the watershed is critical to managing stocks and ensuring adequate spawner returns. Mixed stock, ocean, and river harvesting rates need to be reduced to reduce the current uncertainty about meeting escapement requirements. An important direction for conservation activities in this watershed is the preservation of the critical fish habitat. The priority in conserving fish habitat in the Zymoetz Watershed is to ensure high water quality.

Kitsumkalum Watershed

Environmental Setting

Location

The Kitsumkalum River (also known as the Kalum River) flows southerly 30 km from Kitsumkalum Lake to join the Skeena River right bank, two km west of Terrace. The watershed is bounded on the south by the Skeena River floodplain, to the north by the Tseax River drainage flowing to the Nass River, to the west by northern Kitimat Range, and to the east by the Nass Range. Locally, the Kalum River upstream of Kalum Lake is known as the Beaver River, and the section of the Kalum River from the lake outlet to the canyon is known as the upper Kalum. From the canyon downstream to the Skeena River confluence, local usage denotes the river as the lower Kalum.

Hydrology

The Kitsumkalum Watershed drains the northern portion of the broad low-lying Kitsumkalum-Kitimat trough. The Kitsumkalum is a fifth order stream that drains an approximate area of 2,255 km^2. Elevation ranges from 55 m to just over 2300 m with spectacular mountains to the west and east, rising rapidly from the valley floor to alpine rock and glacial features. The Kalum River has a late May to early June discharge peak, due to snowmelt, with subsequent peaks in most years due to fall rains, generally in October and November. Deep Creek, a tributary of the Kitsumkalum and a portion of the District of Terrace water supply, is the location of the only hydrometric station (08EG017) currently operating within the watershed. Terrace precipitation records show annual precipitation of 1313 mm per year, with 70% falling as rain and 30% falling as snow. Precipitation increases in relation to the elevation gained in the watershed, especially in the Kitimat Range. Kitsumkalum Lake somewhat buffers the lower river from extreme flow conditions.

Kitsumkalum Lake, the canyons at 8 km and 11 km, and the Skeena River confluence control the slope of the river. The lower reaches of tributaries draining east into the Kalum system are generally low gradient (less than 2%), with mid and upper reaches steepening to their headwaters. The exceptions to this general profile are the upper Kitsumkalum River and the Nelson River, which have relatively low gradients for 40 km and 22 km respectively. Both streams carry significant amounts of glacial silt from glaciers in their headwaters. The tributaries draining westward into the Kalum basin trough have relatively low gradients in their lower, high value fish bearing reaches, and then quickly steepen in their headwaters. Clear Creek and Cedar River drain the generally low gradient northern section of the trough.

Kitsumkalum Lake at 122 m elevation has a surface area of 18 km^2 and a mean depth of 81 m. The shoreline of the lake is predominantly rocky and slopes steeply into the lake, restricting productive littoral areas to the shallows at the mouths of tributary streams. The lake is glacially turbid, with an average euphotic zone depth of only 3.8 m, thus limiting primary productivity by light availability. Summer surface water temperature averages 12^0 C. The average thermocline depth in late summer is 25.5 m. Total dissolved solids of 28 mg/L represent low nutrient levels.

Zooplankton biomass is low and consists mainly of diaptomid copepods. As a result, Kitsumkalum Lake has the lowest productivity of any BC sockeye nursery lake studied (Shortreed *et al.* 1998). Primarily because of its high turbidity and its fast flushing rate, Kitsumkalum Lake is considered highly oligotrophic (Shortreed, *cited in* Remington 1996). Redsand Lake, 2 km below Kitsumkalum Lake, has a maximum depth of 16 m, total dissolved solids of 33 mg/L, with an estimated littoral area (<6 m) of 55% of the total area (Grieves 1996). Treston (Mud) Lake, immediately below Redsand Lake, has a maximum depth of 37m, total dissolved solids of 31 mg/L, and an estimated littoral area (<6m) of 50% of the total area.

For much of the summer and fall, the Kitsumkalum River is turbid due to the significant glacial areas in the watershed. This opaque water hinders the observation and recording of fish escapement.

Water Quality

The City of Terrace landfill, located on the first gravel terrace immediately above the Kitsumkalum River floodplain, has an intermittent creek passing through the landfill and draining to the river. An initial investigation in 1992 (Gartner Lee 1993) showed relatively minor elevated leachate concentrations in the intermittent creek. The pollutants are much diluted in the Kitsumkalum River, where the estimated dilution is 61,500:1.

About 1964, the City of Terrace dammed Deep Creek in its headwaters and diverted water into Spring Creek (Hancock 1983). Seven licenses to withdraw water exist on Deep Creek. The lower five km of Spring Creek have been influenced by rural residential development along its banks with the creek supporting water removal under 13 licenses. The City of Terrace has a dam for water impoundment with water removal of 0.289 m^3/s.

Geography

The Kalum-Kitimat trough is the result of the deep-seated boundary fault between the Kitimat Range to the west and the Nass Range to the east. The Kitimat Range bedrock geology is described as Late Cretaceous to Early Tertiary plutonic rocks that form part of the Coastal Mountain Belt. The Nass Range bedrock consists of Early and Middle Jurassic volcanic and minor sedimentary rocks of the Hazelton Group (Clague 1984).

The surficial geology of the Kitsumkalum valley bottom is a legacy of the last Pleistocene glaciation. As deglaciation proceeded, the rising sea advanced far up the depressed valleys. A huge valley glacier retreated up the Kitsumkalum Valley with three standstills, forming large sand and gravel deposits. The present day Kalum Lake is impounded by one of these sandy glacial deposits. In the 10,000 years since deglaciation, the valley bottom was modified by stream erosion and minor deposition of sand, gravel, and silts (Gottesfeld 1985).

Vegetation in the wide, gently sloping valley and on the low elevation slopes consists of forest stands of spruce, hemlock, and limited amounts of cedar representing the Coastal Western Hemlock (CWH) biogeoclimatic zone. As elevation is gained, the CWH is replaced by the Mountain Hemlock zone, while higher again lies the Alpine Tundra zone (Banner *et al.* 1993).

Stream Channels

The lower Kitsumkalum River from Kalum Lake to the Skeena River is a gravel-bed sinuous river meandering within a valley flat that is 1 to 2 km wide. In the last 10,000 years, the glacio-fluvial deposits of the valley were incised and terraced by the Kalum River (Clague and Hiscock 1976). Three canyons were cut into Hazelton formation rocks. The largest, north of Deep Creek (Kitsumkalum IR #2), was widened in the 1920's to allow cedar poles to be floated down the river from the Rosswood area (Kerby 1984). The other two confined canyon sections are between Lean-to and Canyon Creeks. Stream gradient in the Kitsumkalum River ranges from 0.1% below the lake to 0.5% downstream of the main canyon. The river generally flows free throughout the year although shelf and anchor ice forms during colder winters.

The river mainstream has made notable shifts in its course since 1947, with log drives having an appreciable effect. Beginning in the 1940's, through to the mid 1950's, logs were dumped into Kalum Lake and at several other mainstem locations and driven down the river (McNicol 1999). Modifications to the river in 1954 to 1956 to facilitate log movement included: placement of guard logs; log cribbing; rock berms, armouring and sheer sticks on the outside of river bends; dyking to close off back-channels; construction of log storage sites; and the use of dynamite and heavy equipment to dislodge log jams (Grieve 1996, Paish 1975).

Historically, the outlets of both Kalum and Treston (Mud) Lakes were major spawning beds, until large amounts of gravel were removed to aid log driving (G. Llewellyn, *cited in* Grieves 1996). River drives of logs caused scouring and increased bedload movement in the channel. The half-century since the log drives has more or less stabilized the main channel. The large amounts of habitat lost by closing off back channels has not been restored or reconnected. Culp (2002) reports that for several years, substantial numbers of chinook spawners have been observed at the outlet of Kalum Lake; recently, more chinook have been spawning at the outlet of Mud Lake.

Watershed Restoration Program overview assessments (Grieve 1996, Triton 1996) noted many logging related channel impacts on watershed tributaries. These included: changed channel morphology, increased bedload movement, bank failures, sediment loading, and debris accumulation. Several streams, particularly Star Creek and Cedar River, exhibit heavy erosion and scour.

Access

Currently, access for fish throughout the watershed is unobstructed. In the past, the valley's two main north-south access routes have had effects on fish passage due to culvert placement and stream rerouting. The main routes through the Kitsumkalum Watershed start at Highway 16. The Nisga'a Highway passes up the eastern side of the Kalum Valley, passing through the community of Rosswood, then northward into the Nass drainage. The west side of the Kalum Valley is accessed by a road heading north from Highway 16 and joining the Nisga'a Highway 12 km north of Kalum Lake. A myriad of forestry access roads in various states of deactivation and repair branch off the two main roads and provide access to currently roaded areas. The river is navigable by jet boat for most of its length.

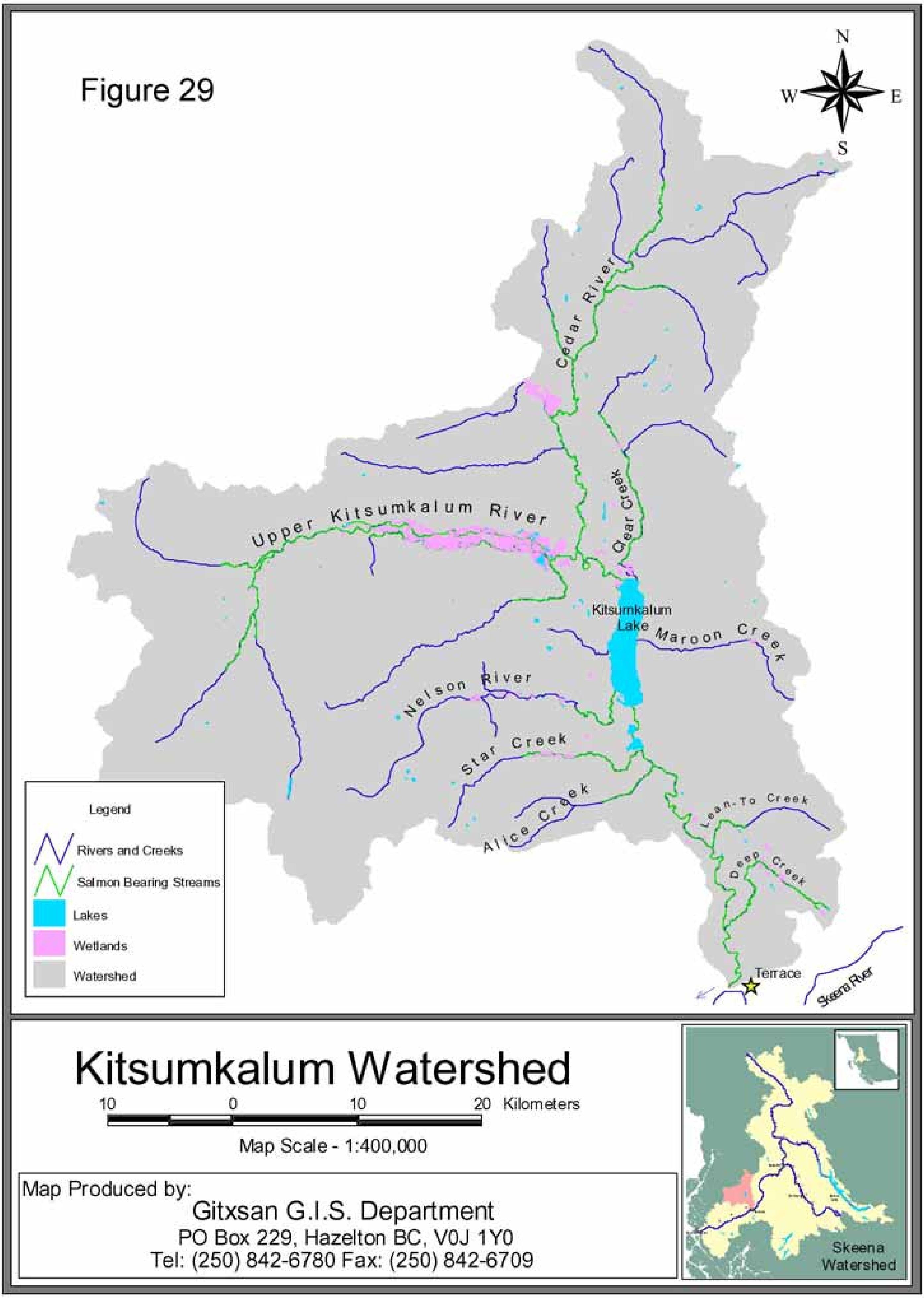


Figure 29
N
W
E
S
Cedar River
Clear Creek
Upper Kitsumkalum River
Kitsumkalum Lake
Maroon Creek
Nelson River
Star Creek
Alice Creek
Lean-To Creek
Deep Creek
Terrace
Skeena River
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Kitsumkalum Watershed
10 0 10 20 Kilometers
Map Scale - 1:400,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values and Resources

High fisheries values are present throughout the Kitsumkalum Watershed. Species present include all six species of Pacific salmon, as well as rainbow trout and cutthroat trout, Dolly Varden char, bull trout, Rocky Mountain whitefish, largescale sucker, peamouth chub, threespine stickleback, and sculpin (DFO 1991). These fish constitute an important resource to First Nations, recreational anglers, and commercial fishermen who depend on the Kalum Watershed production.

Chinook

Kitsumkalum River is one of the three major chinook producers in the Skeena Watershed, along with the Bear and Morice Rivers runs. This stock is especially important, as it has consistently produced the largest-bodied chinook in the Skeena Watershed, as well as on most of the Pacific coast (DFO 1985). In 1984, the Kitsumkalum River summer chinook stock was chosen for monitoring under the chinook "key-stream" program, which was initiated in response to objectives set out in the Canada-US Pacific Salmon Treaty (McNicol 1999). The goal was to use escapement and exploitation information from this stock as an indicator of harvest and exploitation rates on B.C. north coast chinook.

There are two distinct chinook runs in this system. A small early run spawns above Kitsumkalum Lake in Cedar River and Clear Creek in late July though late August (Morgan 1985, Alexander and English 1996). An unknown number of chinook also spawns in the upper Kitsumkalum River above the lake. A much larger summer chinook run spawns in the Kitsumkalum River, downstream of the lake.

Chinook escapement estimates have been recorded since 1961 for the lower Kalum River, Cedar River, and Clear Creek. Escapement to the lower Kalum River increased through the 1960's, and 1970's, with a substantial peak in the late 1980's and early 1990's that averaged 20,000 chinook annually. From the early 1990's to the present, there has been a slow decline to an annual average of approximately 10,000 chinook.

Cedar River and Clear Creek chinook enter the lower Kalum system relatively early, passing through the commercial fishery before the intense activity begins; the run is lightly exploited. Cedar River escapement estimates indicate that approximately 80% of the upper Kitsumkalum chinook run spawns there. The average annual escapement estimate in the late 1950's was 1,125 chinook. The spawning population precipitously declined in the 1960's to an average annual escapement of 94 chinook, ranging from 25 to 200 fish. Throughout the 1970's, a steady increase led to an average annual escapement of 945 chinook, with 890 chinook spawners through the 1980's. In the last decade, the average annual escapement was 564 chinook. Cedar River has significantly productive spawning beds upstream to Sterling Creek and possibly further. Clear Creek supports extensive chinook spawning upstream to the second reach break.

Clear Creek escapement estimates have decreased from the late 1950's and early 1960's, when the average annual escapement was 333 chinook, ranging from 400 to 200 fish. Between 1962 to 1985, it dropped to 140 chinook. Escapement dramatically increased to 400 chinook spawners in 1986 and 1987 and then steadily declined to the present.

Critical spawning beds in the lower Kitsumkalum are concentrated in the lower 3-9 km and in the 0.5 km reach downstream of the Kalum Lake outlet. Spring Creek and Deep Creek debouche into this lower Kalum spawning reach. Deep Creek spawning has dropped from the 400 recorded in 1965 to 10, 3, and 0 recorded in 1991, 1992, and 1993 respectively. Spring Creek had escapement of up to 75 chinook in the 1960's (SEDS database) and 25 in the 1970's (Graham and Masse 1975).

A radio-tagging program was implemented in 1985 to study early-run chinook salmon stocks returning to the upper Kitsumkalum Watershed (Alexander and Koski 1996). The Cedar River and Clear Creek chinook stocks are of concern due to low escapements. The study confirmed the timing separation between the early and late run Kitsumkalum chinook, established the early run spawning proportions (Cedar River 82%, Clear Creek 18%), and provided an estimate of spawning population size through mark-recovery. The early run upper Kalum chinook are smaller in size than the well-known lower Kalum fish (Triton 1996a).

Following fry emergence, chinook have been observed to rear in the lower reaches of the upper Kalum, throughout the three lakes, downstream to the Kalum mouth, and in the lower reach of Spring Creek, Deep Creek, Lean-to Creek, Glacier Creek, Clear Creek, Cedar River, Hadenschild Creek, and Mayo Creek. Results of juvenile outmigrant enumeration indicate that chinook juveniles migrate out of Kitsumkalum River into the Skeena mainstem, primarily as 30-60 day fry, from mid-April to mid-May (Morgan 1985). A small number of 1+ smolts outmigrate, typically in mid-April.

Pink

Pink salmon escapement records date back to 1950 for Deep Creek and to 1961 for the lower Kitsumkalum River. The Kitsumkalum Watershed pink run has been dominated by the odd-year cohort since the early 1960's. Overall, annual escapement was very low until 1977, when 100,000 pink spawned in the lower Kalum River. For 14 years until 1991, the variable odd-year escapement ranged from 40,000 to 150,000 pink salmon. Since then, in the few years of escapement observations until 2000, pink spawners have been less than 2,000.

The Kitsumkalum pink run enters the river in early to mid August and spawns in areas scattered throughout the mainstem up to Treston Lake and Star Creek. There is minor spawning occurring in the lower reaches of the following: Deep Creek, Lean-to Creek, Star Creek, and Spring Creek. Following emergence in the late spring from the spawning beds, fry migrate downstream to the estuary.

Chum

Chum salmon escapement has been recorded since 1950 for Deep Creek, and since 1968 for the lower Kitsumkalum River. Deep Creek escapement estimates peaked in 1950, with 200 chum, and have slowly declined to 25 to 75 spawners over the years. Lower Kitsumkalum River escapement has fluctuated widely since the 1960's, ranging from 2,500 chum in 1988, to 10 in 1982. Decadal average escapements are similar for the last three decades at approximately 650 chum spawners. Anecdotal information suggests that chum spawners are under-estimated in the Kalum system due to glacial turbidity in the river.

The Kalum River chum run enters the river generally in August, with spawning occurring shortly thereafter on beds mainly from 1 km to 7 km above the mouth of the Kalum River. Chum have been observed in the extensive eastside oxbow lakes, south of Glacier Creek (Grieves 1996). Occasionally, chum salmon are observed spawning in the lower reach of the small creek, just north of Lean-to Creek. The fry emerge from the gravel and migrate directly to saltwater.

Sockeye

Escapement estimates for the Kitsumkalum aggregate sockeye stock indicate that in the 1950's, average annual escapement was 3,435 sockeye. The 1960's and 1970's average annual escapement decreased to 2,650, with a further decrease in the 1980's to 1,430 spawners. The 1990's average annual escapement increased to 3,586 sockeye, which surpasses 1950's escapement levels. It is assumed that the increase of sockeye escapement is due to the establishment in the late 1980's of the spawning channel at the north end of Kalum Lake. Bocking and Gaboury (2002) estimated that the total spawning ground capacity is currently in the order of 10-11,000 spawners.

Cedar River sockeye escapement was strong from 1963 to 1974, averaging 1,500 spawners. Since that time, escapement has fallen; recent observations have been few, and it is thought that average annual escapement is currently less than 200 spawners. The Clear Creek sockeye have been in trouble. Since the mid 1960's, the spawner population has decreased from 1,500 sockeye to less than 100 average annual escapements. Dry Creek decreased from an average annual escapement in the 1950's of 200 sockeye to 61 in the 1980's. The current status of Dry Creek sockeye is unknown.

The Kalum sockeye run enters the Kalum River in August and passes through the lower river to Kalum Lake. The Kalum Lake sockeye spawning beds are principally located at the northeast end of Kalum Lake, where there are good gravel beds as well as seepage of clear water. Shore spawners have also been observed close to Hall Creek and Goat Creek. The Cedar River spawners are in scattered patches, though concentrated spawning takes place close to the mouth of Little Cedar River. Clear Creek spawning is patchy with critical beds located from 1-3 km above the mouth. The upper Kalum River is reported to have sockeye spawning to above Mayo Creek. Dry Creek, Mayo Creek, Wesach Creek, and Goat Creek all have spawners at least in some years in their lower reaches. After fry emergence, juvenile sockeye mainly rear in Kalum, Redsand, and Treston Lakes. Juvenile sockeye have been observed in the lower reaches of Mayo Creek, George Creek, Allard Creek, Cedar Creek, and Clear Creek.

Coho

Escapement records for the Kitsumkalum coho aggregate stock are complete from 1960 to the early 1990's. The average annual escapement estimates for the 1960's was 4,150 coho; for the 1970's, 4,548 coho; and for the 1980's, 3,895.

Upper Kitsumkalum River coho had high escapements of 7,500 coho in 1955 and 1958. Since that time, average decadal escapement estimates have been generally under 1,000 coho. Lower Kitsumkalum River coho escapements were under 1,000 until the 1980's, when the average annual escapement was 2,675 coho. This apparent increase in escapement reversed in 1992, but escapement surveys have been sporadic since then. The Cedar River coho average annual escapement was estimated at 713 during the 1960's; in the 1970's, 1,170 coho; and in the 1980's, 506 coho. Average annual escapement estimates have generally stayed below 400 coho for Clear Creek. Escapement for Clear Creek ranges from 1,500 in 1964 to 75 coho over several years in the 1960's.

Coho return to the Kalum system in two main runs. The early run typically arrives in late July to early August, making its way up into Kalum Lake where they hold and mature. The late run coho enter the system through September and into October and typically spread throughout the system to their respective spawning grounds. The main coho spawning production area is in the side channels and groundwater-fed beaver ponds of the lower Kalum Watershed. The upper Kalum sees coho spawning upstream to 45 km (DFO 1991). Dry Creek was noted as having 350 spawners on the ten-year (1965-74) average. Clear Creek supports coho spawning to the upper reaches, while coho in the Cedar River utilize spawning beds up to 25 km. Hadenschild Creek has spawning up to at least 5.6 km.

Historically, the lower reach of Spring Creek supported 300 spawners (Graham 1975) with Deep Creek coho spawners at 580. Graham (1975) reported 50 coho spawners in Glacier Creek. Goat Creek had a ten-year average (1965-74) of 225 in the lower 2-3 km. Star Creek has coho spawning in the lower reach (Paish 1975), while the majority spawn in the marshes of upper Star Creek (Culp 2002). Mayo Creek has spawning in the lower 6 km. After emerging as fry, juvenile coho utilize all the above streams for rearing. Other areas used for the freshwater rearing phase include the lower reaches of Luncheon Creek, Benoit Creek, Allard Creek, George Creek, side channels throughout the system, and Redsand Lake.

Steelhead

Information concerning Kitsumkalum steelhead escapement and population trends is not available. The Kitsumkalum Watershed has three main timing return groups: one peaking in the late summer, another in the late fall, and a third in the spring (DFO 1991). Only summer run steelhead were reported to spawn upstream of Kalum Lake. Radio telemetry studies (Lough and Whately 1984) in the 1980's and MELP tagging records point to the spatial segregation of the runs. Summer fish move above the lake to overwinter; fall run steelhead move into the middle portions of the mainstream and lakes to overwinter; and the spring arrivals remain in the lower river to spawn (Grieve and Webb 1999a). Major overwintering areas are the upper Kalum-Cedar River confluence, the lakes, and slow, deep portions of the Kalum mainstem, particularly above and below the canyons.

Spawning sites recorded above Kalum Lake include the upper Kalum River, Cedar River mainstem and its tributaries, Hadenschild Creek, and Clarence Creek, as well as the Clear Creek mainstem. Culp (2002) reports substantial numbers of steelhead spawners in Deep Creek, with lesser amounts in Lean-to Creek and Glacier Creek. The Kalum Lake outlet extending 750 m downstream provides quality and well-used spawning habitat. Further downstream, spawning occurs on the mainstem Kalum River to the Skeena confluence and occasionally in side channels from Alice Creek to Lean-to Creek. Spawning steelhead have also been reported in Deep Creek and Lean-to Creek. Repeat spawners are reported to be 7.5% of total spawners (Grieve and Webb 1999a). Lough and Whately (1984) reported most spawning to occur during early and mid-May, with most kelts leaving the Kitsumkalum by June. Juvenile steelhead are reported to be present throughout most of the watershed streams.

Fisheries

First Nations Traditional Use

First Nations traditional use of the Kalum Watershed was extensive and varied with village sites, home places and fish houses or stations. Prehistorically, the Kitsumkalum people, whose main village was located immediately northwest of the Kalum-Skeena confluence, hold the watershed territories, although the Cedar River Watershed is also overlaid with stated Gitxsan territorial interest.

Local First Nations territories sustained home places and resources for the last 6,000 years, with traditional use features covering the landscape. Subsistence activities were tightly interwoven with the social structure, the local landscapes, and the broader regional environment. Detailed knowledge and understanding of the environment, the characteristics of each resource, and the seasonal variation in abundance and availability, were necessary to the chiefs and House members for making decisions about what, where, and when different resources were to be harvested. Over time, Kitsumkalum and Gitxsan ancestors developed systems of access, tenure, and resource management. A strong and adaptive semi-nomadic economy, preoccupied with food gathering, was based around the summer salmon food fishery and mid-winter feasting, with dispersal into smaller family groups during the rest of the year to fish, hunt, and gather on the House territories.

Recreational Fisheries

A large sports fishery attracting local residents and non-residents exists within the Kitsumkalum Watershed. Angling effort is primarily directed to coho, steelhead and chinook. The river is Class II water, which requires a Steelhead Stamp, December 1 to May 31, and the release of steelhead angled in the watershed above the signs below the lower canyon. The steelhead fishery begins with the arrival of summer steelhead in late August-early September, with angling distributed throughout the entire river. Winter steelhead fishing is concentrated in the sections from Kalum Lake outlet downstream to Glacier Creek, with less effort directed to the upper Kalum and Cedar Rivers. Coho angling effort is concentrated at the north end of Kalum Lake in September and continues in the lower Kalum through the fall to early November.

Enhancement Activities

In 1981 to 1982, a pilot hatchery was operated on Dry Creek to investigate the incubating and rearing of chinook salmon on that creek; however, the project was found to be unfeasible. The Deep Creek Hatchery has been operated by the Terrace Salmon Enhancement Society (TSES) since 1984, initially functioning primarily as a chinook facility to augment chinook populations in the Zymoetz, Lakelse, and Kalum systems (Tredger 1983b). Since 1986, the hatchery has augmented only Kalum chinook. TSES annually conducts a mark recapture program and a dead recovery program providing an estimate of abundance for Kalum chinook. The society also takes on average 250,000 chinook eggs to be raised in the hatchery, and, since 1998, assesses coho stocks on a variety of Skeena tributaries which include the Lakelse, Zymacord, Kalum, Zymoetz, and the Exstew (Culp 2002). TSES also assesses local chinook and coho stocks, among a variety of other activities. Since the late 1980's, the Kitsumkalum Band has operated a small facility for the incubation and rearing of coho and chum.

A spawning channel for sockeye at the northeast end of Kalum Lake was built in the early 1984, upgraded in the late 1990's (J. Culp 2002), and appears to be functioning well. From 1985 to 1988, the TSES reared Kitsumkalum summer run steelhead to fry at Deep Creek Hatchery, releasing close to 50,000 fry. Various surveys and investigations over the years have investigated potential habitat enhancement possibilities, looking into fish species and population sampling, salmon habitat surveys, and identification of areas of groundwater upwelling.

Development Activities

The principal development activities in the Kitsumkalum Watershed consist of logging, linear development, recreation activities, and urban and housing development.

Forest Resource Development

The Kitsumkalum Watershed is located within and administered by Ministry of Forests, Kalum Forest District. At the conclusion of the Second World War, there was a great demand for lumber, with selectively logged portions of the most valuable timber stands sawn in small bush mills. Large-scale industrial logging started in 1950 with the award of TFL # 1 to Columbia Cellulose. Over the last fifty years, the Kalum Watershed has been extensively logged with very high impacts to fish habitat. The effects of this long history of disturbance have, for the most part, been assessed with the WRP. Watershed health, along with hydrological recovery, is proceeding with approximately 200 km of road deactivated, including pullback of over-steepened fill slopes. Riparian, instream, and off-channel habitat restoration works are helping to re-establish more stable channels and diverse habitats in tributary streams (Ottens 2002). WRP has completed a full Restoration Plan (RP) for the Clear and Douglas Creek Watersheds, while interim RPs have been composed for the remainder of the Kitsumkalum Watershed, excluding Cedar River. The future of these plans is uncertain due to the demise of FRBC.

Mineral Resource Development

There are approximately 30 mineral occurrences including two past producing mines within the watershed. Although several active mining claims exist, the current status of mineral resource development is unknown.

Transportation and Utilities

In the Kitsumkalum Watershed the two main roads, the west side road and the Nisga'a Highway, branch off Highway 16 and provide access to communities to the north. These also access a network of secondary forestry roads that branch out into most tributary drainages. To an extent, fish access has been impeded due to culvert placement and rerouting of watercourses on the main north-south roads that cross all major tributaries in the watershed. Secondary forest development roads crossing unstable slopes, as well as roads crossing alluvial fans of high-energy systems, have caused impacts to fish bearing streams and will have a high rehabilitation cost. Utilities corridors exist on both the east and west sides of the valley, generally paralleling the main roads. A BC Hydro transmission line passes north-south on the west side, while a BC Hydro transmission line and Telus telephone line run through on the east side. These utilities have had light impacts mainly associated with riparian concerns.

Population and Settlement

Relatively minor settlement has occurred in the watershed. Dutch Valley, at the mouth of Spring Creek, and Rosswood, north of Kitsumkalum Lake, provide scattered rural residences for approximately 300 people. The City of Terrace, located at the southeast edge of the watershed, along with its adjacent suburbs, has a population of approximately 19,650 people. The economy is dominated by the forest industry, although tourism is growing and contributing to the growth of sport fishing. It is estimated that 25% of the area's population are fresh water sports fishing enthusiasts, fishing approximately 40,000 days per year in the lower Skeena Valley region.

Watershed Management Issues

High fisheries values are present throughout the Kitsumkalum Watershed. Species present include all six species of Pacific salmon, as well as rainbow trout and cutthroat trout, Dolly Varden char, bull trout, Rocky Mountain whitefish, largescale sucker, peamouth chub, threespine stickleback, and sculpin. The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage. It also provides strong cultural, economic and symbolic linkages, particularly for First Nation peoples, as well as supporting recreational and commercial fisheries.

Kitsumkalum River is one of the three major chinook producers in the Skeena Watershed and is monitored under the chinook "key-stream" program, an action set out in the Canada-US Pacific Salmon Treaty. Pink salmon escapement has fluctuated widely since the 1970's. Chum salmon abundance is relatively stable, while the aggregate of Kitsumkalum sockeye stocks has recovered to 1950's escapement levels.

A large sports fishery attracting local residents and non-residents is established within the Kitsumkalum Watershed. Angling effort is primarily directed to coho, steelhead, and chinook. Over the last fifty years, the Kalum Watershed has been extensively logged with high impacts to fish habitat. The effects of this long history of disturbance have for the most part, been assessed by the WRP. Relatively minor settlement has occurred in the watershed. The economy is dominated by the forest industry, although tourism is growing and contributing to the growth of sport fishing.

The current state of the watershed is affected by past land use practices that have produced cumulative impacts on fish habitat. Proper land management practices must be promoted to maintain the integrity of streams and riparian zones. The most important watershed management issue is dealing with the impact of past logging. The effects of increased erosion, sediment movement, and riparian destruction have declined in the past two decades, but will remain as important issues for the next generation. Future resource development will be guided under the direction statements contained within the recently completed Kalum Land and Resource Management Plan.

Gitnadoix Watershed

Environmental Setting

Location

The Gitnadoix Watershed is located in the Kitimat Range approximately 50 km west-southwest of Terrace. The Gitnadoix River flows north 18 km into the Skeena River left bank. The watershed is bounded in the south by the Giltoyees Creek drainage, to the west by the Khtada drainage, to the east by the Wedeene River, and to the north by the Skeena River floodplain.

Hydrology

The Gitnadoix River is a third order system that drains a watershed area of approximately 546 km^2. Elevations range from approximately 24 to 2180 meters, with the watershed bounded by highly dramatic alpine rock and pocket glacial features. Mean annual precipitation for three years of measurement at Salvus, located close to Kasiks River, was 1783 mm (Beaudry *et al.* 1990). Because of the strong coastal influence, it is likely that the highest discharge peaks of the Gitnadoix River often occur during late autumn, rather than during snowmelt in May and June. Owing to the nature of the steep terrain in the watershed, the tributaries into the Gitnadoix mainstream are often subject to high water flows following heavy rain events.

The Gitnadoix River flows from the headwater lake, Alastair Lake, – the major tributaries downstream being Kadeen, Magar, Dogtag and Clay Creeks, which deliver a substantial volume of the total flow to the river mainstem. Alastair Lake dampens and buffers high water flows from the headwater tributaries. The Gitnadoix flows out of the north end of Alastair Lake with an average width of 45 meters and an average gradient of approximately 1% (Johnson 1976). The 6.9 km^2 Alastair Lake has an elevation of 30 m, an average depth of 24 m, a summer seasonal average thermocline depth of 10.4 m, and a cool hypolimnion. The deep water (>50 m) in the southern end of the lake is a very hospitable environment for juvenile sockeye. The lake is very productive and has one of the three highest photosynthetic rates ever recorded for BC sockeye lakes (Shortreed *et al.* 1998).

