Kitwanga Sockeye Recovery Plan

Backgrounder

Cover photo shows Gitanyow and Kitwanga River, ca. 1960. Note poles and cache pits.

Photo credit: Fisheries Research Board of Canada.

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Backgrounder

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Preamble

This backgrounder has been prepared for the Kitwanga Sockeye Recovery Plan (KSRP) planning table, a Gitanyow Fisheries Authority (GFA) and Department of Fisheries and Oceans (DFO) initiative. It presents a brief profile of biophysical characteristics, a description of the fisheries resource, and known anthropogenic effects on habitats in the Kitwanga Watershed.

Kitwanga sockeye abundance has been in decline for the last five decades. Constraints to sockeye production are not well understood; it is thought they stem from a combination of problems that include high harvest rates in the management of the Skeena River mixed stock fishery and the alteration of critical spawning and rearing habitat.

As in other Skeena sub-basins, social, political, and economic factors influence the status of fish and habitat in the Kitwanga Watershed. For example, one or more of these factors may influence the rate of development of forest harvesting, resulting in riparian, in-stream, or associated effects within the watershed. These factors also influence management of the fish resource and may also affect the location, timing, and focus of fish sustainability or watershed restoration planning.

Concerns regarding Kitwanga sockeye abundance have been voiced since the 1960s, primarily by local First Nations. Since 1998, extensive efforts have been made to identify the cause of the sockeye decline and to rebuild the sockeye stock. The Kitwanga Sockeye Recovery Plan formalizes this process and provides a framework for First Nations, government, industry, and public groups to work together towards stock recovery. Kitwanga sockeye recovery offers an opportunity to link sectorial efforts that may appear to be disconnected at the watershed level. This collaborative approach requires a high degree of coordination and planning. The high social, cultural, and economic values of Kitwanga sockeye will likely promote interest in rehabilitating the populations and their critical habitats. The challenge lies in developing a sockeye recovery vision that fits with present and future community values and interests.

Within Kitwanga Watershed, there are currently other land use plans or planning processes that are inclusive or semi-inclusive of fish and fish habitat. The Kispiox Land and Resource Management Plan (LRMP) is the land use plan currently being implemented. The Kispiox LRMP, approved in 1996, was initiated and led by the Ministry of Forests. The plan creates three categories of management directions for the LRMP area: General Resource Management, Resource Management Zones, and Protected Areas.

Due to the replacement of the *Forest Practices Code* with the *Forest and Range Practices Act* (FRPA), the Kispiox LRMP objectives need to be interpreted within the context of this new legislation. The new Kispiox LRMP objectives under FRPA will form the minimum legal standard that forest licensees must meet when they develop their forest stewardship plans (FSP). These reworked LRMP objectives are limited and focus on biodiversity, wildlife, visual quality, and water. Much of the Kitwanga Watershed lies within the asserted Gitanyow claims area, which is not included in the Kispiox FRPA project, but in a pilot landscape planning project with Gitanyow.

The recently established Gitanyow Pilot Planning Project involves Gitanyow's interests in the Kispiox and Cranberry Timber Supply Areas (TSAs). The purpose of this facilitated planning is to promote sustainable forest management that includes Gitanyow's values and interests. The process will use existing inventory information to provide guidance to Gitanyow, licensees, and the Ministry in subsequent planning and management decisions. Key final plan products include, but are not limited to: a digital map of Gitanyow cultural values/interests, an ecosystem network map, and management objectives for selected resource values.

The lower portion of the Kitwanga Watershed is involved in the Lower Skeena Watershed Sustainability Plan process. This planning process, an initiative of the Gitwangak Chiefs, is a tool based on the natural and cultural features of the Lower Skeena Watershed. The purpose is to make balanced resource stewardship decisions, help create economic development, and communicate Gitxsan ecosystem management, cultural knowledge, and values.

The Kitwanga Watershed Restoration Program (WRP) was initiated in 1995 with aquatic and upland restoration efforts continuing to 2001, when the program was terminated due to a change in provincial government policies. The proposed 2001 Kitwanga Watershed Restoration Plan delineated high priority work that includes riparian assessments, fish access restoration, riparian planting, bank stabilization, instream complexing, and off-channel habitat development at an approximate cost of $750k (McElhanney 2001). These assessments and site works are an outstanding legacy from three decades of forestry development related impacts. The restoration plan does not address cumulative impacts to portions or the overall watershed.

Other current plan processes that could potentially influence or affect the Kitwanga Sockeye Recovery Plan include industrial Forest Development Plans or Forest Stewardship Plans from the three licensees (Kitwanga Lumber Co., Skeena Cellulose Inc., and BC Timber Sales) with tenures in the watershed. Forest Stewardship Plans are expected to describe licensee forest development activities within the framework directions stated in higher-level plans such as the Kispiox LRMP. What these plans contain and how they will be implemented will need to be reviewed from a fisheries perspective to ensure fish values are protected.

As noted above, numerous natural resource planning programs are underway in Kitwanga Watershed that will affect, and be affected by Kitwanga Sockeye Recovery Plan activities. Building relationships, ideas, and products among planning agencies can achieve efficiency in timeframes, content, and participation, and as well, can potentially provide more complete assessment and solutions to complex habitat related problems. The collaboration of fish protection and restoration priorities can often provide unique opportunities for funding agencies.

Environmental Setting

Location

The Kitwanga Watershed is a tributary sub-basin draining south into the right 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. Gitanyow village and Kitwanga Lake, commonly called Kitwancool Lake, lay 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. 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 four to eight 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. Gitanyow Fisheries Authority (GFA) has recently installed stream-gauging stations above and below Kitwanga Lake and close to the mouth of Kitwanga River. Kingston and Cleveland (2003) report Kitwanga Watershed peak annual average discharge is estimated at 68.4 m^3/sec.

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 upper mainstem and the major tributaries, Moonlit Creek and Kitwancool Creek. 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 portion 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. Precipitation is moderately controlled by orographic effects in the mountainous watershed. Mean annual precipitation ranges from 2500 mm on the high elevation windward mountain sides to approximately 500 mm in the valley bottom at Kitwanga.

Figure 1 Kitwanga Wshed map.

Kitwanga Lake and the extensive wetlands upstream of the lake constitute the primary water storage. The lake is a major feature of the watershed. The lake catchment contains high mountain areas that remain snow covered for most of the year. Upper Kitwanga River (defined as Kitwanga River upstream of Kitwanga Lake), Kitwancool Creek, and Deuce Creek drain the Nass Range. Moonlit Creek drains the bulk of the Kispiox Range that is situated to the east.

These tributaries are classed as major and 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 by the glaciers of the last ice age and left behind as a mantle over the landscape or as valley fill deposits. These sediments are easily mobilized by natural and man-induced erosion events such as stream instability and landslide failures.

Water Quality

Water connects land, air, plants, and animals while flowing throughout the varied ecosystems in the watershed. Water is the essence of life on earth and totally dominates the chemical composition of all organisms. Water appears as rivers, streams, lakes, ponds, wetlands, as well as underground storage. Forests, water, fisheries, wildlife, and humans are linked together by the hydrologic cycle. Water quality is defined as the natural physical, chemical, and biological characteristics of water.

Water quality criteria are guidelines concerning the acceptable range of conditions, usually relating to safe levels for a given water use, or particular kinds or classes of water use. Setting water quality objectives involves taking the set of criteria and adapting it to a specific body of water. For example, water quality objectives or guidelines are applied to drinking water, fish and aquatic life, agricultural and mining activities, or forest development. Province-wide ambient water quality criteria include pH, substances that degrade water quality such as nutrients, algae, and particulate matter, low level toxic substances and high level toxic substances, such as cyanide, PCBs, and metals, and microbiological indicators of risks to humans (fecal coliforms, *Giardia*). Other common criteria include dissolved oxygen, total suspended solids, water stage, and biochemical oxygen demand (BOD).

Critical to the review and understanding of water quality is long-term data, which is essential in detecting changes or trends in water quality. Long-term water quality data for the Kitwanga mainstem and its tributaries is non-existent; however, Kitwanga Lake has data from the mid-1940s and from the mid-1990s into the present. The watershed generally has good water quality; however, during flood events or streambank failures, water quality is compromised, due to input of sediment from the many high elevation and steep drainages, which receive fairly high precipitation. 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 (McElhanney 2001).

Processes that affect water quality in forested streams are underpinned by the hydrologic cycle. Water acts as a carrier of materials and energy between the atmospheric and terrestrial portions of the system and the stream. Runoff and streamflow in a small, undisturbed forested watershed are primarily the result of water flowing through the forest soil, rather than over it (Harr 1976). Weather conditions and natural landscape processes cause turbid and high water conditions that affect water quality.

Water temperature influences every biotic component of Kitwanga Watershed stream and lake ecosystems. Temperature sets the rhythm of nearly every living aquatic organism, but most notably, water temperature affects fish. In Kitwanga streams and lakes that salmonids inhabit, the preferred temperature is cold to cool. This temperature regulates metabolism, determines how fast eggs mature, the timing of larval salmon from nursery gravels, and when adult salmon return to their natal streams, among other important life stage events. In addition, several diseases that infect fish are kept in check or at low levels by cold water.

