Kitwanga Sockeye Salmon Recovery Plan (KSRP)

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May 2006

Kitwanga Sockeye Salmon Recovery Plan

Overview

The Kitwanga River is a tributary of the Skeena River located approximately 250 km inland from the ocean near the villages of Kitwanga and Kitwancool. Its riverbanks are home to First Nations People of Gitksan descents, who have inhabited the watershed for thousands of years. In the past the Gitanyow and Gitwangak People harvested salmon from the Kitwanga River in large numbers, a practice that determined the size and location of the villages. Sockeye salmon was the species of choice, making up the main staple of their diets until the 1970's when the fishery was abandoned due to extremely low ocean escapement of adults.

Historically, Kitwanga sockeye returns to the Kitwanga River were in the tens of thousands. More recently, sockeye escapement counts have shown drastic declines to the point where in some years only a few hundred fish made it back to spawn. Exploitation rates on the Kitwanga River sockeye stock over the last one hundred years have been high, which has no doubt impacted the stock. Another factor contributing to the decline is habitat changes within the watershed caused by poor forest harvesting activities. These changes are believed to have affected spawning and rearing areas in a negative manner within Gitanyow Lake, the only known spawning and rearing areas for sockeye salmon within the Kitwanga Watershed.

This plan will form the basis of the Kitwanga Sockeye Salmon Recovery Strategy. An expert panel made-up of First Nation, federal and provincial government agents and other public bodies with a vested interest in Kitwanga sockeye, has been formed to review the available data discussed in this report and to recommend options to rebuild Kitwanga sockeye. Therefore, it is anticipated that this report will be updated as the rebuilding framework for Kitwanga sockeye salmon becomes apparent.

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EXECUTIVE SUMMARY

The Kitwanga River is biologically rich, supporting populations of all six species of salmon found in North America, as well as various species of resident salmonids and coarse fish. A species of significant importance in the Kitwanga River is sockeye salmon. Historically, Kitwanga sockeye numbered in the tens of thousands, and were actively fished for sustenance purposes by the Gitanyow and the Gitwangak who inhabited the watershed. However, drastic declines in stock abundance were observed in the 1960's and today the stock is no longer fished for Food, Social or Ceremonial purposes because of conservation concerns.

Kitwanga sockeye are an evolutionary significant unit as defined by Waples (1995) and therefore an important fisheries management unit. This suggests that Kitwanga sockeye have developed specific life history adaptations and timing regimes that are genetically unique and there is little possibility that neighbouring sockeye populations could replace Kitwanga sockeye naturally, given the extremely limited gene flow and the degree of local adaptation. The Kitwanga sockeye stock is currently at a depressed level and at risk of collapse. The collapse of Kitwanga sockeye could lead to extinction, which should be considered irreversible. The reasons for the stock decline are not completely understood, however it is believed that over-exploitation in the commercial fishery and habitat deterioration in Gitanyow Lake are the main contributors to the stock collapse. Fishery re-constructions for the last 40 years show average exploitation rates on Kitwanga sockeye of over 50%, reaching highs of over 65% in some years. Furthermore, the Kitwanga Watershed was heavily logged beginning in the 1960's and it is believed that both spawning and rearing areas have been negatively impacted by road building and harvesting activities.

In response to the conservation concern for Kitwanga sockeye, the Gitanyow Fisheries Authority (GFA) in co-operation with Fisheries and Oceans Canada (DFO), the Skeena Fisheries Commission and the Province of BC have initiated a rebuilding plan to restore Kitwanga sockeye while retaining the genetic endowment of the stock. The plan identifies potential limiting factors to production and recommends recovery actions.

It is anticipated that the plan will begin implementation in 2006 with funding from the Pacific Salmon Commission – Northern Boundary Fund. Projects that will receive priority for 2006/07 will include:

- The collection and culture of Kitwanga sockeye brood in a hatchery setting in order to release 100,000 fry into Gitanyow Lake in the spring of 2007. If successful this will allow for a production boost in excess of 85% from the egg to fry stage, helping to increase adult recruitment in 2010 and 2011.
- Pilot restoration programs of known Kitwanga sockeye Lakeshore spawning areas. This project will consist of small scale restoration initiatives to clean sediment infiltrated spawning grounds, the removal of macrophytes and the addition of superior quality gravel.
- As in other years, the Kitwanga sockeye smolt output during the spring of 2006 will be assessed, and the escapement of adults during the summer and fall of 2006 will be counted.

SUMMARY

- Kitwanga sockeye originate from Gitanyow Lake, one of the 10 Skeena River wild sockeye producing lakes.

- Kitwanga sockeye salmon are genetically unique and spatially separated from other Skeena River sockeye populations (none or little gene flow).

- Traditionally, the Gitanyow and Gitwangak People who inhabit the watershed fished Kitwanga sockeye, but today the stock is not targeted for Food, Social and Ceremonial purposes due to conservation concerns for the stock.

- Historically, sockeye escapement to Gitanyow Lake numbered in the tens of thousands per year. Today, only a fraction of these historical sockeye escapement numbers persist.

- Recently, sockeye returns to the Kitwanga Watershed have averaged less than 1,200 adults per year. Escapement lows of only a few hundred fish have been observed in 2 out of the last 6 years (2000-2005).

- Stock assessment patterns for Kitwanga sockeye over the last 50 years show low but stable escapement trends, and presently the stock is producing only 5% of the potential for the system.

- Lake productivity studies on Gitanyow Lake have shown that the system is biologically productive.

- Based on the trophic status alone, Gitanyow Lake could produce about one million sockeye smolts per year resulting in an optimum adult escapement exceeding 18,000.

- Exploitation rates on Kitwanga sockeye have been high since the inception of commercial fishing at the mouth of the Skeena River in 1877 (>50% in most years).

- Kitwanga sockeye salmon run timing corresponds almost perfectly with that of the enhancement portion of Lake Babine sockeye.

- Over fishing has stressed the Kitwanga sockeye stock significantly.

- The Kitwanga Watershed has undergone major changes over the last 45 years. Logging has shaped a new landscape, which has altered the ecology of the system.

- It is believed that Gitanyow Lake spawning and rearing areas have been adversely affected by changes to the annual water flow pattern, increased sediment input and increased macrophyte growth.

- Increasing fry production by increasing adult escapements, combined with spawning habitat restoration and/or fry out planting, has been suggested for improving sockeye production from Gitanyow Lake.

BACKGROUND

Geographical Setting

Kitwanga Watershed

The Kitwanga Watershed drains into the right bank of the Skeena River approximately 250 km inland from the ocean or 90 km east of the town of Terrace, BC. 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. It has a catchment area of approximately 833 km^2 and is drained by the Kitwanga River and four major tributaries. The Kitwanga River has four major tributaries including Tea Creek, Deuce Creek, Kitwancool Creek and Moonlit Creek (Figure 1). There is only one lake in the system, called Gitanyow Lake (also called Kitwancool or Kitwanga Lake). The watershed is home to the Gitksan First Nations communities of Gitwangak, and Gitanyow. The village of Gitwangak is located near the confluence of the Kitwanga River, while the village of Gitanyow is situated in the middle of the watershed some 30 km up river.