Geography

The bedrock geology of the Gitnadoix Watershed is characterized by the Coast Mountains Intrusions, consisting of largely eroded, dramatically bold, impressive monolithic granite (Holland 1976). The Gitnadoix Valley is a small north-south lineament that originally was a fiord, though since the end of the Pleistocene has isostatically uplifted and, over time, filled with fluvial sediment at least in the northern section. The lower valley and hill slopes are occupied by the moist maritime Coastal Western Hemlock subzone, which is dominated by hemlock and spruce, with patchy stands of red cedar. The Mountain Hemlock Zone is reached at approximately 600 m elevation. The mountaintops have alpine vegetation. Avalanches, many of which reach the valley floor, annually sweep much of the mountain area. The upper Gitnadoix River floodplain is primarily swampy with single and dispersed cottonwood and patchy coniferous stands.

Stream Channels

The Gitnadoix River channel wanders and meanders through its approximately one km wide floodplain for the upper three-quarters of its length. The typically steep-sided valley walls limit lateral movement on the upper two reaches. The lower reach has a slightly higher grade and distinct lateral bar development. The tributaries for the most part present either a stepped or continuous longitudinal profile with low to moderate gradients steepening in the headwaters.

Access

Access for fish is typically straightforward, with no historical obstruction or access problems noted. The watershed is most commonly accessed by boat or air transport. Boat access is primarily from one of the Highway 16 Skeena River boat launches located at Exchamsiks, Andesite and Exstew. Floatplanes utilize portions of the upper river and the lake. The Gitnadoix Watershed is unroaded, other than the permanently deactivated natural gas line access road that crosses close to its mouth.

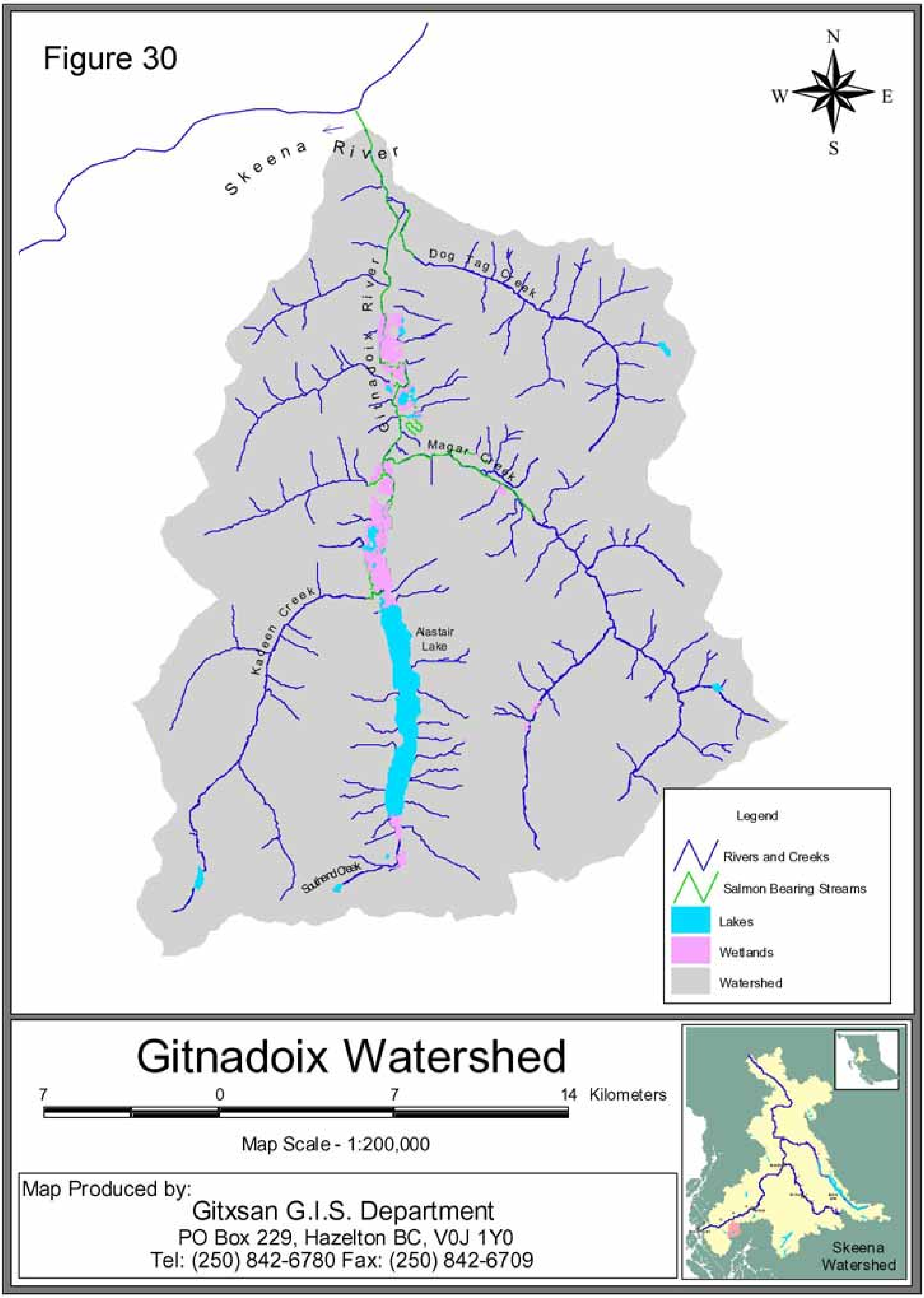


Figure 30
N
W
E
S
Skeena River
Dog Tag Creek
Gitnadoix River
Magar Creek
Kadeen Creek
Alastair Lake
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Gitnadoix Watershed
7 0 7 14 Kilometers
Map Scale - 1:200,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values and Resources

High fisheries values are generally prevalent throughout the low gradient portions of the drainage. All six Pacific salmon species are present, as well as rainbow and cutthroat trouts, Dolly Varden, Rocky Mountain whitefish, and large-scale sucker, peamouth chub, three spine stickleback, and prickly sculpin (Northcote and Taylor 1973). No species-at-risk are thought to occur in the watershed.

Chinook

Gitnadoix River chinook escapement estimates have been recorded since 1967, though escapement data is scant for Magar Creek, Dogtag Creek, and Kadeen Creek. These three tributaries each support 20 to 100 spawning chinook. Escapement on the Gitnadoix River was estimated at 750 chinook for 1967 and 1968. The 1970's average annual escapement was 213 chinook ranging from 400 to 25 fish. The 1980's average annual escapement was 65 chinook ranging from 200 in 1980 and 1981, to a low of 2 chinook in 1983. The 1990's average annual escapement was 38 chinook, ranging from 85 to 10 fish. In short, Gitnadoix chinook have been severely depleted.

The small run of chinook enters the Gitnadoix River in early to mid August with spawning occurring from late August until mid-September. Knowledge of Gitnadoix chinook life histories is limited. However, critical spawning areas observed include: the large, turbulent, lowest reach of Kadeen Creek, the lower reach of Magar Creek, and a small population (15-20) in the lower reach of Dogtag Creek (Graham and Masse 1975). Spawning beds exist on the Gitnadoix River mainstream directly west of Clay Creek fan for approximately 400 m; a 300 m section one km downstream of Magar Creek; and dispersed patches throughout the mainstem channels (Hancock *et al.* 1983, Pinsent and Chudyk 1973, DFO 1991c). Chinook juveniles utilize the mainstream river channels and the lower reaches of accessible tributaries.

Pink

The Gitnadoix pink salmon run is relatively large for a lower Skeena River tributary, but small in comparison with overall Skeena River pink escapement. Escapement estimates have been consistently recorded since the early 1960's and show overall a moderate increase in escapement. Average annual escapement in the 1960's was 770 even-year pink and 3,125 for odd-year pink. In the 1990's, average annual escapement was 2,300 odd-year pink and 7,750 even-year pink. Pink enter the Gitnadoix River generally in early to mid-August, primarily spawning in the lower 7 km of the river.

Magar Creek, Kadeen Creek, and Dogtag Creek also support small pink spawning populations. The few existing escapement estimates indicate that the average annual escapement of the odd-year pink runs in the tributaries is about one third of the total Gitnadoix River escapement. In late April, pink fry emerge and migrate downstream to the Skeena Estuary.

Chum

Chum salmon escapement in the Gitnadoix Watershed has been surveyed for all but one year (1999) since the mid-1960's. Average annual escapement in the 1970's was 1,090 chum, with a decrease in the 1980's to 462 chum. The average annual escapement in the 1990's was increased to 614 chum. Chum escapement data for Dogtag Creek shows average annual escapements in the 1970's of 42 chum, in the 1980's average annual escapement of 575 chum, while in the 1990's average annual escapement was 448 chum. Spawning also occurs in Magar and Kadeen Creeks, but estimates of escapement are not available.

Chum typically enter the river in mid to late August, spawning in the mainstem lower reach in specific patches contiguous to seepage or groundwater flows, with the strongest spawning taking place at the mouth of Clay Creek (Kofoed 2001) and in tributary lower reaches. Chum fry emerge and migrate directly to the sea in the late spring.

Sockeye

From 1950 to the present, sockeye escapement estimates have been recorded for Southend Creek and Alastair Lake. Westside Creek estimates were only recorded in the 1950's, with an average annual escapement of 1,442 sockeye ranging from 3,500 to 400 spawners. Alastair Lake had an average annual escapement in the 1950's of 5,100 sockeye, which then abruptly decreased and remained moderately steady through the next three decades, with an average annual escapement of 1,691 sockeye. The average annual escapement estimate for the 1990's was 3,300 sockeye ranging from 5,000 to 500 fish.

Southend Creek is the main producer of sockeye in the Gitnadoix Watershed (Hancock *et al.* 1983). The average annual escapement estimate for the 1950's was 17,200 sockeye ranging from 35,000 to 8,000 fish. Sockeye escapement then declined in the 1960's to less than 6,500 sockeye, again declining in the 1970's to an average annual escapement of 2,740 sockeye. In the 1980's and 1990's, average annual escapement estimates were 4,600 sockeye. Gitnadoix sockeye escapement has been consistently depressed below the 1950's levels.

Gitnadoix sockeye are unique in that their spawning colours are atypical of other Skeena sockeye stocks. When mature, these sockeye possess a silvery body colour with only a dull red stripe, rather than the typical mature sockeye colours of a bright red body and a green head. Sockeye typically enter the Gitnadoix drainage mid August to mid-September, with an early run to Southend Creek and a late run to Alastair Lake (Whelpley 2002). They then move rapidly upstream into Alastair Lake, occasionally holding at the outlet and the south end of the lake while waiting for water conditions and ripening (Smith and Lucop 1966). Brett (1952) noted that early and late runs spawn in the east and west forks respectively of Southend Creek. Westside Creek's very small alluvial fan is heavily utilized for 150 to 200 m, as is the small alluvial fan of the creek on the east shore, closest to the outlet.

Shortreed *et al.* (1998) noted that juvenile sockeye were distributed throughout the lake with high densities (6,200/ha) of limnetic fish (underestimated due to echo counting limitations at these high densities), of which two thirds were stickleback and the remainder sockeye. Growth rates were low with an average of 1.7 g in October, most likely because of the intense competition from the large numbers of stickleback. Sockeye stomachs were only 20% full and contained nearly 100% *Bosmina,* a lower quality food item. In an earlier study, Simpson (1981) also reported that fall fry from Alastair and Swan Lakes averaged <2 g. Reduction of stickleback numbers would allow the production of larger, less predator resistant zooplankton species, which would likely increase growth and reduce mortality of age-0 sockeye fry (Shortreed *et al.* 1998). One half to one third of sockeye fry spend two years in Alastair Lake. This is an unusual pattern for a low elevation coastal lake and is presumably an adaptation to the low food supply.

Coho

The Gitnadoix coho escapement record is relatively complete since the 1950's. The Gitnadoix River average annual escapement for the 1950's was 11,333 coho. There has been a fairly steady decline since that time. Escapement trends of tributary spawning streams closely follow the pattern indicated for Gitnadoix River except for the lower portion of Magar Creek, which had increased escapement in the 1990's and received most of the coho spawners of the Gitnadoix Watershed in 1999. Overall coho escapement increased markedly in 1999 and 2000 after a decade or more of low escapements.

Coho have been observed to move into the drainage from late August to mid-October and generally spawn throughout the system. The most productive spawning grounds are spread along the mainstem of the river. The lowest reaches on Southend Creek and Kadeen Creek and Magar Creek are the principal tributary spawning grounds (Kofoed 2001), with secondary spawning beds at Clay Creek and Hipp Creek. Juveniles rear throughout the system utilizing off-channel habitat and migrating downstream in the spring melt flow.

Steelhead

The relatively small steelhead run in the Gitnadoix River is suspected to be a few hundred fish. It appears to be a spring run with no known evidence of a summer or fall run fish (Hooton & Hipp, *cited in* Paish 1990). Triton (1998) notes that steelhead migrate upriver between January and May and hold in large pools before spawning in tributaries in spring. Although knowledge of spawning sites is limited, it is thought that the principal spawning grounds are in the upper reach of the river. Rearing and holding areas are abundant and ideal due to the productive aquatic environments of the back channels and oxbow lakes of the upper reaches of the river (Pinsent and Chudyk 1973). Knowledge about winter parr habitat, smolts, sea life duration, and repeat spawning is limited.

Fisheries

First Nations Traditional Use

First Nations traditional use of Gitnadoix Watershed was extensive and varied with village sites, home places, and fish houses or stations. Gitandoix people, a poorly known group whose main village was located at the Gitnadoix and Skeena confluence, held the watershed territories. Dawson (1881) observed house remains standing at this traditional village that secured the particularly rich hunting, fishing and other resources in the drainage's interior territory.

Local First Nations territories sustained home places and resources for the last many thousands of years, with traditional use features covering the landscape. Subsistence activities were tightly interwoven with the social structure, the local landscapes, and the broader regional environment. Detailed knowledge and understanding of the environment, the characteristic of each resource, and the seasonal variation in abundance and availability were necessary to the chiefs and House members for making decisions about what, where, and when different resources were to be harvested.

Over time, Gitnadoix ancestors developed systems of access, tenure, and resource management. A strong and adaptive semi-nomadic economy, pre-occupied with food gathering, was based around the summer salmon food fishery and mid-winter feasting with dispersal into smaller family groups during the rest of the year to fish, hunt and gather on the House territories. Currently, there are eight Indian Reserves within the watershed that represent important fishery locations in use early in the twentieth century.

Recreational Fisheries

The Gitnadoix Watershed is now a Provincial Park and, as such, protects the natural, cultural heritage, and recreational values located within it. The major recreational activity on the Gitnadoix River is sport fishing for salmon and freshwater species, principally Dolly Varden and Cutthroat trout. There has been a steady increase in sport fishing activity on the Gitnadoix system for as far back as official and anecdotal records are available. This increase parallels a steady increase in other parts of the Skeena Watershed. The increase in angling effort helps to create a heavier demand for the quality fishing experiences in the relatively uncrowded setting that the Gitnadoix River is able to provide.

Gitnadoix anglers are guided and unguided, with both generally targeting the spring steelhead and then the September to October coho fishery. The river once supported a chinook sports fishery, but is now closed to angling due to concerns about low escapement (DeGisi 1997a).

There is an inter-sectorial concern on the part of many of the non-guided anglers about the indiscriminate use of large, powerful boats by guides, which detracts from the combined experience of angling and wilderness recreation, as well as disturbing the river bed and banks.

Enhancement Activities

There have been no known enhancement activities to date.

Development Activities

The Gitnadoix Provincial Park is a visually scenic, pristine valley that has had no past development; currently, forestry, mineral, and hydroelectric development are prohibited. There is a natural gas pipeline corridor (Milepost 305) passing through the lower watershed approximately 400 m upstream of the Skeena mainstem confluence. Vehicles and machinery occasionally ford the river when replacement or specific maintenance is needed. In late 1997, the pipeline beneath the river broke due to flood scouring of the substrate, and replacement was required (Triton 1998). The BC Hydro, Skeena-Rupert 287 kV transmission line also passes close by the mouth of the watershed on the Skeena River floodplain (Heenan 2002). There are no residences in the watershed, though two cabins support seasonal trapping efforts.

The Gitnadoix Watershed has never been subjected to any type of industrial activity that would in any way disrupt or change the natural habitat and natural productive capability of the system. The Gitnadoix therefore serves as a baseline for identification of inland habitat changes. The principal influences on the biological and productive capability of the anadromous fish stocks is the exploitation of those stocks in the commercial and recreational fisheries on the Skeena, and changes in the ocean environment.

Gitnadoix Watershed Management Issues

High fisheries values prevail throughout the low gradient portions of the drainage. All six Pacific salmon species are present, as well as rainbow and cutthroat trout, Dolly Varden, Rocky Mountain whitefish, large-scale sucker, peamouth chub, three spine stickleback, and prickly sculpin. No species-at-risk are thought to occur in the watershed. The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage. It also provides strong cultural, economic and symbolic linkages, particularly for First Nation peoples, as well as supporting recreational and commercial fisheries. First Nations traditional use of Gitnadoix Watershed was extensive by Gitandoix people.

Gitnadoix chinook have been severely depleted. The Gitnadoix pink salmon run is relatively large for a lower Skeena River tributary; pink salmon show overall a moderate increase in escapement. Chum salmon escapement has fluctuated, and the current trend is a modest decline. Present sockeye escapement estimates generally show an average 40% decline since the 1950's. The Gitnadoix coho escapement record has been a fairly steady decline since the 1950's, though overall coho escapement increased markedly in 1999 and 2000 after a decade or more of low escapements.

The Gitnadoix Watershed is now a Provincial Park and, as such, protects the natural, cultural heritage, and recreational values located within it. The major recreational activity on the Gitnadoix River is sport fishing for salmon and freshwater species, principally Dolly Varden and Cutthroat trout. Gitnadoix Provincial Park is a visually scenic, pristine valley that has had no past development, and for the foreseeable future, forestry, mineral and hydroelectric development are prohibited.

Kitwanga Watershed

Environmental Setting

Location

The Kitwanga Watershed is a tributary sub-basin draining south into the left bank of the Skeena River about 250 km from the coast. The watershed is bounded to the west by the Nass Range, to the east by the Kispiox Range, to the north by the Cranberry River drainage, and to the south by the Skeena River. The watershed is located north of Gitwangak village, which is 65 km west of Hazelton. Kitwanga Lake also commonly called Kitwancool Lake sits in the middle of the Kitwanga Watershed.

Hydrology

The Kitwanga Watershed is a fifth order system with a catchment area of approximately 833 km^2. Elevation ranges from 2,096 m in the Kispiox Range to 172 m at the Skeena River confluence. The Kitwanga River peak discharges typically occur in May and June due to spring snowmelt, then decrease until September when fall rains and early snowmelt increase stream flows through October. Stream flows decrease through November and December when precipitation falls as snow, with low discharges recorded from January through March. Summer low flows are typically 4 to 8 times greater than winter stream flows and are principally sustained by high elevation snowmelt, while winter low flows are derived from groundwater, lakes, and unfrozen wetlands. Historic stream flow data for the Kitwanga River is not available; however, Gitanyow Fisheries Authorities (GFA) has recently installed stream-gauging stations below Kitwancool Lake and close to the mouth of Kitwanga River.

The Hazelton Mountains, to the west, and the Nass Basin, to the north, exert the major hydrological influences. Kitwanga Valley has a broad low gradient valley bottom, although the watershed as a whole has a moderately high response from water input due to the high gradients of the major tributaries. The low watershed divide to the Nass drainage allows coastal weather systems to enter the watershed, leading to heavier snow packs in the mountains and the northern half of the drainage. The general climate of the watershed is transitional between temperate, maritime coastal climates and the colder, continental climates that characterize the interior of the province.

Kitwancool Lake and the extensive wetlands at the northern end of the Kitwanga Valley constitute the primary water storage. Upper Kitwanga River, Kitwancool Creek, and Deuce Creek, draining the Nass Range, and Moonlit Creek, draining the bulk of the Kispiox Range to the east, are the major tributaries flowing into Kitwancool Lake and the river mainstem. These tributaries contribute to the wide variations in water flows in the main stream. They also transport moderate amounts of bedload in average flood flows and as well, often carry large amounts of suspended sediments. The silt and clay are derived from mudstones of the early Cretaceous, which were ground up by the glaciers of the last ice age and left behind as a mantle over the landscape. These sediments are easily mobilized by natural and man-induced stream instability and landslide failures.

Kitwanga Lake, also called Kitwancool Lake, lies at 376 m elevation. It has a surface area of 7.8 km^2, and is relatively shallow with a mean depth of 5.0 m. The results of limnological sampling (Shortreed *et al.* 1998) showed a pronounced thermal stratification, with an average thermocline depth of 5.7 m, and epilimnetic temperatures exceeding 18^o C, that extended to the lake bottom for up to 30% of the lake's total area during a four to six week period in the mid-summer of 1995. Subsequent limnological data has been collected annually by Gitanyow Fisheries Authority (GFA) since 1999 and Cleveland (2001) suggests that these data show no obvious environmental constraints on fry. The lake is clear with the euphotic zone encompassing the entire water column in most areas of the lake. Macrozooplankton biomass is relatively high, and *Daphnia* abundance makes up more than 60% of the total. With this high production and strong thermal stratification, summer oxygen concentrations may become very low in the lake's hypolimnion (Shortreed *et al.* 1998). Consequently, if long warm summers occur, there may be no deep cold-water refuge available for sockeye juveniles, resulting in decreased growth and predator avoidance.

Geography

The Kitwanga Watershed is comprised of two mountain masses, the Nass Range and the Kispiox Range, divided by a linear down faulted trough. The Kitwanga River on the south end and the Cranberry River to the north, which is part of the Nass Watershed, occupy the trough. The Kitwanga Watershed is principally underlaid by bedrock composed of early Cretaceous, Skeena Group sedimentary rocks in the Nass Basin, and Bowser Lake Group sedimentary and volcanic rocks with a minor granitic intrusion at Hazelton Peak (Gottesfeld 1985). The fluvial and surficial geomorphology of the watershed is strongly influenced by its recent glacial history. Ice from the Coast Ranges flowed southerly down the Nass Basin, with a portion flowing through the Kitwanga Valley into the Skeena. The scoured and grooved mountainsides, as well as Kitwancool Lake, are part of the glacial legacy.

The gentle divide (385 m) between the Cranberry and Kitwanga drainages lies north of Kitwancool Lake; it is occupied on the west by the compound alluvial fan of both the upper Kitwanga River and the Cranberry River. The east side of the divide area is dominated by an extensive floodplain and wetland complex. Because of these indeterminate drainage features it is easy to imagine fish passage from the Skeena to the Nass Valley. Within the Kitwanga River valley, inactive river terraces, higher and wider than the present floodplain, may have been deposited during the Little Ice Age cool-wet period between 200 to 500 years ago (Gottesfeld 1985). These terraces have been the preferred sites for farmland south of Gitanyow village.

Thick blankets of glacial till cover the main valley and mountain valleys and extend up the valley sidewalls. The surface expression conforms generally to the underlying bedrock surface, with bedrock exposure along deeply incised streams and on steep-sided hillocks.

The coastal/interior transition climate is reflected in the major ecological zones. Vegetation in the lower elevation valley is represented by the Interior Cedar Hemlock (ICH) and Coastal Western Hemlock (CWH) zones, which are dominated by forest stands of hemlock, spruce, subalpine fir and to a certain extent, red cedar. In the higher elevations, the ICH and CWH pass into forest cover that is dominated by mature and overmature subalpine fir, represented by the Engelmann Spruce-Subalpine Fir (ESSF) biogeoclimatic zone (Pojar *et al.* 1988). Historically, frequent fire disturbance by Gitxsan people created successional stands of aspen and birch on upland sites. Black cottonwood prevails in floodplain stands, typically mixed with immature spruce and cedar.

Stream Channels

The Kitwanga River mainstem between Kitwancool Lake and the Skeena confluence is approximately 36 km in length. It is low gradient with no effective barriers to anadromous fish passage. The northern two thirds is a wandering gravel bed river. Because of the high suspended sediment load, abandoned channel segments and backwaters fill up with mud more rapidly than in typical gravel bed rivers. The lower 12 km is entrenched 30 to 100 m into a bedrock canyon. From the Skeena River upstream to the lake, mainstem gradients vary from 0.5% to 0.7% slope (MOE 1979).

Giesbrecht (1998) observed channel instability in Reaches 3 and 5 due to logging and clearing of the riparian area, as well as to past road construction. The major problems in the watershed include damaged riparian areas, bank erosion, channel instability, reductions in large woody debris (LWD), and barriers at stream crossings, particularly blocked and perched culverts. Ten Link Creek is the domestic water supply and designated community watershed for Gitanyow village. Currently, sediments generated from an access road slide are compromising water quality. Forest development activities and poor placement of drainage structures along Highway 37 North have adversely affected many tributary streams.

Riparian logging and beaver damming adversely affect an area located north of Kitwancool Lake between the 26-Mile Forest Service Road (FSR) and the Webber FSR. Over 20 beaver dams block a 5 km section of the river to annual adult salmon migration (Cleveland 2002a). Cleveland also notes that logging has negatively influenced most of the streams entering Kitwancool Lake. Recent investigations by the GFA have revealed that several of the larger, high fish value streams are subterranean in their lower reach due to bank de-stabilization from logging in the riparian area and resulting downstream aggradation.

Access

Highway 37 North is a paved, all-weather road that leaves Highway 16 at Gitwangak. This highway provides north-south access with all secondary roads branching off it. The highway links Gitwangak, Gitanyow, and Kitwanga villages with the Nass River valley, as well as Terrace and Hazelton via Highway 16.

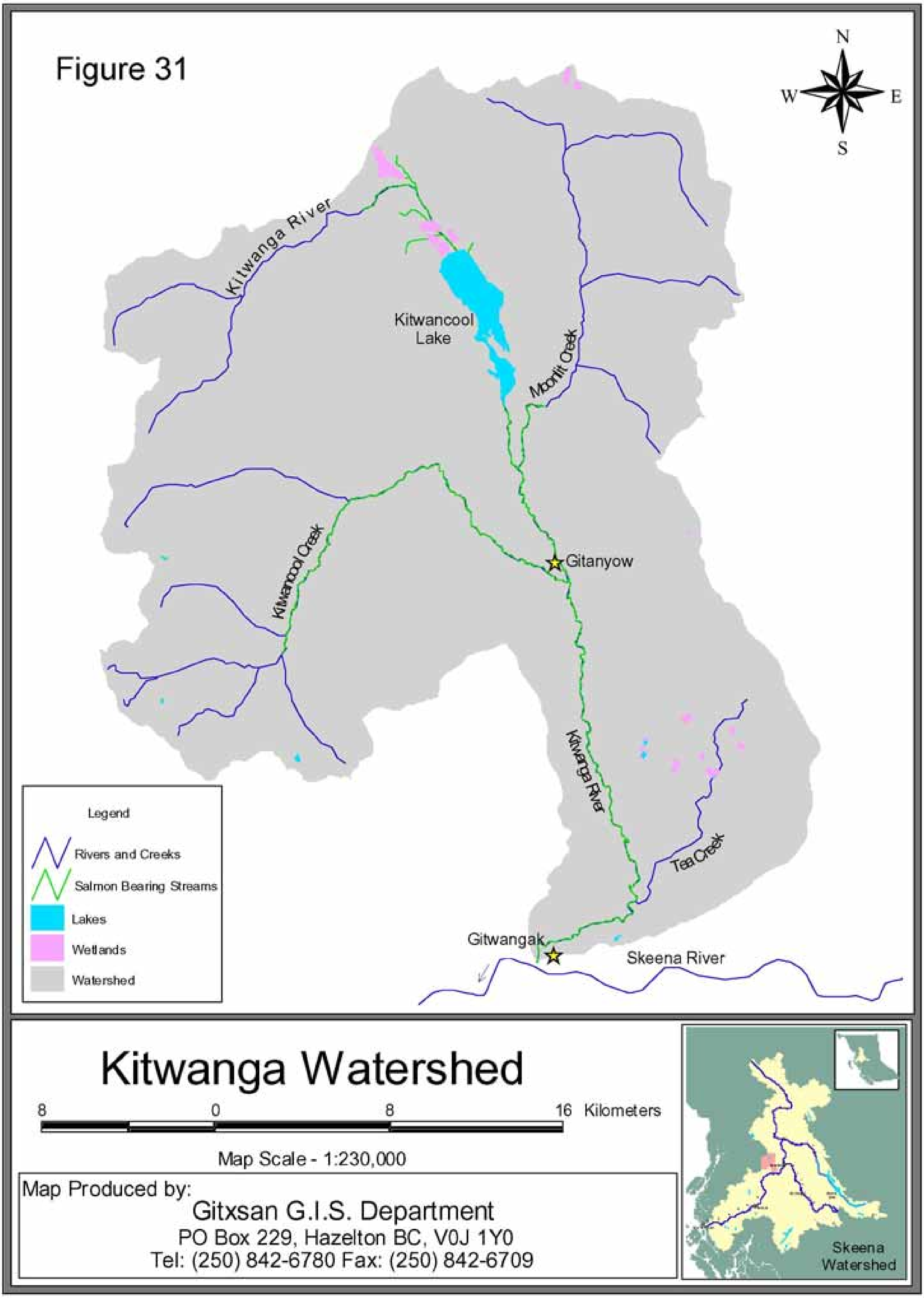


Figure 31
N
W
E
S
Kitwanga River
Kitwancool Lake
Moonlit Creek
Kitwancool Creek
Gitanyow
Kitwanga River
Tea Creek
Gitwangak
Skeena River
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Kitwanga Watershed
8
0
8
16
Kilometers
Map Scale - 1:230,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values and Resources

The Kitwanga River Watershed is a relatively small, but biologically rich river system that has considerable and varied high value fish habitat. Fish species utilizing this habitat include sockeye, coho, pink, chum, and chinook salmon; steelhead, rainbow, and cutthroat trouts, Dolly Varden, kokanee, bull trout, and mountain whitefish. The survival of the sockeye salmon population is a serious concern. Bull trout, which are abundant in this watershed, have been identified as a species of provincial concern (blue listed). The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage. It also provides strong cultural, economic, and symbolic linkages, particularly for First Nation peoples, and as well, supports recreational anglers and commercial fisheries.

Chinook

The relatively small, but strong chinook population in the Kitwanga River contributes a few percent of the total Skeena chinook escapement. In the SEDS database, the escapement trend from 1950 (700 adults) to the mid-1980's (<100) indicates a collapse of the Kitwanga chinook sub-stock. Following the closure of directed net chinook fisheries in 1983 and the Pacific Salmon treaty in 1985, the stock increased to record escapements with average escapement in the 1990's of over 1,500.

Chinook salmon typically enter the Kitwanga system in early August and head to their spawning grounds. The principal chinook spawning areas are the reach below the lake outlet, the lowest reach of the river near the Skeena, and the mainstem reach immediately downstream of Kitwancool Creek confluence (DFO 1991a). Recent spawning assessment surveys conducted by the GFA show that 40% of chinook spawning in the Kitwanga system occurs in the mainstem section 1 km below Moonlit Creek. GFA also noted that approximately 20% of the total chinook spawners were evenly distributed over the lower 12 km of Kitwancool Creek, (McCarthy *et al.* 2002). Rearing takes place throughout the mainstem and lower tributary reaches.

Pink

The Kitwanga River is one of the major pink salmon producing rivers in the Skeena system. The Kitwanga even and odd-year pink runs do not have a well-developed dominance. Compared to other Skeena sub-basin pink populations, the Kitwanga pink population trend since 1950 shows a slight increase. Mean annual escapement since the 1950's to the present is 153,000 odd-year adult pink salmon and 123,000 adult pinks in even years, ranging from 5,000 in 1988 to 400,000 in 1987.

Pink salmon generally enter the Kitwanga River in early to mid-August, in two timing groups. Early spawners use the lower Kitwanga River below Kitwancool Creek, though in years of high abundance they make use of the river up to and including Moonlit Creek. The later (7 to 10 days) spawning group uses the mainstem between Moonlit Creek and the lake outlet (Woloshyn 2002). Major concentrations of pink spawners have also been recorded by GFA from Tea Creek downstream to the Skeena confluence (Cleveland 2002).

Chum

Adult chum salmon returning to spawning grounds in the Kitwanga River made up approximately 40% of the total reported Skeena system chum escapement in the early 1950's (DFO 2001). In 1957, chum adult populations abruptly declined until the mid-1980's, when returning adult numbers increased to an annual average over five years of 1,500 chum into the early 1990's. Since 1993, chum escapement has annually averaged less than 400 fish.

Chum salmon typically return to their Kitwanga River spawning grounds in mid to late August. Principal chum spawning occurs in the lowest reach of the river, in the mainstem reach below the confluence of Kitwancool Creek, and in the section of river below the lake outlet. The GFA has recently observed chum spawners in the mainstem adjacent to Moonlit Creek and to 200m upstream on Moonlit Creek (Cleveland 2002). Upon emergence as fry, the juveniles migrate directly to sea.

Sockeye

Historical BC16 records, maintained between 1919 and 1950 (Smith and Lucop 1966), show Kitwanga River sockeye escapement to be approximately 5,000 to 10,000 spawners. Gitanyow elders indicated that declines in salmon returns began in the 1960's, with most sockeye fishing sites along the Kitwanga River abandoned by the early 1970's (Jacobs and Jones 1999). Escapement since the 1960's has rarely exceeded several hundred spawners; the annual average escapement for the last five-year period is 225 sockeye (Cleveland 2002).

Sockeye adults typically return to the Kitwanga River in early August and pass up the mainstem to their principal spawning grounds. Historically, spawning occurred in the mainstem below the lake outlet and above the lake inlet on Kitwanga River, with extensive spawning along the northern and western lakeshore (Smith and Lucop 1966, Jacobs and Jones 1999). Spawner surveys in 1998 by Jacobs and Jones recorded sockeye spawners only from the lake outlet to just downstream of Moonlit Creek confluence. Recent GFA observations noted sockeye spawners in Kitwancool Lake only (Cleveland 2002).

Shortreed *et al.* (1998) describe Kitwancool Lake as one of the most biologically productive lakes in the Skeena. The zooplankton is dominated by *Daphnia*, a preferred food for sockeye fry. Sockeye fry size however seems small at the end of the first year's growth. Recent scale analysis suggests that juvenile sockeye rear in Kitwancool Lake for two years before migrating as smolts (Williams and Halliday 2002).