Cumulative effects to water quality in the watershed from logging operations are unknown. How water quality is affected in relation to land use activities, particularly forest development, is not well understood or documented for the watershed. Major concerns include the integrity and importance of small streams, hydrologic change, temperature change, sedimentation, and effects to the physical stream structure.

Kitwanga Lake Limnology

Previous limnological studies of Kitwanga Lake include Fisheries Research Board (FRB) investigations in the 1940s, DFO sockeye nursery lake surveys in the 1990s, and Gitanyow Fisheries Authority (GFA) data collection since 1999. McConnell (1946) and McConnell and Brett (1946) reported on the FRB Kitwanga Lake limnological investigation. Shortreed *et al.* (1998, 2001) and Shortreed and Hume (2004) documented DFO sockeye nursery lake findings that focused on trophic status, juvenile sockeye rearing capacity, and factors limiting sockeye productivity. Cleveland (2000, 2003) described GFA data collection involving substrate composition, aquatic vegetation, lake temperature and dissolved oxygen, and intragravel dissolved oxygen surveys. In 2002 and 2003, Shortreed and Hume (2004) conducted limnological, macroinvertebrate, and stable isotope analysis sampling in Kitwanga Lake.

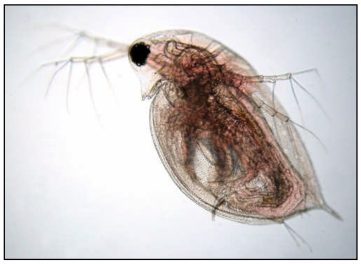
Kitwanga Lake lies at 376 m elevation. The surface area is 7.8 km^2 with a drainage area of 169 km^2. The lake is morphometrically separated into two basins, the northern and southern. The northern basin is approximately five times larger than the southern basin with a maximum depth of 12 m and an average depth of 8.5 m. The southern basin has a maximum depth of 15 m and an average depth of 12 m. The lake is clear with the euphotic zone encompassing the entire water column in most areas of the lake. The lake is considered mesotrophic, which is defined as neither nutrient-rich nor nutrient-poor and is a transition between oligotrophic and eutrophic. The shoreline is irregular, and with several islands produces a relatively long shoreline length of 22.2 km.

The results of limnological sampling in 1994 and 1995 (Shortreed *et al.* 1998) showed a pronounced thermal stratification, with an average thermocline depth of 5.7 m, and epilimnetic temperatures that exceed 18^{o} C. Shortreed *et al.* (1998) found that these temperatures 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. Since 1999, GFA has collected limnological data annually and Cleveland (2001) suggests that these data show no obvious environmental constraints on fry.

Shortreed *et al.* (1998) suggest that with strong thermal stratification, summer oxygen concentrations may become very low in the lake's hypolimnion. 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. The warm, clear epilimnion and an average spring overturn total phosphorus of 10.8 ug/L results in one of the highest photosynthetic rates (PR) ever recorded (Shortreed *et al.* 2001).

Shortreed and Hume (2004) reported similar thermoclines and surface temperatures as Shortreed *et al.* (1998) and Cleveland (2001). This includes observations that hypolimnetic dissolved oxygen (DO) became low enough (<5mg/L) to be deleterious to juvenile sockeye in the north basin from July to October and in the south basin from June to October.

Vertical profiles of DO appeared similar to the survey results in the 1940s. The chlorophyll (CHL) profile was unusual in that there was an accumulation of phytoplankton biomass near the lake bottom, which was most likely the result of large, more dense phytoplankton settling (Shortreed and Hume 2004). Senescence and decay of phytoplankton biomass near the lake bottom likely contributes to the low DO concentrations.



Kitwanga Lake is potentially one of the most productive sockeye nursery lakes in BC. Macrozooplankton biomass is relatively high and Shortreed *et al.* (2001) reported that *Daphnia* abundance makes up 63% of the total. Shortreed and Hume (2004) reported *Daphnia* biomass averaged 87% of total zooplankton biomass. This quantity of Daphnia biomass is among the highest recorded for a B.C. sockeye nursery lake.

***Daphnia,* side view.**

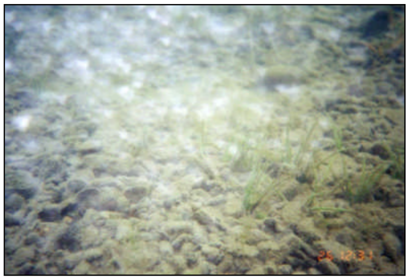
Shortreed and Hume (2004) report that Kitwanga Lake contains substantial numbers of the phantom midge, *Chaoborus* and the cladoceran *Leptodora,* both of which may feed on small cladocerans and so compete with juvenile sockeye. These invertebrates, sampled from August to October, had an average density of 39/m^3 for *Chaoborus* and 20/m^3 for *Leptodora*. *Daphnia* accounted for a large portion of stomach contents of sockeye (67%), followed by *Leptdiaptomus* (18%), Chaoborus (10%) and *Diaphanosoma* (5%) (Shortreed and Hume 2004).

Chaoborus Larva - lateral – magnified.
www.bioimages.org.uk.

Sediment Loading Sensitivity

Water quality of streams, streamflows, and lakes respond to human activity in the terrestrial portion of the watershed. Streams flowing from undisturbed watersheds generally have excellent quality. It is this characteristic that makes them so valuable, not only for fish production but also for human consumption. Small streams provide benefits in the form of fish production and high quality water, and as well hold considerable social, economic, and political significance for a large portion of society.

It has long been established that land use disturbances can induce elevated sediment yields in affected drainage basins. This effect is well documented with respect to forestry activities in British Columbia. Increased sediment yields caused by forestry-related activities can have adverse effects on aquatic ecosystems in both streams (Scrivener *et al.* 1998) and lakes (Miller *et al*. 1997, Beak and Aquafor 1999). Forestry–induced sedimentation has become a major concern in Skeena Basin mountainous regions with high fish and timber values.



Undisturbed substrate beside a redd, Kitwanga Lake.
GFA 2004.

Topographic, geologic, and climatic factors control rates of sediment transfer in Kitwanga Watershed. A major problem encountered in studying disturbed sediment yields in the Skeena Watershed is putting the forestry impacts in context with the high degree of natural spatial and temporal variability in the system (Beak and Aquafor 1999). Although elevated sediment yields are commonly observed during or following road construction and/or timber harvest, the extent to which sediment is transmitted to downstream lakes such as Kitwanga Lake has yet to be established.

Kitwanga Lake acts as a major storage site in downstream sediment transport in the Kitwanga Watershed. The trap efficiency of Kitwanga Lake is unknown; but likely is a function of the lake size and shape, the location of stream inlets and the river outlet, volume of water throughput, and the character of the sediment. The quantity and quality of sediment in the lake reflect the interrelated watershed processes above the point of inflows, as well as internal lake processes (Petts and Foster 1985).

As sediment has the potential to adversely affect fish habitat and production, it is critical that sediment sources in the Kitwanga Watershed, particularly sources above Kitwanga Lake, are clearly delineated in order to understand the sources, yields, nature of transport, storage, remobilization, and the effects on linkages to other ecosystem components. Records of climatic and human-induced changes in the environment are stored in Kitwanga Lake sediments. The sediment records represent relative sequential events over the short-term (e.g. seasonal) and long-term periods (Wetzel 2001) in the lake basin. The goal is to gain insights into the past conditions, past productivity, and the changes that may have caused a difference in Kitwanga Lake productivity. In addition, insights may be gained into future ecosystem functioning, and thus, freshwater implications to sockeye productivity.

Arnaud (1997) demonstrated that the analysis of lake sediments utilizing sediment cores could be a beneficial method for assessing land use impacts on sediment yield at the basin scale, since a long-term sedimentary record can be established reflecting all of the upstream drainage effects. This method is especially attractive in mountainous areas where stream gauging and long-term monitoring are non-existent.

Using paleolimnological records preserved in lake sediments may provide a means of constructing long-term data of past salmon abundance. $\delta^{15}N$ that has been delivered to Kitwanga Lake by returning adult salmon and subsequently deposited in sediments could provide a record of past salmon returns. Holthman *et al.* (2004) found that sedimentary $\delta^{15}N$ values showed little response to historic variation in sockeye escapements even at high spawner densities, but that diatom assemblages responded to changes in spawner densities. Generally, the most common algal microfossils are the siliceous frustules of diatoms. Diatoms are useful paleoecological indicators because their remains commonly occur in abundance, are often well preserved, and most can be identified to the species (Hall and Smol 1999). Kitwanga Lake would be a good sediment core study candidate to help understand past salmon abundance.

Aquatic Vegetation

McConnell (1946) reported shallow shelves at the northern and southern lake ends and several bays with extensive areas of reeds and horsetails. As well, the lake outlet contained a moderate growth of pondweed, water lilies, and water milfoil. At that time, the rooted aquatic vegetation covered about 18% of the total shoreline (McConnell 1946).