The Hazelton Mountains to the west, and the Nass Basin to the north, exert the major hydrological influences. Kitwanga Valley has a broad low gradient valley bottom, although the watershed as a whole has a moderately high response from water input due to the high gradients of the major tributaries. The low watershed divide to the Nass drainage allows coastal weather systems to enter the watershed, leading to heavier snow packs in the mountains and the northern half of the drainage.

The general climate of the watershed is transitional between temperate, maritime coastal climates and the colder, continental climates that characterize the interior of the province. Precipitation is enhanced by orographic effects in the mountainous watershed. Mean annual precipitation ranges from 2500 mm on the high elevation windward mountainsides to approximately 500 mm in the valley bottom at Kitwanga.

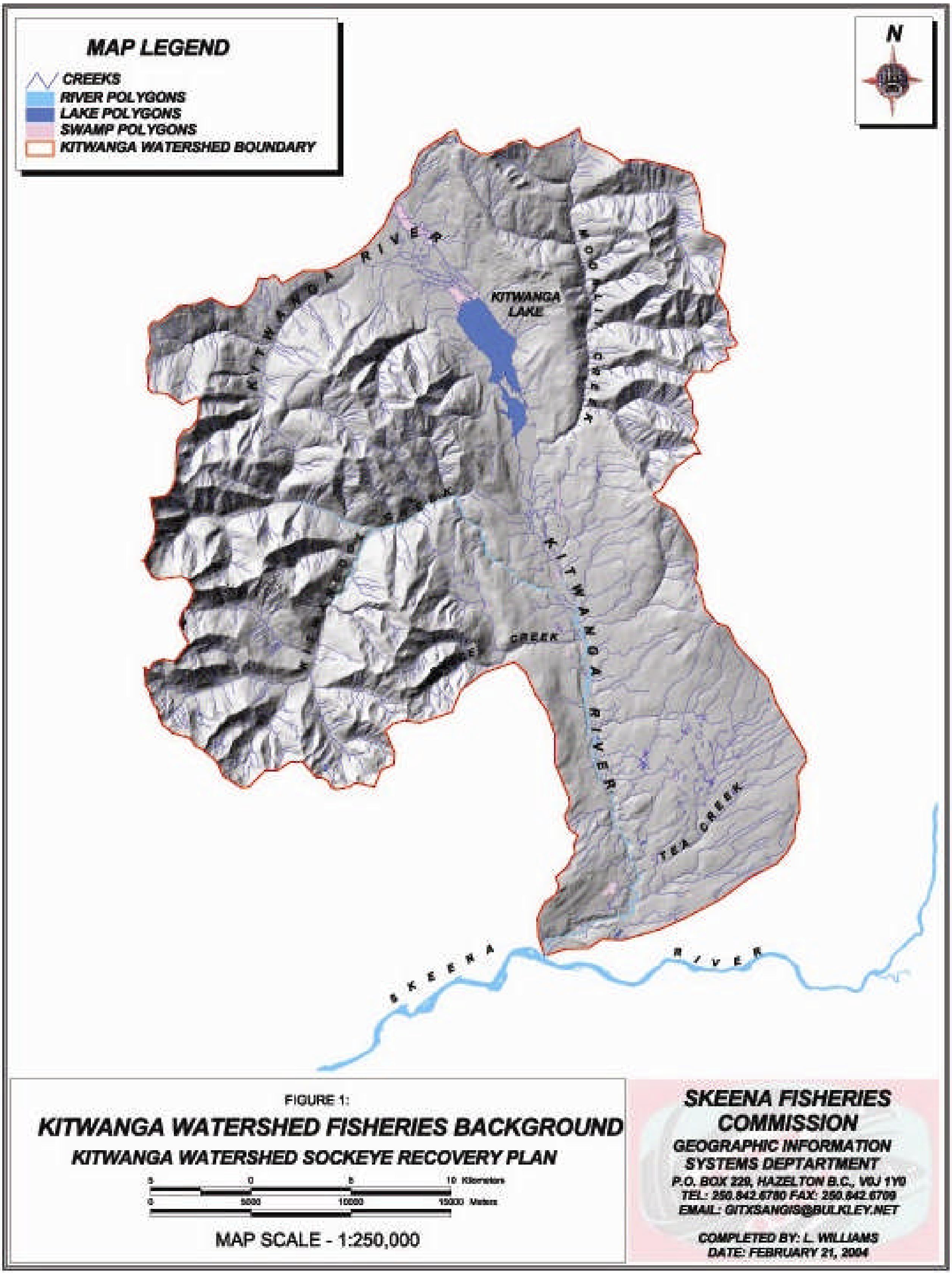
The lake catchment contains high mountain areas that remain snow covered for most of the year. Upper Kitwanga River (above Gitanyow Lake), Kitwancool Creek, and Deuce Creek drain the Nass Range. Moonlit Creek drains the bulk of the Kispiox Range that is situated to the east. These tributaries contribute 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 stream instability and landslide failures. Gitanyow Lake and the extensive wetlands upstream of the lake constitute the primary water storage.

Biologically the Kitwanga Watershed is extremely rich, with an abundance of high valued fish habitat. It supports the following species of salmonids (Gottesfeld et al. 2002):

- Sockeye / Kokanee Salmon (*Oncorhynchus nerka*)
- Chinook Salmon (*O. tshawytscha*)
- Pink Salmon (*O. gorbuscha*)
- Chum Salmon (*O. keta*)
- Coho Salmon (*O. kisutch*)
- Steelhead / Rainbow Trout (*O. mykiss*)
- Cutthroat Trout (*O. clarki*)
- Dolly Varden (*Salvelinus malma)*
- Bull Trout (*Salvelinus confluentus*)
- Mountain Whitefish (*Prosopium williamsoni*).