Coho

Coho salmon in the Kitwanga Watershed are widespread in stream habitat, although knowledge of them is scant. SEDS records show average escapements of less than 300 coho for the 1960's, while the 1970's and 1980's show average escapements of approximately 600 fish annually. SEDS records are very incomplete for the 1990's; however, escapement in 1990 was 2,500 coho. Cleveland (2002) reported mainstem stream walk enumerations of 2300 coho salmon in 2000 and approximately 3500 coho adults in 2001 (Cleveland 2002). There is no known escapement data for any of the tributaries.

Generally, coho migrate into the Kitwanga system from early September to mid-October. They hold in the mainstem and off tributary mouths until fall storms flows permit passage into smaller streams. Coho spawning grounds on the mainstem are concentrated from Kitwancool Lake downstream to 1 km below Moonlit Creek confluence. Other principal spawning areas are the lowest reach of the river and the reach downstream from Kitwancool Creek. The major tributaries – upper Kitwanga River, Moonlit Creek, Kitwancool Creek, Deuce Creek, and Tea Creek – support coho spawning in varying degrees. Coho juveniles are widespread throughout the tributary streams and mainstem. Migration to saltwater occurs one or two years after hatching, but the proportion of these two age classes is unknown. Coho adults return after about 16 months at sea.

Steelhead

The Kitwanga Watershed supports one of the significant steelhead populations in the Skeena Watershed. There is insufficient and uncertain data to adequately assess the current stock status, past escapements, or trends in abundance over time.

Kitwanga River steelhead enter the Skeena River as summer run fish. They migrate into Kitwanga River from August through December. Adult steelhead overwinter in the lower 12 km of the Kitwanga River in the area largely composed of canyons, bedrock outcrops, and pools (Lough 1983). Many steelhead also overwinter in the Skeena River at the mouth of the Kitwanga River (GWA unpublished data). Lough's (1983) radio telemetry study also found steelhead overwintering in the Skeena River, and although no steelhead were found in Kitwancool Lake, the lake may be an important overwintering locale. Lough (1983) reported that Kitwanga River steelhead moved in early May onto spawning sites located throughout the mainstem below Kitwancool Lake, and that spawning activity peaked in mid-May, with most kelts departed by the end of May. The dominant steelhead spawning ground appears to be from Kitwancool Lake downstream to the Moonlit Creek confluence.

The Kitwanga River from Kitwancool Lake to the Skeena has been documented as juvenile rearing habitat (Beere 1993, Bustard 1992, 1993). Over three years, the overall fry and parr combined density was 0.80 juvenile/m^2, significantly greater than that found in similar sampling programs in the Morice system (0.23/m^2) and in the Zymoetz system (0.27/m^2) (Beere 1993). Bustard (1992) reported that 64% of the juvenile fish captured during the 1991 study in the Kitwanga River mainstem were juvenile steelhead, while in lower Moonlit Creek they comprised only 9.4%. Scale aging data from Kitwanga River steelhead indicate that juveniles remained in freshwater for three to five years (mean=3.67), and that the majority of juveniles spent three years (44%) or four years (44%) in freshwater. The data further showed that the majority of steelhead (66.7%) spent two years in the ocean before their first spawning at age six (Grieve and Webb 1999b, Cleveland 2002b).

Fisheries

First Nations Traditional Use

Traditionally, Gitxsan from the Gitanyow and Gitwangak villages used the Kitwanga Watershed. Two Gitxsan House groups from Gitwangak; Gaxsbgabaxs and Sakxum Higookw, utilized the lower portion of the drainage. Gwaas Hlaam and Gwinuu, House groups from Gitanyow, used the upper, major portion of the watershed as their home. Gitanyow village is the only Gitxsan settlement removed from the Skeena or Babine River mainstreams. Its location is along the "grease trail" from the Skeena to the Nass River (Derrick 1978).

The abundant and predictable sockeye salmon stocks provided the Gitxsan with opportunity to harvest and preserve a large amount of high quality food in a relatively short time of intensive effort. The dominant sockeye run was the major focus, as it provided the majority of high-quality dried fish needed to sustain the Gitxsan over the year, and to produce a trade item. Following the passage of the bulk of the sockeye, coho were available well into the autumn, providing both fresh and dried fish. Rainbow trout, steelhead, lake trout, and Dolly Varden char were also fished in their respective habitats and then processed.

Although various fisheries occurred on the Kitwanga River, by far the most intensive fishing effort was the harvest at the weir immediately below Gitanyow village. This productive weir, built across the shallow river, supplied most of the salmon needs for the Gitanyow people. Posts pounded into the river bottom and then overlaid with panels of split cedar secured on the upstream side supported a walkway across the top, enabling access to barrel-type traps. These traps were fitted with a movable panel through which fish could be dipped or gaffed out, or released, dependent on whether the species was desired.

Other fish weirs were also used at the outlet of Kitwancool Lake, at a site downstream from the Kitwanga-Kitwancool confluence and approximately 8 km north of Kitwanga. The Skeena River salmon investigation report (Pritchard 1948) indicated that there were 92 Indian families with six smokehouses living along the Kitwanga River.

Recreational Fisheries

Kitwanga River and Kitwancool Lake attract a moderate recreational fishery that is dominated by regional residents. Angling for chinook and steelhead is popular, particularly at the Skeena-Kitwanga confluence, though steelhead fishers utilize various holes along the mainstem. Kitwancool Lake is fished in all seasons for resident cutthroat and rainbow trout, and is easily accessible. Since 1991, guiding on Kitwanga River has not been permitted. Creel surveys for the chinook and coho fisheries at the mouth of the Kitwanga River were carried out in 2000 and 2001. The sports fishing harvest recorded is small, 113 chinook in 2000 (Gottesfeld 2001) and 25 coho in 2001 (Hall and Gottesfeld 2002). Creel survey data related to the river and lake is discussed in Kingston (2002). Current angling regulations designate the Kitwanga River as Class II Waters year-round, with a Steelhead Stamp mandatory September 1 to October 31. A bait ban is applicable September 1 to December 31(MELP 2000).

Enhancement Activities

Enhancement activities in the Kitwanga Watershed have been ongoing for centuries according to Gitanyow Elders, particularly in regard to beaver populations and fish access management. The Fisheries Research Board operated a counting fence on the lower river close to the Skeena confluence from 1957 to 1960 (DFO 1930-1960). A coho incubation box located at Gitanyow ground channel is in operation to raise 10-12,000 coho eggs annually (Jacobs and Jones 1999, Kingston 2002). Since the mid-1990's, the GFA has been active in enhancement work primarily directed to facilitating fish access, beaver dam mitigation, and salmonid fry salvage (Cleveland 2002).

Development Activities

The principal development activities involve forest development, population and settlement, and linear development. There are few mineral occurrences and no known mineral developments in the watershed.

Forest Resource Development

The Kitwanga Watershed is located within the Ministry of Forests, Kispiox Forest District. Forest development activity began with agricultural clearing by settlers following completion of the Grand Trunk Pacific Railway in 1912. Small-scale lumbering led to small bush mills, and the post-WW II economic boom skyrocketed demand for lumber. Independent cedar pole loggers also saw a demand for poles at this time. In the early 1950's, Columbia Cellulose was granted TFL # 1, which initiated the trend toward the centralization of license holding and milling capacity. Over the years up to 1960, logging was selective with a moderate proportion of residual timber left standing, particularly in the southeastern portion of the watershed. Timber was processed by small, on-site sawmills, whose sawdust piles are still clearly visible from the air. By the mid-1960's, vast areas of accessible timber both west and east of the Kitwanga River up to Kitwancool Lake were logged.

Since the mid-1960's, clearcut harvesting has been the silviculture system of choice. In 1963, consolidation of seven or eight small mills led to establishment of Hobenshield's mill at its present location. From the mid 1960's to the 1970's, the valley bottomlands north of Kitwancool Lake saw their initial logging. The Canadian Cellulose sawmill was constructed in Kitwanga in the early 1970's. During the 1970's, most logging was in the lower, eastern portion of the watershed and in the low-lying country north of Kitwancool Lake, with minor development in the lower Moonlit Creek area. In the 1980's, the upper Kitwanga valley, along with the slopes to the east of Gitanyow and around Kitwancool Lake, saw extensive logging development. Forest development activities also occurred in Moonlit Creek and some mainstem tributaries draining from the east. Further development in the 1990's was concentrated in McKenzie, Manuel, Hanna, and other headwater drainages of the upper Kitwanga River, with widespread and dispersed development elsewhere in the watershed.

The above forest development activities raised fish and fish habitat concerns with First Nation peoples, local residents, and fish conservation interests. Since 1995, the Watershed Restoration Program has been involved in assessing the forestry related impacts and upslope sediment-producing areas in relation to fish and fish habitat (Wildstone 1995). Watershed health has benefited from road deactivation, riparian, in-stream, and off-channel site works to a certain degree. Habitat restoration activities, conducted under the Watershed Restoration Program, include culvert backwatering, placement of LWD, and riparian site works (McElhanney 2001). The planned restoration investment is very large. McElhanney (2001) summarized the 12 assessment and site works projects conducted in the watershed since 1995, and concluded that approximately $750,000 of logging related, prioritized restorative work is still needed.

The large wetland complex drained by Kitwanga River, located north of Kitwancool Lake, which was adversely affected by logging, remains an outstanding compound problem from a fisheries perspective (Cleveland 2002). This problem is due to the beaver expansion following the spread of deciduous trees into clearcuts. The beaver dams have greatly dispersed stream flows from the upper Kitwanga River, blocked anadromous fish passage, and caused increases in stream water temperature.

Future trends regarding forest development activities are uncertain. Skeena Cellulose Incorporated (SCI), which holds a large amount of the allocated cut in the Kitwanga Watershed has terminated its forest development activities due to a series of financial difficulties. Kitwanga Lumber Co., a subsidiary holding of SCI, has managed to stay in logging and sawmill production. This also affects the Ministry of Forests Small Business Program, as SCI is the predominant buyer of the logged Small Business cut volumes. Adding to this uncertain future are high softwood tariffs, high stumpage rates, and proposed structural changes in BC Government forestry legislation and policies. The watershed is managed under the direction of the Kispiox Land and Resources Management Plan (Ministry of Forests 2001a), which provides land use management zoning, objectives and strategies.

Transportation and Utilities

The existing transportation network in the watershed reflects 80 years of steady improvement based on the First Nations trail infrastructure, particularly Highway 37, which follows the "grease trail" (Derrick 1978). Trails were initially widened for packhorses and later improved for wagons, then further improved for vehicular traffic. The railroad provided the main transportation link to the mouth of the watershed up to 1950, when the Kitwanga Backroad, a series of pole logging roads, was connected to roads from Hazelton (Hobenshield 2002). In 1975, improvements to Highway 37 included alignment, pavement, new drainage structures, and the Skeena River bridge crossing. Overall, the development pattern has been spurred by the motive to extract forest products. Most of the watershed, including all major tributaries, is currently roaded to support forest sector activities.

From Highway 16, which passes south of the Skeena River, Highway 37 North runs northerly, following Kitwanga River past Kitwancool Lake and through the divide into the Nass drainage. Other than the paved highway, all other roads are gravel surface. Secondary roads branching off Highway 37 include: the Kitwanga Backroad, Tea Lakes FSR, Mill Lakes FSR, Ten Link Creek Road, Kitwancool FSR, 18 Mile Branch, Moonlit Branch, Rehab Branch, and the Kitwanga Main.

Utilities are limited within the watershed. Electricity is supplied by BC Hydro's provincial grid, with the transmission line closely following the highway and servicing the communities of Gitanyow, Kitwanga, and Gitwangak.

Population and Settlement

The Kitwanga valley has been home to Gitxsan people for thousands of years. Many Euro-Canadian settlers arrived following completion of the railroad in 1912, attracted by the agricultural possibilities. The Kitwanga Watershed population base has slowly grown to total 1,315 people (StatsCan 1996, SNDS1998). Community populations are as follows: Gitanyow 403, Kitwanga 383, and Gitwangak 529.

The majority of watershed residents, when employed, derive their income from the forest sector, though a moderate proportion of Gitanyow and Gitwangak residents are involved in the fishing industry. Basic income has largely flowed from two relatively small sawmills and their associated contract woodlands operations. Severe job losses related to both the forestry and fishing sectors have caused massive unemployment problems. The population trend for the two First Nations communities points to slow, steady growth.

Kitwanga Watershed Management Issues

The Kitwanga River Watershed is a relatively small, but biologically rich river system that has a considerable amount of varied high value fish habitat. Fish species utilizing this habitat include sockeye, coho, pink, chum, and chinook salmon; steelhead, rainbow, and cutthroat trout, Dolly Varden, kokanee, bull trout, and mountain whitefish. The survival of the sockeye salmon population is a serious concern. Bull trout, which are abundant in this watershed, have been identified as a species of provincial concern (blue listed). The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage. It also provides strong cultural, economic, and symbolic linkages, particularly for First Nation peoples, and, as well, supports recreational and commercial fisheries.

There is a relatively small, though strong chinook population in the Kitwanga River. The Kitwanga River is one of the major pink salmon producing rivers in the Skeena system. Compared to other Skeena sub-basin pink populations, the Kitwanga pink population trend since 1950 shows a slight increase. Adult chum salmon returning to spawn have fluctuated greatly since the 1950's. Since 1993, chum escapement has averaged less than 400 fish. Historical BC16 records, maintained between 1919 and 1950, show Kitwanga River sockeye escapement to be approximately 5,000 to 10,000 spawners. Gitanyow elders indicated that declines in salmon returns began in the 1960's. Escapement since the 1960's has rarely exceeded several hundred spawners; the annual average escapement for the last five-year period is 225 sockeye. Coho salmon in the Kitwanga Watershed are widespread in stream habitat, although knowledge of them is scant. Current average escapement is approximately 3,000 adult coho. The Kitwanga Watershed supports one of the significant steelhead populations in the Skeena Watershed.

The principal development activities revolve around forest development, population and settlement, and linear development. There are no known mineral developments in the watershed. Since the early 1970's, the Kitwanga Valley and tributaries have seen extensive clearcut logging development. The large wetland complex drained by Kitwanga River, located north of Kitwancool Lake, which was adversely affected by logging, remains an outstanding compound problem from a fisheries perspective. Most of the watershed, including all major tributaries, is currently roaded to support forest sector activities.

The effects of forest development activities raised fish and fish habitat concerns among First Nation peoples, local residents, and fish conservation interests. Since 1995, the Watershed Restoration Program has been involved in assessing the forestry related impacts and upslope sediment-producing areas in relation to fish and fish habitat. Overall, watershed health has benefited from road deactivation, riparian, in-stream, and off-channel site works to a certain degree. Approximately $750,000 of prioritized logging-related, restorative work has been proposed.

The Kitwanga Watershed population base has slowly grown to a total of 1,315 people in Gitanyow (403), Kitwanga (383), and Gitwangak (529). Severe job losses related to both the forestry and fishing sectors have caused massive unemployment problems. The population trend for the two First Nations communities points to slow, steady growth.

Ecstall Watershed

Environmental Setting

Location

The Ecstall (often pronounced "Oxstall") Watershed is located in the southwest corner of the Skeena Watershed, southeast of Prince Rupert. The watershed is a relatively small sub-basin tributary of the Skeena River, situated 30 km southeast of Prince Rupert, BC, and approximately 10 km upstream from the mouth of the Skeena River. The watershed is bounded to the north by the Skeena River floodplain, to the west and south by tributary basins draining to Telegraph Passage, Grenville Channel and Douglas Channel, and to the east, by Scotia River and the Giltoyees drainage.

Hydrology

The Ecstall River Watershed is a fourth order system with a catchment area of 1,485 km^2. Elevations ranges from 1,935 m to 0 m at the Ecstall-Skeena confluence. The Ecstall River flows generally northwesterly for 94 km from its headwater lake to discharge into the Skeena River estuary. There is an annual May to early June discharge peak due to high elevation snowmelt. The larger floods are rainstorm and rain-on snow flows that can occur from September through the winter, but are most common in October and November. Total mean annual precipitation is 3,683 mm at Falls River, located in the lower watershed. Climate conditions are characterized by high precipitation and generally moderate to cool conditions.

Because of the steep terrain within the watershed, the Ecstall and most of its tributaries are subject to high water flow fluctuations immediately following moderate and heavy rain events. Summer low flows are typically 4-8 times greater than winter stream flows and are sustained mainly by high elevation snowmelt, while winter low flows are derived from lakes, groundwater, and unfrozen wetlands. Snowfall can occur anytime in the period between November and April, with an increasing proportion of the annual precipitation occurring as snowfall at higher elevations. Historic stream flow data exists for the Falls River and Brown Creek; both have been dammed to develop hydroelectric power.

Eleven medium and large-size lakes contribute a substantial amount of water storage within the watershed. Johnston Lake, Lower Lake, and Ecstall Lake are significant within the Ecstall system for high quality rearing habitat and for the moderating influence on their outlet streams water flows.

The Ecstall River is the dominant hydrological feature in the watershed. Brown Creek, Sparkling Creek, Muddy Creek, and Madeline Creek are the major tributaries flowing into the left bank. Major right bank tributaries are Hayward Creek, Big Falls Creek, and Johnston Creek. Of the approximately 80 second order or larger tributaries, 10 are of major consequence; however, most of these tributaries have gradients too steep for fish passage. These streams drain glacial headwaters, deliver moderate amounts of sandy sediment, and in the summer season have silty glacially derived variable flows.

Geography

The distinctly rugged landforms of the Ecstall Watershed are situated within the Kitimat Range of the Coast Mountains. The mountains are bold, impressive, massive, and largely comprised of granitic rocks of the early Tertiary Ecstall Pluton, one of the Coast Range Intrusives. For the most part, the mountains are below 6,000 in elevation. The heavily glaciated north and northeastern sides of the peaks have remnant small glaciers and ice fields (Holland 1976).

The Ecstall valley is a northwest trending fault lineament that extends through the Quall River to Douglas Channel. During retreat of the last ice age glaciers, sea levels underwent a complex series of fluctuations. The Ecstall Valley was briefly a fiord 10,000 to 11,000 years ago, and was subsequently isostatically uplifted and partially filled with fluvial and marine sediments (Gottesfeld 1985). Modern landforms have colluvial and morainal blankets whose surface expression conforms to the underlying bedrock structure. The valley bottoms have glacio-fluvial mantles and glacio-fluvial fans as the dominant surficial features (Clague 1984). Typically, the steep, U-shaped valley slopes rise from the valley to the mountain summits. Along their length, water cascades over falls and down rock faces that are often swept clean of vegetation.

The coastal climate is reflected in the major ecological zones. The Coastal Western Hemlock (CWH) zone represents the vegetation in the valley bottoms and slopes to 400 m. Old-growth conifer stands of western hemlock, western red cedar, Sitka spruce, and amabilis fir dominate the forested landscape. Large spruce, hemlock, and deciduous trees, with salmonberry, ferns and devil's club comprising the principal understory vegetation, characterize floodplains and alluvial sites. The floodplain upstream from Muddy Creek is dominated by large spruce and is undoubtedly one of the richest and most diverse ecosystems on the North Coast (Liepens 2002). The CWH zone passes upward into the Mountain Hemlock (MH) zone, which is dominated by mountain hemlock and amabilis fir with occasional spruce, red cedar, and yellow cedar. A well-developed shrub layer is mostly composed of Alaska blueberry, false azalea, and red and black huckleberries (Banner *et al.* 1993).

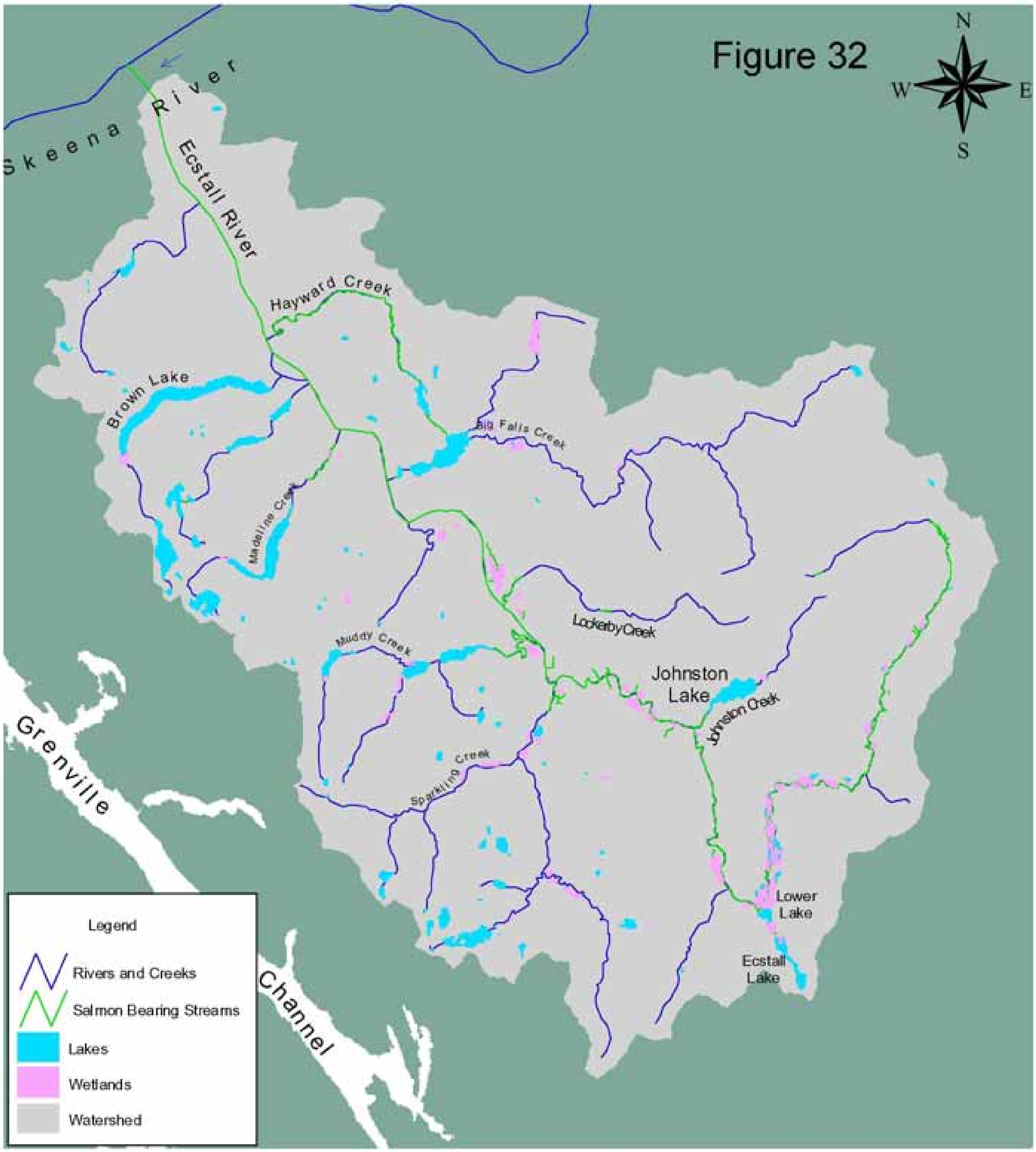
Stream Channels

Tidal influence extends approximately 42 km upstream of the Ecstall River mouth to Sparkling Creek. This reach of the river is a single, confined channel with relatively little floodplain that is mainly comprised of inside meander bends and tributary mouths. The lower section of the lower reach exhibits a continuous channel, while the upper section possesses a sinuous, irregular pattern. At low water, the braided nature of the channel with its periodically changing shoals and bars is evident. The gradient is close to 0%, but the tide accelerates the river flow on the ebb tide and retards it on the flood.

The second reach, which extends approximately 18 km from Sparkling Creek to Lower Lake Creek (also known as Ecstall Creek), is a single threaded, irregular sinuous channel, with an average floodplain width of 1 km. A stable channel amid relic channels and extensive wetlands characterizes the third reach and the one km wide floodplain. The upper reach is braided and heavily aggraded, reflecting the drainage of huge quantities of sediments from the many adjacent glaciers and ice fields. Alluvial fans and avalanche deposition from the steep slopes dominate the 500 m wide floodplain. The majority of the tributary streams in this reach rapidly increase in gradient once off the floodplain.

Access

Access to and within the Ecstall Watershed is limited to either air or boat travel. Road travel is possible to Hayward, Big Falls, and Carthew Creeks, and to an un-named creek south of Big Falls, via the logging road network that originates in the Scotia River drainage. Riverboats travel a considerable distance up the Ecstall mainstem; however, local knowledge is needed for successful navigation.



Ecstall Watershed

10 0 10 20 Kilometers

Map Scale - 1:320,000

Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709

Fisheries Values and Resources

Ecstall River Watershed is a relatively small, but biologically productive river system that has diverse high value fish habitats. Fish species utilizing its habitats include: sockeye, coho, pink, and chinook salmon; steelhead trout, rainbow trout, Dolly Varden char, and mountain whitefish. Eulachon spawn in the tidal portions. The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage. It also provides strong cultural, economic, and symbolic linkages, particularly for First Nation peoples, and supports recreational and commercial fishing.

Chinook

Based on data from the DFO's SEDS, the aggregate Ecstall River chinook stock is one of the top producers in the Skeena Watershed. Ecstall River chinook were not as heavily harvested by the mixed stock fishery as were many other Skeena chinook sub-populations. Following the closure of directed net chinook fisheries in 1983, the river mainstem run appears to have rebounded until 1990. Escapements since then have been poorly sampled but appear to be depressed. The Johnston Creek chinook run, which averaged 2,900 adult spawners in the 1950's and 1960's, declined precipitously in 1970 to 300 returning adults and has stayed depressed to the present time (DFO 2001). The lower reach of Sparkling Creek and the outlet tail pond of Big Falls Creek also support chinook spawning; however, the escapement data is scant and too limited to assess population trends over time.

The critical chinook spawning ground in the Ecstall system is the lower section of the 1.4 km low gradient reach of Johnston Creek between Ecstall River and Johnston Lake, which possesses excellent gravels. Adults return in early to mid-August and spawn shortly thereafter. Other significant spawning grounds on the Ecstall River occur in scattered pockets from the upper tidal limit, with higher densities between Johnston Creek upstream past Lower Lake Creek for 6 km (Ginetz 1976). Spawning is also prevalent, to a lesser degree, in the lower reach of Sparkling and Big Falls Creek. The Ecstall River chinook start arriving in early July, spawning notably earlier than the Johnston Creek run (Jantz *et al.* 1989). The Johnston Creek run may remain suppressed because of inadvertent harvest in pink salmon seine catches (Winther 2002).

Ecstall chinook age structure is believed to be similar to that of the nearby Skeena Test Fishery, which does not sample Ecstall River. It is thought that chinook fry emigrate from mid-April to early June, as is typical of Skeena chinook, and utilize the lower Ecstall and lower Skeena Rivers for rearing habitats. The Ecstall chinook are genetically separable from all other Skeena stocks and seem more related to north coast populations (Winther 2002).

Pink

The Ecstall system has a relatively small pink population that spawns in the mainstem, Hayward Creek, Big Falls Creek outlet, Johnston Creek, Lockerby Creek, Madeline Creek, Muddy Creek and Sparkling Creek. The Ecstall River pinks were abundant for four decades until pink adult abundance decreased in the 1960's. Populations rebounded in the early 1980's. Since 1994 odd years have been dominant with record high returns. Johnston Creek up to the late 1930's had relatively strong runs of pink salmon (FRB Ann Rpt.). Johnston Creek and the other 6 creeks within the watershed that support pink spawners have little data to assess escapement trends.

Adult pink salmon typically arrive in the Ecstall River in early August with peak spawning from mid-August through to September. Principal spawning in the mainstem tributaries is generally in their lowest reaches, while mainstem spawning occurs in scattered pockets above the tidal range. Significant mainstem spawning beds are located in the 15 km stretch upstream of Sparkling Creek and extending to Lower Lake Creek. Fry typically emerge in late March to mid-April and emigrate downstream to the estuary.

Chum

The Ecstall River receives the largest escapements of chum salmon in Area 4, averaging 65% of the total over the forty-year period, 1950 to 1990. Ecstall chum escapements fluctuate highly from year to year, with the range since 1950 from 75,000 to 500 adult spawners; however, decadal averages have generally stayed similar. The proportion of Ecstall spawners relative to the total chum escapement for Area 4 has increased from approximately 20% in the 1950's to as high as 85% in the 1990's. Johnston Creek has seen a steady decline from 1,500 spawners in the 1950's to less than 200 annually since the early 1980's.

Although escapement data is not available prior to the 1940's, Skeena fish catch information from 1900-1930 indicates significantly larger Skeena chum populations than at present. Annual catches in the 100,000 to 200,000 range were commonplace, with the majority of fishing occurring in the Skeena and Ecstall Rivers.

The main run of chum salmon into the Ecstall system occurs throughout August with peak arrivals in mid August. The main spawning grounds are along the mainstem above the tidal range, from Sparkling Creek to Lower Lake Creek. Tributaries supporting chum spawning are: Madeline Creek, Big Falls Creek, Lockerby Creek, Johnston Creek, and Sparkling Creeks, all of which currently have few spawners, or else have not been observed and counted in recent years.

Sockeye

Within the Ecstall Watershed, sockeye return to spawn in the Johnston Creek and Lake system and the Ecstall Creek and Lake system. Brett (1952) estimated that average escapement to Johnston Lake was 1% of the total Skeena escapement. Johnston Lake escapement counts have been conducted fairly regularly since the mid-1920's. Johnston Lake sockeye escapement decreased rapidly in the 1950's and stayed depressed (<1,000) until the early 1970's. A peak return of 7,500 sockeye was recorded in 1972; this return probably reflects the lack of fishing due to the 1972 strike. Returning spawners then dropped off to less than 1,000 fish until 1995 when the historic abundance levels of the 1940's were reached and maintained until the present. A lack of escapement data for Ecstall Creek limit discussion on population trends.

Sockeye run timing into the Ecstall River was reported by FHIIP (DFO 1991d) to occur from June through August, with spawning from mid-September to mid-October. Sockeye have been observed in mid-June in Johnston Lake. The principal sockeye spawning grounds in the Johnston system are the 600 m reach downstream of Johnston Lake outlet with beach spawning in the lake, concentrated at the inlet end. Ecstall Creek, located between Ecstall Lake and Lower Lake, is the primary spawning bed for Ecstall and End Lakes. Upon emergence from the gravel, fry rear in the stream-headed lakes – Johnston Lake, Ecstall Lake, and Lower Lake probably for one year before emigrating to saltwater.

Coho

Coho from the Ecstall drainage contributes a substantial proportion to the overall Skeena coho population. Along with the Ecstall River mainstream, Lockerby Creek, Johnston Creek, Madeline Creek, Hayward Creek, and several un-named creeks support coho spawners. Ecstall River is the only stream that has semi-regular escapement counts. Escapement in 1984 and 1990 reached 10,000 spawners, with the 18-year annual average escapement to the present indicating approximately 4,300 coho adults. Coho populations did not decline in the 1970's and 1980's as they did in the upstream portions of the Skeena Watershed.

Coho arrive in Ecstall River typically in late September and head to scattered spawning pockets along the mainstem and tributary mouths. The start, peak, and end of coho spawning periods are not known. Pre-spawning movement into back channels and tributary streams is often delayed due to low water flows. Coho spawn in the lower tributary reaches and in the lower section of Johnston Creek. In the mainstem, coho have been observed spawning upstream as far as 92 km. Most of the recent escapement to the Ecstall Watershed has spawned in the mainstream from 5 km above Ecstall Creek to the headwaters (Wagner 2002). Recent DFO helicopter counts have observed strong numbers of adult spawners in Johnston Creek tributaries, Ecstall Lakes system, and generally the entire mainstem above the tidal range (Finnegan 2002). Coho juveniles spend one or two years in freshwater before emigrating to saltwater.

Steelhead

Steelhead are known to be winter run and present in the watershed, but information about their life history and populations is scant. Steelhead have been observed in the Johnston system as early as mid-February, though most appear in March and April (Chudyk 1974). They have been observed spawning in the lower section of Johnston Creek (DFO 1991d).

Fisheries

It is important to note that before 1936, gill netting was permitted in the Ecstall River (Brett 1952). This historical commercial fishing practice most likely significantly reduced the escapement of sockeye, chinook, chum, pink, and coho to the Ecstall River.

First Nations Traditional Use

First Nations traditional use of the Ecstall Watershed was extensive and varied with village sites, home places and fish houses or stations. The watershed is within the territory of the Tsimshian, who were divided into fifteen local groups that were politically autonomous but shared close links. The Gitzaxlaal held the watershed territories with two main seasonal villages: Spiksuut, located at the Ecstall-Skeena confluence, and Txalmisoo', located at Big Falls Creek (Halpin and Seguin 1990).

Salmon was a most important food for the Tsimshian. The very abundant and predictable sockeye salmon stocks provided the Gitzaxlaal with opportunity to harvest and preserve a large amount of high quality food in a relatively short time of intensive effort. The sockeye run was the major focus, as it provided the majority of high-quality dried fish needed to sustain the Gitzaxlaal over the year, and to produce a trade item. Following the passage of the bulk of the sockeye, coho were available until early winter, providing both fresh and dried fish. Salmon were primarily caught in weirs, or by spear, then processed by smoke-drying. Herring, ground fish, a variety of marine invertebrates, and sea mammals were harvested; however, the eulachon was probably the most important non-salmonid resource fished. A major aboriginal trail extended from the Ecstall Valley to provide linkage to Douglas Channel. It ran parallel to the Ecstall River, passed Ecstall Lake, crossed the divide, and continued downstream along Quall River to Kitkiata Inlet.

Recreational Fisheries

Sport fishing in the watershed is limited due to access considerations; however, river boat access provides transportation to the popular chinook fishery on Johnston Creek. In flood flows, a cascade is created at the canyon 1.2 km upstream of the Ecstall River. "Johnston Falls" generally attracts regional chinook angling enthusiasts (Neilson 2002). The Ecstall River and its tributaries are managed as Class II waters year-round, and a Classified Waters License is required (MELP 2000).

Enhancement Activities

There have been no known enhancement activities to date.