Cleveland (2003) reported on the 2002 Kitwanga Lake aquatic vegetation survey. The lakeshore was divided into thirty-five sections, and then further divided into sub-sections that were characterized by similarity in physical features. For each sub-section, vegetation abundance was visually estimated to the percentage of total sample area occupied by vegetation. The vegetated areas were investigated to determine the relative abundance of each individual plant species.

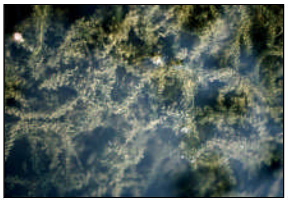
Canadian waterweed (*Elodea canadensis*).

Nineteen plant species were collected during the shoreline survey. Results showed that the entire lake margin was dominated by Canadian waterweed (*Elodea canadensis)*, with smaller amounts of northern water milfoil *(Myriophyllum sibiricum)*, and variable amounts of pondweed *(Potamogeton gramineus)* (Cleveland 2003).

The most abundant plant species was Canadian waterweed, representing 55% of the total area covered by plants, and occurring in 34 of the 35 sections surveyed. Northern water milfoil was the second most abundant plant species, representing 20 percent of the total area covered by plants and occurring in all 35 sections surveyed. Variable pondweed represented 10 percent of the total area covered by plants and also occurred in all 35 sections surveyed. Several species were relatively widespread; however, they only represented a minor portion of the total area covered by these plants: berchtolds pondweed (*Potamogeton berchtoldii*), whitewater buttercup

(*Ranunculus aquatilis*), Richardsons pondweed (*Potamogeton richardsonii*), stonewart (*Chara* sp.), and flatstem pondweed (*Potamogeton zosteriformus*). The other twelve species of macrophytes identified were only found in isolated location in low numbers.

The amount of *Elodea canadensis* in Kitwanga Lake has been steadily increasing. Gitanyow residents and Gitanyow Fisheries Authority have raised concerns as to how the growth is affecting lake quality and health, as well as fisheries values. Canadian waterweed lives entirely underwater, with the exception of small white flowers that bloom at the surface and are attached to the plant by delicate stalks. It produces winter buds from the stem tips that overwinter on the lake bottom. In the fall, leafy stalks will detach from the parent plant, float away, root, and start new plants. This is *Elodea's* most important method of spreading, with seed production playing a relatively minor role. Silty sediments and water rich in nutrients favour the growth of *Elodea*.



Elodea Canadensis.
plants.usda.gov/cgi_bin/topics.

Common Name	Scientific Name	Species Composition (%)	Coverage Area (m^2)	Frequency of Occurrence (%)	
				35 sections	237 sub-sections
Canadian waterweed	*Elodea candensis*	55.4%	99511	97%	95%
Northern water milfoil	*Myriophyllum sibiricum*	19.9%	35737	100%	95%
Variable pondweed	*Potamogeton gramineus*	10.4%	18725	100%	74%
Broadleaf pondweed	*Potamogeton natans*	2.8%	5070	23%	9%
Richardsons pondweed	*Potamogeton richardsonii*	2.1%	3744	40%	16%
Whitewater buttercup	*Ranunculus aquatilis*	2.0%	3643	43%	13%
Quillwort	Isoetes sp.	1.8%	3313	31%	9%
Flatstem pondweed	*Potamogeton zosteriformus*	1.1%	1915	37%	14%
Stonewart	*Chara sp.*	0.9%	1668	40%	15%
Berchtolds pondweed	*Potamogeton berchtoldii*	0.8%	1526	46%	19%
Algae sp.		0.8%	1358	3%	8%
Water horsetail	*Equisetum fluviatile*	0.7%	1173	3%	0.4%
Bushy pondweed	*Najas flexilis*	0.4%	650	31%	8%
Lemna	*Lemna sp.*	0.3%	600	3%	0.4%
Western yellow pond Lily	*Nuphar polysepalum*	0.2%	365	9%	2%
Bur reed	*Sparganium sp.*	0.2%	365	3%	1%
Common bladderwort	*Utricularia vulgaris*	0.1%	143	14%	2%
Tufted loosestrife	*Lysimachia thyrsiflora*	0.0%	46	3%	0.4%
Coontail	*Ceratophyllum demersum*	0.0%	12	3%	0.4%

Table 1: Species composition, coverage area, and frequency of occurrence of 19 aquatic plant species collected from Kitwanga Lake, (Cleveland 2003).

Colonization of the littoral zone by significant *Elodea* growth has reached levels that seasonally occlude beaches and shorelines. Sockeye in Kitwanga Lake are beach spawners. Cleveland (2005) noted that over 60% of the shoreline is presently covered with rooted aquatic vegetation.

As this vegetation has the potential to severely change fish habitat, a component of the Kitwanga Sockeye Recovery Plan could address possible disturbance effects involving aquatic vegetation and sediment loading. There is a suspected relationship between fine sediment accumulations, especially those containing iron (Downie 2005), that provide a rooting medium for *Elodea* and subsequent *Elodea* growth in Kitwanga Lake. Sharpe (2005) notes that once *Elodea* is established, it creates its own sediment trap, which very likely exacerbates the problem. This relationship, if indeed it exists, and the slow process towards eutrophication that is occurring with the marked increase in rooted plant biomass needs to be clearly understood if successful water quality restoration characteristic of the natural pre-development setting is to be achieved.

Geography

The Kitwanga Watershed is part of the Hazelton Mountains, which are comprised of two mountain masses, the Nass Range and the Kispiox Range. A linear down-faulted trough divides these two ranges. 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. There are minor granitic intrusions at Hazelton Peak and unnamed peaks west of Kitwanga Lake (Gottesfeld 1985). The bedrock consists mostly of highly fractured siltstones, claystones, and shales.

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 Kitwanga Lake, are part of the glacial legacy.

Gully incised into bedrock, upper Kitwanga River.

North of Kitwanga Lake between the Cranberry and Kitwanga drainages lies a gentle divide (390 m); 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. Clague (1984) suggested that a through flowing river may have occupied the Cranberry–Kitwanga valley at some point prior to or during the Pleistocene. The change from through flowing to discontinuous drainage likely resulted from differential deepening of the Nass and Skeena valleys. Because of the present indeterminate drainage features it is easy to imagine fish passage between the Skeena to the Nass Valley.

Ice sheet erosion of the sedimentary rock formed the ridge–swale plain topography east of Kitwanga River (BC Dept of highways 1975). 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). 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.

View northwest across Kitwanga Lake showing terrain and forests.
GFA 2003.

Stream Channels

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 that occurred between 200 to 500 years ago (Gottesfeld 1985). These terraces are the present day sites of Gitanyow and Kitwanga villages and have been the preferred sites for farmland in the southern part of Kitwanga valley. Below the high, inactive terraces are more recent fluvial deposits where the river actively meanders on the Kitwanga floodplain.

Sediment moved by Kitwanga River includes fine suspended material such as silts or clays carried throughout the year, and coarse bedload such as gravels, cobbles, and boulders, which are only carried during flood flows in the spring and fall. Suspended sediment may adversely affect fish, but has no influence on stream channel stability unless there is large-scale mobilization of fine sediment on a fan or aggraded channel section. Mobilization of coarse bedload material during floods can cause channel erosion and changes in channel location determining channel stability.

Bedload material is also classified according to whether the sediment sources are external or internal to the river. External sediment is derived from tributaries, landslides, or failing streambanks. In a stable river system, external sediment input is equal to the sediment output at the lower end of the reach. Both internal and external sediment can be stored within the reach for significant periods. Internal sediment is derived from the stream channel and floodplain erosion. Where sediment input and output for a reach does not balance, then changes occur to internal sediment storage to regain a dynamic equilibrium for the river.

Kitwanga Lake Tributaries

Several unnamed tributaries into Kitwanga Lake have been degraded by forestry related activities that contributed significant sediment into the lake. Giesbrecht *et al.* (1998) reported on Tributary 48, a third order stream that is located on the western shore of Kitwanga Lake. This stream has extensive channel and bank erosion as well as loss of riparian structure and function. Giesbrecht *et al.* (1998) suggested that the current stream position on the alluvial fan is down a former roadbed, due to evidence in the channel and the large-scale sediment deposited where the channel was aggraded and dewatered.

View upstream on Tributary 48.
Biolith 1998.

Tributary 45, another third order stream draining into the western shore of Kitwanga Lake, exhibits erosion damage and destabilization (Giesbrecht *et al.* 1998). Further downstream and lower on the fan, the creek was dewatered due to sediment aggradation. Cleveland noted that logging has negatively influenced most of the streams entering Kitwanga 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.

Kitwanga River

Overall, the Kitwanga Watershed has very high stream densities due to abundant precipitation and steep slopes. The Kitwanga River mainstem between Kitwanga Lake and the Skeena confluence is approximately 36.5 km in length. From the Skeena River upstream to the lake, mainstem gradients vary from 0.5% to 0.7% slope (Ministry of Environment 1979) with an average channel width of 15 m. The Kitwanga River is low gradient with no effective barriers to anadromous fish passage. The lower 12 km is for the most part entrenched 30 to 100 m into a bedrock canyon. The northern two thirds of the lower Kitwanga River is a wandering gravel bed river. Because of the high suspended sediment load of the Kitwanga River, abandoned channel segments and backwaters fill up with mud more rapidly than in typical gravel bed rivers.