A data query of the BC Ministry of Sustainable Resource Management Fisheries Inventory websites also list the following fish species as being present in the Kitwanga Watershed (BC MSR 2006):

- Prickly Sculpin (*Cottus asper*)
- Slimy Sculpin (*Cottus cognatus*)
- Largescale Sucker (*Catostomus macrocheilus*)
- Longnose Sucker (*Catostomus catostomus*)
- White Sucker (*Catostomus commersoni*)
- Northern Pikeminnow - formerly known as N. Squawfish (*Ptychocheilus oregonensis*)
- Peamouth Chub (*Mylocheilus caurinus*)
- Pygmy Whitefish (*Prosopium coulteri*)
- Redside Shiner (*Richardsonius balteatus*)
- Threespine Stickleback (*Gasterosteus aculeatus*)


MAP LEGEND
CREEKS
RIVER POLYGONS
LAKE POLYGONS
SWAMP POLYGONS
KITWANGA WATERSHED BOUNDARY
N
KITWANGA RIVER
KITWANGA LAKE
CREEK
TEA CREEK
SKEENA RIVER
FIGURE 1:
KITWANGA WATERSHED FISHERIES BACKGROUND
KITWANGA WATERSHED SOCKEYE RECOVERY PLAN
MAP SCALE - 1:250,000
SKEENA FISHERIES COMMISSION
GEOGRAPHIC INFORMATION SYSTEMS DEPTARTMENT
P.O. BOX 229, HAZELTON B.C., V0J 1Y0
TEL: 250.842.6780 FAX: 250.842.6709
EMAIL: GITXSANGIS@BULKLEY.NET
COMPLETED BY: L. WILLIAMS
DATE: FEBRUARY 21, 2004

Kitwanga River

The Kitwanga River drains to the south. The UTM coordinates at its confluence with the Skeena River are 09055840 N, 6106300 E (Cleveland 2000). It is a fifth order stream with a mainstem length of approximately 61 km and an average channel width of 15 m (5-40m). The river can be broken into the Upper Kitwanga River and the Lower Kitwanga River, the divide being Gitanyow Lake. The Lower Kitwanga River has a mainstem length of approximately 36 km and receives drainage from the four major tributaries in the system (Cleveland 2000). There are seven homogenous stream reaches in the lower river with gradients ranging from 0.5 – 0.7% (Rabnett 2005). Most of these reaches have a substrate composition of cobbles and gravels making them appropriate for spawning salmon. The Upper Kitwanga River has a mainstem length of approximately 25 km and no major tributaries. The upper section can be broken into five reaches with gradients ranging from 0.5 – 7%, with a barrier falls located approximately 12.5 km upstream of Gitanyow Lake. The reach directly above Gitanyow Lake can be described as a complex wetland of multiple meandering channels, with a fine-grained substrate. The area houses an extremely healthy population of beavers. The beavers keep the lower part of the Upper Kitwanga River dammed in most years, significantly restricting water flow and fish passage (McCarthy et. al. 2003).

Gitanyow Lake

Gitanyow Lake is located at an elevation of 376 m (Gottesfeld et al. 2002). It has a surface area of 7.8 km^2 and drains an area of 169 km^2. It receives flow from the Upper Kitwanga River and several other smaller streams mostly concentrated on its west side. It has a volume of approximately 52 million m^3 (DFO 1975). Based on annual average discharges of between 2.3 – 2.6 m^3 / s at the outflow it is predicted that the lake flushes itself 1.5 times per year with most of the flushing occurring between April – July and from mid October to the end of November (GFA 2004). The lake can morphologically be separated into two basins, the north basin being five times larger than the south (Photograph #1).

Photograph #1: Aerial view of Gitanyow Lake taken in July of 2002.

Gitanyow Lake is considered 1 of the 10 important Skeena sockeye salmon producers (Cox-Rogers et. al. 2003). It has the highest photosynthetic rate ever recorded in BC, potentially making it the most productive sockeye nursery lake in the province (Shortreed et al. 1998). *Daphnia* makes up most of the lakes zooplankton biomass (87% in 2004), making it the highest *Daphnia* producer in BC (Photograph #2). *Dapnia* are the preferred food source of juvenile sockeye.

Photograph #2: Enlarged view of a Daphnia (www.bioimages.org.uk)

Species Biology

Description

Sockeye salmon are one of the six Pacific salmon species found in BC. Like all salmonids, sockeye possess an adipose fin distinguishing them from other Families of fishes. Sockeye along with their salmon cousins are distinct from other salmonids because they possess 12 or more anal fin rays. Sockeye can be further distinguished from other salmon because they:

- Possess a large number of long slender gill rakers (28-40)
- Have fine black speckling on their backs
- Have relatively few pyloric caeca (45-115)
- Have no black spotting on their bodies.

Other visual characteristics that aid in the identification of sockeye at sea include a greenish blue metallic colouration on their head and back, bright silver sides and a white belly. As sockeye enter freshwater and approach their respective spawning grounds they undergo striking morphological changes. Spawning sockeye develop bright red bodies (including fins), pale greenish heads, prolonged hooked snouts, gaping mouths and a small hump before the dorsal fin. Colouration changes in females are similar to males but other morphological changes are much less. Juvenile sockeye are silvery in colour with a greenish sheen above the lateral line along their backs. They can be distinguished from other salmon fry by examining parr marks and gill rakers. Sockeye parr marks are short, oval and concentrated above the lateral line with a length less than the vertical diameter of the eye. Sockeye gill rakers are numerous on the first arch with a length almost equal to the length of the gill filaments.

Adult sockeye salmon are classed as one of the smaller Pacific salmon (usually only bigger than pink salmon). The size of an adult sockeye is directly linked to the number of years that it spends feeding in the ocean. Generally, sockeye spend 2 to 3 years at sea and return to spawn at a fork length of 41 – 61 cm (Groot et al. 1995). The size of juvenile sockeye is also linked to the amount of time it spends in freshwater. However, unlike the ocean environment there is a larger variation in physical, chemical and biological features of individual nursery lakes to effect juvenile growth. Temperature and the availability of food are usually the main factors that affect sockeye juvenile sizes. Most sockeye juveniles emigrate to the ocean after spending 1 or 2 years in freshwater (sometimes after 3 years). Smolts usually have an average fork length between 60 – 200 mm, and an average weight between 2.0 – 83.9 g (Groot et al. 1998).

Kitwanga Sockeye Biology

Kitwanga sockeye salmon look a lot like other sockeye salmon you would find along the BC westcoast. In fact, the only way to distinguish sockeye populations is by conducting DNA testing. Adult sockeye returning to the Kitwanga River can vary physically and morphologically depending on how ripe they have become. Usually the earlier returning fish are bright and silver when they are first seen in the river at the beginning of July and until the middle of August when they start to show a little colour (Photograph #3). By the beginning of September and into the middle of October we see the last fish enter the river, the fish become progressively darker taking on their red and green phases, and their distorted body shapes (Photograph #4).

Photograph #3: Adult Kitwanga sockeye captured on August 18, 2003 at Kitwanga River Salmonid Enumeration Facility (~4 km upstream from the mouth or the river).

Photograph #4: Adult Kitwanga sockeye captured on November 13, 2001 at Kitwanga River Temporary Fence (~32km upstream from the mouth of the river).