Development Activities

The principal development activities within the Ecstall Watershed revolve around forestry and utilities. In the recent past, there was also mineral development and town site development.

Forest Resource Development

In 1872, Port Essington was established as a trading post then grew into a substantial and thriving community by 1890 with a high demand for lumber and steamboat cordwood. By 1900, the five canneries built at the mouth of the Ecstall River were a hub of activity, and the demand for lumber was continuously high. By the 1906, the water-powered Brown's Mill was supplying lumber and box wood for the many canneries on the Skeena River (Large 1996, Harris 1990).

Small scale logging along the Ecstall mainstem by hand, boat, and steam power was the preferred method for many years. Early logging occurred primarily within the tidal range and was directed to easily accessible spruce trees, singly and in clumps. Logging these trees by hand, boat, and steam power, initially from the river, led to A-frame logging that was utilized into the 1960's to reach further back and up on to the side hills. Brown's Mill continued to operate until the late 1980's.

Large-scale industrial logging first occurred in the watershed in the late 1980's, when the logging road network from Scotia River was extended through the low elevation pass and down Carthew Creek. Logging also occurred along the Ecstall mainstem in the mid and late 1980's. There is currently extensive logging in the valley bottoms of Hayward Creek, Carthew Creek, Big Falls Creek, and Brown Lake. Jyrkkanen (1996) discussed logging-related impacts to these sub-basin drainages assessed under the auspices of the WRP. Progressive clearcuts are proposed for Lockerby Creek and many of the remaining forested stands in the above-mentioned creeks. The logging road network from Kumealon Inlet extends into Brown Lake, where extensive logging is proposed (Interfor 2001).

The Ecstall Watershed is within the Ministry of Forests, North Coast Forest District. International Forest Products is the major licensee operating in the area. The future trend will be a continuance of the present: logging the highly valuable and easily accessible valley bottom stands, with the priority effort directed to the most valuable stands in order to cover the high road development costs.

Mineral Resource Development

Mineral resource development within the watershed has focused on the large, massive sulphide deposit located near the Johnston-Ecstall confluence. This deposit has been the object of many extensive drilling programs, and over 1 km of tunnels was developed in the 1930's. Until economic conditions change substantially, this property will not progress to mineral production.

Transportation and Utilities

Two small hydroelectric developments are located within the Ecstall Watershed: the Falls River Project and Brown Lake Project. The Falls River Project was built in 1930 for the Northern B.C. Power Co. and acquired by BC Hydro in 1964. The project consists of a dam, two penstocks, and a 7 MW nominal power plant with 27 km of transmission line running down the east side parallel to the Ecstall River. The transmission line continues across the Skeena River and onward to Prince Rupert providing electric power to the city and the larger grid (BCFWRP 2001).

The Brown Lake Project was built in 1997 for Synex Energy Resources Ltd. The project consists of a 1.5 m high dam near the outlet of Brown Lake, with a 600 m tunnel to a powerhouse near sea level, generating 6 MW. The power is delivered via submarine cable to the BC Hydro grid and an interconnection with the 69 kV transmission line on the east bank of the Ecstall River (Sigma 1993).

Transportation to and within the Ecstall Watershed is limited to either air or boat travel. Road travel is limited to Hayward, Big Falls, Carthew, and an un-named creek south of Big Falls via the logging road network that originates in the Scotia River drainage. Riverboat travel is possible for a considerable distance up the Ecstall mainstem; however, local knowledge is needed for successful navigation.

Ecstall Watershed Management Issues

The Ecstall River Watershed is a small though biologically productive river system that has diverse high value fish habitats. Fish species utilizing its habitats include: sockeye, coho, pink, chum, and chinook salmon as well as steelhead, rainbow trout, Dolly Varden char, and mountain whitefish. Eulachon spawn in the tidal portions. The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage. It also provides strong cultural, economic, and symbolic linkages, particularly for First Nation peoples, and supports recreational and commercial fishing.

The aggregate Ecstall River chinook stock is one of the top producers in the Skeena Watershed. The Ecstall system has a relatively small pink salmon population. The Ecstall River pinks were abundant for four decades until pink adult abundance decreased in the 1960's. Populations rebounded in the early 1980's, and since 1994, odd-year pink salmon returns have been the record highs. The Ecstall River receives the largest escapements of chum salmon in Area 4, averaging 65% of the total Skeena Watershed over the forty-year period, 1950 to 1990. Ecstall chum escapements fluctuate highly from year to year, with the range since 1950 from 75,000 to 500 adult spawners; however, decadal averages have generally remained similar.

Within the Ecstall Watershed, sockeye escapement decreased rapidly in the 1950's and stayed depressed until the early 1970's, when returning spawners dropped off to less than 1,000 fish. Sockeye stocks increased briefly from 1970-1976. Low escapements are recorded until 1995 when the historic abundance levels of the 1940's were reached and maintained until the present. Coho from the Ecstall drainage contributes a substantial proportion to the overall Skeena coho population and probably did not decline in the 1980's and 1990's as they did in the upstream portions of the Skeena Watershed. Steelhead are known to be winter run and present in the watershed, but information about their life history and populations is scant.

First Nations traditional use of the Ecstall Watershed was extensive and continues into the present at moderate levels. Sport fishing in the watershed is mostly limited to the popular chinook fishery on Johnston Creek. The principal development activities within the Ecstall Watershed revolve around forestry and utilities. In the recent past, there was also mineral development and settlement with Port Essington and Brown's Mill.

Large-scale industrial logging first occurred in the watershed in the late 1980's, with current extensive logging in the valley bottoms of Hayward Creek, Carthew Creek, Big Falls Creek and Brown Lake. The future trend will be a continuance of the present: logging the highly valuable and easily accessible valley bottom stands, with the priority effort directed to the most valuable stands. Two relatively small hydroelectric developments are located within the Ecstall Watershed: the Falls River Project and Brown Lake Project. The transmission line crosses the Skeena River and runs to Prince Rupert.

Skeena River West

Environmental Setting

The Skeena River West is not a true watershed but is an area of distinctive and important habitat in the multichannel reach of the Skeena below Terrace and above tidal influence. It was selected due to its productive and abundant pink and chum salmon spawning populations, as well as its varied and high quality juvenile habitat used by coho, chinook, and steelhead that have dispersed from many tributaries upstream.

Location

The Skeena River West area is located from Shames River to Kasiks River, 38 km southwest downstream on the Skeena River mainstem and floodplain in west central BC. Shames River and Kasiks River are respectively 23 km and 61 km west of Terrace on Highway 16.

Hydrology

The climatological regime of lower Skeena River is characterized by substantial winter precipitation and comparatively smaller amounts in the summer. Mid-winter temperatures in the valley bottom are usually below freezing, and snowfall can occur anytime from October to April. An increasing proportion of the annual precipitation occurs as snowfall as elevation is gained, particularly above 450 m. Mean annual precipitation for 3 years of measurement at Salvus, located close to Kasiks River, was 1783 mm (Beaudry *et al.* 1990).

Snowmelt throughout the upper Skeena Watershed east of the Coast Range contributes to the peak spring freshets that are in almost all years the largest floods in the lower river. Water levels in the main river channels and back channels fluctuate seasonally; they are high from May to early July, drop for the summer months, rise to intermediate levels in the fall, and reach their annual low levels late in the winter season. Many of the back channels and side channels flows off the Skeena River north bank have no drainage structures but drain through rip-rap and coarse fill in the CN Rail grade and, to a lesser extent, the rip-rap underlying Highway 16.

Major tributaries draining into this reach of the river from the north are the Kasiks, Exchamsiks, and the Exstew Rivers, while the Gitnadoix River drains into the south bank. Spring tides back up the Skeena River almost to the Kasiks River. Saltwater is present at high tides upstream to about Kwinitsa Creek about 5 km above the Khtada river. The limit of saltwater influence marks the downstream end of the "watershed".

Geography

The Skeena River cuts through the mostly granitic heavily glaciated Kitimat Range of the Coast Mountains in a distinct U-shaped valley. The valley walls are composed of steep bedrock, which is locally covered with veneers of colluvium and till with interspersed tributary stream alluvial fans and debris cones (Clague 1984). The steep-sided former fiord has been filled with sediment carried by the river since deglaciation, 10,000 years ago (Gottesfeld 1985). Skeena River sediment deposition has formed a wide low-lying valley flat that contains many islands and gravel bars, sizeable logjams, and extensive back channels and wetland areas.

The coastal climate is reflected in the major ecological zones. The Coastal Western Hemlock (CWH) zone represents the vegetation in the Skeena and major tributary valley bottoms and mid-elevations to 400 m. Old-growth rainforest conifer stands of western hemlock, western red cedar, Sitka spruce, and post-logging seral deciduous stands dominate the forested landscape. Large spruce, hemlock, and deciduous trees, particularly cottonwood, with salmonberry, ferns and devil's club comprising the principal understory vegetation, characterize floodplains and alluvial sites. The CWH zone passes upward into the Mountain Hemlock (MH) zone, which is dominated by mountain hemlock and amabilis fir with occasional spruce, red cedar and yellow cedar. A well-developed shrub layer is mostly composed of the blueberries, false azalea, and black huckleberry (Banner *et al.* 1993).

Stream Channels

The Skeena River West area is the mid-portion of the immense fluvial deposition zone extending from Terrace to Telegraph Point. Numerous divided channels, backwaters, and swampy areas resulting from shifting islands and gravel bars characterize the lower Skeena floodplain, which averages 2.5 km in width. In this section of the Skeena River, islands range in size up to 300 ha and in the past have undergone substantial change, resulting in this being the most dynamic section of the entire river. Hogan and Schwab (1989) reviewed the historical sequence of air photos from 1937-1988, which indicated that significant change in stream channel morphometry has occurred over the last 50 years.

The Skeena River channel from Shames River to Kasiks River is characterized as a wandering gravel bed river with a straight and sinuous channel pattern. Islands in the river channel are frequently or continuously overlapping with two or more river flow branches (Schwab and Hogan 1989). Most river channels have complex histories of abandonment, filling, re-excavation, and reuse. The gradient of the river in this stretch averages 40-50 cm/km. The river slope decreases uniformly from Terrace to the estuary, as does the size of gravel in the river deposits. Gravels at Terrace are cobbles about 10 cm diameter, while most sediment below the Kasiks River is sand-sized.

A unique and dominant feature of this river section is the large logjams, which range from a few tree lengths to logs piled massively and continuously for up to a km (Bustard 2002). The larger logjams exceed 20,000 m^3 in volume. There is no other BC river entering the coast with such a large extent of logjams and log piles. These log piles are important structural features that promote sediment deposition when located on or adjacent to a mid-channel bar; if positioned at the mouth of a back channel, they stabilize and train the river channel. Unlike logjams elsewhere in the Skeena Watershed, these large logjams provide juvenile habitat at all river stages. Side channels regulated by logjams do not get scoured and provide important habitat for coho and chinook juveniles. A singular feature of these side channels is the very large amounts of stonefly larvae (Drewes 2002).

The Grand Trunk Pacific Railway (GTP) was constructed in the 1910-1914 period on the north bank of the Skeena River. Construction practices (rip-rapping) effectively reduced the lateral movement of the river in some areas and blocked off much of the floodplain and many side and back channels. Recent railroad upgrading and highway construction has further restricted river movement and prevents the rejuvenation of channels behind the transportation corridor.

Access

Access to Skeena River West is most easily accommodated by Highway 16, which follows the north bank of the Skeena River. Highway access provides boat launch options at Andesite Side channel, at the mouth of the Exchamsiks River, and at the mouth of Exstew River, as well as the popular boat launches at the Kitsumkalum River mouth below Terrace.

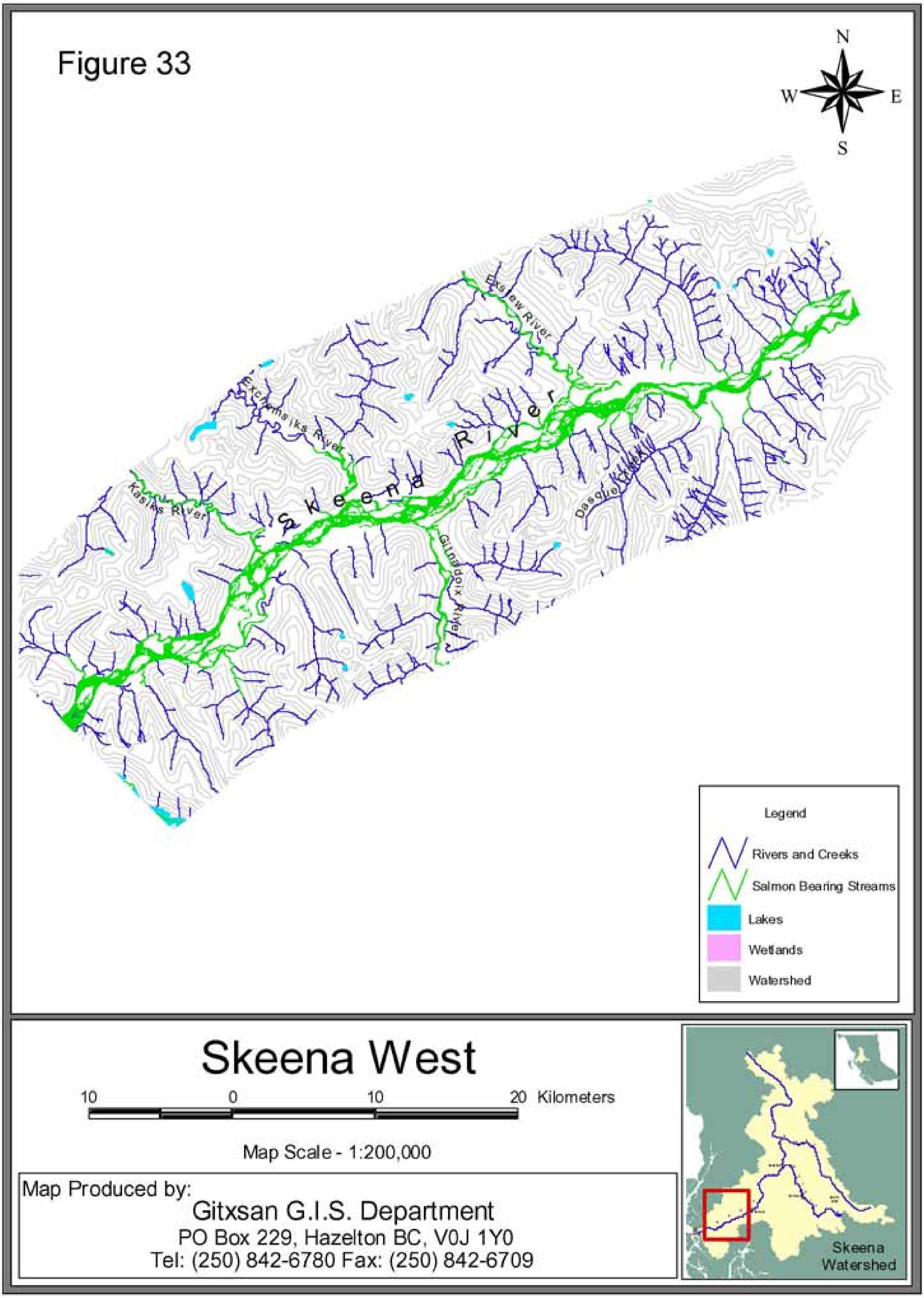


Figure 33
N
W
E
S
Exstew River
Exchamsiks River
Kasiks River
Skeena River
Gitnadoix River
Legend
Rivers and Creeks
Salmon Bearing Streams
Lakes
Wetlands
Watershed
Skeena West
10 0 10 20 Kilometers
Map Scale - 1:200,000
Map Produced by:
Gitxsan G.I.S. Department
PO Box 229, Hazelton BC, V0J 1Y0
Tel: (250) 842-6780 Fax: (250) 842-6709
Skeena Watershed

Fisheries Values and Resources

The Skeena River West area has high fish values, as the Skeena River is the second most important salmon producer in BC, with annual escapements of over two million fish. All species of salmon, as well as steelhead and cutthroat trout, and Dolly Varden char, are present in this section of river for some period. Some species such as sockeye mostly migrate through the area, while others such as pink and chum salmon spawn in large numbers within this reach. Juvenile fish migrating downstream to saltwater use the extensive network of side channels and wetlands. Adult enumerations tend to be difficult due to turbid water conditions that can persist from May through to early winter. Despite the high fisheries values and ease of access to the Skeena West area, fish use of this section of the river is relatively poorly understood.

Chinook

SEDS data (DFO 2001) for the last 30-year period show an annual mean escapement of 935 chinook with a range from 200 to 3500 fish. Chinook salmon spawn from mid-August through September in the Skeena River West area with chinook age 4 and 5 dominating the escapement (Godfrey 1968). Chinook salmon spawning occurs in the Skeena River mainstem in scattered pockets. Fisheries studies conducted for BC Hydro (1983) inventoried two chinook spawning sites: the north channel gravel bar, west of Hudson Bay Flats, and the main channel gravel bar, south of the mouth of Shames River. Bustard (1991) reports anecdotal evidence of chinook spawning on the outside edge of Gravel Island during some years. DFO (1991) documents chinook spawning on the north bank of the Skeena for approximately 8 km downstream of Shames River confluence.

Juvenile chinook were the predominant juvenile fish captured within the Skeena River West area during two of the three periods sampled by Bustard (1991). During April, chinook juveniles comprised 49% of the fish captured, rising to 64% of the total catch in late summer and declining to 23% during the early winter catch. Tredger (1984) reported that chinook fry dominated the boat shocking catches in the lower Skeena in 1983. Tredger estimates indicated 522 chinook fry per km of channel in this section of the Skeena during August. Side channel estimates were about 40% higher than in the main channel. Bustard's (1991) sampling in back channels that are blocked to adult movement by riprap, found no chinook juveniles present. Shepherd (1978) reported chinook fry catches between 1.5 and 18 fish/trap in this section of the river during sampling in September 1976, while attempting to sample the best potential habitat. It is likely that the juvenile chinook rearing in Skeena River West are mostly juveniles that have migrated downstream from many other streams, as well as progeny of chinook from nearby spawning areas.

Sockeye

A small population of sockeye spawn in Esker's Slough. Recorded escapements from the 1980's were 10 to 25 fish. This stock is noteworthy because it is one of the rare river type stocks in the Skeena Watershed. Sockeye with river type life histories are better known in the Nass and Stikine Rivers, where some successful stocks rear in habitat similar to the Skeena River West back channels.

Pink

Pink salmon are the most abundant species of salmon spawning in the Skeena River West area. The size of escapements increased greatly in the late 1980's, becoming the second largest stock in the Skeena Watershed. The odd-year cohort was dominant through the 1980's and 1990's. The mean annual escapement in the 1980's was 102,000 for even years and 334,000 fish for odd-years. For the 1990's, an average of 68,000 pinks returned annually in the even years, while the mean annual escapement for the odd-years was 405,000 pinks. Escapement estimates since 1970 range from 3,500 in 1982, to over 750,000 in 1989 and 1991 (DFO 2001).

Pink salmon spawning is widespread throughout the mainstem and sub-channel gravel bars, including back channels. It is probable that spawning locations change on an annual basis depending on discharge levels and the changing river channels (Bustard 1991). Typically, pink spawning peaks the first week of September and is usually finished by late September to early October.

Chum

Small, but significant populations of chum salmon spawn in the Skeena River West area; however, these spawners normally represent 20 to 30% of the total Skeena chum escapement. It is commonly thought that the commercial fishery heavily exploited lower Skeena chum salmon before 1930. Since the 1960's, the SEDS data (DFO 2001) suggest that chum runs have been relatively weak. The mean annual average escapement to Skeena River West over the thirty-year period, 1970 to 1990, was 2,750 chum salmon, ranging from a low of 75 chum in 1982, to 20,000 fish in 1988. Escapement levels have fluctuated from year to year, although decadal averages have changed little. General observations suggest that documented chum spawner abundance is understated due to water conditions and timing (Whelpley 2002, Bustard 2002).

Chum salmon typically enter the area to spawn August 20, with peak spawning from August 25 to September 10, and small numbers of chum appearing until October 10 (Bustard 1991). DFO's (1991) stream information summary maps show 22 spawning sites within the area; BC Hydro (1983) described many of these sites as being cut-off channels or channels fed by groundwater seepage. Bustard (1991, 1993) documented significant spawning populations in Andesite, Shames, S-Bend, Twin Islands, and Exstew side channels, as well as associated island complexes, which together are estimated to comprise over 20 to 30 % of the total Skeena River West escapement.

Bustard (1991) confirmed the importance of upwelling groundwater for chum spawning and noted the presence of warm groundwater inflows that kept some side channels open for 300 chum spawners, while nearly all the lower Skeena was iced over. Bilton *et al.* (1967) report that Skeena River chum mature at age 3 to 5 years, with age 4 spawners predominant. After emerging from the gravel from mid-March to early May Chum fry spend little time in freshwater before migrating downstream.

Coho

Coho are widely distributed throughout the Skeena River West area, though data concerning escapement, distribution, and habitat is scant. Coho do not generally spawn in the main Skeena River channels; however, Bustard (1991, 1993) did observe limited spawning in the mainstream. Exstew Slough, Esker Slough, Andesite Backchannel and many un-named back channels are important coho spawning grounds. Most coho spawning takes place in the tributary streams that include Gitnadoix, Kasiks, Exchamsiks, and Exstew Rivers. The majority of coho in the Skeena River system mature at age 3 or 4, after rearing for either 1 or 2 years in freshwater and 1 year in the ocean (BC Hydro 1983).

After emergence, coho fry disperse downstream along the margins of the Skeena River and move into back channels and wetlands that are accessible during spring and fall high water. Fry presumably leave after one year in high water events, and only a few fish remain for a second year (Bustard 1993). Coho juveniles are able to move through both the highway and railroad grades during high water flow periods (presumably through culverts) to use several large back channels. However, use of these back channels is less than that of similar nearby areas that are more accessible to fish (Bustard 1991).

Steelhead

Summer and winter-run steelhead move through the Skeena River West area, and there is no documented evidence of spawning in the side channels or mainstem channels. Lough (1981) noted that 14% of the 95 summer-run steelhead tagged in the lower Skeena River during August were still present in the lower river six months later. Lough suspected that most of these fish subsequently entered lower Skeena tributaries such as Kitsumkalum, Gitnadoix, Lakelse and Zymoetz Rivers to spawn. No steelhead were captured during driftnet surveys at seven possible spawning locations sampled in mid-May (Bustard 1991).

Juvenile steelhead use of the area is widespread. The catch composition of steelhead juveniles sampled by Bustard (1984, 1991) and Tredger (1984) showed that parr percentage of the total catch was 16.6% in April and 5.0% in late summer/fall. Parr estimates for this area of the Skeena were 50 parr/km of channel. This compares to estimates of up to 200 parr/km in the lower Bulkley River, 83 parr/km in the Kispiox River, and 4 to 10 parr/km in the Morice River. Steelhead parr estimates were 2.5 times higher in side channels than in mainstream sites (Tredger 1984).

Juvenile steelhead may spend up to 5 years in freshwater, although most spend 2 to 4 years in tributary streams and the lower Skeena River before smolting (Whately *et al.* 1977). Bustard's (1991) and Tredger's (1984) juvenile steelhead sample catches indicated that 97% were age 1+ and 2+ parr. Steelhead juveniles frequented logjams and riprap sites most often in the spring, with riprap and cobble sites preferred through the summer and early winter. Bustard (1991) found that side channel sites received little use compared to mainstem areas, while Tredger (1984) found that catches of steelhead parr were 2.5 times higher in side channels compared to mainstem sites.

Fisheries

First Nations Traditional Use

The Skeena West area has long been the traditional homeland of coastal Tsimshian peoples. First Nations traditional use and occupancy of the lower Skeena areas was extensive and well documented by oral history and early Euro-Canadian visitors. Seven distinct groups held territories from Terrace downstream to the Skeena mouth. Within the Skeena West area, four Tsimshian groups, Gitsees, Ginakangeek, Gitando, and the Gitandoix, possessed village centres typically located close to the Skeena River and used traditional territories owned by various lineage heads (Inglis and MacDonald 1979). The structure of Tsimshian cultural was widespread with integral connections to the environment they inhabited. This shared social structure was composed of a matrilineal kinship society, and exogamous clans divided into houses, with crests, oral histories, and a land tenure system of territories managed through a public forum process called the feast.

Gitsees territories were located in the Kasiks River drainage, with a village close to the mouth. Ginakangeek (Ginaxangits) occupied a village site at the mouth of Exchamsiks River and used the rich resource territories in the Exchamsiks and Exstew drainages on the north sides of the Skeena River, as well as several small tributary streams opposite the mouth of the Exchamsiks River. The Gitandoix people used the Gitnadoix drainage with villages located at the mouth and by the Magar Creek confluence. In addition to the village site located close to the Shames River mouth, Gitando ancestral territories included the Shames River drainage (Inglis and MacDonald 1979).

Halpin and Seguin (1990) suggested that these lower Skeena people extended their territories coastward and built new winter villages in Venn Pass, where the weather was milder. They continued to return to their territories on the Skeena in the summer for salmon fishing and resource gathering. After establishment of Fort Simpson in 1834, many of the lower Skeena First Nation groups moved to the area surrounding the fort. Some of the lower Skeena Tsimshian are now in Kitsumkalum Village and continue to use the Skeena West area for traditional activities. Barbeau (1915-1936) described House group origins and settlement patterns in the Skeena West area.

Salmon are an integral part of the Tsimshian culture and one of the main food sources. The abundant chum salmon was a particularly important food resource preserved in the Skeena West area. Because the fat content was relatively low and the dried product less likely to spoil, they were smoke-dried in great quantities. A strong and adaptive semi-nomadic economy, pre-occupied with food gathering, was based around the summer salmon food fishery and mid-winter feasting.

Recreational Fisheries

The sports fishery in the Skeena River West area provides important recreation and aesthetic values for the public. Salmon draws local residents from northwest BC and non-resident tourists into the Skeena West area with its extraordinary fishing opportunities. Easy access to gravel bars and boat launch sites is afforded from Highway 16 or the railroad grade. The most popular boat launch sites are located at Andesite Sidechannel, near the mouth of the Exchamsiks River, and the launch site near the mouth of the Exstew River.

The guided and unguided sport fishery targets chinook, coho, pink, steelhead, and chum, with the most popular fishing locales being at China Bar, Shames Bar, Polymar Bar, Gitnadoix Bar, Chainsaw Bar, Electric Bar, 17, 18,19 Mile Bars, and Andesite Bar. The one commercial fishing lodge on the lower Skeena is located close to Shames River and has accommodations for 35 angling enthusiasts. Anecdotal information indicates that intense angling pressure is detrimental to chinook salmon populations at the mouth of Kasiks, Exchamsiks, and Exstew Rivers (Kofoed 2002). Creel surveys have been conducted on the lower Skeena for a number of years (Thomas 1999, 2001); however, the sampled area does not coincide with the Skeena West area. The Skeena River mainstem from 1.5 km above Kitsumkalum River downstream to the Exchamsiks River is designated Class II waters, July 1 to September 30, with a Steelhead Stamp required for angling of steelhead (MELP 2000).

Enhancement Activities

Andesite Sidechannel has been the location for the development of a small groundwater-fed channel for chum salmon enhancement by DFO. The project has been abandoned due to lack of success in getting chum spawners to use the channel. Chum salmon from Andesite Sidechannel have been used as an egg source in an effort to build up lower Skeena chum populations. In the late 1980's, up to 230,000 chum eggs from there were incubated at Kitsumkalum Hatchery and released back into Andesite Sidechannel; this program was cancelled in 1990.

Development Activities

The dominant development activities in the Skeena River West area revolve around logging, transportation, and utilities. Mineral exploration development has been slight and remote from the area of interest. Population and settlement other than by First Nations in the past has been very limited.

Forest Resource Development

The rich forest resources of the Skeena West area have always been important to the native Tsimshian and in more recent times to Euro-Canadians. The early Tsimshian culture made extensive use of red and yellow cedar for their longhouses, canoes, poles and crests, cookware and clothing. Other wood, such as spruce, alder, birch, and juniper, was carved or woven.

Commercial forest exploitation did not begin until the early 1890's, when large quantities of firewood were cut for steam-driven paddle wheelers, which regularly traveled the Skeena River. The construction of the railway necessitated clearing of the right-of-way, which was subsequently widened during WWII with completion of Highway 16 (Kerby 1984).

Selective logging of spruce occurred in the 1940's. In the late 1950's, clearcut logging of the high value Sitka spruce stands commenced on the Skeena West floodplain sites and islands. By the late 1960's, the floodplain Sitka spruce stands were nearly eliminated. Sitka spruce logs were skidded with cats and dumped into the river where they were boomed and towed to the Port Edward pulp mill. Some of the skid trails, which were often deeply engraved into the floodplain, are currently used by coho for rearing habitat. In the late 1950's and early 1960's, forest harvesting activities began in the lower reaches of Shames, Exstew, Exchamsiks, and Kasiks River valleys. More recent logging in the area has been restricted to upland areas. The Ministry of Forests, Kalum Forest District, administers the Skeena West area.

Transportation and Utilities

The Skeena River has been used for thousands of years as a transportation waterway, primarily by canoes. In the early 1890's, steam-powered paddle wheelers began regular, seasonal use that continued until the Grand Trunk Pacific (GTP) Railway was completed in 1912. Paddlewheel use in this section of the Skeena River did not require any rock-removal or channel alterations.

Linear development is intense on the northern bank of the Skeena River with CN Rail and Highway 16 situated on the floodplain for much of their length. Railway construction practices effectively caused many instances of blocked access to fish. Completion of Highway 16, linking Prince Rupert and Terrace in 1944, saw the continuation of similar practices that restricted fish access. Numerous back channels and side channels were cut off to returning adults, and abutments of bridges across tributary streams aggravated natural sediment deposition in fans, often requiring frequent channel dredging to avoid washouts.

On the south side of the Skeena River, the floodplain islands have relatively lighter linear development in the form of the BC Hydro 287 kV transmission line as well as the Pacific Northern Gas (PNG) pipeline to Prince Rupert. This utility corridor is serviced by road to a point opposite Salvus, where the natural gas pipeline crosses the Skeena River and passes up the Kasiks River valley. Maintenance problems on the BC Hydro transmission line have been minimal, other than tower base erosion problems, which consequently were rip-rapped. The PNG pipeline was built in the 1960's with construction practices that impacted fish and fish habitat. In 1993, the pipeline across Skeena River broke due to river scour and was re-installed under the river by directional drilling (Powell 1995).

In the mid-1950's through until the early 1960's, Columbia Cellulose dumped logs into the Skeena River from approximately half of its Terrace operations, as well as from logging operations downstream from Terrace. These logs were then boomed, held in storage grounds, and towed down the Skeena to the pulp mill at Port Edward.

Skeena West Management Issues

All species of salmon, as well as steelhead, cutthroat trout, and Dolly Varden char are present in this section of river for some period of the year. Some species such as sockeye mostly migrate through the area, while others such as pink and chum salmon spawn in large numbers. Juvenile fish rearing or migrating downstream to saltwater use the extensive network of side channels and wetlands. Despite the high fisheries values and ease of access to the Skeena West area, use by fish of this section of the river is relatively poorly understood. The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage. It also provides strong cultural, economic, and symbolic linkages, particularly for First Nation peoples, and supports recreational and commercial fishing.

Chinook salmon spawning occurs in the Skeena River mainstem in scattered pockets. Juvenile chinook are the predominant juvenile fish captured within the Skeena River West area. A small, noteworthy population of sockeye spawn in Esker's Slough; it is one of the rare river type spawning stocks in the Skeena Watershed. Pink salmon are the most abundant spawning species in the Skeena River West area; pink spawners have recently increased, becoming the second largest stock in the Skeena Watershed. Small, but significant populations of chum salmon spawn in the Skeena River West area. Despite their small numbers, these spawners normally represent 20 to 30% of the total Skeena chum escapement. Coho are widely distributed throughout the Skeena River West area, though data concerning escapement, distribution and habitat is scant with most coho spawning taking place in the tributary streams that include Gitnadoix, Kasiks, Exchamsiks, and Exstew Rivers.

Summer and winter-run steelhead move through the Skeena River West area, although there is no documented evidence of spawning in the side channels or mainstem channels. Juvenile steelhead use of the area is widespread. The sports fishery in the Skeena River West area provides important recreation and aesthetic values for the public. Salmon draws local residents from northwest BC and tourists into the Skeena West area with its extraordinary fishing opportunities. Easy access to gravel bars and boat launch sites is afforded from Highway 16 or the railroad grade. The most popular boat launch sites are located at Andesite Sidechannel, near the mouth of the Exchamsiks River, and near the mouth of the Exstew River.

The guided and unguided sport fishery targets chinook, coho, pink, steelhead, and chum with the most popular fishing locales being at China Bar, Shames Bar, Polymar Bar, Gitnadoix Bar, Chainsaw Bar, Electric Bar, Seventeen, Eighteen, and Nineteen Mile Bars, and Andesite Bar. The one fishing lodge on the lower Skeena is located close to Shames River and has accommodations for 35 angling enthusiasts. Anecdotal information indicates that intense angling pressure is detrimental to chinook salmon populations at the mouth of Kasiks, Exchamsiks and Exstew Rivers.

The dominant development activities in the Skeena River West area have been logging, transportation, and utilities. Mineral exploration development has been slight and remote from the area of interest. Population and settlement other than past First Nations has been very limited. By the late 1960's, most of the floodplain Sitka spruce stands were nearly eliminated.

Linear development is intense on the northern bank of the Skeena River with CN Rail and Highway 16 situated on the floodplain for much of their length. Railway and highway construction practices effectively caused many instances of restricted access to back channels and side channels fish. On the south side of the Skeena River, the floodplain islands have linear development in the form of the 287 kV transmission line and the PNG pipeline to Prince Rupert.

Strategic Overview

Environmental Issues

Anthropogenic environmental damage is widespread in the Skeena Watershed, though not serious enough to interfere with normal functioning of most ecosystems. The habitat in general is in relatively good condition, although there are localized areas of high impacts. It is widely recognized that land management practices have permitted the degradation of forestlands, water quality, and fish habitat in the watershed. However, insufficient data exist for most sites to quantify cumulative and non-point impacts. Linear development and settlement have also affected areas of fish habitat.