Reach classification and description follows the Kitwanga Watershed Restoration Program as described in Giesbrecht *et al.* (1998). Reach 1 of the Kitwanga River is 3.4 km in length, an average gradient of 0.6%, and influenced by the Skeena River. The substrate is composed of cobbles and gravels, though the lower 250 m is covered in fines.

View upstream, Kitwanga River, reach 1.
Biolith, 1998.

Reach 2 is slightly entrenched into bedrock with several sections of naturally eroding banks. Reach 2 is 2.7 km in length with an average width of 30 m and a gradient of less than 1%. Riparian forest on a section of the east bank was logged and the west bank has several slumps due to an old logging related road (Giesbrecht *et al.* 1998).

View downstream, Kitwanga River, reach 2.
Biolith, 1998

Reach 3 is 3.7 km in length with an average width of 40+ m. Meandering of reach 3 channel has eroded the fine bank material. Beaver activity provides year round rearing in several low and high water side channels. Sections of riparian vegetation on both banks have been cleared by beavers and for rural development (Giesbrecht *et al.* 1998).

View across Kitwanga River, reach 3.
Biolith 1999.

Reach 4 is 3.5 km in length with an average width of 20+ m and similar to Reach 2 in character. The channel is incised in bedrock with a substrate of boulders and cobbles. The gradient is less than 1% overall, though several sections are 2-3%. The riparian is intact with mature coniferous and deciduous forests and no known logging impacts (Giesbrecht *et al.* 1998).

View across Kitwanga River, reach 4.
Biolith 1999.

Reach 5 is 13.6 km in length and ranges from 15–140 m in width. The reach is a wandering gravel bed river with many side channels, debris jams, and extensive abandoned channels, with a relatively narrow floodplain that is up to 600 m in width. Some sections of the reach are active but stable, while other sections are unstable. Channel movement is dominantly by lateral migration of river meanders, with minor amounts by channel avulsions (Gilchrist 1999). Notable unstable portions include the channel downstream of the Mill Creek FSR crossing in the lower section of the reach.

Kitwanga River, reach 5.
Biolith 1999.

Reach 6 is 6.1 km in length and extends upstream immediately above Kitwancool Creek confluence. The average gradient is approximately 1% with a cobble and gravel substrate and a stable channel. The floodplain is narrow ranging from 80-200 m in width. Riparian forests border the river other than the section adjacent to Gitanyow village.

Reach 7 is 3.5 km in length and extends from Moonlit Creek upstream to the outlet of Kitwanga Lake. The meandering channel is braided with multiple side channels and is stable across a comparatively wide floodplain. The riparian forest is intact except for a 600 m section on the east bank of the river.

Kitwanga River and Moonlit Creek confluence.
Biolith 1999.

Kitwanga Lake is classified as Reach 8. The mainstem upstream of the lake, termed the upper Kitwanga River, is approximately 25.4 km in length. Reach 9 extends approximately 4.4 km from Kitwanga Lake to approximately 600 m downstream from the Weber FSR Bridge. The lower portion of the reach is a single channel incised into the wetland. The reach is low gradient with an average gradient of 0.5% and is part of a large, complex wetland characterized by substrate with fine texture materials, multiple channels, beaver dams, and impoundments.

Riparian logging followed by copious beaver activity have adversely affected the upper portion of reach 9 and the lower portion of reach 10, both of which lie on the compound fan. Both the logging and beaver activity likely contributed to a significant rise in the water table. This area is located north of Kitwanga Lake between the 26-Mile Forest Service Road (FSR) and the Webber FSR. Cleveland (2002a) reported over twenty beaver dams blocking a 5 km section of the river to annual adult salmon migration.

Typical beaver flooded area, reach 9.
Biolith 1999

Reach 10 extends 1.6 km to one km upstream of the Weber FSR Bridge. The average gradient ranges from 2% to 1% at the upper and lower sections of the reach. The substrate consists mainly of gravels and channel stability is good except for the lower 200 m where suspected aggradation causes dewatering (Giesbrecht *et al.* 1998).

Reach 10 showing sediment deposits.
Biolith 1999.

Reach 11, of upper Kitwanga River extends 3.2 km into the mountainous valley upstream of the fan. Channel gradient varies between 2 and 3% with a riffle-pool morphology and a gravel and cobble substrate (Giesbrecht *et al.* 1998). Reach 12 extends 3.3 km upstream with an average gradient of 3% to a barrier falls. The channel has been impacted by a road related slide that contributed significant sediment from the east bank. Reach 13 extends approximately 9.0 km upstream into the alpine. Gradients vary from 4-7% with a variety of substrate types. Channel integrity is good other than the bank instability adjacent to the Jackson Main FSR river crossing.

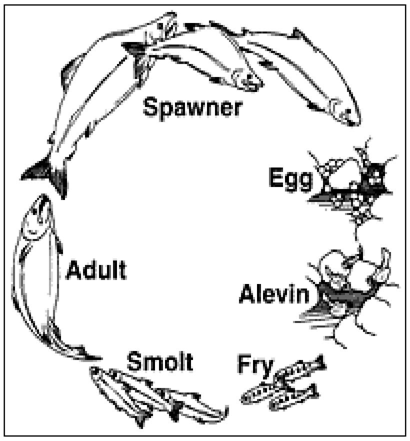
Giesbrecht *et al.* (1998) observed channel instability in Reaches 3 and 5 due to logging and clearing of the riparian area, as well as to past road construction. The major problems in the streams of this watershed include damaged riparian areas, bank erosion, channel instability, reductions in large woody debris (LWD), and barriers at stream crossings. Overall, forest development activities and poor placement of drainage structures along Highway 37 North have adversely affected a number of tributary streams.

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 thought to be abundant in this watershed, have been identified as a species of provincial concern. The fish community contributes to the ecology, nutrient regime, and structural diversity of the drainage.

Pacific salmon, *Oncorhynchus* spp. have been, and continue to be, intricately connected to the cultural history and economy of the Kitwanga Watershed and its First Nations peoples for thousands of years. The salmon provides strong cultural, economic, and symbolic linkages for First Nation people, and as well, supports recreational anglers and commercial fisheries.

A key theme of Pacific salmon is that they are anadromous and semelparous, meaning they spend a portion of their life in the ocean and return to freshwater to spawn, after which they die. Their habitat includes the freshwater watershed of origin and a large portion of the North Pacific Ocean.



Each fall, drawn by natural forces, salmon return to the rivers which gave them birth. Once the salmon reach their spawning grounds, they deposit thousands of fertilized eggs in the gravel. Each female with a male in attendance beside her, digs a redd. By using her tail, the female creates a depression in which she releases her eggs. At the same time, the male releases a cloud of milt. When the female starts to prepare her second nest, she covers the first nest with gravel that protects the eggs from predators. This process is repeated several times until the female has spawned all her eggs.

Adult salmon die following their long journey and spawning. Their carcasses provide nourishment and winter food for birds and wildlife, and provide nutrients to the river for the next generation of salmon and other fish. As the salmon eggs lie in the gravel they develop an eye – the first sign of life within. Over months, the embryo develops and hatches as an alevin. The alevin carries a yolk sac that provides food for two to three months. Once the nutrients in the sac are absorbed, the free-swimming fry move up and emerge into the water.

Depending on the species, fry may live in fresh water for a year or more, or may go downstream to the sea at once – it varies by species. Fry ready to enter salt water are called smolts. Young salmonids stay close to the coastline when they first reach the sea. After varying lengths of time, the smolts move out into the open ocean, and, depending on the species, spend from one to four years eating and growing in the North Pacific Ocean. Then they return to their home streams to spawn and die.

The data source of salmon stock status within the Kitwanga Watershed is the Salmon Escapement Database System (SEDS) maintained by DFO (DFO 2003). This data set consists of a variety of annual spawning ground observations of census areas collected since 1950. The data quality varies from observer to observer and place to place. Since 2000, Gitanyow Fisheries Authority has collected the data. While appreciating the great value of the data records, non-fence counts can only be utilized as indicators of general trends and at best reflect relative abundance rather than actual values. This SEDS data is the best available and exceeds the qualitative data available for steelhead, trout, and other non-anadromous, freshwater species. In general, the number of stocks counted increased from 1950 to 1990 and declined after 1992. Coho are probably the most poorly estimated fish.

In 1999, the Gitanyow Fisheries Authority (GFA) established the Kitwanga River Sockeye Rebuilding Program. This program was developed to determine the factors limiting sockeye production and to restore the stock to historic levels of abundance. A key component includes accurately estimating sockeye escapement on an annual basis to monitor the health of the stock and to assess the effectiveness of restoration efforts.