GFA has sampled Kitwanga sockeye adults extensively over the past 6 years. Sampling to determine fork length measurements of returning adults was conducted through a temporary counting fence stationed near Gitanyow Lake in 2001 and 2002 (~32 km upstream from the confluence of the Kitwanga and Skeena Rivers) and then through the Kitwanga River Salmonid Enumeration Facility (KEF) in 2003, 2004 and 2005 (~4 km upstream from the confluence of the Kitwanga and Skeena Rivers). Mean sockeye fork lengths broken down by sex for the sampling period are presented in Table #1.

Table #1: Kitwanga sockeye adult fork lengths for sampling conducted between 2001 and 2005 (Cleveland et al. 2001, Cleveland 2002, Kingston et al. 2003, Cleveland 2004, Cleveland 2005).

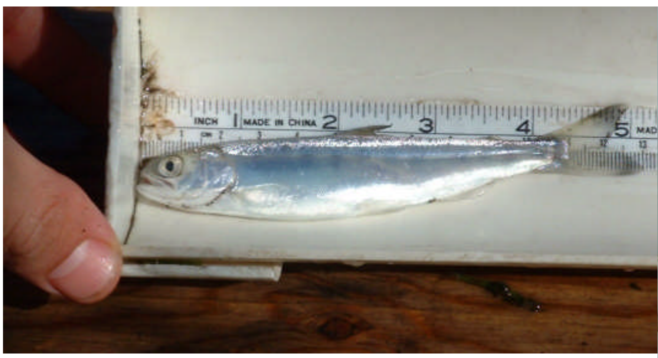
Year	Sample Size (N)	Percent Run	Mean Male Fork Length (cm)	Mean Female Fork Length (cm)	Combined Mean Fork Length (cm)
2001	85	37%	60.8	58.4	59.8
2002	260	27%	59.1	54.6	56.9
2003	120	4%	58.8	55.3	56.6
2004	128	10%	58.3	56.4	57.1
2005	401	43%	57.5	57.2	57.5
Totals	994	24%	58.9	56.4	57.6

Over the last 5 years Kitwanga sockeye have had an average fork length measurement of 57.6 cm. Females were slightly shorter than males with mean fork lengths of 56.4 cm, while males had a mean fork length of 58.9 cm. Quinn studied sockeye female fork lengths in Alaska and showed that female sockeye had an average fork lengths of ~57 cm (Quinn 2005). Groot and Margolis reported similar mean female fork lengths for two Skeena River sockeye stocks. Scully Creek (Lakelse sockeye) sockeye averaged 54.4 cm while Lower Babine sockeye averaged 58 cm (Groot et. al. 1998). The importance of size relates more to females because it can affect factors such as fecundity and survival. Larger females produce larger and more numerous ova as compared to the ova from smaller fish. Larger ova produce larger fry, larger fry usually have a survival advantage over smaller ones. Furthermore, larger females can usually dig deeper redds, providing extra protection for incubating offspring (Quinn 2005).

Kitwanga sockeye smolts have been sampled through various smolt enumeration projects conducted by the GFA from 2000 – 2005. Overall, it is believed that smolts leave Gitanyow Lake predominantly after spending one year in freshwater, but some appear to stay for an additional year. When Kitwanga sockeye smolts were initially aged by the Pacific Biological station in 2001, it was determined that smolts were almost all 2 years olds, but since then additional scale samples have been examined to clarify the current age estimates (2005 ages unavailable for this report). It has been hypothesized that Kitwanga fry may undergo periods in the late summer where they are unable to access food due to elevated temperatures in the epilimnion. It is thought that this period of starvation and hence reduced growth was interpreted as a winter annulus during the initial aging, but this has since been corrected (Shortreed 2004). Sockeye smolts leave Gitanyow Lake silvery white in colour, with a greenish back speckled with dark spots (Photographs #5 and #6). The average length and weight of a Kitwanga smolt is 108 mm and 12 g respectively (Table #2). Kitwanga sockeye smolts are relatively large compared to Babine Lake smolts, Kitwanga smolts are almost twice as long and 2.5 times heavier (Groot et. al. 1998).

Table #2: Kitwanga sockeye smolt fork lengths and weights for sampling conducted between 2001 and 2004 (Williams et al. 2002, McCarthy 2005).

Year	Sample Size (N)	Mean Fork Length (cm)	Mean Weight (g)
2001	1,750	103.5	10.2
2002	1,389	103.9	10.6
2003	1,025	112.3	14.0
2004	465	114.1	14.4
2005	259	116.4	13.4
Totals	**4,888**	**110.4**	**12.5**



Photograph #5 – Sockeye smolt showing silvery white undersides and belly.

Photograph #6 – Kitwanga Sockeye showing greenish back, speckled with dark spotting.

General Sockeye Life History

Sockeye salmon are anadromous (meaning they migrate from the sea to freshwater to reproduce) and semelparous (meaning they die shortly after reproducing). Adults usually spend two or three years in saltwater before traveling back to freshwater to spawn and die, although a small percentage stay one and four years before returning. Sockeye exhibit a multitude of life history strategies in British Columbia that allows them to adapt and flourish in various habitats from the low lands along the coast to the high interior plateau. The natural variations in freshwater habitats that they inhabit play an intricate part of the sockeye salmon's existence, allowing them to be specialists, suited to the environments that they inhabit. For the most part, sockeye demes originate from specific lakes where they have learned to adapt over thousands of years to localized environmental conditions. Sockeye do not stray very far from their natal streams (Groot et al. 1998). Therefore, they do not readily inter-breed with other sockeye stocks. Because of this, sockeye populations are usually genetically isolating from one another (with some exceptions).

In general, sockeye migrate from the sea to their freshwater natal stream from May until October of every year, where they home to the specific areas where they originated (Meehan 1991). Run timings are quite consistent from year to year and spawning usually takes place between August and November. Spawning areas are usually located in stream settings associated with lakes, but lakeshore-spawning sites are also common. Females seek out well-oxygenated nesting areas composed of small to medium size gravels (Meehan 1991). Once suitable nesting areas are selected, dominant males court the females. The females will then dig the redds, which is usually shortly followed by spawning (Groot et al. 1998). Fertilized eggs are deposited in the nest and buried by the females. It is common for a female to have several nests in each redd. Redds are vigorously protected by territorial females that guard the nests until shortly before they die (Groot et al. 1998). Both male and female sockeye die after spawning.

Embryos incubate throughout the winter months (between 80-140 days) and emerge as fry in the spring usually between April and May, depending on water temperatures (Meehan 1991). After emergence, fry migrate to their respective nursery lakes where they spend 1 or 2 years (sometimes 3 in cold unproductive lakes) grazing on zooplankton. Lacustrine juvenile sockeye spend most of their time in the limnetic zone of the their nursery lakes. They conduct diel vertical migrations to access food under the cover of darkness to avoid predation (Groot et al. 1998). The most important food source of juvenile sockeye are planktonic crustaceans, particularly copepods and cladocerans. The preferred food of juvenile sockeye is *Daphnia* and if given the choice young sockeye will feed exclusively on these macrozooplanktons (Shortreed et. al. 1998). After a freshwater residency, fry undergo smoltification where they physiologically prepare themselves for the salt-water challenge that awaits them. Usually, sockeye smolts will commence their downstream descent in either April or May in large schools under the cover of darkness. It should be noted that some sockeye exhibit "river-type" life histories with juveniles that live for one or more years in river channels, there are also "ocean-type" where juveniles descent into the ocean shortly after emergence (Meehan 1991).