Land use practices in the Skeena Watershed such as forestry, grazing, agriculture, urbanization, linear development, and mining disrupt aquatic ecosystems by altering watershed processes that ultimately influence the attributes of streams, rivers, lakes, and the estuary (Chamberlin *et al.* 1991). Most human activities effects on watershed processes result from changes in vegetation, and soil characteristics, which in turn, affect the rate of delivery of water, sediments, nutrients, and other dissolved materials from upland areas to stream channels.

Land use activities within riparian zones can alter the amount of solar radiation reaching the stream surface, affect the delivery of coarse and organic materials to streams, and modify fluvial processes that affect bank and channel stability, sediment transport, seasonal streamflow patterns, and flood dynamics. Disconnecting streams from their floodplains further alters hydrologic processes, nutrient cycles, and vegetation characteristics (Beschta *et al.* 1995). Other human activities that influence salmonids and their habitats include large-scale harvesting of salmon and introduction of non-native species and hatchery salmonids.

Forest Development Activities

Damage from forest development activities is found in all of the watersheds discussed except for the Bear Watershed, where development is proposed, and the Gitnadoix, which has been preserved as a Provincial Park. In general, most watersheds are recovering well from logging impacts dating from 20 to 40 years ago that were concentrated in the lower portions of the watersheds – those most likely to be inhabited by anadromous fish. Logging in many areas is now is focusing on headwater hill slopes that are frequently mountainous. Generally, early logging sites that have regenerated forests not yet grown sufficient volume to be harvested as second growth.

Within the watershed, forest development activities alter natural fish habitats and ecology, mainly through changing vegetative cover, watershed hydrology, sedimentation and erosion rates, and to a small degree, through application of silvicultural chemicals.

Removal of riparian stands by forest harvesting has produced an outstanding legacy. Stream bank stability, which controls overall channel integrity, is a function of channel and stream bank components that are largely influenced by riparian vegetation (Swanson *et al.* 1982). In the past, Destabilized streambanks due to past logging have often resulted in increased bedload movement, which typically caused widening and shallowing, as well as simplification of stream channels. This in turn has led to habitat loss and declining productivity of fish stocks. In addition, removal of riparian forests results in warming of summer flows due to the loss of shading, often to the extent that salmonids are stressed by high temperatures. Riparian vegetation also keeps streams warmer in the winter and helps to limit the amount of freezing of the streambed. Finally, riparian vegetation provides the bulk of the energy of the food web in small streams. Alteration of the amount and type of riparian vegetation can change the composition of stream algae and stream invertebrates communities. Stream invertebrates are important dietary staples of stream dwelling fish.

Forest development activities and clearing of utilities corridors substantially reduced riparian habitat within the lower Zymoetz River floodplain, leading to a 25 to 30% loss of off-channel habitat (Lewis and Buchanan 1998). These activities also led to a large, highly mobile volume of bedload that will continue to pulse down-channel and de-stabilize the floodplain for many years to come (Weiland and Schwab 1996).

Forest development practices, particularly road construction, can substantially increase delivery of sediments to streams through both surface erosion and slides. The effects of forest practices on sediment transport are greatly increased in the steeper topography and wetter climate in the western portion of the watershed. These effects are dependent on a number of local site conditions including moisture, vegetation, topography, and soil type, as well as on specific aspects of the activity and proximity to the stream channel.

Within the Skeena Watershed, the art of assessing watershed impacts of logging is in a state of growth. Critical threshold methods popular in the 1980's set a percentage of watershed cut restrictions that evolved into an expert system such as the Watershed Workbook (Wilford 1987). Watershed Assessment Procedures (WAP) 1 and 2 are indicator models that use point scores of measured watershed characteristics or land-use patterns to score the overall health or impact of logging on the watershed (BC MoF and BC MoE 1999). Watershed management involves making decisions in a complex system with many variables. Generalizations are difficult to make and challenge geomorphological knowledge in establishing cause and effect links between management and hydrologic outcomes (Carver 2000).

Transportation

The significant impacts along transportation corridors of the Skeena Watershed are blocked fish access and habitat alteration. In many places fish passage is restricted by roads and railroads because of poor design and construction of culverts and other drainage structures. Perched or hanging culverts, and culverts with steep slopes causing water velocity barriers, are the two most common problems with drainage structures. The highway and railway corridors passing through the Skeena River and Bulkley River valleys have, in the past, created access problems for returning spawners and restricted access to juvenile freshwater rearing habitat. They continue to do so today, although to a lesser extent.

The CN Rail line and Highway 16 road fills are blocking many back channels and sloughs in the lower Skeena and in the upper Bulkley, resulting in difficult or impossible fish passage, and have eliminated productive fish habitat. The CN Rail line between Terrace and Hazelton provides difficult fish passage at many Skeena tributaries, particularly at low flows. An example of altered habitat is the 70% loss of the floodplain downstream of the Highway 16 Bridge crossing the Zymoetz River. This was due to channelization that directed the flow under the bridge, which effectively moved the apex of the alluvial fan significantly downstream from its natural position (Pollard 1986). Other transportation related problems deal with the use of herbicides on electric transmission lines and placement and servicing of natural gas lines.

Urbanization

Urbanization concerns in the Skeena Watershed are light at the present time. Lakelse Watershed retains very high fish values centered at Lakelse Lake. There are moderate to strong concerns regarding settlement and development adjacent to and on the lakeshore. The Lakelse Watershed supports a relatively high number of seasonal and full-time residences enjoying a variety of rural, high quality lifestyles. Lakelse Lake is believed to be the most heavily utilized lake recreationally in the region (MoE no date). Mount Layton Hotsprings Resort operates pools, water slides, a restaurant, and a motel on the east shore of Lakelse Lake. Also located on the east side of the lake, as well as the northeast corner, are two Provincial Parks, which are popular stopping-off points for local and non-local water-based recreation, picnic, and camping activities.

The east and west sides of the lake are largely developed. These developments, with their associated septic systems and occasional stream diversions, affect fish and fish habitat. There is a standing concern about phosphate additions to the lake from sewage, with any development at or impinging on Lakelse Lake. The lake has been described as a phosphorous limited system that is literally in danger of becoming mesotrophic, or even eutrophic (Remington 1996).

Settlement patterns in the watershed reflect the major river trunk system. The major urban settings are Terrace, the Hazeltons, Smithers, and Houston. Gitanyow, Gitwangak, Kitwanga, Kispiox, Moricetown, and Telkwa are smaller population centers. All these settlements are on the mainstem Skeena or Bulkley Rivers, with the exception of Gitanyow, which is on the Kitwanga River. Future projections suggest that urban areas will occupy an increasing, but still small, fraction of the landscape.

These ten population centers discharge treated sewage into the Skeena Watershed, relying on facultative or aerated lagoons (Remington 1996). Remington notes that there is considerable variation in the amount and type of monitoring data collected for each of these sewage facilities. These community sewage discharges threaten their receiving waters with oxygen depletion, solids settling, enrichment or eutrophication of streams, and toxicity. These ten communities utilize solid waste disposal landfill sites operated by the Bulkley-Nechako and Kitimat-Stikine Regional Districts. Landfill leachate has the potential to affect ground water and surface run-off down gradient of the landfill. The potential effect is dependent on leachate quantity and quality.

Agriculture

Agriculture within the Skeena Watershed is concentrated along the wide valley bottoms of the Bulkley and Kispiox Rivers. Agriculture has a relatively small impact overall in the watershed. Impacts to fisheries values are highest in the upper Bulkley Valley, and less significant in the lower Bulkley Valley and the Kispiox Valley. This is similar to the level of impact reported by Paish and Associates in 1983. One of the most important concerns is the clearing of agricultural land on floodplains, near streams or on active fans, and the removal of riparian vegetation. Another substantial concern is livestock grazing and watering along tributaries, which tends to break down stream banks leading to an increase in sedimentation. The production of nutrient laden runoff from farmyards and cattle feeding lots can be a local problem. The use of water for irrigation, particularly from smaller streams, can contribute to increased water temperatures and inadequate stream flows for fish.

Industrial Pollution

Industrial pollution in the watershed is relatively minor, mostly due to the lack of industry. The Port Edward sulphite pulp mill was constructed in 1950. Impacts to water quality were severe with near sterilization of Wainwright Basin. In the 1970's, the mill was renovated to a Kraft process mill, which greatly decreased pollution problems.

Mining

Parts of the Skeena Watershed contain high value mineral resources, some of which have been exploited in the past; others are likely to be developed in the future. There are no mines currently operating in the watershed. There are no outstanding major pollution problems at this time. Duthie Mine, located in the upper Zymoetz drainage, has had tailings leachate problems over the last 50 years; however, remediation and mitigation of the minor acid rock drainage (ARD) has recently been completed. The Silver Queen mining property, located immediately east of Owen Lake, has shown associated elevated levels of zinc and copper in the lake. Remediation efforts consisting of wetland treatment, and contaminated drainage improvements have been ongoing throughout the 1990's (Remington 1996).

Three large open pit mines that recently operated in the watershed, though shut down in the 1990's, are known to generate ARD: Equity Silver Mine, Bell Mine, and Granisle Mine. These mines now operate elaborate monitoring and treatment programs to safeguard the receiving environment from ARD. In short, ARD is a serious environmental concern at these three mines; however, current toxicity and deleterious discharges are relatively minor and in control.

Natural Environmental Disturbance

In the Skeena Watershed, natural environmental disturbance commonly occurs as large floods and changes in streams with unstable channel configuration. Coastal areas are likely to experience intense fall rainstorms that produce large floods. The prevalent steep slopes have many shallow landslides that carry sediment into the valley bottom and often into streams. These two factors typically produce high discharge and coarse sediment dominated systems with rapid changes to channel configuration. Impacts from logging may result in simplification of channels and conversion of small streams from pool and riffle to plane form. Disturbance of floodplain and riparian stands is associated with dramatic changes in rivers such as the Kitsumkalum and the Zymoetz Rivers. Streams are much quieter on the Nechako Plateau in the interior and do not seem to respond much to logging disturbance. In these areas large stream alterations occur from extraordinary floods, and then mostly on steeper gradient reaches (Beaudry and Gottesfeld 2001). Streams in the transition zone such as the Kitwanga and Kispiox Rivers are intermediate in their responses.

The likelihood of stream channel change is also dependent on the geological setting. Streams with bedrock-bounded channels cannot move, and change is limited to variation in the thickness of the gravel bed. Stream stability is also related to the availability of sediment. Watersheds with abundant loose gravel material are likely to have streams with wide and shallow channels easily modified by floods. On the other hand, streams that are inset into glacial lake deposits, a common situation in the eastern portion of the Skeena Watershed, tend to have very stable conformations.

Cumulative Effects

The decline of various salmon stocks in the watershed has resulted from the cumulative effects of water and land use practices, fish harvest management strategies, enhancement practices, and natural fluctuations in environmental conditions. Because of the longitudinal nature of river and stream ecosystems, the accrual of effects is significant along both spatial and temporal dimensions. Activities that take place in headwater streams influence the suitability of habitats in downstream reaches – for example, temperature change and sediment input – and affect the response of ecosystem components to additional stresses. Similarly, activities that have occurred in the past may influence current habitat conditions through residual effects on landscape vegetation and aquatic biota.

Accumulation of localized or small impacts can result in cumulative watershed level changes to fisheries. Accumulations of effects, often from unrelated human activities, pose a serious threat to fisheries (Burns 1991). The effects of increased sedimentation on spawning gravels will be the same, whether the sediment resulted from livestock grazing, logging, road building, mining, or a pipeline crossing. The same is true of other variables such as water temperature, dissolved oxygen concentrations, channel morphology, or quantity and distribution of instream cover (Remington 1996). Loss of habitat elements such as large woody debris can have effects lasting from 80 to 160 years (Sedell and Swanson 1984). Cumulative losses of one element of fish habitat may result in long-term compound problems.

Within the context of conserving and restoring fish populations and their habitats in the Skeena Watershed, the concept of cumulative effects has two significant and important underlying premises. Fundamentally, individual actions that are by themselves relatively minor may be damaging when coupled with other actions that have occurred or may occur elsewhere in Skeena Watershed sub-basins. Historical and current patterns of land use activities and practices, particularly forest development, though other factors as well, have a significant bearing on how salmonid populations will respond to further anthropogenic disturbances. Within the Skeena Watershed, traditional management strategies that have relied on site-specific analysis without regard for other activities that have occurred or may occur within the watershed will generally fail to protect salmonid populations against cumulative effects. This concept underlies the development of watershed and ecosystem approaches to land and resource management (Spence *et al*, 1996).

Secondly, declines in the Skeena Watershed salmonid populations are the product of numerous incremental changes in the environment and fish populations. Recovery and conservation of salmonid populations may proceed in a similar way – through incremental improvements in habitat conditions, the use of alternative management strategies in relation to fish harvesting, and viewing the watershed as connected in regard to land use activities and practices. This means that individuals can and must play an active role in salmonid conservation and restoration even if tangible efforts are slow to manifest.

To define cumulative impacts to fish habitats in the Skeena Watershed, short-term and long-term datasets that measure water quality are critical. Few adequate datasets exist within the watershed, except, perhaps, for studies conducted in Babine Lake. Remington (1996) reviewed water quality and identified datasets critical to the assessment of long-term cumulative impacts in the Skeena Watershed. Environmental parameters not usually included in water quality sampling are also important to stream health. These include measures of the integrity of riparian areas, measures of snowmelt rates in non-forested areas (hydrological recovery after logging or other land disturbance), measures of runoff rates in urban and industrial zones, measures of stream channel form and rates of change, and monitoring of climatic changes.

Information constraints prevent many parameters from being articulated that define cumulative impacts to the tributary watersheds and the Skeena Watershed as a whole. The lack of detailed information about fish populations and their habitats, currently and in the past, limits knowledge that relates to conservation goals. The first and most critical step in resolving land and resource use problems is in recognizing that problems exist; then their nature and magnitude can be defined. This lack of basic information concerning the status of fish populations and habitats does not facilitate strategic and operational conservation solutions.

Table 5. Environmental issues in the selected Skeena Watersheds.
These issues are discussed in the preceding sections. Both natural and man-caused environmental stresses are listed. There are no serious agricultural or industrial pollution impacts in the watersheds listed.

Watershed	Logging Impacts	Transpt. Impacts	Urb'n't	Channel Change	Large Floods	Summer Low Flow	Agricult	Industr Pollut	Mining
Babine R.	X	x				X			X
Bear R.	x	X				x			
Morice R.	X	x		x	x				x
Kispiox R.	X	x		x		x			
Kitwanga R.	X	x		x	x	x			
Zymoetz R.	X	X		X	X				x
Lakelse R.	X	X	x						
Kitsumkalum R.	X	x		X					
Skeena R. West	X	X		x					
Gitnadoix R.				x					
Ecstall R.	x				X				

External Environmental and Anthropogenic Factors

The Skeena Watershed is influenced by environmental changes and changes in human activities outside the watershed. The effects of some of these changes are key watershed issues and priorities. The most important factors are: ocean survival of anadromous fish, global climate change, marine interception fisheries, and proposed fish farms to be located on the north coast.

Ocean Survival and Productivity

The physical, chemical, and biological state of the northeast Pacific Ocean environment influences the growth, survival and distribution of Skeena anadromous fish. Understanding ocean processes and the portion of the salmon lifecycle in the ocean environment is essential for Skeena salmon conservation. For many years, the potential for salmon production in the ocean was considered to be unlimited. Observations over the past two decades have clearly demonstrated that the ocean can constrain salmon production and that the capacity of the ocean to produce salmon is not constant over time and locations. Multi-year changes in the state of the ocean contribute directly to variations in salmonid growth, returning spawners, and recruitment.

Beamish *et al.* (1999) noted that the climate and ocean systems of the North Pacific are dynamic, and in addition to interannual variability, there are evident decadal-scale states. Climate-ocean systems experience these steady states, or regimes, that lasts for decades and also abruptly shift from one state to another within one year. The shift between the two states of the North Pacific climate is called the Pacific Decadal Oscillation (PDO). Regime shifts occurred in 1925, 1947, 1977, and 1989. The productivity of British Columbia fisheries appears to respond to these abrupt changes in climate-ocean states. A general decline in salmon abundance after 1989, as exhibited in fish catch, was evident in key stocks (PFRCC 2001). By the mid to late 1990's, coho abundance in the Skeena, particularly in the Babine system, was so low that unprecedented closures were implemented to protect the at-risk populations, while production of sockeye, pink, and chum salmon was moderately depressed (DFO 2001). Other than coho, Skeena River salmon stocks did not receive the dramatic reductions that were evident in many Central and South Coast stocks in recent years. It was generally concluded that there was very poor ocean survival, probably in the early ocean life when juvenile salmon are inshore and subject to high predation and adverse habitat conditions (PFRCC 2001).

El Niño events such as that of 1991-1992 and 1997-1998, bring warmer water to the BC coast. There is an expansion northward of ocean fish such as hake and mackerel, which may be major predators of salmon. There is also a decline in deep water upwelling along the coast, which decreases seawater nutrients and hence plankton productivity. The decline of ocean survival and reduced growth rate of first year salmon are correlated with this ocean warming (DFO 2000). The effects of decreased ocean survival are most apparent on the south coast of B.C. but appear to be spreading northward.

Mueter *et al.* 2002 emphasize the importance of regional summer sea surface temperature (SST) in the relative inshore areas which are used by salmon for several months after they reach salt water. They posit that southern salmon stocks have decreased recruitment in times of high summer SST, while northern stocks have increased survival rates. The transition between the southern and northern pattern is in southeast Alaska for chum and pink salmon and northern BC for sockeye. The difference in response to higher in-shore temperatures by these three salmon species may reflect differences in their patterns of early dispersal in the North Pacific.

Climate Change

One of the effects of the ongoing global climate warming is an increase in the occurrence and intensity of El Niño conditions that correlate with ocean warming along our coast. The Pacific Decadal Oscillation (PDO) Index is another measure of the warming trend in the eastern North Pacific. It has been in a positive phase (warming) since 1978 except for a few brief periods, one of which was 1999-2001 (DFO 2000, 2001b). In general, times of positive PDO index show decreased ocean survival of first year salmon. It seems likely that ocean survival problems in northern B.C. will persist and perhaps become worse with continuing global warming over the next century.

Another correlate of global warming is an increase in drought in the Northern Interior of B.C. This area includes the portion of the eastern Skeena Watershed sub-basins on the Nechako Plateau. Climate modeling suggests that late summer drought resulting in low stream flows that limit fish access in the Upper Bulkley and the Babine Lake area will persist and, on the average, worsen with time (Boer *et al.* 2000, Price *et al.* 2001).

Marine Interception Fisheries

Adverse effects of harvest on salmonids are particularly difficult to control in mixed stock fisheries where multiple species, stocks, and age classes are harvested together. Mixed stock fisheries occur before stocks segregate into discrete spawning runs. In mixed stock fisheries there is strong pressure to maximize the catch of abundant productive stocks, with the result that weak stocks are overfished and decline. Strong and weak stocks are harvested at comparable rates, as are wild and hatchery or enhanced salmon. With naturally small populations and populations that have been depressed by human activities, escapement may be insufficient, with the mixed stock fishery, to maintain genetic diversity and offset the probability of undesirable declines. In addition to reducing the total escapement of salmonids, harvesting alters the population age and size structure. Ricker (1981) showed that the mean sizes of Pacific salmon harvested in BC waters has decreased over the past 30 to 60 years, which Ricker attributed in part to cumulative genetic effects caused by selective removal of larger individuals in troll and gillnet fisheries.

Creating and maintaining a fisheries management regime that keeps all or most salmon stocks at a productive level is extremely difficult in a mixed stock fishing environment. There is a need for establishment of management goals targeting realistic exploitation rates that takes conservation of wild stocks into effect.

Fish returning to the Skeena River are subjected to a number of sequential mixed stock fisheries. These include commercial seine, troll, and gillnet fisheries in Alaska and in B.C. Since the modification of the Pacific Salmon Treaty in 1999, catches of B.C. bound salmon have decreased in Alaska. Interception rates for chinook, steelhead and sockeye have declined. Coho interception remains a problem; especially since Skeena coho are caught as incidental catch in the very large Alaska coho fishery.

Mixed stock fisheries in B.C. include seine and gillnet fisheries in Areas 1, 3, 4, and 5. Reduction in exploitation rates has been achieved for coho, chinook, steelhead, and early run sockeye stocks. Still, overall exploitation rates remain high for chinook, steelhead, and non-Babine sockeye, and some stocks remain well below their productive capacity.

Recent development of selective fishing methods to harvest the target stocks – Babine sockeye – without harvesting non-target steelhead and coho has shown modest success. While progress has been made in selective seine fisheries, there had been only limited results in selective gillnet fisheries until 2001, when mortality rates of released coho were significantly reduced from about sixty percent to well below forty percent (PFRCC 2001). In the Skeena Watershed, opportunities are now being pursued to harvest sockeye in up-river terminal fisheries that avoid most of the mixed stock problem.

Fish Farms

Early this year the B.C. Government proposed to double the number of existing net cage aquaculture facilities (salmon farms). This involves expanding salmon farm operations to the north coast. It is anticipated that many of the new fish farms will be in the Prince Rupert area, perhaps mostly to the south of Prince Rupert. At this point specific sites for proposed salmon farms are not known. The local impacts of aquaculture facilities will vary, but it will be difficult to find sites that have adequate currents to disperse fish farm waste and to avoid negative interactions with passing wild salmon stocks.

Concerns about distant effects of fish farms revolve around two issues: disease transmission to wild fish populations and escapes of farmed salmon. Existing B.C. fish farms have had many outbreaks of diseases, especially IHN (infectious hematopoietic necrosis), IPN (infectious pancreatic necrosis), furunculosis (*Aeromonas salmonicida*), and infestations of sea lice (*Lepeophtheirus salmonis*) as described by Ellis (1996). IHN is an especially serious concern considering the problems that already exist with this disease in Babine Lake, as well as other sockeye stocks. The epidemiology of many of these diseases is poorly understood, but there are instances of transmission to passing wild sockeye and chinook salmon. Fish farms may serve as a reservoir of some of these diseases. Although the transmission patterns are complex, in general the more infected fish on the coast, the higher the likelihood is of the disease spreading to wild fish (Tully and Whelan 1993).

The experience in Europe serves as a warning. Sea lice outbreaks, originating from salmon farms, have become so common that many populations of sea trout, an anadromous form of brown trout (*Salmo trutta*) are in serious danger of extermination and no longer available for sports fishing. *Gyrodactylus salaris*, a parasitic flatworm, was spread by transfer of fish to and among salmon farms and has nearly wiped out many wild Atlantic salmon stocks in Norway. Efforts to control the spread of this parasite included poisoning all fish in streams with infested fish. Furunculosis, a virulent bacterial disease, spread from fish farms to many natural streams (Johnsen and Jensen 1994).

It is likely that most or all of the proposed salmon farms will raise Atlantic salmon. In southern B.C., hundreds of thousands of Atlantic salmon have escaped from salmon farms. They have successfully matured and entered at least 29 streams on the south coast (McKinnell and Thomson 1997). Spawning has taken place in some of these streams. First and second year parr are present in at least one stream (Volpe *et al.* 1999). Presumably these fish will spread into other streams where they will compete with native species. The effects of the introduction of a new salmonid species to B.C. are unknown. The spread of an invading species is facilitated if native populations are not filling habitat to capacity. This is unfortunately the situation in regard to steelhead stocks, which Volpe *et al.* (2001) suggest are the fish species most likely to be affected.

Skeena Fish and Community Values

Fish are close to the heart for people in the Skeena Watershed. The presence of salmon is a strong part of cultural and community identity in the Skeena. Prince Rupert has long been a commercial fishing centre, and fishing is a strong part of its identity. Terrace labels itself "Big Fish Country." Houston has as its symbol the "world's largest fly rod." First Nations people and communities have been sustained through the millennia by the bountiful harvest available in the Skeena River and its tributaries. In all these ways, fish and the productivity of the Skeena are part of the regional sociology.

The Skeena Watershed is a productive basin, yielding millions of adult salmon each year, which support commercial, recreational, and aboriginal fisheries. These fisheries are important not only for their commercial value, but also for their cultural and environmental value. Although large, the fish resource is finite, and there are significant differences of perspective among the three major user groups. These differences mainly reflect the importance of the fisheries to the economic, cultural, and community structure of the region.

The abundant natural resources of the Skeena River have sustained fisheries for thousands of years, beginning with the First Nations Tsimshian, Gitxsan, Wet'suwet'en and Ned'u'ten people. The traditional harvest of surplus to conservation needs in terminal fisheries, on a stock-by-stock basis, allowed for optimal utilization of the salmon resource, which delineated the cultures, in terms of sustainability and socio-politically. In assessing the results of the traditional fishery, it is clearly observable that First Nations management of the salmon fisheries left a fish resource that was vigorous, diverse, and healthy at the advent and incursion of the commercial cannery fisheries on the Skeena stocks in the late 19th century.

European settlers arrived in pursuit of fur, and as the fur trade declined, Europeans changed their focus primarily to the sockeye fishery. Over time, the commercial fishery expanded, developing a very mobile fishing fleet, high capacity catch technology, and processing facilities, which moved the fishery seaward. The sport fishery developed more recently, becoming popular in the early 1970's, as people gained more leisure time and disposable income.

Salmon is the mainstay of the various commercial, sport, and aboriginal fisheries. Fisheries and Oceans Canada (DFO) has management responsibilities for the fish resources in tidal waters of British Columbia, including the commercial and the tidal sport fishery. The main commercial Area 4 salmon harvest on the coast in is early July through to late August. July fisheries are scheduled to coincide with the peak of the run of the enhanced sockeye stocks. August fisheries are timed to harvest the large pink salmon returns. The large recreational fishery in the Skeena Watershed is composed of both freshwater and tidal sport fisheries.

DFO manages the tidal sport fishery while the freshwater fishery management is divided between the DFO and the Provincial Ministry of Water, Land and Air Protection (WLAP); the salmon species are managed by the DFO, and freshwater, non-anadromous species including steelhead are managed by WLAP. The tidal fishery, is in general, more focused towards acquiring fish for food, and anglers are allowed to catch and keep a wide variety of species. In the upriver areas, catch and release and/or detailed angling restrictions for certain species and areas, apply specifically to many sub-basins in the watershed.

All three fisheries sectors – commercial, sport, and aboriginal – contribute in a significant and distinct way to the economy and quality of life in the Skeena Watershed and that of its residents. The continuation of regional benefits from each fishery depends on the long-term health of a variety of salmon stocks and species.

The Skeena Watershed Committee (SWC), a multi-stakeholder committee with interests in the fishery resources of the Skeena Watershed was created in 1991. Representatives included members from the following aboriginal, commercial, and recreational fishing sectors, as well as government ministries:

- Skeena Fisheries Commission (SFC) representing the indigenous Tribal Nations of the Skeena Watershed
- North Coast Advisory Board (NCAB), Commercial Fishery Caucus representing the Skeena River commercial salmon industry
- Skeena Watershed Sportfisherman's Coalition and the North Coast Co-Management Committee of the Sport Fishing Advisory Board representing the Skeena River sports anglers
- Department of Fisheries and Oceans (DFO)
- Ministry of Environment, Lands and Parks (MELP) and the Ministry of Agriculture, Fisheries and Food (MAFF)

The SWC was born out of anger, turmoil, and recrimination, but evolved into a consensus-based process (Skeena Watershed Committee 1996). Over a period of three years, plans and organizing resulted in an increased level of communication and understanding between all groups and members, laid out a three-year fishing plan, and presented educational and planning workshops. Overall, SWC laid a foundation for watershed management on a fish first basis and a framework of northern solutions for and by northern people.

Fish Conservation Organizations

Watershed protection concerns, fish habitat protection, and stream stewardship by Skeena Watershed fish conservation groups have expanded and become focused in the past three decades. Before then, little serious thought was given to the impact that increasing development could have on freshwater habitat. Watershed residents, the community groups they belong to, and government agencies responsible for habitat protection and management did not really address the potential urgency of habitat loss.

Attention slowly shifted to fish habitat, water quantity, and water quality as potential and ongoing development progressed. Major fish conservation issues at that time included Kemano II, closure plans of the Equity and Noranda open-pit mines, sediment production and mobilization impacts by the forest sector, and lack of adequate fish passage through drainage structures at many places along the watershed transportation network. Critical to conservation efforts has been the on-going awareness and education of the intricate mysteries of salmon, ocean survival, and freshwater ecology in the Skeena basin.

Influential in this expansion was the rise in awareness of the importance of fish stocks and the support provided by community advisors from DFO. The Salmonid Enhancement Program (SEP), operating since the late 1970's, helped to increase local awareness of salmon and local conservation. Initiated in 1995, the Watershed Restoration Program, sponsored by the Province of B.C., fostered involvement by First Nations, local conservation groups, the forest industry, and environmental organizations. The Fisheries Renewal program, sponsored by the Provincial and Federal governments in 1997, and the HRSEP program of DFO created opportunities for many local organizations to become involved in assessing and restoring fish habitat. The projects sponsored by these programs generally helped to build capacity and create opportunities for development of technical expertise and led to the establishment of many bio-technicians and consultants themselves into the Skeena Watershed communities.

For the many groups contacted in this planning process, the major concerns centered on funding levels and how their expertise and contributions to the overall Skeena fish picture could be improved. Cutbacks in government funding will potentially see an erosion of some of the community groups dependent on that funding and points to their need of becoming self-sufficient and sustainable entities. Although a number of government programs support community group initiatives, there does not appear to be a comprehensive understanding of how scarce government and private sector funding and resources can best be used to enable community groups to play a stronger role in the protection of Skeena fish and fish habitat.

At present, there are important community groups and First Nations involved in these programs in the Prince Rupert, Terrace, Lakelse Lake, Gitwangak, Gitanyow, Gitsegukla, Hazelton, Kispiox, Moricetown, Smithers, and Houston areas. Many fish conservation groups are involved in enhanced fish production, improvement to degraded habitat, hands-on streamside activities, and fish and fish habitat advocacy, while some groups limit their activities to a single purpose.

Aboriginal Fisheries Organizations

The following aboriginal organizations in the Skeena Watershed have an interest in and experience with management of fisheries resources:

- Tsimshian Tribal Council
- Kitsumkalum Band
- Kitselas band
- Gitanyow Fisheries Authority
- Gitxsan Watershed Authority
- Wet'suwet'en Fisheries
- Ned'u'ten Fisheries

Community Groups

The community groups involved in fish stewardship and conservation activities are varied. They range from sportsmens' organizations to groups with a focus on a single stream to environmental research organizations. The diversity and number of groups is particularly large in the Bulkley Valley, due to leadership of the Nadina Community Futures organization. The Northern Stewardship Society has been active in coordinating community fisheries involvement in the Terrace area. It is a coalition of approximately ten community groups, many of which were contacted for discussion of watershed planning objectives. About 30 community groups are listed below; quite possibly, some are missing. This total does not include groups that may use the protection of habitat as part of a broader objective, although the two goals may be complementary.

Community Stewardship Groups in Prince Rupert

- Community Fisheries Development Center
- Oona River Resource Assn
- Prince Rupert Salmon Enhancement Society
- Prince Rupert Sportsfish Advisory Board
- Prince Rupert Streamkeepers

Community Stewardship Groups in Terrace

- Northwest Stewardship Society
- Steelhead Society - Northwest Branch
- Terrace Rod & Gun Club
- Terrace Sportsfish Advisory Board
- Northwest Watershed Enhancement Society
- Terrace Salmonid Enhancement Society
- Watershed Bio-Enhancement Society
- Terrace Watershed Guardian Society
- Terrace and District Angling Guides Association
- Terrace-Kitimat Partners for Salmonids

Community Stewardship Groups in Hazelton

- Sik-e-dak Developers Society
- Chicago Creek Community Enhancement Society
- Suskwa Restoration Society
- Mission Creek Stewardship Committee
- Kispiox Band Council
- Gitsegukla Band Council
- Lax Skiik Ventures
- Kispiox Valley Steelhead Coalition
- New Hazelton Elementary Stream Keepers

Community Groups in Smithers and Houston

- Toboggan Creek Salmon and Steelhead Enhancement Society
- The Steelhead Society of BC – Bulkley Valley Branch
- Upper Bulkley River Roundtable
- Nadina Community Futures
- BC Federation of Fly Fishers
- Northwest Region BC Wildlife Federation
- Drift Fishers Federation of BC
- Pleasant Valley Anglers Society
- Northwest Institute for Bioregional Research
- Northwest Region, BC Wildlife Federation

Fish Status Summary

Sockeye

Most sockeye populations are sufficiently stable that there are no short-term concerns about survival of the stocks. However, the decline of several sockeye stocks that are seriously depressed and at risk of extirpation is a serious conservation concern. These stocks are: Kitwancool Lake, Bulkley Lake and Maxan Lake, and Cedar River and Clear Creek. The Kitwancool Lake sockeye have declined from historic escapement in the 20,000 range in the 1940's to several hundred fish. At this point it is not clear whether the problem lies in recruitment, spawning habitat, rearing capacity, or a combination of these factors (Cleveland 2001). However, it is likely that, since these sockeye run along with the large Fulton River sockeye stock, commercial catch targeted on the Babine fish has impacted recruitment. On genetic grounds, maintaining a population size of at least several hundred fish is required for long-term survival (Waples 1990).

Bulkley Lake and Maxan Lake sockeye are one or two small stocks in the headwaters of the Bulkley River east of Houston. Escapements were 50-600 until 1978. The stock or stocks then appear to have collapsed, and recent records shows a few or no fish returning. In 2001, several sockeye that may have been heading upstream to Bulkley Lake were spotted at a coho counting weir in Houston. Maxan Creek does not have sufficient flow to allow sockeye passage in some summers, and high water temperatures could also cause access problems. This information strongly suggests that the Bulkley Lake sockeye are at high risk of extirpation.