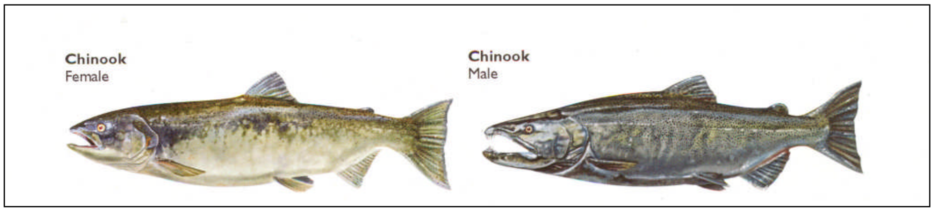
A temporary enumeration facility was established downstream of Kitwanga Lake and sockeye escapement was recorded in 2000 (Cleveland & Kingston 2001), 2001 (Cleveland 2002b), and 2002 (Kingston & Cleveland 2003). The data collected was limited to sockeye and to some extent, coho abundance. In 2003, the Kitwanga River Permanent Salmonid Enumeration Facility, located 4 km upstream of the mouth of the river, was constructed and is presently in use.

Kitwanga River Salmonid Enumeration Facility, 2003.

Chinook Salmon

Chinook salmon are an important part of Skeena aboriginal fisheries, being next in importance to sockeye. Chinook are the largest species of salmon in the Kitwanga Watershed. In general they are fish of larger streams and spawn in faster moving water with coarser gravel than other salmon. Chinook are the first salmon species to return to freshwater, resulting in the popular name "springs." Early stocks arrive in May and June, late stocks in June and July with late runs tending to be more coastal stocks. Chinook salmon stocks in the Skeena Basin are classified primarily as stream-type, though both ocean-and stream-type fish are thought to be present in most populations in varying proportions. Chinook stocks are usually relatively small (Healey 1991).

Chinook originating from Oregon through to Alaska are widely mixed along the Pacific coast. Coastal fisheries therefore intercept fish originating in many rivers. In Alaska, the commercial net, tidal sport, and especially the commercial troll fisheries harvest a sizable proportion of Skeena chinook. In Canada, the northern net and northern troll fisheries have traditionally been the most important commercial harvesters of these stocks. Currently, tidal and freshwater sport fisheries account for a larger portion of the annual harvest. In the last few years, the marine sports fishing component, although small, has increased and in conjunction with the sports fishing in the Lower Skeena below Terrace, is an important part of the overall Skeena chinook exploitation.



The Skeena chinook stock aggregate includes over 75 discrete spawning populations. Skeena aggregate chinook escapement trends showed a general decline until the late 1980s (DFO 2003). This decline led to management actions that progressively decreased the commercial and sports catches. Restrictions on the North Coast chinook commercial fisheries and on river sports fishing began in the mid 1970s (Ginetz 1976). The 1985 Canada–U.S. Pacific Salmon Treaty, with its chinook annex, put in place provisions that dramatically increased chinook escapement to the Skeena Watershed. It is likely that the increase in escapement from 1985 on is due to the restriction on chinook harvest in Alaska and Canada that took effect with the Pacific Salmon Treaty.

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 700 adults in 1950 to less than 100 in the mid-1980s indicated 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 from the 1990s to the present of over 1,500.

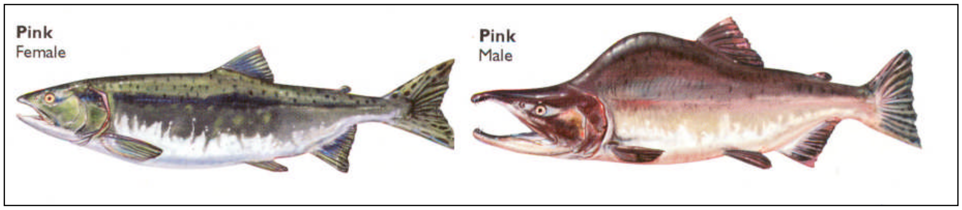
Chinook salmon typically enter the Kitwanga system in early August and depending on water levels and temperature, hold or head to their spawning grounds. The principal chinook spawning areas are the reach below the lake outlet, the lowest reach of the river near the Skeena, and the mainstem reach immediately downstream of Kitwancool Creek confluence (DFO 1991). Recent spawning assessment surveys conducted by the GFA showed 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 in some years (McCarthy *et al.* 2002).

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 and the excluded fish are displaced downstream. 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.

Pink Salmon

The Kitwanga River is one of the major pink salmon producing rivers in the Skeena system. Pink salmon are exclusively two years old at spawning time meaning that odd and even year stocks are genetically separate. 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) summarized mark and recapture experiments that showed approximately 10% straying in pink salmon with most straying to nearby streams. The genetic structure of pink salmon populations reflects this pattern of straying, though only regional patterns of stock separation have been described. In general the odd and even-year lineages of pink salmon are more different genetically than stream populations over large areas (Heard 1991).



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 from the 1950s to the present is 153,000 odd-year adult pink salmon and 123,000 adult pinks in even years, with ranges from 5,000 in 1988 to 400,000 in 1987. In the late 1950s and early 1960s, an intensive pink salmon survey that included enumeration, as well as water and air temperatures was conducted on Kitwanga River. Adult spawners and smolts were counted through a fence located close to the Skeena River during 1959 and 1960. Strip counts were conducted from the mouth up to Kitwanga Lake; these were followed by aerial counts, and in some years documented with aerial photographs.

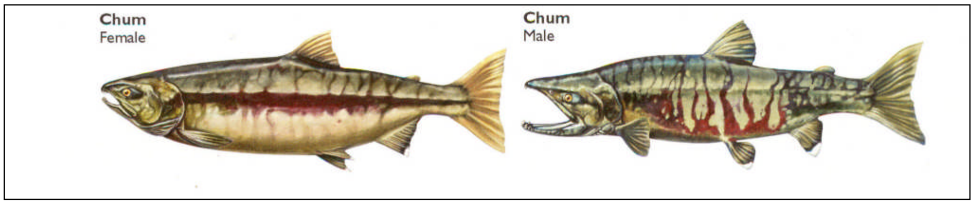
Large numbers of pink salmon generally enter the Kitwanga River in early to mid-August, in three timing groups. Early spawners use the lower Kitwanga River downstream of

Kitwancool Creek, with major concentrations from Tea Creek downstream to the Skeena confluence. In years of high abundance they may make use of the river up to and including Moonlit Creek. A second spawning group usually arrives seven to ten days later that prefers the mainstem between Kitwancool Creek and Moonlit Creek, and in years of high abundance spawn up to the lake outlet (Woloshyn 2002). The third group usually spawns between Moonlit Creek and Kitwanga Lake.

Immediately after they emerge from the gravel in the spring, the young pink fry move down to saltwater and after a few months in the estuary and nearshore zone, they move out into the open ocean in large schools. There, pink salmon feed on zooplankton and krill, which gives their flesh the bright pink colour for which they are named.

Chum Salmon

Chum salmon are the least abundant of the six Pacific salmon species in the Skeena Watershed. In the Skeena Watershed, chum salmon live two to five years with three and four year old chum comprising approximately 20% and 80% of the returning fish. There is an extraordinary variability in year-to-year chum salmon returns. Annual escapement estimates in the SEDS have varied one hundred fold over the past fifty years.



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 generally stayed at low levels over the last fifty years. With the exception of the spectacular high escapement in 1988, the average escapement has 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.

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 southern Alaskan net fisheries. Charles and Henderson (1985) calculated an overall exploitation rate of between 50% and 83% for the years between 1970 and 1982 on the north coast. This relatively high exploitation rate is probably restricting the chum population to low escapements levels. Chum are also taken in small numbers in First Nations food fisheries. In general, chum are probably the Skeena Watershed salmon species in the greatest danger of significant loss of spawning stocks and genetic diversity. In 2003, a chum genetic program was initiated in the Skeena Watershed with the aim of separating stocks at the river tributary level; results have not yet been evaluated. Chum salmon are large, robust swimmers, but do not leap and are reluctant to enter long-span fish ladders; upstream migration is often stopped at the first significant fish passage barrier.

In relation to other Skeena sub-basins, chum spawning is significant in the Kitwanga River. 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 1950s (DFO 2003). In 1957, chum adult populations abruptly declined until the mid-1980s, when returning adult numbers increased to an annual average over five years of 1,500 chum into the early 1990s. Since 1993, chum escapement has annually averaged less than 400 fish. Chum salmon escapement through the Kitwanga fence was 1,775 in 2003 and 1,169 in 2004 with peak timing in the first two weeks of September.

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. GFA has recently observed chum spawners in the mainstem adjacent to Moonlit Creek and to 200m upstream on Moonlit Creek (Cleveland 2002b). Fry emerge early in the spring and migrate to the Skeena estuary immediately upon hatching. Chum salmon smolts typically remain in the Skeena Estuary for one to several months, growing rapidly before dispersing in the ocean (Healey 1980). There is apparently a high degree of variability in chum survival rates early in their marine life.

Sockeye Salmon

Sockeye salmon are an extremely important food for First Nations residents of Gitanyow and Gitwangak. Aboriginal fisheries have operated for at least 6,000 years, and at present, sockeye salmon are the single most important food item as well as being a cultural icon. The large-scale utilization of the abundant and predictable salmon stocks formed the foundation of their traditional economy. An intricate First Nations salmon fisheries management system in Kitwanga Watershed left a diverse and healthy fish resource at the opening of the Euro-Canadian commercial fishery in the late-19th century (Rabnett *et al.* 2001).