After smoltification and exodus from freshwater occurs, young sockeye spend up to a few months actively foraging in the estuarine environment along the coast. At this stage in their lives they feed on a variety of organisms including copepods, insects, amphipods, euphasiids and fish larvae (Groot et al. 1998). As sockeye become acclimated to their new saltwater environment they move northward and northwestward along the coast. As they mature BC sockeye feed in huge areas extending westward to the Aleutian Islands, northward into northern Gulf of Alaska, and southward to about 40°N (DFO Flier – "The incredible Salmonids"). In the open ocean sockeye graze on euphausids (Photograph #7), hyperiid amphipods (Photograph #8), small fish and squid. Copepods, pteropods and crustacean larvae are also eaten but to a lesser extent (Groot et. al. 1998).

Photogragh #7: Depiction of a euphausiid (www.bbsr.edu)

Photograph #8: Depiction of a hyperiid amphipod (www.mywebpages.comcast.net)

Kitwanga Sockeye Life History

Kitwanga sockeye, although genetically distinct from other Skeena sockeye, exhibit similar life history characteristics. Adults return to freshwater predominantly as four and five year old fish after spending 2 or 3 years feeding in the ocean. Migrations to the mouth of the Skeena River from ocean feeding grounds culminate from June through September each year. Once they leave saltwater, they continue their journey up the Skeena River and it is predicted that it takes Kitwanga sockeye between 2-3 weeks to reach the confluence of the Kitwanga River (Aro et. al. 1968). Local anecdotal information indicates that in some years Kitwanga sockeye mill around at the mouth of the Kitwanga River for as long as a few weeks, as they await environmental cues to signal an upstream accent. However, this has never been scientifically verified.

The first sockeye usually enters the Kitwanga River by the second week of July and continue to arrive into the beginning of October. The bulk of the run enters the river during the second and third week of August (Figure 2).

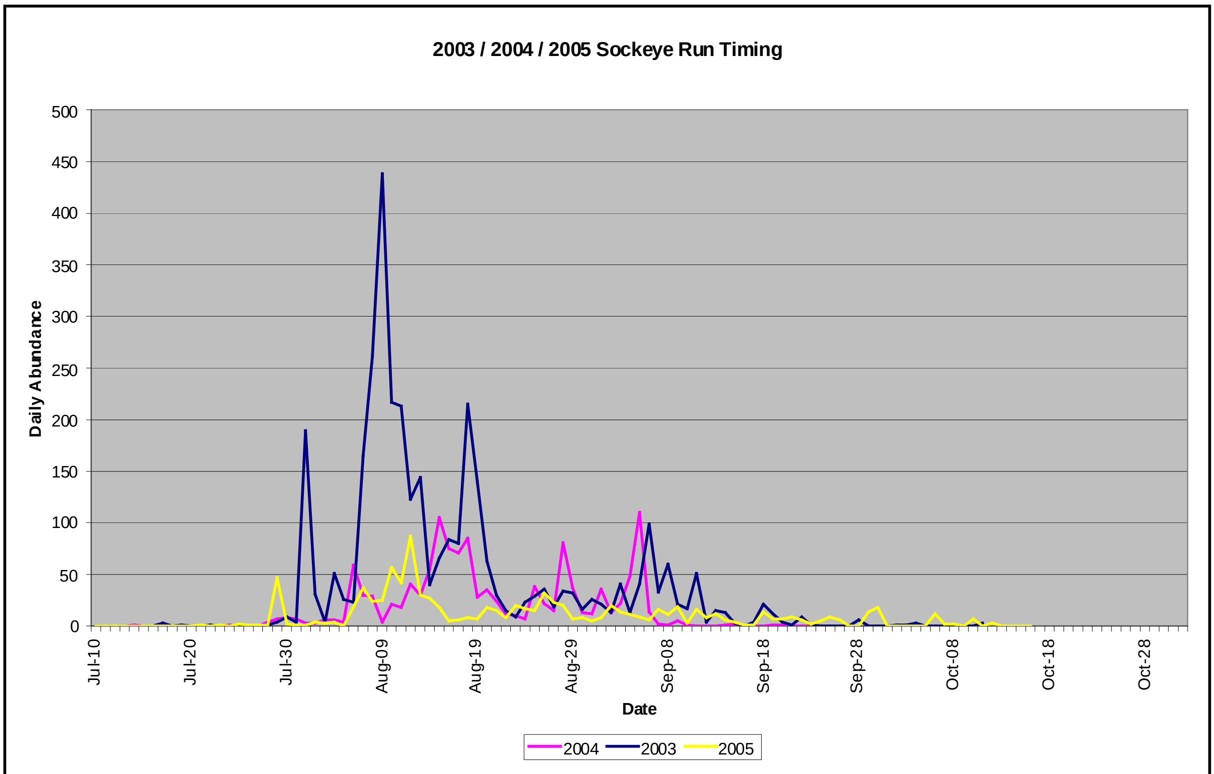


Figure 2. Kitwanga River sockeye salmon run timing at the KEF for 2003,2004 and 2005 (Kingston 2006).

Sockeye make their way up the Lower Kitwanga River traveling some 36 km upstream to Gitanyow Lake. Based on visual observations of sockeye movement in the Kitwanga River, it would appear that as the sockeye approach the lake their migration slows considerably and sometimes stalls for more than a week. In some years schools of sockeye have been observed by GFA staff holding in the mainstem of the river in reach 6 below the confluence with Moonlit Creek. This migration stalling can probably be attributed to the physiological stresses associated with warming river waters as sockeye approach the lake in the early part of the season. This concept will be discussed further in the habitat section of this report.

Kitwanga sockeye enter Gitanyow Lake from mid-August to the beginning of October. Spawning takes place from September to November. A lot of effort has gone into determining current sockeye spawning ground locations and to date only lakeshore spawning sites along the narrows of the western shoreline have been identified (Figure 3). Present day spawning is believed to be isolated to areas concentrated along the western lakeshore in and around the narrows of Gitanyow Lake. However, it is possible that spawning also takes place in deeper sections of the lake where thorough investigations have not been performed. In 2003, several redds were discovered while scuba diving in the center of the narrows at a depth of 9 m (Cleveland[a] 2003). The nests looked identical to other confirmed sockeye redds seen along the lakeshores of Gitanyow Lake. Therefore, it is possible that Kitwanga sockeye also spawn at depths were they can not be readily seen.