Clear Creek and Cedar River are northern tributaries of Kitsumkalum Lake. These sockeye streams have had declining spawner numbers since the 1960's. Clear Creek had over 1000 spawners until the 1960's and has declined to very low numbers in the 1990's. It is not clear whether sockeye spawned in Clear Creek in the past few years. Nearby Cedar River has had less dramatic declines from around 1500 spawners in the 1970's to several hundred in the 1990's, with a peak of 1000 escapement in 1998. A positive feature of north Kitsumkalum Lake sockeye escapement is the success of a small artificial spawning channel near the outlet of Clear Creek that is producing several thousand returning adults and has thus somewhat compensated for the decline of the stocks from the two nearby streams.

Morrell (2000) lists Upper Tahlo Creek, a tributary of Babine Lake above Morrison Lake, as a stock of high concern. It is not included in this list because it appears to be sporadic in its use by sockeye. It might be simply an extension of the lower Tahlo Creek spawning stock used in years of when there is enough flow to permit sockeye access above Tahlo Lake.

There is evidence in early fisheries reports in the DFO, BC16 files of two sockeye spawning areas no longer in use: Seeley Lake and Canyon Lake. Since the Seeley Lake spawning locality is at the current crossing of Highway 16, it is unlikely that recent occurrences would be overlooked. There are no known recent records for the Seeley Lake and Canyon Lake stock, and they are believed extirpated.

In recent decades, over 90% of the Skeena sockeye came from Babine Lake stocks (West and Mason 1987, McKinnell and Rutherford 1994). This proportion increased from pre-1960 levels of about 80% (Brett 1952), largely due to the success of the Babine Lake sockeye spawning channels built at Fulton River and Pinkut Creek in the 1960's. The nearly thirty non-enhanced sockeye stocks that also rear in Babine Lake seem to be maintaining their historic run strength.

Coho

Coho salmon are widely dispersed throughout the Skeena Watershed. They are the most widespread of the salmon species and show the least amount of concentration into few productive stocks. Currently there are eight stocks of particular concern that include Khyex River, Gitnadoix River, Morice River and tributaries, Upper Bulkley River, Fiddler Creek, Zymoetz River and tributaries, Bear River, and Babine Lake.

Gitnadoix River and tributaries such as Kadeen Creek and Southend Creek have had great reductions in their coho runs since the early 1970's. Present escapements are less than 10% of early escapements, though these numbers may have resulted from high water or other difficult counting conditions. However, Dog Tag Creek, a lower tributary, seems to have a stable escapement trend, and enough coho are still present for rebuilding. The Gitnadoix coho are of high interest to First Nations in that an aboriginal weir fishery exploited them.

The Bulkley River system has shown serious declines in coho since the 1970's. The Morice River, with its tributaries, was a leading coho producing river in the 1950's with an average escapement of over 10,000. The three escapement counts from the 1990's average less than 800. The decline in coho escapement is similar in the Upper Bulkley River. In the 1990's, most of the recorded escapement of coho in the Bulkley River (74%) was from Toboggan Creek – in part supplied by a hatchery on that creek.

Fiddler Creek is the principal coho producing stream between the Zymoetz River and the Kitwanga River. It had coho escapements of 400 to 750 in the 1970's. Recent escapements have been very low. In 2001, a relatively good year, the escapement was 75. This coho population is important to the Gitxsan who harvested this stock in the past.

The Zymoetz River was one of the principal producers of coho in the 1950's to 1970's with annual escapements of about 5,000. In recent years, escapement estimates have been well under 1000. The decline in coho seems especially severe in the lower portion of the river, which has experienced numerous development impacts and associated channel instability.

All Babine Lake coho stocks show a serious decline since the 1970's. Juvenile density estimates are also low when compared to other portions of the Skeena (Holtby *et al.* 1999). The decline in coho is especially large in the southern tributaries of Babine Lake such as Pinkut Creek, Shass Creek, and Pierre Creek. Although recent records are of poor quality, the stocks in Shass Creek and Pierre Creek seem at high risk of extirpation. The general cause of decline in these stocks is high exploitation rates and poor smolt to adult survival. These are compounded by the increased occurrence of drought in this low precipitation and dry portion of the Skeena Watershed.

Bear River and Bear Lake and the upper part of the Sustut River have a severe decrease in coho escapement. Juvenile density estimates are also low when compared to other portions of the Skeena (Holtby *et al.* 1999). Although escapement records are of poor quality in this remote area, it seems that the current escapements are less than 10% of the historic levels. Escapement estimates from the 1990's suggest that the spawning population is now less than 200, a level that merits serious concern.

Pink

There are probably at most a few biologically definable pink salmon subpopulations that occupy the Skeena River. These stocks each occupy large portions of the watershed. There is an exceptional variability in stock recruitment from year to year, perhaps due to variation in survival of fry early in their ocean residence. These characteristics and the general robust size of spawning stocks mean that there are no identifiable stocks at risk. Pink salmon are the one species of Pacific salmon that has been expanding in the Skeena River. Total escapement doubled from the 1950's to the 1990's. Total run size before harvest averaged >5 million in the 1980's and 1990's.

In the 1980's, pink salmon increased their range in the Morice River. The population expanded rapidly and exceeded 600,000 in 1991. The Skeena River West escapement also grew rapidly during this interval. Lakelse River continues to be the leading pink salmon producer. Lakelse River spawning occurs mostly in the few kilometres below the lake outlet. These gravels are consequently the most productive natural spawning area in B.C. Because of the generalized population structure in pink salmon and the relatively high rate of straying, there is little concern about the continued survival of small pink salmon populations. We assume that these areas are repopulated in years of high return when straying is maximal.

Chinook

Chinook are the largest species of salmon in the Skeena Watershed. In general they are fish of larger streams and spawn in faster moving water with coarser gravel than other salmon. Typical chinook stocks are relatively small (Healey 1991). The largest Skeena chinook stocks, Bear River and Morice River, have average escapements under 20,000 in their most productive decade. Most stocks have average escapements of fewer than 500 chinook

The overall chinook escapement to the Skeena Watershed may be a fifth or less of the escapement a hundred years ago. A potential problem with many chinook stocks is that at times of poor overall returns to the Skeena, the smaller stocks may be eliminated. When stock numbers fall below several hundred, there is a significant chance of loss of genetic diversity, adversely affecting the chances of long-term survival (Franklin 1980, Waples 1990).

The chinook in Deep Creek are a small stock, with escapement in the hundreds in the 1970's, in the tens in the 1980's, and near zero in the past decade. Spawning chinook have been noted in the past few years, but they might be escapees from the Deep Creek Hatchery. The run timing is apparently similar to the adjacent lower Kitsumkalum River. This stock may be part of the larger lower Kitsumkalum River run.

The Upper Bulkley system had low chinook escapements from the 1960's to the 1980's. There has been substantial recovery since 1988. There were record high abundance runs in 2000 and 2001, years of high summer flows. The Upper Bulkley stock is an early run stock that is genetically distinct from the larger and later Morice River run (Beacham *et al.* 1996).

Two chinook stocks on the lower Skeena River have seen substantial declines. The Zymagotitz (Zymacord) River has a very small chinook stock. It is difficult to enumerate this stream. As far as the field counts can be trusted, there were about 100 spawners at the peak in the 1970's. Escapement estimates for the 1990's have declined to about 25. Erlandsen Creek, a tributary of the Zymagotitz River, has had typical escapements of about 20 fish, in 2001, there a record high escapement of 140 chinook. The low escapement numbers for the Zymagotitz stocks are reason for concern about long-term survival. The Gitnadoix River chinook stock has declined from about 400 in the 1960's to an average of less than 40 in the 1990's. Overall, escapement has been poor for the past 20 years. In the past two decades the Gitnadoix tributary, Magar Creek, has been supporting increasing numbers of chinook. Two escapements in the past four years have been 300.

The Shegunia River supported an important traditional Gitxsan chinook fishery. Escapement data are poor, but numbers appear to be depressed since the 1950's. Hatchery reared fry and smolt from this stock were released from 1986 to 1994. Increases from this outplanting may have contributed to a short-term increase in escapement, but long-term recovery is not apparent. Logging from the 1970's through to the present may be a contributing factor to the declining trend due to the watershed having a high sediment-producing regime. Since the 1950's, the Salmon River Road has provided anglers with easy access to the critical holding area

Babine River chinook escapement has been poor since the 1960's. It has not recovered in the past two decades as many other stocks have, despite supplementation by hatchery production. The peak of this run is in late July and early August, coinciding with the sockeye and pink salmon fisheries. Although population levels are depressed, this stock currently has adequate escapement for maintenance.

Lakelse River and Coldwater Creek are a small stock with peak escapements of approximately 400 chinook in the 1970's and 1980's. The adult spawning population declined strongly since 1990. The average count for the 1990's is about 100. Coldwater Creek is a tributary of the Lakelse River adjacent to the chinook spawning area below Lakelse Lake. In the 1980's and early 1990's, the escapement of chinook to Coldwater Creek exceeded that of Lakelse River. Counts are not available for either locality for the last two seasons, which saw strong stock recovery in many other parts of the Skeena Watershed. This is an early chinook run, with spawning mostly occurring in mid-July and August.

Hatchery releases of fish raised in the Deep Creek hatchery were made from 1986 to 1991 but do not appear to have helped. The population size of this stock, based on available data, appears alarmingly small. It is possible that the Lakelse and Coldwater chinook enumerations are the same fish changing their spawning destinations based on habitat conditions. If this were true, then the total watershed chinook count would appear relatively stable. This situation exists with the Gitnadoix River and Magar Creek chinook as well.

The Ecstall River includes two census areas for chinook, Johnston Creek and Ecstall River. This river was one of the top five producers in the 1950 to 1970's. It has since declined severely. Sports fishing impacts were noted in the 1970's and may have contributed to the decline. The commercial fisheries exploitation rate for this stock may be exceptionally high, restricting the ability of the Ecstall River chinook to recover. In the 1990's, escapement averaged 650, about one seventh of the 1950's and 1960's escapement, and one third of the 1970's escapement. Although population levels are severely depressed, this stock has adequate escapement for maintenance.

The Suskwa River has a small chinook stock. Peak escapements during the last fifty years were several hundred. Recorded escapement values in the period from 1988 to 1992 ranged from 0 to 60. No records are available after that date. This watershed had heavy logging impacts in the 1970's and 1980's and continues to have large-scale, stream bank landslide activity. The present level of chinook escapement does not suggest a stable population level or long-term survival of this population.

Chum

Chum salmon are the least abundant of the six Pacific salmon species in the Skeena Watershed. Chum are most common in the coastal portion of the Skeena Watershed. The most important spawning areas is the Ecstall River and Skeena River West. Other spawning areas are near the mouths of large tributary streams and in back channels along the Skeena River from Terrace to Kispiox. Significant spawning occurs in the Kitwanga and Kispiox Rivers. Smaller stocks are present in the lower portions of several other Skeena River tributaries. Chum are rare in the Bulkley River and in the Skeena River above the Kispiox River confluence.

There is an extraordinary variability in year-to-year chum salmon returns. Annual escapement estimates (SEDS Database) have varied one hundred fold over the past fifty years. Chum salmon stocks were apparently much larger in the early twentieth century. In the Skeena River mouth fishery, the commercial catch of chum salmon between 1916 and 1928 was over 200,000 per year (Argue et al. 1986). This suggests an escapement about ten times larger than that of the recent past. Chum salmon escapements have been low for the last 50 years. With the exception of the spectacular high escapement in 1988, the average escapements have been declining over this period. The decline in chum salmon stocks is basin wide, suggesting that much of the problem is in the marine realm. Similar declines have taken place in the mid-coast region and in southeast Alaska non-enhanced stocks. This suggests that a major component of the decline in chum salmon is decreased ocean survival.

On the Skeena River, several spawning areas regularly used in the past, such as the backchannel near Thornhill above Terrace, no longer support spawning fish (Kofoed 2001). On the other hand, several field workers suggest that the mainstem Skeena River chum populations below Terrace are under-reported because of turbid water conditions at spawning time (Kofoed 2001, Bustard 2002, Culp 2002).

Of special note is the extremely low levels or loss of the once large Lakelse River chum stock. The formerly large Kispiox River stock has also declined dramatically, but there are still chum present. Other stocks with very poor recorded returns are Kleanza Creek, Fiddler Creek, Deep Creek, Zymoetz River, and Zymacord River.

Steelhead

Skeena Watershed streams support both sea-going and resident populations of *Oncorhynchus mykiss*. The anadromous populations are known as steelhead, including both summer run steelhead that return in July and August and winter run populations that return from November to March in the Skeena system. Summer run steelhead are more numerous and found throughout the watershed; winter run steelhead are limited to the coastal portions of the Skeena, from the Terrace area downstream.

Overall, the Tyee Test Fishery best estimates escapement to the Skeena Watershed. This site provides a useful estimate for the summer run portion of the steelhead. Little data is available to estimate the winter run component. There are few good data to record steelhead escapements at individual streams. It is clear that the Bulkley-Morice is the most important spawning stream. Based on population estimates for the Bulkley River (Mitchell 2001, Saimoto, 2002) and test fishery data from the Tyee Test Fishery, the Bulkley-Morice likely accounts for one quarter to more than one half of the total escapement in recent years. Babine, Bear, Kitwanga, Kispiox, and Zymoetz Rivers also contribute sizable numbers (Heath et al. 2002, Whately and Chudyk 1976). It is likely that the six watersheds identified above produce at least 80% of the Skeena Watershed steelhead.

Changes to steelhead populations in tributary watersheds in the Skeena are hard to identify due to a shortage of relevant information. While catch per unit effort (CPUE) applied to sports fisheries is not a solid measure of abundance, the most useful source of data is the Steelhead Harvest Analysis (Ministry of Water, Lands and Air Protection 1991). In general, the pattern of catch reported for the major steelhead streams – the Morice, Kispiox, and Babine Rivers – shows an increase in fishing effort and catch over the past 35 years. On these rivers the pattern of total catch, including released fish, resembles the Tyee estimates for summer run steelhead. The Lakelse River steelhead sports fishing catch has been declining since 1988. Year 2000 catches are estimated at about one quarter of the 1988 to 1990 catch. The Gitnadoix River, which has only winter run steelhead, shows a similar pattern, but with a marked improvement in 1999 and 2000.

Resident Freshwater Fish

In comparison to salmon, information is sparse on resident, non-anadromous freshwater fish in both fluvial (streams) and lacustrine (lake) habitats of the Skeena Watershed. Indeed, much of the watershed is poorly known and may contain populations of special interest or status that are currently unknown. Ecological and life history information that permits goods conservation planning is simply not available. There are 32 known species of fish in the Skeena system; of these, 26 are freshwater species (McPhail and Carveth 1993a). Eighteen of these species regularly enter the sea and are widespread along the north coast.

Freshwater species and populations inhabiting the Skeena system include rainbow trout cutthroat trout, kokanee, bull trout, Dolly Varden char, lake trout, river lamprey, pacific lamprey, western brook lamprey, green sturgeon, white sturgeon, American shad, lake whitefish, pygmy whitefish, mountain whitefish, longfin smelt, eulachon, peamouth chub, northern pike minnow, longnose dace, redside shiner, longnose sucker, white sucker, largescale sucker, burbot, threespine stickleback, coastrange sculpin, and prickly sculpin.

Ranking of productive watersheds

The eleven Skeena watersheds described in the previous sections have diverse qualities. What they do share is their extraordinary high quality habitat, which leads to high fish productivity. Some of these watersheds are highly productive for only two species, others for most Pacific salmon species. The Kispiox Watershed is a leading producer of all six species. The following table lists the salmon species for which the watershed is one of the top producers. This table ranks watersheds on the basis of fish values alone. Other values are considered in the Strategic Overview Matrix section that follows. The final selection of candidate watersheds considers the fish values and other watershed values, as well as characteristics which are covered in the Strategic Overview Matrix.

Table 6. Major productive watersheds by species.

Watershed	Coho	Chinook	Pink	Chum	Sockeye	Steelhead	Ranking
Babine R.	X	X	X		X	X	5
Bear R.		X			X	X	3
Morice R.	X	X	X		X	X	5
Kispiox R.	X	X	X	X	X	X	6
Kitwanga R.		X	X	X		X	4
Zymoetz R.					X	X	2
Lakelse R.	X		X	X	X	X	5
Kitsumkalum R.	X	X		X	X		4
Skeena R. West			X	X			2
Gitnadoix R.	X			X	X		3
Ecstall R.	X	X		X			3

Note: The Bear River steelhead rating is for the whole Sustut River area; the Morice River steelhead rating includes the adjacent Bulkley River area.

Strategic Overview Matrix

This strategic overview considers and identifies social, political, economic, cultural, and ecological values for and within the Skeena Watershed. It also identifies resources potentially available for the Skeena WFSP within the selected watersheds, and in particular for the Stage II candidate watersheds.

An overview of the socio-political aspects of the eleven selected watersheds is presented in Table 7. Overall priorities are assigned based on the pattern of ranking. If all criteria are ranked "high," then the overall ranking is "very high."

Cultural and social values are loosely defined as the level of awareness and interest in fish, including intangible values, within the watersheds. Generally, the presence of salmon and freshwater non-anadromous fish is a strong part of cultural values and community identity within the Skeena Watershed. The cultural and social value to local communities, First Nations, and sport fishing enthusiasts is high for all watersheds except the Bear Watershed, which is inaccessible by road and has very few visitors.

Economic value of fish is high in all of the watersheds because they are productive and support aboriginal, recreational, and commercial fisheries as well as enhancing community stability. Aboriginal values, which reflect First Nations interests, concerns, and priorities, are delineated in the First Nations priorities.

Stakeholders are defined in this planning process as the non-aboriginal community and user groups with an interest level and support for the Skeena WFSP within the watersheds. There are many active and diverse community stewardship and fish conservation groups that support fish sustainability planning, site works, and monitoring. The sustainability/attainability criterion is a measure of the tractability of the environmental problems in the watershed and the feasibility of working there. This criterion includes factors that may limit the ability of degraded fish populations or habitats to recover on their own. Human resource availability includes technical expertise to facilitate watershed planning and conservation initiatives in adjacent or nearby communities.

Information and data availability about the specific watersheds is rated. The previous fish projects rating signifies number of past fish sampling surveys, habitat biophysical studies and inventories, enhancement, impact, and other fishery related activities. Government priority is rated with respect to identified fish populations and habitats within the selected watersheds as areas or species of management concern, provincially significant species, species at risk, or targeted watersheds. Accessibility ratings reflect road, boat, or air access to and within the watershed. Overall priority is a roll-up on the above values, information, and factors.

Table 7. Strategic Overview Matrix

Watershed	Cultural& Social Value	Economic Value	Ist Nation Priorities	Stakeholder Priorities	Sustainabiliy/ Attainability	Human Res. Availability	Data Available	Previous Fish Projects	Gov't Priority	Access	Overall Priority
Babine	Hi	Hi	Hi	Hi	Hi	Mod	Hi	Hi	Hi	Hi	Hi
Bear	Mod	Hi	Hi	Mod	Lo	Lo	Lo	Lo	Mod	Lo	Lo
Morice	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	V Hi
Kispiox	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	V Hi
Kitwanga	Hi	Hi	Hi	Mod	Hi	Hi	Hi	Hi	Hi	Hi	Hi
Zymoetz	Hi	Hi	Hi	Hi	Hi	Hi	Mod	Hi	Hi	Hi	Hi
Lakelse	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	Hi	V Hi
Kitsumkalum	Hi	Hi	Hi	Hi	Hi	Hi	Mod	Hi	Hi	Hi	Hi
Skeena West	Hi	Hi	Hi	Hi	Hi	Hi	Mod	Mod	Mod	Hi	Mod
Gitnadoix	Hi	Hi	Hi	Hi	Lo	Hi	Lo	Lo	Hi	Mod	Mod
Ecstall	Hi	Hi	Hi	Hi	Hi	Hi	Mod	Mod	Mod	Mod	Mod

Candidate Watersheds

To select candidate watersheds for Stage II, we first considered species ranking from Table 6. The species ranking is the number of salmon species for which the watershed is or has been a top producer in one or more decades of the past 50 years. This ranking reflects the quality of fish habitat since the time before most of the habitat impacts, which began with large scale logging development late in the 1950's. Since multiple species are required for high values, this index focuses on a diversity of aquatic types. The watershed ranking is then compared to the strategic overview matrix priorities that summarize the social, political, economic, cultural, and ecological values.

Stage I of the Skeena WFSP sets watershed priorities for fish sustainability planning. The watersheds selected in the Skeena Stage 1 WFSP process are: the Kispiox, the Morice, and the Lakelse watersheds. Stage II planning lays the foundation for the development of detailed WFSP action plans to maintain or restore the productive capacity of watersheds that have been identified as Stage II candidates.

Watershed	Salmon Species Ranking	Strategic Overview Priority	Stage II Candidate
Babine	5	Hi	
Bear	3	Lo	
Morice	5	V Hi	Yes
Kispiox	6	V Hi	Yes
Kitwanga	4	Hi	
Zymoetz	2	Hi	
Lakelse	5	V Hi	Yes
Kitsumkalum	4	Hi	
Skeena West	2	Mod	
Gitnadoix	3	Mod	
Ecstall	3	Mod	

Table 8. Selection of Stage II candidates.
The salmon species ranking is the summary column from Table 6, the Strategic Overview Priority is the summary Overall Priority column from Table 7.

The candidate watershed selections of the Skeena WFSP Stage II were extracted from summaries of watershed resources and impacts described in the individual watershed descriptions. Values and interests were identified in the Strategic Overview Matrix. These factors are included in the Strategic Overview Matrix (Table 7). These Stage II candidate watersheds reflect the "fish first" focus of WFSP and its emphasis on maintaining healthy watersheds. Over the past 50 years, the Morice, Kispiox, and Lakelse watersheds have seen repeated fish conservation efforts based in aboriginal, or community, and government concerns related to their high value fish and habitat.

Paish and Associates 1983 reviewed the fish habitat values and resource development threats for the Skeena Watershed two decades ago; they reviewed logging, agriculture, transportation corridor, urban development, mining, and hydro development risks and rated streams by their productivity and habitat quality. They concluded that the highest priority watersheds were the Babine, Kispiox, and Lakelse Watersheds.

Kispiox Watershed

This watershed possesses highly productive habitat for all six Pacific salmon species. It is one of the top five salmon producers for each of the six species. It is the only watershed in the Skeena with this rating.

The most serious environmental problems relate to intensive logging that occurred from the early 1970's to the late 1990's. The Watershed Restoration Program has prepared prescriptions for addressing many of the logging related problems. Transportation related problems are moderate and mostly related to providing fish passage at road crossings. The Kispiox Watershed is positioned in the transition zone from coastal to interior conditions, which makes major rainstorms infrequent and of relatively low intensity. The transition zone also makes it likely that summer dry periods will be of short duration. In short, the environmental problems of the Kispiox are tractable. The high fish values in this watershed need recognition and positive movement toward protection of areas of critical habitat and conservation of the fish populations.

There is an active Watershed Stewardship group in nearby Hazelton with representation from nine local conservation organizations and First Nations groups. First Nations groups have taken the lead in community involvement in fisheries habitat issues. Technical expertise to facilitate watershed planning and conservation initiatives is available in Hazelton and the adjacent communities of Terrace and Smithers. The overall rating on the Strategic Overview matrix is "Very High."

Morice Watershed

The Morice River has excellent habitat for five of the six Pacific salmon species. The rearing habitat for steelhead, coho and chinook is extremely valuable. This river supports salmon runs that are among the top five for five species.

The most significant environmental problems are related to intensive logging that started in the 1970's and continues at present in the ultimate headwaters. Transportation impacts are relatively minor, being related to the logging road network. Providing fish access is the principal problem. There is a small mine that has operated sporadically over the past 80 years in the Owen Creek drainage. Current pollution problems are at a scale that can be addressed. The Morice Watershed is positioned in the transition zone from coastal to interior conditions, which makes major rainstorms infrequent and of relatively low intensity. Morice Lake and other various lakes serve as buffers against large floods. The transition zone also makes it likely that summer dry periods will be of short duration, at least in the western part of the watershed. In short, the environmental problems of the Morice are manageable. An important direction for conservation activities in this watershed needs to be preservation of critical fish habitat.

Houston and Smithers have an active watershed stewardship group with at least ten community member organizations. The technical expertise for planning and design of fish conservation plans, as well as the community leadership, exists in Smithers. Smithers has a DFO Community Advisor and is a Provincial Government centre. The overall rating on the Strategic Overview matrix is "Very High."

Lakelse Watershed

The Lakelse Watershed supports all six species of Pacific salmon. It is a leading producer of five of the six species. The spawning and rearing habitat of the Lakelse River is superb. The Lakelse drainage was logged in the 1950's to 1980's. Impacts are severe to about one half of the streams in the drainage. Transportation impacts are noteworthy with highways, railroad, and power and natural gas lines. Large landslides are common within the drainage. Intense fall storms promote extreme erosion of headwater streams. Housing and recreation development on Lakelse Lake creates conflict with fish conservation values. Lakelse Lake is the most heavily utilized recreational lake in the Skeena Watershed. The possible eutrophication of Lakelse Lake is a serious concern. Many of the restoration objectives are achievable; others will take many years to recover.

Terrace has an active watershed stewardship program and a DFO Community Advisor. There are at least ten active stewardship groups in the Terrace area. Several fisheries and watershed consultants are located in this community, which has the potential to carry out a WFSP process. The overall rating on the Strategic Overview matrix is "Very High."

Acknowledgements

Fisheries and Oceans Canada and the Ministry of Water, Land and Air Protection, Fisheries Management Branch funded this report. This report represents a compilation, synthesis, and analysis of a wide variety of information and sources. The authors and the Skeena WFSP Steering Committee express their appreciation and thanks to the following individuals and organizations for their interest, support, and contributions. Over 40 of the following people commented on an earlier draft of this report.

From Fisheries and Oceans Canada we would like to thank: Brenda Donas, Mitch Drewes, Barry Finnegan, Martin Forbes, Dale Gueret, Colin Harrison, Aubrey Jackson, Mike Jakubowski, Dorothy Kliester, Vesna Kontic, John Lubar, Lidia Jaremovic, Lana Miller, Tom Pendray, Bruce Shepherd, Brian Spilsted, Barb Spencer, Ivan Winther, Dan Wagner, Peter Woloshyn, Clarence Neilson, and Gordon Millar. Special thanks to Dave Peacock and Steve Cox-Rodgers for enduring endless questions patiently and their concise review.

From the Ministry of Water, Land and Air Protection we would like to acknowledge and thank for their time, expertise and constructive review: Dana Atagi, Mark Beere, Troy Larden, Jeff Lough, Paul Giroux, Darren Fillier, and Art Tautz. From the Ministry of Sustainable Resource Management we would like to thank: Bob Copley, James Cuell, Brian Fuhr, Matt Jessop, Loretta Kent, Sarma Liepins, Eamon O'Donohue, Sandra Sulmya, and Andy Witt. From BC Parks we would like to thank: Lyle Gawalko. From the Ministry of Transportation we would like to acknowledge Dave St. Thomas. From the Ministry of Forests we would like to thank Mike Buirs, Howard Debeck, Allen Harrison, Jason Howard, Ralph Ottens, Jim Pojar, Jim Schwab, and Dave Wilford.

We would also like to thank First Nations' leaders, biologists, and elders who contributed their knowledge and expertise to this project. Some of these people include: Bill Blackwater, Lyle Bolton, Mark Cleveland, Walter Joseph, Derek Kingston, Charlie Muldon, Gord Sterritt, Lars Reese-Hansen, Bill Spence, and Stephan Schug.

Watershed stewardship organisations and Community group representatives contributed to this report. Special thanks are due to Bridie O'Brien, Chris Culp, Jim Culp, Garnet Duell, Ed Hobenshield, Dave Silver, Tasha Sutcliffe, Ian Maxwell, Doug Webb, Mary Swenson, and Greg Tamblyn.

We would like to recognize Paul Veltmeyer and Rick Brauer at Skeena Cellulose Inc, Doug Witala at Pacific Inland Resources, Walter Simcoe at Canadian Forest Products, and Melissa Todd at Houston Forest Products for their interest and support.

Thank you Andrew Webber of the Kitimat-Stikine Regional District and Pam Hext of the Regional District of Bulkley-Nechako for your interest and information.

Consultants, retired government officers, and people with specialized local knowledge that contributed to this report are: Dave Bustard, George Kofoed, Mike McCarthy, Brad Pollard, Kim Haworth, Irene Weiland, Dennis Towers, and Mike Whelpley.

Special thanks and appreciation is due to the following people for help with the GIS mapping, research and report production: Robert Fritzsche, Kathy Holland, Elmar Plate, Richard Wright, Howard Sexsmith Jr., Lance Williams, and Gordon Wilson.

References Cited

Abelson, D. 1976. Lakelse Lake Water Quality Study. Technical Report, Water Resources Service, Pollution Control Branch, Victoria, BC.

AES. 1993. Twenty year summary of selected northwest weather stations. Atmospheric Environment Services. Environment Canada.

Anonymous 1964. Skeena River sockeye and pink salmon *in* Inventory of the Natural Resources of British Columbia. 15th B.C. Natural Resources Conference.

Anonymous. 2001a. Freshwater fishing regulations synopsis. BC Government.

Anonymous. 2001b. Skeena Bulkley Region Resource Management Plan, 2002-2006.

Alexander, R.F. and K.F. English. 1996. Distribution, timing and numbers of early-run salmon returning to the Kitsumkalum River Watershed in 1995. Prepared by LGL Ltd. For DFO, Skeena Green Plan, Prince Rupert. 82p. Draft.

Argue, A.W., C.D. Shepard, M.P. Shepard, and J.S. Argue. 1986. A compilation of historic catches by the British Columbia commercial salmon fishery, 1876 to 1985. Internal DFO Report.

Bahr, M. 2002. Examination of bull trout (*Salvelinus confluentus*) in the Morice River watershed. Biology Program, UNBC, Prince George BC. Prepared for Canadian Forest Products, Houston Forest Products and BC Min. of Water, Land and Air Protection, Smithers, BC. Unpublished manuscript.

Bams, R.A. and A.S. Coburn. 1962. Experimental hatchery operations. *In* Withler, F.C. *Eds.* Studies in salmon propagation. Annual Report of the Biological Station, Nanaimo, BC. 1961-1962: D1

Banner, A., W. McKenzie, S. Haeussler, S. Thomson, J. Pojar, and R. Trowbridge. 1993. A field guide to site identification and interpretation for the Prince Rupert Forest Region. Land Management Handbook No. 26. Ministry of Forests, Victoria, BC.

Barbeau, M. 1915-1936. Unpublished manuscripts, field notes, etc. Northwest Coast Files (BF Series), Canadian Museum of Civilization, Ottawa.

Barbeau, C.M. 1917. Growth and federation of the Tsimshian Phratries. Proceeding of the 19th International Congress of Americanists, Washington. pp. 402-408.

Baxter, J.S. 1997a. Kispiox River steelhead: summary of current data and status review, 1997. BC Environment. Skeena Fisheries Report SK-100. MELP, Skeena Region. Smithers, BC.

Baxter, J.S. 1997b. Upper Sustut, Lower Sustut, and Bear River steelhead: Summary of current data and status review, 1997. Skeena Fisheries Report SK-98. MELP, Skeena Region. Smithers, BC.

Beacham, T.D., J.R. Candy, K.J. Supernault, T. Ming, B. Deagle, A. Schultze, D. Tuck, K.H. Kaukinen, I.R. Irvine, K.M. Miller, and R.E. Withler. 2001. Evaluation and application of microsatellite and major histocompatibility comples variation for stock identification of coho salmon in British Columbia. Trans. Amer. Fish. Soc. **130:** 1116-1149.

Beacham, T.D., R.E. Withler, and A.P. Gould. 1985. Biochemical genetic stock identification of pink salmon (*Oncorhynchus gorbuscha*) in Southern British Columbia and Puget Sound. Can. J. Fish. Aquat. Sci. **42:** 1474-1483.

Beacham, T.D., A.P. Gould, R.E. Withler, C.B. Murray, and L.W. Barner. 1987. Biochemical genetic survey and stock identification of chum salmon (*Oncorhynchus keta*) in British Columbia. Can. J. Fish. Aquat. Sci. **44:** 1702-1712.

Beacham, T.D., R.E. Withler, and T.A. Stevens. 1996. Stock identification of chinook salmon (*Oncorhynchus tshawtscha*) using minisatellite DNA variation. Can. J. Fish. Aquat. Sci. **53**: 380-394.

Beacham, T.D. and C.C. Wood. 1999. Application of microsatellite DNA variation to estimation of stock composition and escapement of Nass River sockeye salmon (*Oncorhynchus nerka*). Can. J. Fish. Aquat. Sci. **56 (2)**. 297-310.

Beamish, R.J., G.E. McFarlane, and J.R. King. 1999. Fisheries climatology: understanding decadal scale processes that naturally regulate British Columbia fish populations. *In* Fisheries Oceanography: A science for the new millennium. T. Parsons and P. Harrison [eds].

Beaudry, P. 1992. Sediment monitoring program Nilkitkwa Watershed – working plan. Forest Sciences Section, Prince Rupert Forest Region, BC Ministry of Forests, Smithers, BC.

Beaudry, P.G., D.L. Hogan, and J.W. Schwab. 1990. Hydrologic and geomorphic considerations for silvicultural investments on the lower Skeena River floodplain. FRDA Report 122. Victoria, BC.

Beaudry, P.G. and A. Gottesfeld. 2001. Effects of forest-harvest rates on stream-channel changes in the Central Interior of British Columbia. *In.* D.A.A. Toews, and S. Chatwin *Eds.* Watershed Assessment in the southern interior of British Columbia. Res. Br., B.C. Min. For., Victoria, BC. Work. Pap. 57/2001.

Beere, M.C. 1991. Radio telemetry investigations of Babine River steelhead, spring 1990. Skeena Fisheries Report SK-71. MELP, Skeena Region. Smithers, BC.

Beere, M.C. 1993. Juvenile steelhead surveys in the Kitwanga, Morice, and Zymoetz Rivers, 1993. Skeena Fisheries Report SK-90. MELP, Skeena Region. Smithers, BC.

Beere, M.C. 1996. Movements of summer run steelhead trout tagged with radio transmitters in the Babine River during spring, 1994. Skeena Fisheries Report SK-94. MELP, Skeena Region. Smithers, BC.

Beere, M.C. 2002. Personal communication. WALP, Skeena Region. Smithers, BC.