Kitwanga River sockeye salmon abundance has fluctuated at low levels since the early 1960s raising concerns for the stock. Historical escapement records, maintained between 1919 and 1950 (Smith and Lucop 1966), estimated Kitwanga sockeye escapement to be approximately 5,000 to 10,000 spawners annually, though there is inter-annual variability. Escapement since the 1960s has rarely exceeded several hundred spawners, except in 1985 when there were an estimated 2,200 spawners. Gitanyow Fisheries Authority recorded 231 in 2000, 221 in 2001, 978 in 2002, 3,377 in 2003, and 1,264 spawners in 2004. Shortreed and Hume (2004) describe recent sockeye productivity surveys that show juvenile sockeye utilize less than 5% of Kitwanga Lake rearing capacity.

The limiting factors to Kitwanga sockeye production are not well understood. It is highly suspected that a combination of factors has contributed to a low abundance of Kitwanga sockeye. These factors include freshwater habitat modification and degradation upstream of Kitwanga Lake, poor fry recruitment, poor early marine survival, and over-exploitation in the coastal mixed stock fishery. The vulnerability of the Kitwanga sockeye population to any of these factors likely increased as their productivity was eroded by the other interrelated factors.

In the past, spawning occurred in the Kitwanga mainstem below the lake outlet and along the northern and western lakeshore (Smith and Lucop 1966, Jacobs and Jones 1999). Spawner surveys in 1998 by Jacobs and Jones recorded 195 sockeye spawners from the lake outlet to just downstream of Moonlit Creek confluence. Recent GFA observations noted sockeye spawners only in Kitwancool Lake (Cleveland 2002a). Perhaps there were a number of distinctly different sockeye stocks that included river spawners and lake spawners.

Presently, most Kitwanga sockeye spawn on beaches in Kitwanga Lake during September and October. After spawning, their carcasses are either eaten or decompose in the lake. The females construct nests called redds in gravel substrate and bury their eggs immediately after fertilization. The eggs hatch into alevins and remain buried throughout the winter. Free-swimming fry emerge from the gravel during May and feed primarily on zooplankton. The lake is biologically productive with abundant plankton populations, the main food source for sockeye fry. After rearing in Kitwanga Lake for one or two years, the sockeye become smolts in April and May and swim out of the lake down Kitwanga River to the sea. In 2001, the Kitwanga River sockeye smolt program sampled 1,750 smolts for length and weight; average length was 103.5 mm and average weight was 10.2 g. Probably most or all of the smolts are 1 year freshwater residents although a growth check during hot summer weather complicates scale reading.

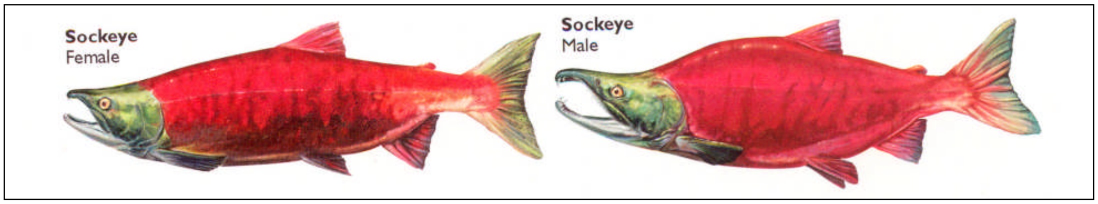
Smolts adapt to the ocean environment while feeding in the Skeena Estuary before typically travelling northward, where they spend one to three years in the North Pacific foraging on amphipods, fish, squids, and euphausiids (Burgner 1991). Most Kitwanga sockeye (approximately 70%) mature at age four after spending two winters in the ocean, while the other 30% return at age five. Cox-Rodgers *et al.* (2004) estimated Kitwanga sockeye run timing into Area 3/4/5 from 2000 to 2002. Timing and density was highly variable ranging from June 15–August 18th. For commercial fisheries management planning, Kitwanga stock timing is considered as Late Non-Babine (LNB).

Kitwanga Lake sockeye are a genetically distinct population (Wood & Holtby 1999) equivalent in differentiation to the evolutionary significant units in the US (Waples 1995) and hence form an important fisheries management unit. In contrast, river dwelling sockeye are relatively similar genetically (Wood 1995, Beacham and Wood 1999). All the life history adaptations and their timing are genetically unique to the Kitwanga stock. There is little possibility that neighbouring sockeye populations could rescue Kitwanga sockeye naturally, given the extremely limited gene flow and the degree of local adaptation. The Kitwanga sockeye stock is at a depressed level and at risk of collapse. The collapse of Kitwanga sockeye could lead to extinction, which should be considered irreversible. Consequently the preservation of even small sockeye populations is important to the preservation of species diversity.

The Skeena sockeye salmon fishery began with the first cannery operations in 1877. The high commercial value of sockeye salmon led to a high exploitation rate of Skeena River sockeye in a series of Alaskan, BC coast, and in-river fisheries. In 1907, thirty years after the industry was established, approximately 1.6 million sockeye were canned. There was an overall decline of 50% in the catch from 1910 to 1955. Sockeye salmon were harvested predominantly by gillnets in the Skeena River until the 1930s when powered vessels moved out into Chatham

Sound, Ogden Channel, Brown Passage, and other Skeena Estuary fishing locations. A seine fishery was introduced in the 1950s and grew rapidly through the next two decades.

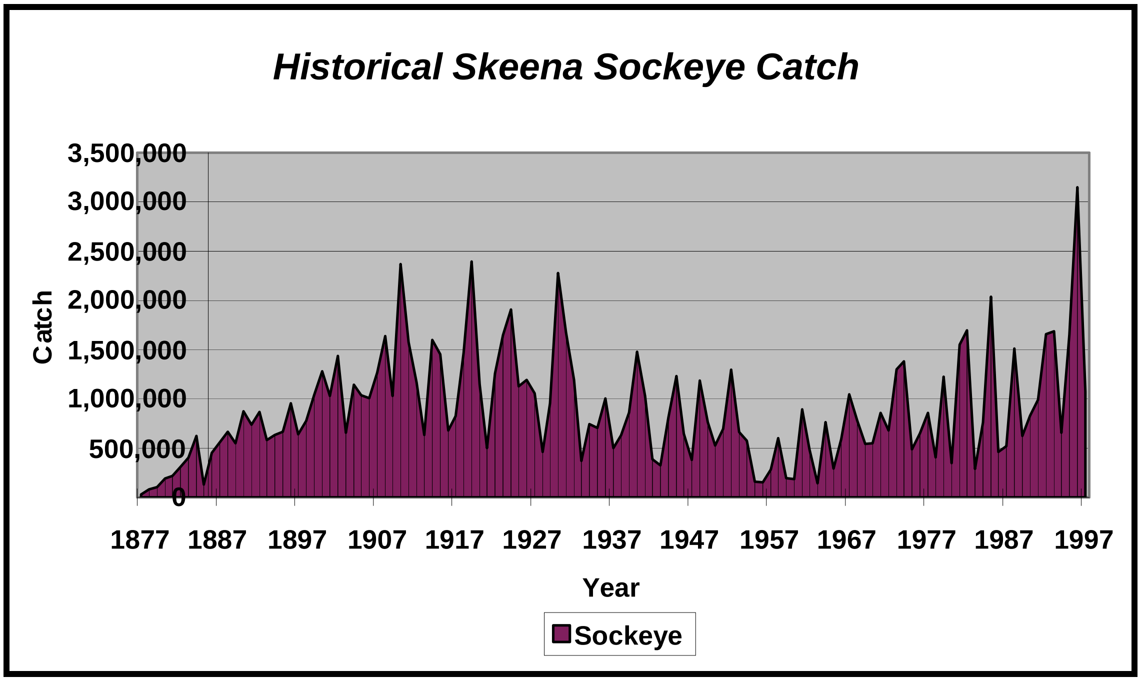
In most years Skeena sockeye salmon migrate homeward through Southeast Alaska, and a significant proportion of the total run may be harvested in Alaskan gillnet and seine fisheries. Since 1985, the Canada–U.S. Pacific Salmon Treaty has limited catches in Alaskan fisheries of Skeena sockeye salmon to 13.8% of the Nass and Skeena runs.



The Canadian commercial catch of Skeena sockeye salmon generally increased after 1970 to a record high of 3.7 million fish in 1996, then declined in 1997, due to disease problems in the Babine stocks (Wood 2001). Over this period, exploitation rates have been fairly constant, averaging 61%, but since 1970 have exceeded 70% four times (Rutherford *et al.* 1999). These relatively high exploitation rates have led to the decline of less productive sockeye stocks.