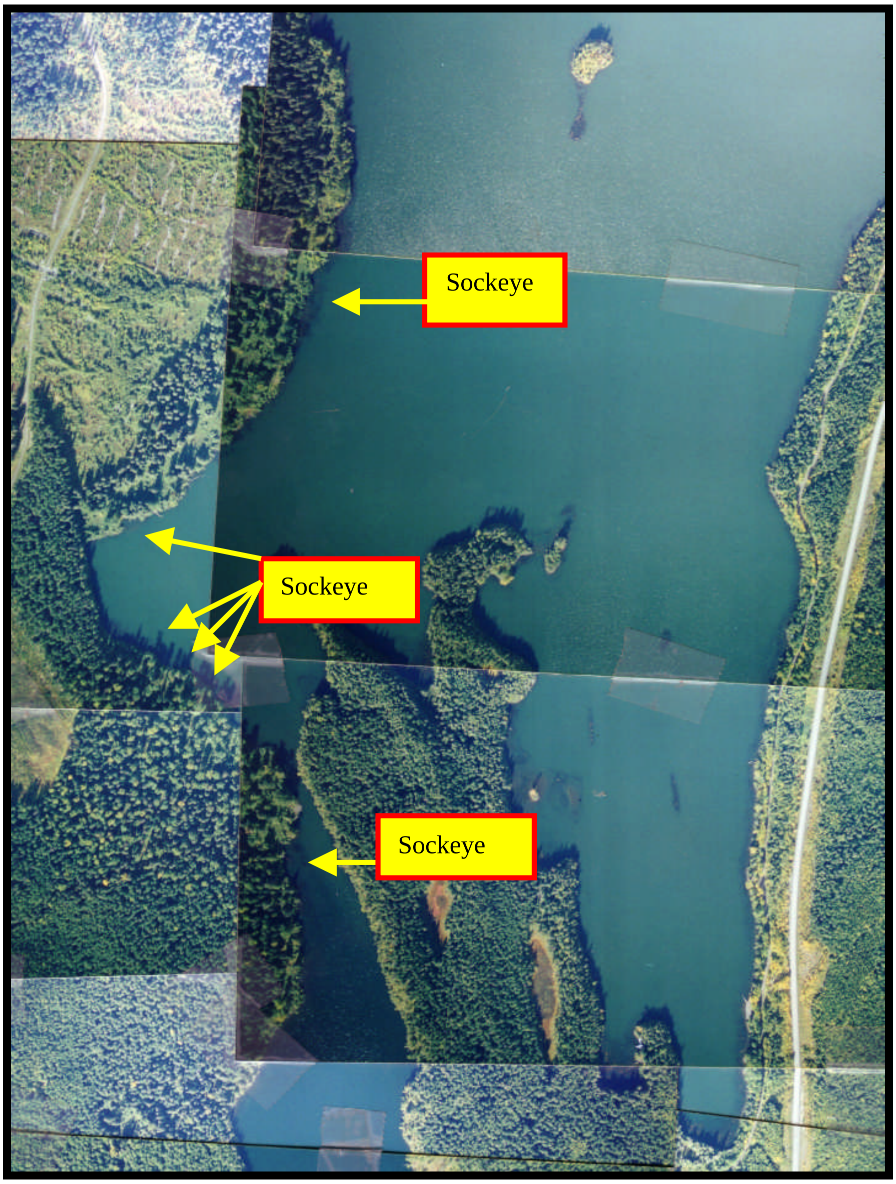


Figure 3: Present day sockeye spawning locations (1999, 2002-2005)

Historically, sockeye have been documented to spawn all along the western and northern shorelines of Gitanyow Lake, and in the river (Figure 4). Gitanyow and Gitwangak Elders describe sockeye densities as being so thick in Gitanyow Lake that the north and west sides of the lake would turn red with spawning sockeye in some years (Jacobs et. al. 1999). Elders also have oral histories that speak of sockeye spawning in the Lower Kitwanga River directly below the lake and in the Upper Kitwanga River. Historical DFO reporting supports some of the Elders accounts, for example:

- In 1929 Fishery Officer G.A. McGrath drew a map showing sockeye spawning locations, where he highlighted most of the north shore and a section along the west bank of the narrows as active spawning sites (DFO BC16 File for 1929).

- In September of 1946 McConnell and Brett visited Gitanyow Lake and gill netted sockeye from the shores of Gitanyow Lake. Their results showed that 10-15% of the adult sockeye caught were spawned-out giving evidence of lacustrine spawning (Photograph #9 & #10, McConnell et. al. 1946).

- In 1956 and 1958 Fishery Officer V.H. Giraud wrote "spawning takes place for the most part in the narrows of the lake", "sockeye use this river to reach Kitwanga Lake but do not spawn in it, spawning in the lake can not be accurately estimated" (DFO-BC16 Files for 1956 & 1958).

Photograph #9: Dean Fisher taking dead sockeye from net in 1946.

Photograph #10: McConnell releasing a live male sockeye from the net in 1946.

There has only been one recent account of sockeye river spawning in the Kitwanga and that was observed by NewGen Resource Consultant. According to NewGen, 192 sockeye were observed spawning downstream of the lake outlet on October 5, 1998 (Jacobs et. al. 1999). From 1999 to 2005 the GFA have been actively seeking out sockeye spawning areas in the Kitwanga Watershed. To date sockeye have been observed spawning along the western shoreline of Gitanyow Lake near the narrows in 1999 and 2002 through 2005 (Photograph #11). All observed spawning activity can be described as "light" meaning redds and or sockeye have only been found at the sites in low densities, usually representing less than 25% of any given years run. No sockeye river spawners have been observed since 1998.

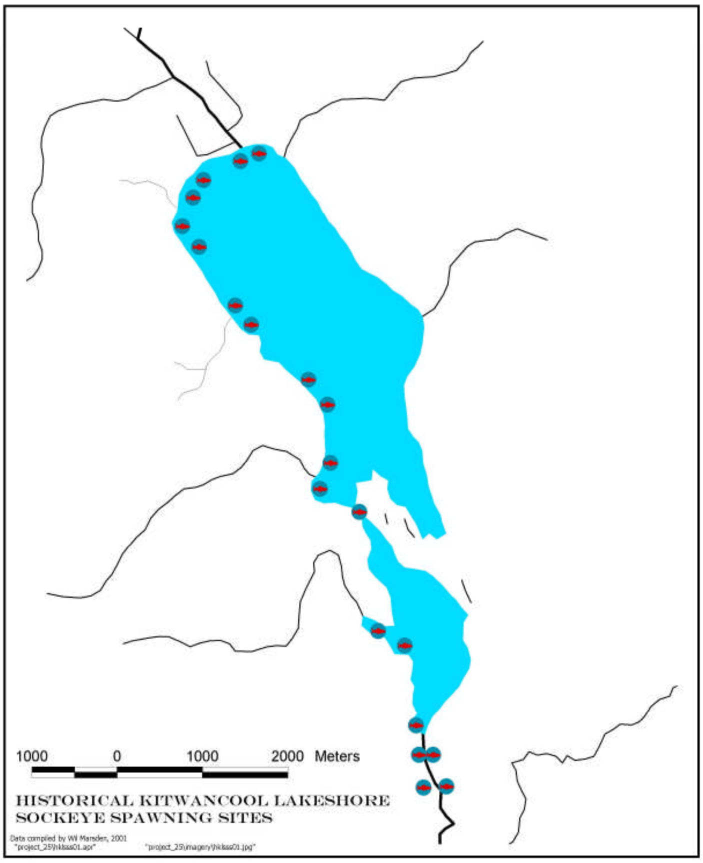


Figure 4: Map of historical Kitwanga sockeye spawning areas.