BCCF. 1999. Morice detailed fish habitat/riparian/channel assessment for watershed restoration – Nanika and Lamprey sub-basins. British Columbia Conservation Foundation. Smithers, BC.

BCFS. 1956. Babine Lake maps (5 sheets). 1:40 ch. scale. File P380-P530. BC Forest Service, Victoria, BC.

BCFWRP. 2001. Big Falls Creek Watershed. *In* Bridge-Coastal Fish and Wildlife Restoration Program, Vol. 2.

BC Hydro. 1983. Skeena-Rupert 500 kV transmission line. Environmental and socio-economic assessment. Vols. 1 & 2, Report No. ESS-20. Fisheries section prepared by D.B. Lister for BC Hydro.

BC Ministry of Environment Lands and Parks, and Fisheries and Oceans Canada. 2001. Watershed-based fish sustainability planning: Conserving B.C. fish populations and their habitat. A guidebook for participants. Co-published by B.C. Ministry of Environment, Lands and Parks and Canada Dept. of Fisheries and Oceans.

BC MoE. Skeena River lake and stream management files. Various dates and authors. BC Ministry of Environment. Smithers, BC.

BC MoF and BC MoE. 1999. Coastal watershed assessment procedure guidebook (CWAP). Interior watershed assessment procedure guidebook (IWAP). BC Ministry of Forests and BC Ministry of Environment. Victoria, BC.

BC Parks. 2000. Management direction statement for Babine River Corridor Provincial Park. Skeena District, Smithers, BC.

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. *In* Salo, E.D. and T.W. Cundy. *Eds*. Streamside Management: forestry and fisheries interactions. University of Washington, Institute of Forest Resources, Contribution 57. pp191-232.

Beschta, R.L., J.R. Boyle, C.C. Chambers, W.P. Gibson, S.V. Gregory, J. Grizzel, J.C. Hagar, J.L. Li, W.C. McComb, M.L. Reiter, G.H. Taylor, and J.E. Warila. 1995. Cumulative effects of forest practices in Oregon. OSU. Corvallis, Oregon.

Bilton, T.H. and M.P. Shepard. 1955. The sports fishery for cutthroat trout at Lakelse Lake, British Columbia. Fish. Res. Bd. Can., Pacific Coast Stat. Rept. (104): 38-42.

Bocking, R. and M. Gaboury. 2002. Clear Creek (Milgeelde): Sockeye habitat condition and capability assessment. LGL Ltd. for Kitsumkalum Band Council. Sidney, B.C.

Boer, G.J., G. Flato, and D. Ramsden. 2000. A transient climate change simulation with greenhouse gas and aerosol forcing: projected climate to the 21st century. Climate Dynamics. **16**:6 427-450.

Brett, J.R. 1952. Skeena River sockeye escapement and distribution. J. Fish. Bd. Can., **8** (7) 1952.

Brown, R.F. 1980. Groundwater reconnaissance for salmonid enhancement opportunities on Lakelse, Kitsumkalum, and Tseax River systems. Unpublished memo, DFO. Vancouver, BC.

Brown, W. 1823. Summary report for New Caledonia 1822-23. Hudson's Bay Company Archives, B188/e/1.

Buirs, M. 2002. Personal communication. LIM, Morice Forest District.

Burns, D.C. 1991. Cumulative effects of small modifications to habitat: AFS Position Statement. Fisheries **16** (1): 12-17.

Busack, C.A. and K.P. Currens. 1995. Genetic risks and hazards in hatchery operations: fundamental concepts and issues. Am. Fish. Soc. Symp. **15**: 71-80.

Bustard, D. 1975. Proposed Smithers tree farm license, preliminary resource presentation – Fish and wildlife values. Ministry of Environment, Smithers, BC.

Bustard, D.R. 1983. Juvenile salmonid winter ecology in a northern British Columbia river – a new perspective. Smithers, BC.

Bustard, D. 1984. Preliminary evaluation of fish utilization of Kasiks Channel and adjacent Skeena River sidechannels. Smithers, BC.

Bustard, D. 1986. Assessment of stream protection practices in the interior of the Prince Rupert Forest Region, Smithers, BC.

Bustard, D. 1987. Babine Lake creel survey 1985–1986. Smithers, BC.

Bustard, D. 1989. Assessment of rainbow trout recruitment from streams tributary to Babine Lake. Smithers, BC.

Bustard, D. 1990. Sutherland River rainbow trout radio telemetry studies 1989. Prepared by Dave Bustard and Associates for, BC Min. of Environment.

Bustard, D. 1991. Lower Skeena River fisheries studies Exchamsiks River to Andesite Creek. Smithers, BC.

Bustard D.R. 1992. Juvenile steelhead surveys in the Kitwanga, Morice, Sustut, and Zymoetz Rivers, 1991. Smithers, BC.

Bustard, D. 1993a. Lower Skeena River 1992 fisheries studies Exchamsiks to Andesite. Smithers, BC.

Bustard D.R. 1993b. Juvenile steelhead surveys in the Kitwanga, Morice, Sustut, and Zymoetz Rivers, 1992. Smithers, BC.

Bustard, D. 1993c. Fisheries assessment of bridge crossing sites in the upper Bear River.

Bustard, D. 1997 Assessment of juvenile coho populations in selected streams within the Skeena Watershed 1997. Smithers, BC.

Bustard, D. 2002. Personal communication. Smithers, BC.

Campton, D.H. 1995. Genetic effects on hatchery fish on wild populations of Pacific salmon and steelhead: What do we really know? Am. Fish. Soc. Symp. **15**: 353-377.

Carlander, K.D. 1969. Handbook of freshwater fishery biology. Vol. 1. Iowa State University Press, Iowa.

Carver, D. 2000. Using Indicators to assess hydrologic risk. *In* Watershed assessment in the Southern Interior of British Columbia: workshop proceedings. Ministry of Forests Research Program. Victoria, BC.

Chamberlin, T.W., R.D. Harr, and F.H. Everest. 1991. Timber harvesting, silviculture, and watershed processes. *In* W.R. Meehan [ed.] Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19. Am. Fish. Soc., Bethseda, Maryland.

Charles, A.T., and M.A. Henderson. 1985. Chum salmon (*Oncorhynchus keta*) stock reconstructions for 1970-1982 Part 1: Queen Charlotte Islands, North Coast and Central Coast, British Columbia. Department of Fisheries and Oceans, Can. Manuscript Rpt. of Fish. Aquat Sci. No. 1814. 91p.

Chilcote, M.W. 2002. The adverse reproductive consequences of supplementing natural steelhead populations in Oregon with hatchery fish. Can. J. Fish. Aquat. Sci. in press.

Chudyk, W.E. 1972a. Bear River report. On file at MELP, Smithers, BC.

Chudyk, W.E. 1972b. Memo to file. Skeena Lake and stream management files. MELP. Smithers, BC.

Chudyk, W.E. 1974. Ecstall River report. On file at MELP, Smithers, BC.

Chudyk, W.E. and M.R. Whately. 1980. Zymoetz and Clore River steelhead trout. Skeena Fisheries Report SK79-3. BC Fish and Wildlife Branch, Smithers, BC.

Church, M., R. Kellerhals, and T.J. Day. 1989. Regional clastic sediment yield in British Columbia. Can. J. Earth Sci. **26**, 31-45.

Clague, J.J. 1978. Terrain Hazards in the Skeena and Kitimat River basins, British Columbia. Geological Survey of Canada, Paper 78-1A. Vancouver, BC.

Clague, J.J. and S.R. Hiscock. 1976. Sand and gravel resources of Kitimat, Terrace, and Prince Rupert, British Columbia. Geological Survey of Canada, Paper 76-1A. Vancouver, BC.

Clague, J. 1984. Quaternary geology and geomorphology, Smithers-Terrace-Prince Rupert area, British Columbia, Memoir 413, Geological Survey of Canada.

Cleugh, T.R. and B.C. Lawley. 1979. The limnology of Morice Lake relative to the proposed Kemano II power development. Volume 4. Fisheries and Marine Service, Department of the Environment. Vancouver, BC.

Cleugh, T.R., C.C. Graham, and R.A. McIndoe. 1978. Chemical, biological and physical characteristics of Lakelse Lake, BC. Fish. Mar. Ser. Man. Rep. 1472. Dept. of Fisheries and Environment, Vancouver, BC.

Cleveland, M.C. 2000. Limnology of Kitwanga Lake: an attempt to identify limiting factors affecting sockeye salmon (*Oncorhynchus nerka*) production. Gitanyow Fisheries Authority. Kitwanga, B.C.

Cleveland, M.C. 2001. Kitwanga salmon enhancement program 2000/01. Unpubl. report by Gitanyow Fisheries Authority for Habitat Restoration and Salmon Enhancement Program. Fisheries and Oceans Canada.

Cleveland, M. 2002a. Personnel communication. Gitanyow Fisheries Authority. Gitanyow, BC.

Cleveland, M.C. 2002b. Kitwanga River fisheries treaty related measure #3: the 2001 adult steelhead/sockeye salmon enumeration and data gathering initiatives. Gitanyow Fisheries Authority. Kitwanga, B.C.

Cox-Rodgers, S. 1985. Racial analysis of Skeena River steelhead trout by scale pattern analysis. M.Sc. thesis. University of British Columbia. 138 p.

Cox-Rodgers, S. 2000. Skeena sockeye and Nanika sockeye production trends. Memorandum. DFO. Prince Rupert, BC.

Cox-Rodgers, S. 2001. Sockeye presentation at 2001 Post-Season Review, North Coast areas 1-6. Prince Rupert, BC.

Culp, C. 2002. Personal communication. Deep Creek Hatchery Manager, Terrace.

Culp, J. 2002. Personal communication. Terrace Salmon Enhancement Society, Terrace.

Dams, R. and D. Bustard. 1996. Lower Skeena tributaries adult coho surveys and GSI sampling 1995.

Davis, J.C. and I.G. Shand. 1976. Acute and sublethal copper sensitivity, growth and saltwater survival in young Babine Lake sockeye salmon. Fish Marine Ser. Tech. Rep. 847, 55p.

Dawson, G.M. 1881. Report of an exploration from Port Simpson on the Pacific Coast, to Edmonton on the Saskatchewan River, 1879. Dawson Brothers, Montreal.

DeGisi, J. 1997a. Gitnadoix River Provincial Recreation Area – Fisheries information summary. Prepared for BC Parks Skeena District, Smithers, BC.

DeGisi, J. 1997b. Swan Lake Provincial Park – Fisheries information summary. Prepared for BC Parks Skeena District, Smithers, BC.

DeGisi, J.S. 2000. Babine River Corridor Provincial Park - Fisheries information summary. Prepared for BC Parks Skeena District, Smithers, BC.

deLeeuw, A.D. 1991. Observations on cutthroat trout of the Lakelse River system, 1986, and implications for management. Skeena Fisheries Report #SK-79. BC Environment, Fish and Wildlife Branch, Smithers, B.C.

deLeeuw, A.D., Cadden, D.J., Ableson, D.H., Hatlevik, S. 1991. Lake trout management strategies for northern British Columbia, BC Environmnt, Fisheries Branch.

Department of Fisheries of Canada. 1964. Fisheries problems associated with the development of logging plans within the Morice River drainage system. Vancouver, B.C.

Derrick, M. 1978. Adaawhl Gitanyaaw. Gitanyow history project. Gitanyow, BC.

DFO. 1930–1960. Department of Marine and Fisheries, Annual Narrative Reports, Babine-Morice Area, District #2, BC.

DFO. 1985. Pacific region salmon resource management plan. Vol. 1, Technical report.

DFO. 1991a. Fish habitat inventory and information program. Stream Summary Catalogue. Subdistrict 4C Hazelton. Department of Fisheries and Oceans, Vancouver, BC.

DFO. 1991b. Fish habitat inventory and information program. Stream Summary Catalogue Subdistrict 4D, Upper Skeena-Babine. North Coast Division, Department of Fisheries and Oceans.

DFO. 1991c. Fish habitat inventory and information program SISS Stream Summary Catalogue. Subdistrict 4B Terrace. Department of Fisheries and Oceans, Vancouver, B.C.

DFO. 1991d. Fish habitat inventory and information program SISS Stream Summary Catalogue. Subdistrict 4A Lower Skeena. Department of Fisheries and Oceans, Vancouver, BC.

DFO. 1999. Stock status of Skeena River coho salmon. DFO Science Stock Status Report D6-02 (1999).

DFO. 2000. 1999 Pacific region state of the ocean.

DFO. 2001. SEDS. (Salmon escapement data system) Pacific Biological Station, Nanaimo, BC.

DFO. 2001b. 2000 Pacific region state of the ocean. DFO science ocean status report 2001-01.

Dombroski, E. 1952. Sockeye smolts from Babine Lake in 1951. Pac. Prog. Rep. 91: 21-26.

Dombroski, E. 1954. The sizes of Babine Lake sockeye salmon smolt emigrants, 1950-1953. Pac. Prog. Rep. 99: 30-34.

Donas, B. 2000. Personal communication. DFO Community Advisor, Smithers, BC.

Donas, B. 2002. Personal communication. DFO Community Advisor, Smithers, BC.

Drewes, M. 2002. Personal communication. DFO Community Advisor. Terrace, BC.

Dyson, J.B. 1955. The Babine rock and earth slide. Thesis. UBC, Vancouver, BC.

Ellis, D.W. 1996. Net Loss: The Salmon Netcage Industry in British Columbia. David Suzuki Foundation. Vancouver, B.C.

Envirocon Ltd. 1980. Kemano completion hydroelectric development environmental impact assessment. Volume 4: Fish Resource Studies, Morice System. MELP, Smithers.

Envirocon Ltd. 1984. Fish resources of the Morice River system: baseline information. *In* Environmental studies associated with the proposed Kemano Completion Hydroelectric Development. Vancouver, BC.

Environment Canada. no date. Temperatures and precipitation 1941-1970 British Columbia. Atmospheric Environment Services. Downsview, Ont.

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

Environment Canada. 1991. Historical streamflow summary British Columbia to 1987. Inland Waters Directorate, Water Resources Branch, Water Survey of Canada. Ottawa, Ont.

Environment Canada. 1993. Canadian Climate Normals 1961-1990, Vol. 1. British Columbia. Environment Canada, Ottawa.

Ethier, D. 2002. Personal communication. Prospector. Hazelton, BC.

Evans, S.G. 1982. Landslides and surficial deposits in urban areas of British Columbia: A Review. Can. Geotech. J. 19: 269-87

Farina, J.B. 1982. A study of salmon migrating and spawning in the Nechako River system and Morice and Nanika Rivers. Alcan Smelters and Chemicals Limited. Kitimat, BC.

Finnegan, B. 2002. Personal communication. DFO, Stock Assessment Division. PBS, Nanaimo, BC.

FISS. 2001. Fisheries Data Warehouse, web site.

FOC. 1984. Towards a fish habitat decision on the Kemano Completion Project: A discussion paper. Fisheries and Oceans. Vancouver, BC.

FOC & MoE 1984 Salmonid Enhancement Program. Annual Report 1984. Fisheries and Oceans Canada and Ministry of Environment, Province of BC.

Foote, C.J., C.C. Wood, and R.E. Withler. 1989. Biochemical comparison of sockeye salmon and kokanee, the anadromous forms of Oncorhynchus nerka. Can. J. Fish. Aquat. Sci. **46**: 149-158.

Foerster, R.E. 1968. The sockeye salmon, *Oncorhynchus nerka*. Bull. Fish. Res. Board Can. 162:422p.

Foskett, D.R. 1948. Bear Lake. Appendix 5 Lakes of the Skeena River drainage. Skeena River salmon investigations interim report. Fisheries Research Board, Nanaimo, BC.

Franklin, I.R 1980. Evolutionary change in small populations. *In* Soule M.E. and B.A. Wilcox *Eds*. Conservation Biology: an evolutionary-ecological perspective. Sinauer. pp. 135-150.

FRB. 1947. Annual reports of the Pacific Biological Station 1945–1948. Fisheries Research Board of Canada. Nanaimo, BC.

FRB. 1948. Fisheries Research Board Pac. Prog. Rep. No. 74: 1948. Pacific Biological Station, Nanaimo, BC.

Gartner Lee. 1993. Leachate assessment field manual and preliminary landfill leachate assessment reports. Report prepared for Skeena Region MELP, Smithers, BC.

Geertsema, M. and J.W. Schwab. 1995. The Mink Creek earthflow, Terrace, British Columbia. Proc. 48th Can. Geotech. Conf. Pp. 625-633.

Giesbrecht, S., G. Grieve and M. Prins. 1998. Level 1 detailed assessment of fish and fish habitat in the south Kitwanga River and its tributaries. Biolith Scientific Consultants Inc. Terrace, BC.

Gilchrist, A. 2001. Clear Creek in the Kitsumkalum Watershed: stream channel stability assessment. Prepared for Kitsumkalum Band Council and DFO.

Ginetz, R.M.J. 1976. Chinook salmon in the North Coastal Division. Tech. Rept. Ser. No. PAC/T-76-12. Fish. Mar. Serv., Dept. Env., Vancouver, BC.

Giroux, P.A. 2002. Shelagyote River Bull Trout (*Salvelinus confluentus*) Life History. BC Min. of Water, Land and Air Protection, Fish and Wildlife Science and Allocation Section, Smithers, BC.

Godin, B., M. Ross and M. Jones. 1985. Babine Lake data from chemical and biological surveys May 1983, May 1984, July 1984. Environmental Protection Service Canada, Pacific Yukon Region.

Godin, B., M. Hagen and G. Mitchell. 1992. Babine Lake monitoring June 19-22, 1990. Environmental Protection Service Canada, Pacific Yukon Region.

Godfrey, H., W.R. Hourston, J.W. Stokes, and F.C. Withler. 1954. Effects of a rock slide on Babine River salmon. Fisheries Research Board of Canada. Bulletin No. 101. Ottawa, Ont.

Godfrey, H. 1955. On the ecology of Skeena River whitefishes, *Coregonus* and *Prosopium.* J. Fish. Bd. Canada, **12** (4), 1955.

Godfrey, H. 1968. Ages and physical characteristics of maturing chinook salmon of the Nass, Skeena and Fraser Rivers in 1964, 1965, and 1966. Fish. Res. Bd. of Canada, Man. Rep. No. 967.

Gordon, D., A. Lorenz, and M. Friesen. 1996. Lakelse WRP Project, Level 1 fisheries assessment. Terrace, BC.

Gottesfeld, A. 1985. Geology of the northwest mainland. Kitimat Centennial Museum Assoc. Kitimat, BC. 114 p.

Gottesfeld, A.S. 1996. British Columbia flood scars: maximum flood-stage indicators. Geomorphology **14** 319-325.

Gottesfeld, A.S. 2001. 2000 Kitwanga River creel survey. Gitxsan Watershed Authorities, Hazelton, B.C.

Gottesfeld, A.S. and L.M.J. Gottesfeld. 1990. Floodplain dynamics of a wandering river, dendrochronology of the Morice River, British Columbia, Canada. Geomorphology, **3**: 159-179.

Gottesfeld, A., C. Muldon, E. Plate, and R. Harris. 2000. Steelhead habitat utilization and juvenile density in streams of the Kispiox Watershed 1998-99. Gitxsan and Wet'suwet'en Watershed Authorities. Unpublished report. Hazelton, BC.

Graham, C.C. and W. Masse. 1975. Presentation to Environment and Land Use Secretariat for Terrace-Hazelton forest resource study. Dept. of Environment, Fisheries and Marine Branch, Prince Rupert, BC.

Grieve, G. 1996. Level 1 assessment of fish and stream habitat for the Kitsumkalum River east and the Cedar River and Clear Creek Watersheds. Terrace, BC.

Grieve, G.D. and D. Webb. 1997. Lakelse River steelhead: summary of current data and status review, 1997. Skeena Fisheries Report SK-105. MELP, Skeena Region. Smithers, BC.

Grieve, G.D. and D. Webb. 1999a. Kitsumkalum River steelhead: summary of current data and status review, 1997. Skeena Fisheries Report SK-106. MELP, Skeena Region. Smithers, BC.

Grieve, G.D. and D. Webb. 1999b. Kitwanga River steelhead: summary of current data and status review. Skeena Fisheries Report SK-101. MELP, Skeena Region. Smithers, BC.

Griffiths, J.S. 1968. Growth and feeding of the rainbow trout *Salmo gairdneri* and the lake trout *Salvelinus namaycush* from Babine Lake, British Columbia. University of Victoria, B.C.

GWA. 2000. 1999 Kispiox Watershed coho stock assessment. Gitxsan Watershed Authorities. Unpublished report. Hazelton, BC.

GWA. 2001. 2000 Kispiox Watershed coho stock assessment. Gitxsan Watershed Authorities. Unpublished report. Hazelton, BC.

Haas, G.R 1998. Indigenous fish species potentially at risk in BC, with recommendations and prioritizations for conservation, forestry/resource use, inventory, and research. Ministry of fisheries management Report No. 105.

Hackler, J.C. 1958. Factors leading to social disorganization among the Carrier Indians at Lake Babine. M.A. Thesis. San Jose State College, Ca.

Hall, P.E., and A.S. Gottesfeld. 2002. Kitwanga River-mouth creel survey. Gitxsan Watershed Authorities, Hazelton, B.C.

Hallam, R. 1975. A brief of EPS water quality monitoring and surveillance activities on Babine Lake, 1974-1975.

Halpin, M. and M. Sequin. 1990. Tsimshian Peoples. *In* Handbook of North American Indians: Northwest Coast. Volume **7**. Smithsonian Institution, Washington, DC.

Halupka, K.C., M.D. Bryant, M.F. Wilson, F.H. Everest. 2000. Biological characteristics and population status of anadromous salmon in southeast Alaska. Gen. Tech. Rep. PNW-GTR-468. Portland, or: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. 255 p.

Hancock, M.J., A.J. Leaney-East and D.E. Marshall. 1983. Catalogue of salmon streams and spawning escapements of Statistical Area 4 (Lower Skeena River) including coastal streams. Can. Data. Rep. Fish. Aquat. Sci. **395**: xxi + 422p.

Hankin, D.G. and M.C. Healey. 1986. Dependence of exploitation rates for maximum yield and stock collapse on age and sex structure of chinook salmon (*Oncorhynchus tshawytscha*) stocks. Can. J. Fish. Aquat. Sci. **43**:1746-1759.

Harris, E.A. 1990. Spokeshute: Skeena River memory. Orca, Victoria, BC.

Harrison, C. 2002. Personal communication. DFO, Fulton River Project.

Hart, J.L. 1973. Pacific fishes of Canada. Bulletin 180, Fisheries Research Board of Canada. Ottawa, Ontario.

Håstein, T and T. Lindstad. 1991. Diseases in wild and cultured salmon: possible interaction. Aquaculture, 98: 277-288.

Hastings, N., A. Plouffe, L.C. Struik, R.J.W. Turner, R.G. Anderson, J.J. Clague, S.P. Williams, R. Kung, and G. Tacogna. 1999. Geoscape Fort Fraser, British Columbia; Geological survey of Canada, Miscellaneous Report 66, 1 sheet.

Hatfield Consultants. 1989. Babine Lake near Bell Mine: water/sediment quality and benthic macroinvertebrate communities. Prepared for Noranda Minerals Inc.

Hatlevik, S.J., K. Diemert, and M.R. Whately. 1981. A creel survey of the Lakelse Lake cutthroat trout sport fishery, June-August, 1979. BC Min. of Environment, Fisheries Branch, Smithers, BC. SK Report # 28.

Hatlevik, S.J. 1999. Lake classification in the Fort St. James Forest District. MELP, Smithers, BC.

Healey, M.C. 1980. The ecology of juvenile salmon in Georgia Strait, British Columbia, *In* McNeil, W.J. and D.C. Himsworth. *Eds.* Salmonid ecosystems of the north Pacific. Corvallis Oregon, Oregon State University Press: 203-229.

Healey, M.C. 1991. Life history of chinook salmon *(Oncorhynchus tshawytscha). In* Groot C. and L. Margolis *Eds.* Pacific salmon life histories. UBC Press Vancouver, Canada. 311-394.

Heard, W.R. 1991. Life history of pink salmon *(Oncorhynchus gorbuscha). In* Groot C. and L. Margolis *Eds.* Pacific salmon life histories. UBC Press, Vancouver, Canada. 119-230.

Heath, D.D., S. Pollard and C. Herbinger. 2001. Genetic structure and relationships among steelhead trout (*Oncorhynchus mykiss*) populations in British Columbia. Heredity **96** 618-627.

Heath, D.D., C. Busch, J. Kelly, and D.Y. Atagi. 2002 Temporal change in genetic structure and effective population size in steelhead trout (*Oncorhynchus mykiss)*. Molecular Ecology **11**(2), 197-214.

Heenan, G. 2002. Gord Heenan, Personal communication. BC Hydro. Terrace, BC.

Helgerson, H. 1906. Thirty-Eighth Annual Report, 1906, Department of Marine and Fisheries. Ottawa, Ont.

Higgins, M.J. and G. Munby. 2000. Pre-spawning mortality in sockeye salmon associated with gill parasites in the Babine Lake systems – 1999 observations. Unpublished report, Pacific Biological Station.

Higgins M.J. 2001. Pre-spawning mortality in sockeye salmon associated with gill parasites in the Babine Lake systems during the 2000 spawning season. Unpublished Report, Pacific Biological Station.

Higgins, M.J. 2002. Personal communication. Pacific Biological Station.

Hilborn, R. 1992. Hatcheries and the future of salmon in the Northwest. Fisheries, Vol. **17** (1): 5-8.

Hobenshield, E. 2002. Personal communication. Kitwanga, BC.

Hogan, D.L. and J.W. Schwab. 1989. Floodplain and channel stability of the lower Skeena River. Unpublished report. Ministry of Forests, Smithers, BC.

Holland, S.S. 1976. Landforms of British Columbia. Bulletin 48. Queen's Printer, Victoria, BC.

Hols, G. 1999. Marks of a century. A history of Houston, B.C. 1900-2000. Houston, BC.

Holtby, B., B. Finnegan, D. Chen, and D. Peacock. 1999. Biological assessment of Skeena River coho salmon. Canadian Stock Assessment Secretariat Research Document 99/140.

Holtby, L.B., R. Kadowacki and L. Jantz. 1994. Update of stock status information for early run Skeena River coho salmon (through the 1993 return year). PSARC Working Paper S94-4: 44p.

Horn, H. 2001. Inventory assessment of the Morice LRMP area.

Horrall, R.M. 1981. Behavioral stock-isolating mechanisms in Great Lakes fishes with special reference to homing and site imprinting. Can. J. Fish. Aquat. Sci. **38**: 1481-1496.

Hutchison, W. W., H.C. Berg and A. V. Oukulitch (compilers) 1979. Geology – Skeena River, British Columbia – Alaska, Geological Survey of Canada Map 1385A. Ottawa Ontario.

Imbleau, L.G.J. 1978. A creel survey of the Lakelse River cutthroat trout sport fishery. BC Min. of Environment, Fisheries Branch, Smithers, BC. SK Report # 16.

Inglis, R., and G. MacDonald. 1979. Skeena River prehistory. Archaeological Survey of Canada. Mercury Series, No. 87. Ottawa, Ont.

Interfor. 2001. A16841 Scotia River 2001-2005 Forest Development Plan. Terrace, BC.

Irvine, J.R., and N.T. Johnston. 1992. Coho salmon (*Oncorhynchus kisutch*) use of lakes and streams in the Keogh River drainage, British Columbia. Northwest Science 66(1): 15-25.

Jacobs, M. and T. Jones. 1999. Kitwanga River salmon recovery initiative 1998.

Jakubowski, M. 2002. Personal communication. DFO, North Coast Stock Assessment. Prince Rupert, BC.

Jantz, L., B. Rosenburger and S. Hildebrandt. 1989. Salmon escapement and timing data for Statistical Area 4 of the North Coast of British Columbia. Unpublished MS, DFO, Prince Rupert, BC.

Jenness, D. 1937. The Sekani Indians of British Columbia. National Museum of Canada. Bulletin No. 84. Ottawa, Ont.

Jenness, D. 1943. The Carrier Indians of the Bulkley River: Their social and religious life. Anthropological Papers, No. 25. Smithsonian Institution, Washington, D.C.

Johnsen, B.O., and A.J. Jensen 1994. The spread of furunculosis in salmonids in Norwegian rivers. Journal of Fish Biology. **45**: 47-55.

Johnson, W.E. 1956. On the distribution of young sockeye salmon (*Oncorhynchus nerka*) in Babine and Nilkitkwa Lakes, BC. J. Fish. Res. Board Can. **13**: 695-708.

Johnson, W.E. 1958. Density and distribution of young sockeye salmon (*Oncorhynchus nerka*) throughout a multibasin lake system. J. Fish. Res. Board Ca. **15**: 961-982.

Johnson, W.E. 1961. Aspects of the ecology of a pelagic, zooplankton eating fish. Verh. Internat. Verein. Limnol. **14**: 727-731.

Johnson, W.E. 1964. Quantitative aspects of the pelagic, entomostracan zooplankton of a multibasin lake system over a 6-year period. Verh. Internat. Verein. Limnol. **15**: 727-734.

Johnson, W.E. 1976. The morphometry of Alastair Lake. Manuscript Report Series, No. 819, Fisheries Research Board of Canada. PBS, Nanaimo, BC.

Joseph, Walter. 2001. Personal communication. Wet'suwet'en Fisheries, Moricetown, BC.

Jyrkkanen, J., G. Wadley, D. Vegh, R. Collier, T. Lattie, G. Wilson, L. Petersen, and C. Hillis. 1995. Kispiox Watershed restoration program project level 1 final report: The impact of logging on the Kispiox watershed and recommendations for level II restoration works.

Jyrkkanen, J. 1996. Interfor North Coast chart watershed restoration project, level 1. Terrace, BC.

Kerby, N. 1984. Greater Terrace official settlement plan: Background studies and planning recommendations. Prepared for Kitimat-Stikine Regional District. Terrace, BC.

Kerby, N. 1997. Kispiox land use study, background report. Prepared for Kitimat-Stikine Regional District. Terrace, BC.

Kingston, D. 2002. Kitwanga River fisheries treaty related measure #1: coho escapement and habitat relocation/expansion; habitat studies and creel surveys. Gitanyow Fisheries Authority. Kitwanga, B.C.

Kobrinsky, V. 1977. Ethnohistory and ceremonial representation of Carrier social structure. PhD Thesis. UBC. Vancouver, BC.

Kofoed, G. 2001. Personal communication. Retired Fishery Officer, Terrace, BC.

Kofoed, G. 2002. Personal communication. Retired Fishery Officer, Terrace, BC.

Kondzela, C.M., C.M. Guthrie, S.L. Hawkins. 1994. Genetic relationships among chum salmon populations in southeast Alaska and northern British Columbia. Can. J. Fish. Aquat. Sci. **51**(supl. 1): 50-64.

Koski, W.R., Alexander, R.F., and K.K. English. 1995. Distribution, timing, fate and number of coho salmon and steelhead returning to the Skeena Watershed in 1994. Report by LGL Limited, Sidney, BC. for Fisheries Branch, British Columbia Ministry of Environment, Lands, and Parks. Victoria, BC.

Kussat, R. and K. Peterson. 1972. An assessment of the effects on the Morice and Bulkley River systems of a pulp mill at Houston, B.C. Fisheries Service, Dept. of Environment. Northern Operations Branch, Prince Rupert, BC.

Kussat, R. 1973. Upper Skeena counting fences: Bear, Sustut and Johanson Rivers. DFO internal report. Prince Rupert, BC.

Large, R.G. 1996. The Skeena, river of destiny. Heritage House, Surrey, BC.

Larkin, P.A., and J.G. McDonald. 1968. Factors in the population biology of the sockeye of the sockeye salmon of the Skeena River. J. Anim. Ecol. **37** p. 229-258.

Levy, D.A. and K.J. Hall. 1985. A review of the limnology and sockeye salmon ecology of Babine Lake. Westwater Research Center, University if British Columbia. Westwater Tech. Rep. No. 27. Vancouver, BC.

Lewynsky, V.A. and W.R. Olmstead. 1990. Angler use and catch surveys of the lower Skeena, Zymoetz (Copper), Kispiox, and Bulkley River steelhead fisheries, 1989. ESL Environmental Sciences Limited. Vancouver, BC.

Lewis, A. 2000. Skeena steelhead and salmon: a report to stakeholders. Steelhead Society of British Columbia, Bulkley Valley Branch. Smithers, BC.

Lewis, A.F.J. and S. Buchanan. 1998. Zymoetz River steelhead: Summary of current data and status review, 1997. Skeena Fisheries Report SK-102. MELP, Skeena Region. Smithers, BC.

Liepens, S. 2002. Personal communication, MWALP, Prince Rupert, BC.

Liknes, G.A. and P.J. Graham. 1988. Westslope cutthroat trout in Montana: life history, status, and management. Amer. Fish Soc. Symp. **4**: 53-60.

Lindsey, C.C. and W.G. Franzin. 1972. New complexities in zoogeography and taxonomy of *P. coulteri* (*Prosopium coulteri*). J. Fish. Res. Board of Can. **29**(12): 1772-1775.

Loedel, M. and P. Beaudry. 1993. A study of forest interception at the Date Creek silvicultural systems project. Ministry of Forests, Forest Sciences. Smithers, BC.

Lord, C.S. 1948. McConnell Creek map-area, Cassiar District, British Columbia. Geological Survey of Canada, Memoir 251. Ottawa, Ont.

Lough, M.J. 1980. Radio telemetry studies of summer run steelhead trout in the Skeena River drainage, 1979, with particular reference to Morice, Suskwa, Kispiox, and Zymoetz River stocks. Skeena Fisheries Report SK-29. MELP, Skeena Region. Smithers, BC.

Lough, M.J. 1981. Commercial interceptions of steelhead trout in the Skeena River-radio telemetry studies of stock identification and rates of migration. Skeena Fisheries Report SK-32. MELP, Skeena Region. Smithers, BC.

Lough, M.J. 1983. Radio telemetry studies of summer run steelhead trout in the Cranberry, Kispiox, Kitwanga, and Zymoetz Rivers and Toboggan Creek, 1980. Skeena Fisheries Report SK-33. MELP, Skeena Region. Smithers, BC.