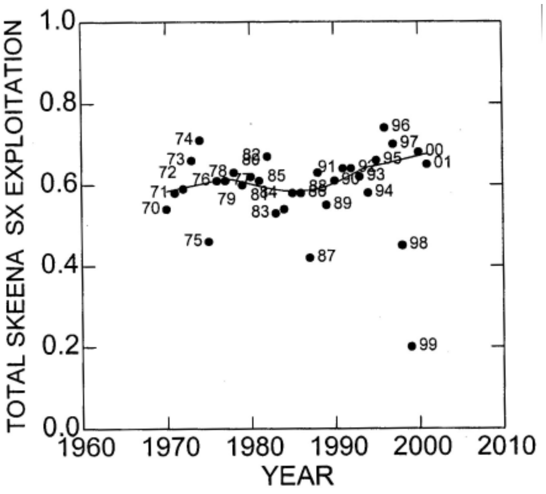
Sockeye salmon are the most valuable commercial fish of the Skeena Watershed and have consequently received much research and management attention. Important sources of information are found in Brett 1952, Larkin and McDonald 1968, Smith *et al.* 1987, Rutherford *et al.* 1999, Shortreed *et al.* 1998 and 2001, and Wood *et al.* 1997. The total annual Skeena Basin sockeye run size (i.e. before harvest) averages several million fish. The vast majority of Skeena sockeye return as four and five year old fish, although three year old males (jacks) are common in some years. Skeena sockeye fry typically rear in lakes; therefore, the adults usually spawn in streams either tributary to lakes or near the outlet of lakes.

Babine sockeye studies and investigations began with the Fisheries Research Board of Canada in the 1940s. In the 1960s, the Babine Lake Development Project (BLDP) constructed artificial spawning channels and dams to provide for water flow regulation; these were located at Pinkut Creek and Fulton River, tributaries of Babine Lake. The BLDP project boosted sockeye production to the point that enhanced Babine sockeye represents at least 90% of the overall aggregate run of sockeye salmon in the Skeena River. In contrast, prior to the enhancement work, Babine sockeye represented less than 80% of the overall Skeena sockeye aggregate (Wood *et al.* 1998). The maintenance of high exploitation rates for Skeena sockeye has precipitated conservation concerns for various wild Skeena sockeye stocks, including the Kitwanga River sockeye population (Cleveland 2004).



Cleveland 2004

Graph shows aggregate Skeena sockeye catch between 1877 and 1997.



Proportion of sockeye harvested in all fisheries 1970-2001. The line is a LOWESS smoothed regression.

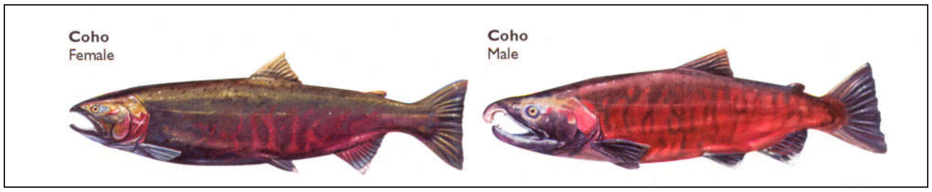
From Cox-Rodgers 2001.

Coho Salmon

Coho salmon in the Skeena Watershed are composed of approximately twenty-five major populations and numerous smaller ones. Coho salmon are widely dispersed throughout the watershed and show the least amount of concentration into a few, large 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).

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, and in years of low flows may typically stray to other nearby streams or spawn further downstream after holding. Sandercook (1991) suggested that typical straying rates are less than 1% with most straying to nearby similar streams. The genetic structure of coho reflects this pattern of straying adults with Wood and Holtby (1999) showing straying rates of less than 1% are sufficient to ensure gene flow between nearby streams. Coho appear to wander freely within their spawning stream, taking advantage of fall floods to pass barriers such as beaver dams in order to occupy new upstream areas.

In general, Skeena coho stocks declined significantly in the 1980s and 1990s. The decline in coho stocks is attributed mainly to a combination of Alaskan and Canadian troll and net fisheries and unknown ocean survival factors. Tagging information available for Babine coho suggests that the stocks have a distinct ocean distribution off southeast Alaska.



Total exploitation rates before 1998 ranged for the most part from 60% to 75%. 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. The low escapements of Skeena coho in the 1980s and 1990s raised concerns about coho survival, especially survival of stocks spawning upstream of Terrace. DFO responded to this management crisis by instituting significant changes to the commercial and sports fisheries in 1998 and 1999 that were directed at reducing the catch to zero. Severe restrictions on commercial fishing continued through 2001. These actions along with better-than-average ocean survivals has increased escapements in recent years.

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 because they spawn earlier in cold-water tributaries and have longer 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. Coho are usually the last salmon to spawn in the fall with spawning occurring from the end of September through December.

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 rearing typically takes place in low gradient streams, ponds, and lakes. In ponds and lakes, juveniles inhabit the near-shore littoral zone (Irvine and Johnston 1992). Riverside channels and small streams with structural complexity that includes stones, logs, and overhanging vegetation provide preferred habitat. Coho are dependent on low gradient streams (<2%) for rearing habitat (Nass *et al.* 1995). Coho frequently occupy small upstream habitats, often moving into these small spawning streams when heavy fall rains increase water flows, allowing them to get over obstacles such as beaver dams.

Coho mostly smolt after two winters and migrate downstream to the ocean with the spring high water, but the proportion of age classes is unknown. Smolts to adult survival rates are a measure of ocean survival. Coho adults return after about 16 months at sea. The general pattern through the1990s in Oregon, Washington, and British Columbia was a decline in ocean survival. Mortality is highest in the first year at sea and probably in the first months.

Coho salmon in the Kitwanga Watershed are widespread in stream habitat, although knowledge of them is scant. Escapement records show escapement trends of less than 300 coho for the 1960s, while the 1970s and 1980s show average escapements of approximately 600 fish annually. Records are incomplete for the 1990s; however, escapement in 1990 was 2,500 coho (DFO 2003). GFA mainstem stream walks and weir enumerations recorded 2300 coho salmon in 2000, approximately 4,000 in 2001, 2,002 coho in 2003, and 2,760 fish in 2004. Counts of coho spawners are notoriously difficult and often underestimate true escapement numbers.

Coho dipnetted from fence sampling box.
Gitanyow Fisheries Authority 2004.

Generally, coho migrate into the Kitwanga system from early September to mid-October. They hold in the mainstem and off tributary mouths until fall storm 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 (DFO 1991). The major tributaries – upper Kitwanga River, Moonlit Creek, Kitwancool Creek, Deuce Creek, and Tea Creek – support coho spawning in varying degrees, though there is no known escapement data for any of the tributaries (DFO 1991).

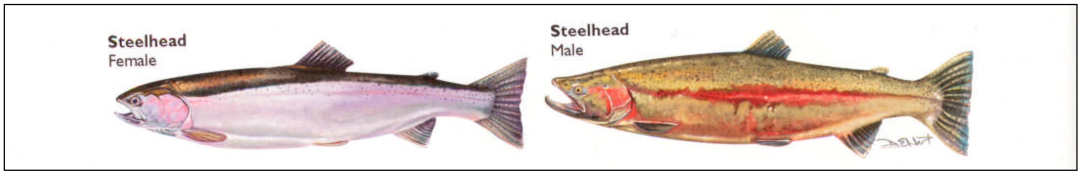
Steelhead

The Kitwanga Watershed supports one of the significant steelhead populations in the Skeena Watershed. Kitwanga Watershed supports summer-run steelhead populations that enter the mouth of the Skeena in July through September, arriving in the area beginning in August and continuing into autumn (DFO 1991). This run supports aboriginal and recreational fisheries.

Overall, the Tyee Test Fishery provides the best estimates for summer run steelhead escapement trends to the Skeena Watershed. Summer run steelhead arrive relatively late in the Skeena along with coho salmon. 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.

Total summer run escapement estimates based on the Tyee index data began in 1956. 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 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. Spence and Hooton (1991) suggested a minimum escapement target of 26,500 for Skeena River summer run steelhead, assuming no upriver harvest. Allowing for aboriginal food fisheries, the minimum escapement should be at least 28,000; however, the available data suggests only 9 of the last 45 years have met this criterion.

Low levels of straying are characteristic of steelhead and where straying occurs, it is likely to streams close to the spawning stream (Quinn 1993, Heath *et al*. 2001). 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. It is not known whether Kitwanga steelhead are a separate stock or are related to mid Skeena River or Zymoetz River stocks and to what degree, if any.



There is little 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. Changes to steelhead populations in Skeena tributary watersheds are hard to identify due to a shortage of relevant information. In 2003 and 2004, GFA enumerated steelhead with a resistivity counter at the

Kitwanga counter fence. This facility will allow accurate determination of adult steelhead on an annual basis.

Lough's (1983) radio telemetry study identified important adult overwintering areas in the lower 15 kilometres of the Kitwanga River, which contains extensive bedrock outcroppings and deep back-eddy pools. Lough (1983) also found steelhead overwintering in the Skeena River, and although steelhead were not found in Kitwanga Lake, the lake may be an important overwintering locale. Data from Kitwanga scale aging showed that juveniles stayed in freshwater for three to five years (mean = 3.67years) and in saltwater one to two years (mean = 1.67 years). The age before first spawning ranged from four to seven years with the majority (44.4%) being six years old (Grieve and Webb 1999).

Lough (1983) reported that Kitwanga River steelhead moved in early May onto spawning sites located throughout the mainstem below Kitwanga Lake, and that spawning activity peaked in mid-May, with most kelts departing by the end of May. The dominant steelhead spawning ground appears to be from Kitwanga Lake downstream to the Moonlit Creek confluence, though the lower 2 km above the Skeena River are also preferred. Kitwancool and Tea Creeks are also identified as spawning areas (Lough 1983, Grieve and Webb 1999). Cleveland (2002b) reported at least 145 steelhead adults returned to spawn in 2001.