Photograph #11: Spawned out Kitwanga sockeye found along western shoreline in the narrows of Gitanyow Lake in 2002.

Kitwanga Sockeye Distribution

Freshwater

The freshwater range of a Kitwanga sockeye extends for 286 km, from the estuarine environment at the mouth of the Skeena River to the head of Gitanyow Lake. The Skeena River is used mainly as a transportation corridor to allow smolts to emigrate to the ocean and to allow adults to travel back upstream to Gitanyow Lake. Juvenile stages from egg through smolts utilize Gitanyow Lake. Adult sockeye hold in the deep portion of the lake until they are ready to spawn along the lakeshores.

Ocean

As Kitwanga sockeye juveniles mature on the BC coast they move along the continental shelf northward into the Gulf of Alaska and then into northern feeding grounds in the open ocean. Distribution in the ocean extends westward to the Aleutian Islands, northward into northern Gulf of Alaska, and southward to about 40°N (Figure 5).

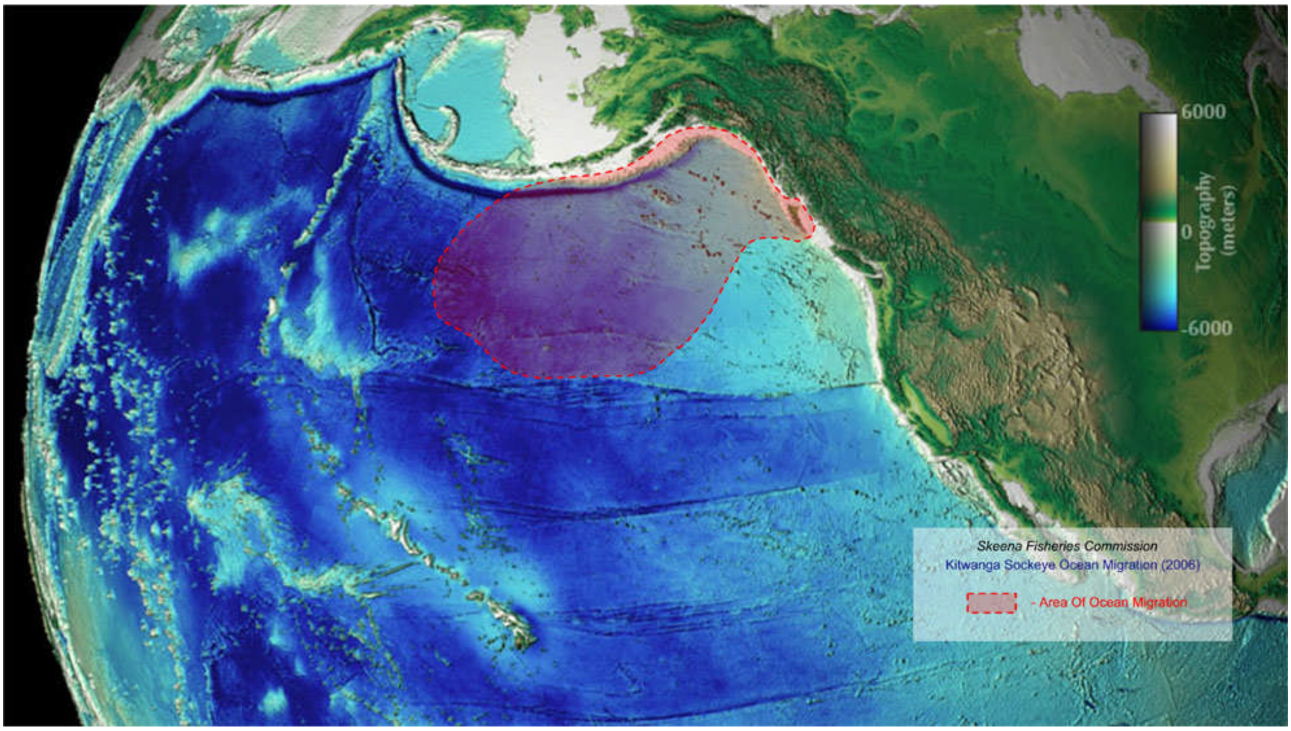


Figure 5: Map highlighting in red the ocean range of Kitwanga sockeye.

STOCK STATUS

Historical Escapements

Determining historical escapement trends for Kitwanga sockeye can be somewhat difficult given that counts represent data from a diverse series of surveys using differing techniques, with decreasing coverage over time. Historical accounts of stock size are mostly limited to non-numeric quantitative descriptions of abundance from traditional knowledge and DFO BC16 Files, of varying accuracy collected by a number of surveyors under varying environmental conditions. In addition we discovered several other estimates of sockeye escapements in archived DFO reports. These sources are discussed in more detail below. Despite these uncertainties, the archival data can still be considered an invaluable picture into the past. Figure 6 depicts estimated sockeye escapements to Gitanyow Lake from 1921 through 2005. The records indicate that Kitwanga sockeye escapements in the first part of the 20th Century were fairly stable around 4,000-5,000 fish. In the second part of the 20th Century fewer estimates of spawning sockeye were made but escapement numbers are much lower.