Lough, M.J. and M.R. Whately. 1984. A preliminary investigation of Kitsumkalum River steelhead trout, 1980-81. Skeena Fisheries Report SK-81. MELP, Skeena Region. Smithers, BC.

Loughran, L., L.P. Elworthy, and R. Frith. 1974. Kispiox valley resource study. Regional District of Kitimat-Stikine. Terrace, BC.

Maclean, D.B. 1983. Aldrich Lake: a data report on water quality and biological data from the receiving waters of the area around the abandoned Duthie Mine. MELP Waste Management Branch Skeena Region Rep. 83.05. Smithers B.C.

Maniwa, T., D Leach, and P. Hall, 2001. Tchesinkut Lake Creel Survey, 2000-2001. BC Min. of Water Land and Air Protection, Fisheries Branch, Skeena Region Smithers, BC. SK Report # 131.

Maloney, D. 1995. 1995 survey of TSS concentrations in headwater streams of the Nilkitkwa and Nichyeskwa Watersheds. Forest Sciences Section, Prince Rupert Forest Region, BC Ministry of Forests, Smithers, BC.

Martin, N.V. and C.H. Oliver. 1980. The lake char, *Salvelinus namaycush*, *In* E.K. Balon [ed.] Chars: Salmonid fishes of the genus *Salvelinus*. Dr. W. Junk Publishing, The Hague, Netherlands.

Maxwell, I. 2002. Personal communication. Lakelse Community Association.

McCart, P.J. 1965. Growth and morphometry of four British Columbia populations of pygmy whitefish (*Prosopium coulteri*) J. Fish. Bd. Canada **22**(5): 1229-1255.

McCart, P.J. 1970. Evidence for the existence of sibling species of pygmy whitefish (*Prosopium coulteri*) in three Alaskan lakes. *In* C.C. Lindsey and C.S. Woods [ed.] Biology of Coregonid Fishes. University of Manitoba Press. Winnipeg, Man.

McCarthy, M., M. Cleveland and D. Kingston. 2002. The 2001 Kitwanga River chinook salmon enumeration initiative. Gitanyow Fisheries Authority. Kitwanga, B.C.

McDonald, J., and J.M. Hume. 1984. The Babine Lake sockeye salmon enhancement program: Testing some major assumptions. Can. J. Fish. Aquat. Sci. **40**: 70-92.

McElhanney Consulting Services Ltd. 2001. Watershed restoration plan Kitwanga River Watershed.

McKean, C.J.P. 1986. Lakelse Lake: water quality assessment and objectives. Water Management Branch, MELP, Victoria, BC.

McKinnell, S. and D. Rutherford. 1994. Some sockeye salmon are reported to spawn outside the Babine Lake Watershed in the Skeena drainage. PSARC Working Paper S94-11. 52p.

McKinnell, S. and A.J. Thomson 1997. Recent events concerning Atlantic salmon escapees in the Pacific. ICES Journal of Marine Science. **54** 1221-1225.

McNicol, R.E. 1999. An assessment of Kitsumkalum River summer chinook, a North Coast indicator stock. CSAS Res. Doc. 99/164. Fisheries and Oceans Canada. Ottawa, Ont.

McPhail, J.D. and C.C. Lindsey 1970. Freshwater fishes of northwestern Canada and Alaska. Fish. Res. Board Ca. Bull. **173**: 381.

McPhail, J.D. and C.B. Murray. 1979. The early life history and ecology of Dolly Varden (*Salvelinus malma*) in the upper Arrow Lakes. University of British Columbia, Van., BC.

McPhail, J.D. and R. Carveth. 1993a. Field keys to the freshwater fishes of British Columbia. Aquatic Inventory task force of the Resources Inventory Committee. B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. Canada.

McPhail, J.D. and R. Carveth. 1993b. A foundation for conservation: The nature and origin of the freshwater fauna of British Columbia. Queens Printer for B.C., Victoria, B.C. Canada.

Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. BC Ministry of Forests, Special Report, Series 6. Victoria, BC.

MELP. 1997. Draft angling use plan – Babine River. Ministry of Environment, Lands and Parks. Smithers, BC.

MELP. 2000. BC Freshwater fishing regulations synopsis. MELP, Victoria, BC.

Miles, M. 1990. Assessment of fluvial hazards; Zymoetz River section, Smithers to Terrace gas pipeline route. Prepared for: Pacific Northern Gas, Vancouver, BC.

Miles, M. 1991. Linear developments: Innovative techniques for sediment control and fisheries habitat recreation. *In* Yuzyk, T. and B. Tassone, Eds. Proceedings of the BC-Yukon sediment issues workshop. April 24-26, 1990 Vancouver, BC Water Resources Branch, Pacific and Yukon Region, Environment Canada, Vancouver, BC.

Ministry of Water, Lands and Air Protection. 1991. Steelhead Harvest Analysis. Database maintained by the Fish and Wildlife Branch of the British Columbia Ministry of Water, Lands and Air Protection.

Ministry of Environment. 1979. Assessment of the impact of the Kemano II proposal on the fish and wildlife resources of the Nanika – Morice systems. Victoria, BC.

Ministry of Forests. 1988. Swan Lake/Brown Bear Lake wilderness designation process: Wilderness management options report. Kispiox Forest District & Regional Recreation Section, Prince Rupert Forest Region, Ministry of Forests, Smithers, BC.

Ministry of Forests. 2000. Access management direction for the Babine Watershed – Kispiox Forest District. Hazelton, BC.

Ministry of Forests. 2001a. Kispiox land and resource management plan – Amended.

Ministry of Forests. 2001b. Skeena-Bulkley Region resource management plan. Smithers, BC.

Ministry of Lands, Parks and Housing. 1984. Kispiox Valley crown land plan. Smithers, BC.

MoE. Various dates and authors. Skeena River lake and stream management files. BC Ministry of Environment. Smithers, BC.

MoE. 1979. Aquatic biophysical maps (93M/5, 103P/9, 15). Resource Analysis Branch, Ministry of Environment. Victoria, BC.

MoF. 2001. Kalum land and resource management plan. Ministry of Forests, April 2001, Terrace, BC.

Mitchell, S. 2001. A Petersen capture-recapture estimate of the steelhead population of the Bulkley/Morice River systems upstream of Moricetown Canyon during autumn 2000, including synthesis with 1998 and 1999 results. Report to Steelhead Society of British Columbia, Bulkley Valley Branch. 45 pp.

Moore, D. 1993. Babine River - Slide hazard assessment. BCHIL, Vancouver, BC.

Morgan, J.D. 1985. Biophysical reconnaissance of the Kitsumkalum River system, 1975-1980. E.V.S. Consultants Ltd. For DFO, 1985.

Morice, A.G. 1978. The History of the Northern Interior of British Columbia. Interior Stationery, Smithers, B.C.

Morrell, M. 1985. The Gitxsan and Wet'suwet'en fishery in the Skeena River system. Gitxsan-Wet'suwet'en Tribal Council, Hazelton, BC.

Morrell, M. 2000. Status of salmon spawning stocks of the Skeena River system. Northwest Institute for Bioregional Research. Smithers, BC.

Mueter, F.J., Peterman, R.M., and Pyper, B.J. 2002. Opposite effects of ocean temperature on survival rates of 120 stocks of Pacific salmon (*Onchorhyncus* spp.) in northern and southern areas. Can. J. Fish. Aquat. Sci. **59**: 456-463.

Nass, B.L., M.G. Foy, and A. Fearon-Wood. 1995. Assessment of juvenile coho salmon habitat in the Skeena River Watershed by interpretation of topographic maps and aerial photographs. LGL Project No. EA#664. Report to DFO pacific Region.

Naziel, W. 1997. Wet'suwet'en traditional use study. Office of the Wet'suwet'en, Moricetown, BC.

Neilson, C. 2002. Personal communication. DFO, Prince Rupert, BC.

Nelson, J.S. 1968. Distribution and nomenclature of North American kokanee, *Oncorhynchus nerka*. J. Fish. Res. Board Can. **25**: 409-414.

Newell, D. 1993. Tangled webs of history: Indians and the law in Canada's Pacific Coast fisheries. University of Toronto Press. Toronto, Ont.

Nijman, R. 1986. Bulkley River basin: water quality assessment and objectives. Water Management Branch, MELP, Victoria, BC.

Nortec Consulting. 1997. Kispiox Watershed restoration project. Contract #CSK2087 CSK2072. Final Report and appendices.

Nortec Consulting. 1998. Morice Watershed restoration project level II: Report-Assessment and survey and design. Smithers, BC.

Northcote, T.G. and G.D. Taylor. 1973. Limnology and fish of the Gitnadoix River-Alastair Lake system in relation to ecological reserve considerations.

Ottens, R. 2002. Personal communication. Ministry of Forest, Kalum WRP.

PFRCC. 2001. Pacific Fisheries Resource Conservation Council. Annual report 2000-2001.

Paish, H. 1975. CN Meziaden project, Mile 0 – 75 environmental impact study. Vol. 1. Thurber Consultants Ltd. Smithers, BC.

Paish, H. & Associates. 1983. A strategic overview of the Skeena and Nass Drainages. Prepared for the Department of Fisheries and Oceans.

Paish, H. & Associates. 1990. Gitnadoix River recreational fisheries assessment. Coquitlam, BC.

Patrick, T. 2001. Personal communication. Bear Lake, B.C.

Peacock, D., B. Spilstead, and B. Snyder, B. 1997. A review of stock assessment information for Skeena River chinook salmon. PSARC Working Paper S96-7.

Peacock, D. 2002. Personal communication. North Coast Stock Assessment, DFO, Prince Rupert.

Pinsent, M.E. 1969. A report regarding the suitability of Owen Creek, BC as a potential site for the construction of artificial spawning facilities for steelhead trout. Fish and Wildlife Branch. Smithers, BC.

Pinsent, M.E. 1970. A report on the steelhead anglers of four Skeena Watershed streams during the fall of 1969. Fish and Wildlife Branch, Smithers, BC.

Pinsent, M.E. and W.E. Chudyk. 1973. An outline of the steelhead of the Skeena River system. BC Fish and Wildlife Branch, Smithers, BC.

Plate, E., C. Muldon, and R. Harris. 1999. Identification of salmonid habitat utilization and stock enumeration in streams of the Kispiox River Watershed, 1998-99. Gitxsan and Wet'suwet'en Watershed Authorities. Hazelton, BC.

Pojar, J., F.C. Nuszdorfer, D. Demarchi, M. Fenger, T. Lea, and B. Fuhr. 1988. Biogeoclimatic and Ecoregion Units of the Prince Rupert Forest Region. Map.

Pollard, B.T. 1996. Level 1 fisheries assessment for the Zymoetz River. R.J.A. Forestry Ltd. Terrace, BC

Powell, L. 1995. Habitat and habitat management in the Skeena Watershed. DFO. Prince Rupert, BC.

Price, D. T., D.W. McKenney, D.W. Caya, and H. Côté. 2001. Transient climate change scenarios for high-resolution assessment of impacts on Canada's forest ecosystems. Report to Climate Change Action Fund and Canadian Institute for Climate Studies.

Pritchard, A.L. 1948. Skeena River salmon investigations interim report. Appendix 3. Fisheries Research Board, Nanaimo, BC.

Psutka, J.F. 1996. Babine River slopes inspection. BCHIL, Vancouver, BC.

Psutka, J.F., and P.A. Rapp. 1996. Babine River slide hazard assessment. BCHIL, Vancouver, BC.

Quinn, T.P. 1993. A review of homing and straying of wild and hatchery-produced salmon. Fisheries Research. **18**, 29-44.

Rabnett, K. 2000. Past into the present. Cultural heritage resources review of the Bulkley TSA. Hazelton, BC.

Rabnett, K. 2001. Selected Wet'suwet'en cultural heritage within portions of Morice landscape unit planning areas. Office of the Wet'suwet'en, Smithers, BC.

Rabnett, K., K. Holland and A. Gottesfeld. 2001. Dispersed traditional fisheries in the upper Skeena Watershed. Gitxsan Watershed Authorities, Hazelton, BC.

Rankin, D.P., and H.J. Ashton. 1980. Crustacean zooplankton abundance and species composition in 13 sockeye salmon (*Oncorhynchus nerka*) nursery lakes in British Columbia. Can Tech. Rep. Fish. Aquatic Sci. 957.

Rankin, L. 1999. Phylogenetic and ecological relationship between giant pygmy whitefish (*Prosopium spp*.) and pygmy whitefish (*Prosopium coulteri*) in north-central British Columbia.

Reese-Hansen, L. 2002. Personal communication. Terrace, B.C.

Regional District of Bulkley-Nechako. 1998. Houston/Topley/Granisle official community plan technical supplement. Burns Lake, BC.

Remington, D.J., J. Wright and L.J. Imbleau. 1974. Steelhead angler-use survey on the Zymoetz, Kispiox, and Bulkley Rivers. Fish and Wildlife Branch, Smithers, BC.

Remington, D. 1996. Review and assessment of water quality in the Skeena River Watershed, British Columbia, 1995. Can. Data Rep. Fish. Aquat. Sci. **1003**: 328 p.

Rescan Environmental Services. 1992. Bell 92 project closure plan support. Document H: Existing environmental conditions of Babine Lake in the vicinity of Bell Mine. Prepared for Noranda Minerals Inc.

Ricker, W.E. 1981. Changes in the average size and average age of Pacific salmon. Can. J. Fish. Aquat. Sci. **38**: 1636-1656.

Riddell, B. and B. Snyder. 1989. Stock assessment of Skeena River chinook salmon. PSARC Working Paper S89-18.

Riley, R.C. and P. Lemieux. 1998. The effects of beaver on juvenile coho salmon habitat in Kispiox River tributaries. Unpublished report for DFO. Smithers, BC.

Rutherford D.T., C.C. Wood, M. Cranny, and B. Spilstead. 1999. Biological characteristics of Skeena River sockeye salmon (*Oncorhynchus nerka*) and their utility for stock compositional analysis of test fishery samples. Can. Tech. Rep. Fish. Aquat. Sci. 2295: 46p.

Rysavy, S. 2000. Calibration of a multimetric benthic invertebrate index of biological integrity for the Kispiox River Watershed. Bio Logic Consulting, Terrace, BC.

Saimoto R. 2002. Personal communication. Smithers Fisheries Biologist.

Saimoto, R.K. 1994. Morice River Watershed assessment 1994: Survey of logging related impacts on Cedric, Lamprey, Fenton, and Owen Creeks. SKR Environmental Consultants, Smithers, BC.

Sandercook, F.K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). *In.* Groot C. and L. Margolis *Eds.* Pacific Salmon Life Histories. UBC Press, Vancouver, Canada. 395-445.

Scarsbrook, J.R. and J. McDonald. 1975. Purse seine catches of sockeye salmon (*Oncorhynchus nerka*) and other species of fish at Babine Lake, British Columbia, 1973. Fish. Res. Board Can. Tech. Rep. 515.

Scarsbrook, J.R., P.L. Millar, J.M. Hume and J. McDonald. 1978. Purse seine catches of sockeye salmon (*Oncorhynchus nerka*) and other species of fish at Babine Lake, British Columbia, 1977. Fish. Res. Board Can. Data Rep. 69.

Schug, S. 2002. Personal communication. Wet'suwet'en Fisheries. Smithers, BC.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Bull. 184.

Sedell, J.R. and F.J. Swanson. 1984. Ecological Characteristics of streams in old-growth forests of the Pacific Northwest. *In* Fish and wildlife relationships in old growth forests. Amer. Inst. Fish. Res. Bio. Morehead, City NC.

Septer, D. and J. W. Schwab. 1995. Ministry of Forests, Research Program. Victoria, BC.

Shepard, B.B., K.L. Pratt, and P.J. Graham. 1984. Life histories of westslope cutthroat and bull trout in the upper Flathead River basin, Montana. EPA Contract No. R008224-01-5.

Shepherd, B.G. 1975. Upper Skeena chinook stocks. Evaluation of the Bear-Sustut, Morice, and Lower Babine stocks. Fisheries and Marine Service, Department of the Environment. Vancouver, BC.

Shepherd, B.G. 1976. Upper Skeena chinook stocks in 1976. Fisheries and Marine Service, Department of the Environment. Vancouver, BC.

Shepherd, B.G. 1978. Minnow traps as a tool for trapping and tagging juvenile chinook and coho salmon in the Skeena River system. In: Proceedings of the 1977 Northeast Pacific Chinook and Coho Salmon Workshop. Fish. and Mar. Ser. Tech. Rep. No. 759.

Shepherd, B.G. 1979. Salmon studies associated with the potential Kemano II hydroelectric development: Volume 5 Salmon studies on Nanika and Morice River and Morice Lake. Dept. of Fish and Environ. Vancouver, BC.

Shirvell, C., and B. Anderson. 1990. Bear River trip report. PBS, Nanaimo, BC.

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. Fish. Aquat. Sci. 2240: 78p.

Shortreed, K.S., K.F. Morton, K. Malange, and J.M.B. Hume. 2001. Factors limiting juvenile sockeye production and enhancement potential for selected B.C. nursery lakes. Canadian Science Advisory Secretariat. DFO, Cultus Lake, BC.

Shortreed, K.S. 2002. Personal communication DFO limnologist.

Sigma Engineering Ltd. 1993. Brown Lake project environmental impact development. Vol. 1. Vancouver, BC.

Simpson, K., L. Hop Wo, and I. Miki. 1981. Fish surveys of 15 sockeye salmon nursery lakes in British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1022: 87 p.

Sinclair, W.F. 1974. The socio-economic importance of maintaining the quality of recreational resources in northern British Columbia: the case of Lakelse Lake. DFO and Kitimat-Stikine Regional District. PAC/T-74-10 NOB/ECON 5-74.

Skeena Watershed Committee. 1996. Facing and forming the Future. Workshop Proceedings. January 19 & 20, 1996. Prince Rupert, BC.

Slaney, T.L., K.D. Hyatt, T.G. Northcote, and R.J. Fielden. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. Fisheries **21**(10) 20-35.

Small, M.P., R.E. Withler, and T.D. Beacham. 1998. Population structure and stock identification of British Columbia coho salmon, *Oncorhynchus kisutch*, based on microsatellite DNA variation. Fish. Bull. **96**, 843-858.

Smith, G.R. and R.F. Stearly. 1989. The classification and scientific names of Rainbow and Cutthroat trouts. Fisheries **14**: 4-10.

Smith, H.D. and J. Lucop. 1966. Catalogue of salmon spawning grounds and tabulation of escapements in the Skeena River and Department of Fisheries Statistical Area 4. Fisheries Research Board of Canada, Manuscript Report Series No. 882. Biological Station, Nanaimo, BC.

Smith, H.D. and J. Lucop. 1969. Catalogue of salmon spawning grounds and tabulation of escapements in the Skeena River and Department of Fisheries Statistical Area 4. Fisheries Research Board of Canada, Manuscript Report Series No. 1046, (Biological Station, Nanaimo, BC.

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 tagging fence and rates of travel through the Skeena and Babine Rivers. Fish. Res. Board Can. Tech. Rep. 418.

Smith, J.L. and G.F. Berezay. 1983. Biophysical reconnaissance of the Morice River system, 1979-1980. SEP Operations, Fisheries and Oceans Canada.

Smith, H.D., L. Margolis, and C.C. Wood. 1987. Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. **96**. 486 p.

Smith, W. 2002. Personal communication. Retired Ranger, Morice Forest District.

SNDS 1998 Skeena Native Development Society. 1998 Labour Market Census.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. Mantech Environmental Technology, Inc.

Spence, C.R., M.C. Beere, and M.J. Lough. 1990. Sustut River steelhead investigations 1986. Skeena Fisheries Report SK-64. MELP, Skeena Region. Smithers, BC.

Spence, C.R., and R.S. Hooton. 1991. Run timing and target escapements for summer-run steelhead trout (*Oncorhynchus mykiss*) stocks in the Skeena River system. PSARC Working Paper S91-07.

Statistics Canada. 1996. Census information; Enumeration areas data.

Sterritt, G. 2001. 2001 Kispiox Watershed coho stock assessment. Gitxsan Watershed Authorities. Unpublished report. Hazelton, BC.

Sterritt, G. and A.S. Gottesfeld. 2002. 2001 Upper Kispiox sockeye stock assessment. Unpublished report. Gitxsan Watershed Authorities.

Stewart, C. 2002. Ministry of Water Lands and Air Protection, Smithers. Personal communication.

Stockner, J.G. and K.R.S. Shortreed. 1975. Phytoplankton succession and primary production in Babine Lake, British Columbia. J. Fish. Res. Board Can. 32: 2413-2427.

Stockner, J.G. and K.R.S. Shortreed. 1976. Babine Lake monitor program: Biological and physical data for 1974 and 1975. Fish. Res. Board Can. MS Rep. 1373:34p.

Stockner, J.G. and K.S. Shortreed. 1979. Limnological Studies of 13 sockeye salmon (*Oncorhynchus nerka*) nursery lakes in British Columbia, Canada. Fish. Mar. Serv. Tech. Rept. No. 865. 125 pp.

Strimbold, F. 2002 Personal Communication. Long-time Topley resident.

Stuart, K.M. 1981. Juvenile steelhead carrying capacity of the Kispiox River system in 1980, with reference to enhancement opportunities. Min. of Environment, Fish and Wildlife Branch, Smithers, BC.

Swanson, F.J., S.V. Gregory, J.R. Sedell, and A.G. Campbell. 1982. Land-water interactions: the riparian zone. Edmonds, R.L. *Ed. In* Analysis of coniferous forest ecosystems in the western United States. US/IBP Synthesis Series 14. Hutchinson Ross Publishing Co.

Sword, C.B. 1904. 1905 Annual Report, Department of Marine and Fisheries, Fisheries: 36 (1903) pp. 254-255. Fisheries: 37 (1904) pp. 238-239. Ottawa, Ontario.

Takagi, K. and H.D. Smith. 1973. Timing and rate of migration of Babine sockeye stocks through the Skeena and Babine Rivers. Fish. Res. Board Can. Tech. Rep. 419.

Tallman, D. 1997. 1996 Kispiox River sport fishery survey summary report. J. O. Thomas and Associates, Vancouver, BC.

Talon Development Services. 2002. Ned'u'ten Fisheries Strategic Plan 2002.

Tautz, A.F., B.R. Ward, and R.A. Ptolemy. 1992. Steelhead trout productivity and stream carrying capacity for rivers of the Skeena drainage. PSARC Working Paper S92-6 and 8.

Taylor, G.D. 1968. Report on the preliminary survey of steelhead of Skeena River drainage streams. Fish and Wildlife Branch, Prince George, BC.

Taylor, G.D. and R.W. Seredick. 1968. Preliminary inventory of some streams tributary to Kispiox River. Fish and Wildlife Branch. Smithers, BC.

Taylor, J.A. 1995. Synoptic surveys of habitat characteristics and fish populations conducted in lakes and streams within the Skeena River Watershed, between 15 August and 12 September, 1994.

Taylor, J.A. 1996. Assessment of juvenile coho population levels in selected lakes and streams within the Skeena Watershed, British Columbia, between 11 and 31 August, 1995.

Taylor, J.A. 1997 Synoptic surveys of coho populations and associated habitat characteristics in selected lakes and streams within the Skeena River Watershed, British Columbia, between 10 August and 2 September, 1996.

Tetreau, R. 1982. Stream files, Min. of Environment, Smithers, BC.

Tetreau, R.E. 1999. Movement of radio tagged steelhead in the Morice River as determined by helicopter and fixed station tracking, 1994/95. Skeena Fisheries Report SK-125. MELP, Skeena Region, Smithers, BC.

Traxler, G.S., J. Richard, and T.E. MacDonald. 1998. *Ichthyophthirius multifilis* (ich) epizootics in spawning sockeye salmon in British Columbia, Canada. J. Aquat. Animal Health **10**:147-157.

Tredger, C.D. 1981 to 1986. Various Morice River stock assessment and fry monitoring reports. BC Environment, Smithers, BC.

Tredger, C.D. 1983a. Juvenile steelhead assessment in the Kispiox River (1980-1982). BC Min. of Environment, Fish and Wildlife Branch, Smithers, BC.

Tredger, C.D. 1983b. Kitsumkalum River reconnaissance report. MoE Stream files, Smithers, BC.

Tredger, C.D. 1984. Skeena boat shocking program – 1983. Fish Habitat Improvement Section, MoE. Victoria, BC.

Triton Environmental Consultants. 1996a. Kalum WPR Project, Vol. 1: Level 1 fisheries assessment, level 1 riparian assessment. Terrace, BC.

Triton Environmental Consultants. 1996b. Lakelse WRP project, final summary report. Unpublished Report. Terrace, BC.

Triton Environmental Consultants. 1998. Fisheries assessment, Gitnadoix River and Skeena Sidechannels. Prepared for Pacific Northern Gas. Triton Environmental Consultants. Terrace, BC.

Triton Environmental Consultants. 1999. Upper Zymoetz WRP. Overview fish and riparian assessment. Terrace, BC.

Triton Environmental Consultants. 2001. 2000-2005 Kispiox Watershed restoration plan. Terrace, BC.

Tully, O. and K.F. Whelan. 1993. Production of nauplii of *Lepeophtheirus salmonis* (Krøyer)(Copepoda: Caligidae) from farmed and wild salmon and its relation to the infestation of wild sea trout (*Salmo trutta L.*) off the west coast of Ireland in 1991. Fisheries Research 17: 187-200.

Varnavskaya, N.V., C.C. Wood, and R.E. Everett. 1994. Genetic variation in sockeye salmon (*Oncorhynchus nerka*) populations of Asia and North America. Can. J. Fish. Aquat. Sci. **51**. 132-146.

Vernon, E.H. 1951. The utilization of spawning grounds on the Morice River system by sockeye salmon. B.A. Thesis, UBC. Vancouver, BC.

Volpe, J.P., B.R. Anholt, and B.W. Glickman. 2001. Competition among juvenile Atlantic salmon (*Salmo salar*) and steelhead trout (*Oncorhynchus mykiss*): Relevance to invasion potential in British Columbia. Can. Journ. Fish. and Aquat Sci. 58 197-207.

Volpe, J.P., E.B.Taylor, D.W. Rimmer, and B.W. Glickman,. 2000. Natural reproduction of aquaculture escaped Atlantic salmon (*Salmo salar*) in a coastal British Columbia river. Conservation Biology 14: 899-903.

Wadley, G. and L. Gibson. 1998. Kispiox River channel assessment. Unpublished report prepared for Ans'payaxw Development Corporation.

Wagner, D. 2002. Personal communication. DFO, Area 4 Resource Management, Prince Rupert.

Walters, C.J. 1988. Mixed-stock fisheries and the sustainability of enhancement production for chinook and coho salmon. *In* W.J. McNeil, Ed. Salmon production, management, and allocation. Oregon State University Press. Corvallis, Or.

Waples, R.S. 1990. Conservation genetics of Pacific salmon: Effective population size and the loss of genetic variability. J. Heredity **81**:267-276.

Waples, R.S. 1991. Genetic interactions between hatchery and wild salmonids; lessons from the Pacific Northwest. Can. J. Aquat. Sci. **48** (Suppl. 1): 124-133.

Waples, R.S. 1995. Evolutionary significant units and the conservation of biological diversity under the endangered species act. American Fisheries Society Symposium **17**: 8-27.

Ward, B.R., A.F. Tautz, S. Cox-Rodgers, and R.S. Hooton. 1993. Migration timing and harvest rates of the steelhead populations of the Skeena River system. PSARC Working Paper S93-6.

Water Survey of Canada. Environment Canada, Hydrometric Station 08EB004.

Weiland, I. and J. Schwab. 1991. Nilkitkwa area, Bulkley TSA. Slope stability and surface erosion assessment. Forest Sciences Section, Prince Rupert Forest Region, BC Ministry of Forests, Smithers, BC.

Weiland, I. 1993. Sediment source mapping in the Nilkitkwa River and Nichyeskwa Creek area. Smithers, BC.

Weiland, I., and J. W. Schwab. 1996. Floodplain erosion hazard assessment, lower Zymoetz River, British Columbia. Unpublished Report for BC Ministry of Forests. Smithers, BC

Weiland, I. and D. Maloney. 1997. Review of surface erosion potential ratings Nilkitkwa area, Bulkley TSA. Smithers, BC.

Weiland, I. 2000a. Road construction upslope of unstable terrain – effects on downslope hydrology and terrain stability, McCully and Date Creek Watersheds, Kispiox Forest District. Weiland Terrain Sciences, Smithers, BC.

Weiland, I. 2000b. Reconnaissance sediment source mapping, Kispiox River Watershed, Kispiox Forest District. Weiland Terrain Services, Smithers, BC.

West, C.J., and J.C. Mason. 1987. Evaluation of sockeye salmon (*Oncorhynchus nerka*) production from the Babine Lake Development Project. Pp. 176-190 *In* Smith, H.D., L. Margolis, and C.C. Wood. Eds. Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96.

Wet'suwet'en Chiefs. 2001. Wet'suwet'en landscape unit planning process. Office of the Wet'suwet'en, Smithers, BC.

Wet'suwet'en Treaty Office. 1996. Morice Watershed restoration project. Smithers, BC.

Whately, M. R. 1977. Kispiox River steelhead trout. B.C. Technical Fisheries Circular No. 36.

Whately, M.R., W.E. Chudyk, and M.C. Morris. 1978. Morice River steelhead trout: the 1976 and 1977 sportfishery and life history characteristics from anglers' catches. Fish. Tech. Circ. No. 36. Smithers, BC.

Whately, M.R. and W.E. Chudyk. 1979. An estimate of the number of steelhead trout spawning in Babine River near Babine Lake, spring, 1978. Skeena Fisheries Report SK-23. MELP, Skeena Region. Smithers, BC.

Whelpley, M.C. 1983. Lakelse River project, 1982/83. Stream files, Min. of Environment, Smithers, BC.

Whelpley, M.C. 1984. Lakelse River project, 1983/84. Stream files, Min. of Environment, Smithers, BC.

Whelpley, M.C. 2002. Personal communication. Terrace, BC.

White, W.H. 1953. Supplementary geological report on the Babine slide.

White, W.H. 1964. Re-examination of the Babine slide.

Whitwell, T. 1906. Skeena River hatchery. Annual Report Department of Marine and Fisheries, Fisheries:**38** (1905) pp. 257-259.

Wild, J. 1991. Babine River slide investigation. Letter to file 8030-B8.

Williams, B. and P. Halliday. 2002. The 2001 Kitwanga River sockeye salmon (*Oncorhynchus nerka*) smolt sampling program. Gitanyow Fisheries Authority. Kitwanga, BC.

Williams, R.A., G.O. Stewart, and P.R. Murray. 1985. Juvenile salmonid studies in the Sustut and Bear Rivers, B.C. Envirocon Ltd. Report for D.F.O.

Williams, I.V., T.J. Brown, and G. Langford. 1994. Geographic distribution of salmon streams of British Columbia with an index of spawner abundance. Can. Tech. Rep. Fish. Aquat. Sci. 1967: 200p.

Wildstone Resources Ltd. 1995. Level 1 assessment for the Kitwanga Watershed. Vol. 1.

Wilford, D.J. 1985. A forest hydrology overview of the Kispiox Watershed. Ministry of Forests, Smithers, BC.

Wilford, D.J. 1987. Watershed workbook: forest hydrology sensitivity analysis for coastal British Columbia Watersheds. BC Ministry of Forests. Smithers, BC.

Wilford, D., M. Sakals, H. DeBeck, and G. Marleau. 2000. Tsezakwa Creek fan. Ministry of Forests, Smithers, BC.

Wilkes, B. and R. Lloyd. 1990. Water quality summaries for eight rivers in the Skeena River drainage, 1983 – 1987: the Bulkley, upper Bulkley, Morice, Telkwa, Kispiox, Skeena, Lakelse and Kitimat Rivers. Skeena Region MELP, Environmental Section Report 90-04.

Wilson, M.F. 1997. Variation in salmonid life histories: patterns and perspectives. U S Department of Agriculture Forest Service, Pacific Northwest Research Station, Res. Pap PNW-RP-498. 50pp.

Wilson, T. and A. Gottesfeld. 2001. Juvenile coho population assessment in selected streams within the Gitxsan Territories 2001. Gitxsan and Wet'suwet'en Watershed Authorities. Unpublished report. Hazelton, BC.

Winther, I. 2002.Personal communication. DFO, North Coast Stock Assessment.

Wisley, W.A. 1919. Report of the Commissioner of Fisheries for the year ending December 31, 1919. Province of British Columbia, Victoria, BC.

Withler, R.E., K.D. Le, J. Nelson, K.M. Miller, and T.D. Beacham. 2000. Intact genetic structure and high levels of genetic diversity in bottlenecked sockeye salmon (*Oncorhynchus nerka*) populations of the Fraser River, British Columbia. Can. J. Fish. Aquat. Sci. **57**: 1985-1998.

Woloshyn, P. 2002. Personal communication. DFO Fisheries Officer. New Hazelton, BC.

Wood, C.C., B.E. Riddell, D.T. Rutherford, and R.E. Withler. 1994. Biochemical genetic survey of sockeye salmon (*Onchorhyncus nerka*) in Canada. Can. J. Fish. Aquat. Sci. **51**. 114-131.

Wood, C.C. 1995. Life history variation and population structure in sockeye salmon. American Fisheries Society Symposium **17** 195-216.

Wood, C.C., and C.J. Foote. 1996. Evidence for sympatric genetic divergence of anadromous and nonanadromous morphs of sockeye salmon (*Oncorhynchus nerka*). Evolution **50** 1265-1279.

Wood, C., D. Rutherford, D. Bailey and M. Jakubowski. 1997. Babine Lake sockeye salmon: Stock status and forecasts for 1998. CSAS Research Document 97/45. Fisheries and Oceans Canada, PBS, Nanaimo, BC.

Wood, C.C., and L.B. Holtby. 1999. Defining conservation units for Pacific salmon using genetic survey data. p. 233-250. *In* Harvey, B., C. Ross, D. Greer, and J. Carolsfeld *Eds*. Action before extinction: An international conference on conservation of fish genetic diversity. World Fisheries Trust, Victoria, Canada.