Steelhead fry emerge between mid-August and mid-September and are widespread throughout smaller tributaries that offer suitable refuge; however, the highest densities are found in the mainstem between Skeena River and Kitwanga Lake (Beere 1993, Bustard 1992, 1993). Over three years, the overall combined density for fry and parr 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%.

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, located between Kitwanga River and Kitwancool Creek, 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).

Weir on Kitwanga River, 1945, located approximately 2 km downstream of Lake. FRB of Canada.

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 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 (Morrell 1985). 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 gaff, net, and weir fisheries occurred on the Kitwanga River, by far the most intensive fishing effort was the harvest at weirs above and below Gitanyow village (Prince 2005). These productive weirs, built across the shallow river, supplied most of the salmon needs for the Gitanyow people. Known fish weir locations include the outlet of Kitwanga Lake, multiple sites from the lake outlet to Gitanyow village, at a site downstream from the Kitwanga-Kitwancool confluence, and another, approximately 8 km north of Kitwanga.

Posts pounded into the river bottom and then overlaid with panels or pickets of split cedar or saplings that were secured on the upstream side formed the basic structure. This often supported a walkway across the top that enabled access to barrel-type (moohl) traps. The traps were often fitted with a movable panel through which fish could be dipped, gaffed out, or released, dependent on whether the species was desired.

Fish weir on the Kitwanga River, note basket traps on far shore.
Louis Shotridge, 1918 (CMC, 71-8442).

In 1998, Gitanyow Elders described their recollections in regard to Kitwanga sockeye, historic spawning locations, approximate sockeye numbers, declines in salmon abundance, and changes observed in the watershed, in taped interviews and at a workshop on the constraints to Kitwanga sockeye production, (Jacobs and Jones 1999). Gitanyow Elders indicated that declines in salmon returns began in the 1960s, with most sockeye fishing sites along the Kitwanga River abandoned by the early 1970s (Jacobs and Jones 1999).

Traditional basket fish trap (moohl) similar to that used in Kitwanga River weirs.
K'san Historical Museum, Hazelton.

Elders indicated that declines in salmon coincided with an increase in industrial logging, with the fish weir on lower Kitwanga River, and increased commercial fishing at the coast. Comments were also made on the increase in Kitwanga Lake summer temperatures, the observed increase of aquatic plants in the lake, and an increase in beaver activity (Jacobs and Jones 1999). All of the Elders interviewed recounted historic concentrations of spawning adults in Kitwanga River downstream of the lake.

Recreational Fisheries

Kitwanga River and Kitwanga Lake attract a moderate recreational fishery that is predominantly made up of regional residents. Angling for chinook, coho, and steelhead is popular, particularly at the Skeena-Kitwanga confluence, though steelhead fishers utilize various sites along the mainstem. Kitwanga Lake is fished in all seasons for resident cutthroat and rainbow trout, and is easily accessible from Highway 37 North. Since 1991, guiding on Kitwanga River has not been permitted.

GFA 2002

Anglers at Skeena–Kitwanga River confluence.

Creel surveys for chinook and coho fisheries at the mouth of the Kitwanga River were conducted in 2000 and 2001. The recorded sports fishing harvest is small; 113 chinook in 2000 (Gottesfeld 2001) and 25 coho in 2001 (Hall and Gottesfeld 2002). Creel survey data related to seasonal angling and species fished for the river and lake is discussed by 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 (MWLAP 2005).

Enhancement Activities

The Fisheries Research Board operated a counting fence focused on pink salmon enumeration on the lower river close to the Skeena confluence from 1959 to 1960. A coho incubation box located at the Gitanyow ground channel has been in operation to raise 10-12,000 coho eggs annually (Jacobs and Jones 1999, Kingston 2002). Since the mid-1990s, the GFA has been active in enhancement work primarily directed to facilitating fish access, beaver dam passage mitigation, and salmonid fry salvage (Cleveland 2005).

Development Activities

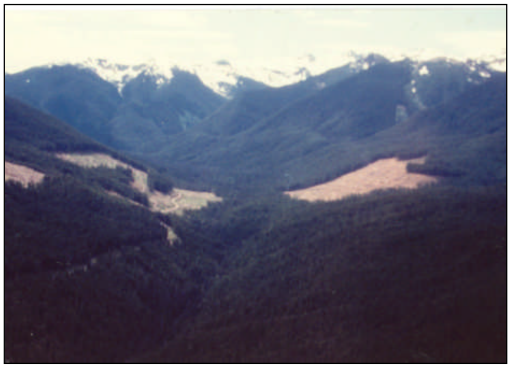
The principal development activities involve forest development, population and settlement, and linear development. There are few mineral occurrences and no known mineral developments in the watershed.

Forest Resource Development

The Kitwanga Watershed is located within the Ministry of Forests, Skeena Stikine 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 the demand for lumber. Independent cedar pole loggers also saw a high demand for poles at this time. In the early 1950s, 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. In 1962, logging was initiated adjacent to Kitwanga Lake. By the mid-1960s, many accessible timber stands in the valley bottom from the Skeena River to the Cranberry River were being logged.

Since the mid-1960s, clearcut harvesting has been the preferred silviculture system. In 1963, consolidation of seven or eight small mills led to the establishment of Hobenshield's mill (now Kitwanga Lumber Company) at its present location in Kitwanga, BC. The Canadian Cellulose sawmill was constructed in Kitwanga in the early 1970s. During the 1970s, 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 1980s, the upper Kitwanga valley, along with the slopes to the east of Gitanyow and around Kitwanga 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 1990s was concentrated in McKenzie, Manuel, Hanna, and other headwater drainages of the upper Kitwanga River, with widespread and dispersed development elsewhere in the watershed.



View westward to upper Kitwanga River.

Figure 2: Kitwanga Wshed showing Forestry.

In the early 1990s, forest development activities raised fish and fish habitat concerns with First Nation peoples, local residents, and fish conservation interests. From 1995 to 2001, the Kitwanga Watershed Restoration Program was involved in assessing the forestry related impacts and upslope sediment-producing areas in relation to fish and fish habitat (McElhanney 2001). 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). McElhanney (2001) summarized the twelve 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 Kitwanga Lake, which was adversely affected by logging and roadbuilding, remains an outstanding compound problem from a fisheries perspective (Cleveland 2002a). This problem is due to the beaver expansion following the spread of deciduous trees into clearcuts, and most likely, an increase in the water table. The beaver dams have 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, and is currently in receivership. Kitwanga Lumber Co. has managed to stay in logging and sawmill production. The Ministry of Forests, BC Timber Sales program is active in the west Kitwanga Lake and Tea creek areas. Adding to the uncertain future are high stumpage rates, and the results based *Forest and Range Practices Act*. 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.

The Kispiox LRMP, as well as other integrated resource management plans that preceded it, have not been effective in managing and maintaining water quality, stream channel integrity, riparian values, and fish habitat. This sub-regional land use plan is biased towards timber extraction; objectives involving fresh water, riparian and streambank integrity, and fisheries are weak and vague, or appear to have been ignored, at the site-specific and watershed level. This situation is exacerbated by inter-agency disputes, and the lack of commitment by government agencies and planners to fund their own and other programs such as the Watershed Restoration Program (WRP), and to monitor plan effectiveness.

Transportation and Utilities

The existing transportation network in the watershed reflects eighty 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. 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 Kitwanga Lake and through the divide into the Nass drainage. Highway 37 North, a paved all-weather road provides north-south access with all secondary roads branching off it. The highway links Gitwangak, Gitanyow, and Kitwanga villages with the Nass River valley. Secondary roads branching off Highway 37 include: Kitwanga Backroad, Tea Lakes Forest Service Road (FSR), Mill Lakes FSR, Ten Link Creek Road, Kitwancool FSR, 18 Mile Branch, Moonlit Branch, Rehab Branch, 26 Mile FSR, 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. 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, SNDS 1998). 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. The population trend for the two First Nations communities points to slow, steady growth.

Cumulative Effects

The decline of biological diversity in the watershed, particularly viewed by the decline in various salmon stocks, has resulted from the cumulative effects of land use practices, fish harvest management, 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 – can 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.

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, or other activities. 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 problems.

Within the context of conserving and restoring biodiversity in the Kitwanga 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 the watershed. Historical and current patterns of land use activities and practices, particularly forest development, though other land use and practices as well, have a significant bearing on how salmonid populations will respond to further anthropogenic disturbances. Within the Kitwanga Watershed, past resource extraction management strategies that have relied on site-specific analysis without regard for other activities that have or may occur within the watershed have generally failed to protect salmonid populations against cumulative effects.

Secondly, declines in the Kitwanga sockeye are the product of numerous incremental changes in their habitat and population. Recovery and conservation of salmonid populations may proceed in a similar way - through incremental improvements in habitat conditions, using 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 and agencies can and must play an active role in salmonid conservation and restoration even if tangible efforts are slow to manifest.

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