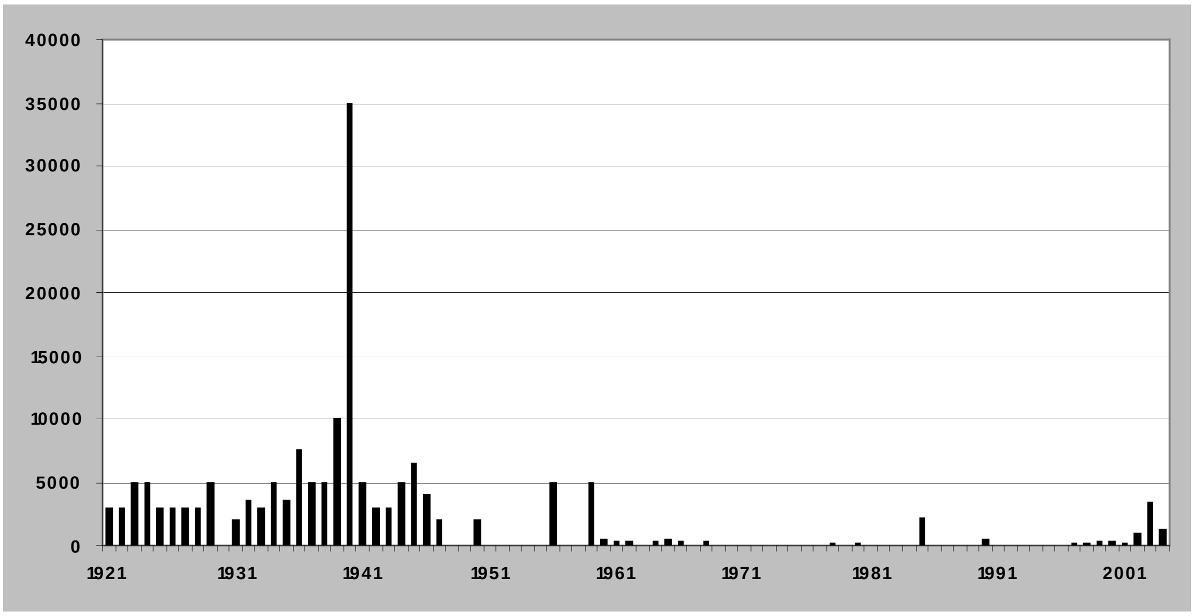
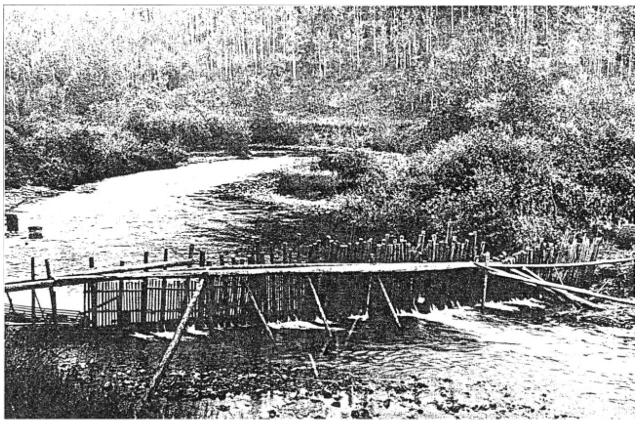


Figure 6: Estimated sockeye salmon escapements to Gitanyow Lake from 1921-2005 (DFO SEDS records).

Traditional Knowledge

The oldest indications of Kitwanga sockeye abundance come from the oral histories told by the Gitanyow and Gitwangak People. These Gitksan House Clans have inhabited the Kitwanga Watershed for over 5,000 years and their oral histories speak of salmon being so thick in the fall that a person could not see the bottom of the of the XSI T'AX (Kitwanga River) (Derrick 1978). Traditionally, sockeye were the most important food in the Kitwanga system and they were harvested at well-established T'ins (weirs). T'ins could be found spread-out all along the river, with the most popular ones being concentrated around the village of Kitwancool and directly below Gitanyow Lake (Photograph #12 and #13, Prince 2005). Weirs were the most popular fishing method used by the Gitanyow because they were extremely effective and worked well in the shallow swift flowing currents of the Kitwanga River (Rabnett *et. al.* 2002). They were constructed of wooden posts, which were pounded into the stream bottom. The weirs were equipped with moveable basket type traps that allowed fishers to dipnet only the desired fish out for retention, while releasing undesirable fish upstream of the weir.

In 1998, interviews were conducted with Gitanyow Elders. A Gitanyow story recounts certain years when the salmon did not return and famines ensued (Jacobs et. al. 1999). In more recent times elders described historic concentrations of spawning sockeye on Gitanyow Lake as turning the shorelines red (Jacobs et. al. 1999). The Elders also told that declines in salmon returns began in the 1960’s and that most fishing sites were abandoned along the Kitwanga by the early 1970’s.



Photograph #12: Salmon weir at Kitwancool (Shotridge 1919).

Photograph #13: Salmon weir ~2km downstream from Gitanyow Lake (Fisher 1945).

Fishery inspector reports support Oral History accounts of abundant salmon in the Kitwanga River. Pritchard (1945) reported: “the indians do not only catch and cure salmon for their own use, but hoard it up for sale and barter. It is a sort of legal tender amongst them, 10 salmon for a dollar and so many for a blanket”. He goes on to say: “it would appear on the basis of tagging experiments that the indians are able to catch as much as 25% of spawning runs of salmon in some years”. He also reported that between 1935 and 1945 the Indians caught 38,930 sockeye on the Kitwanga system, and that in 1945 there were 92 First Nation families with 6 smoke houses living along the Kitwanga River (Cleveland 2000).

DFO BC16 Files

DFO BC16 spawning escapement data for the Kitwanga River extends back with gaps to 1921. The value of the data lies in the utility of the salmon spawning trends rather than the actual values presented in the records. Most BC16 surveys consisted of single yearly spawning ground observations, which did not allow for accurate determination of adult escapement. Most species were fairly well represented in the BC16 Files for the Kitwanga River during the 20th Century, except for sockeye. It becomes apparent early in the DFO records that few estimates of sockeye escapement were made, probably because they did not spawn in the river like the other salmon.

Other Sources

Two other sources of information relating to historical Kitwanga sockeye escapements were found while doing the research for this plan.

The first was produced by McConnell and Brett from the DFO Pacific Biological Station. McConnell spent the summers of 1945 and 1946 studying Gitanyow Lake and during his stay he conducted spot counts of migrating sockeye. During these counts he observed an average of 200 sockeye per day passing a set point between July 24th and August 24th. Based on his observations he estimated that in 1945 the run was probably greater than 6,000. He returned in 1946 and indicated that the sockeye run appeared to be a little bit smaller. This time he estimated it at 4,000 sockeye (McConnell et. al. 1947).

The second source consisted of a data set found in the DFO achieves at the Pacific Biological Station in Nanaimo, BC. The data set came from log books of a fence operation that DFO had installed at the mouth of the Kitwanga River (~3 km downstream of KEF) in 1959. The fence was set-up to establish an index count for returning pink salmon. In this data set samplers made specific reference to catching sockeye salmon and a total of 4,009 were counted between August 3rd and September 2nd. Because the fence was run for only a portion of the season, the sockeye that were counted only represented a portion of the total run. The portion of the 1959 sockeye run that is known had timing close to that of 2003, 2004 and 2005 (Figure 7). Assuming that the 1959 sockeye run was similar throughout it would have totaled 5,011 sockeye.

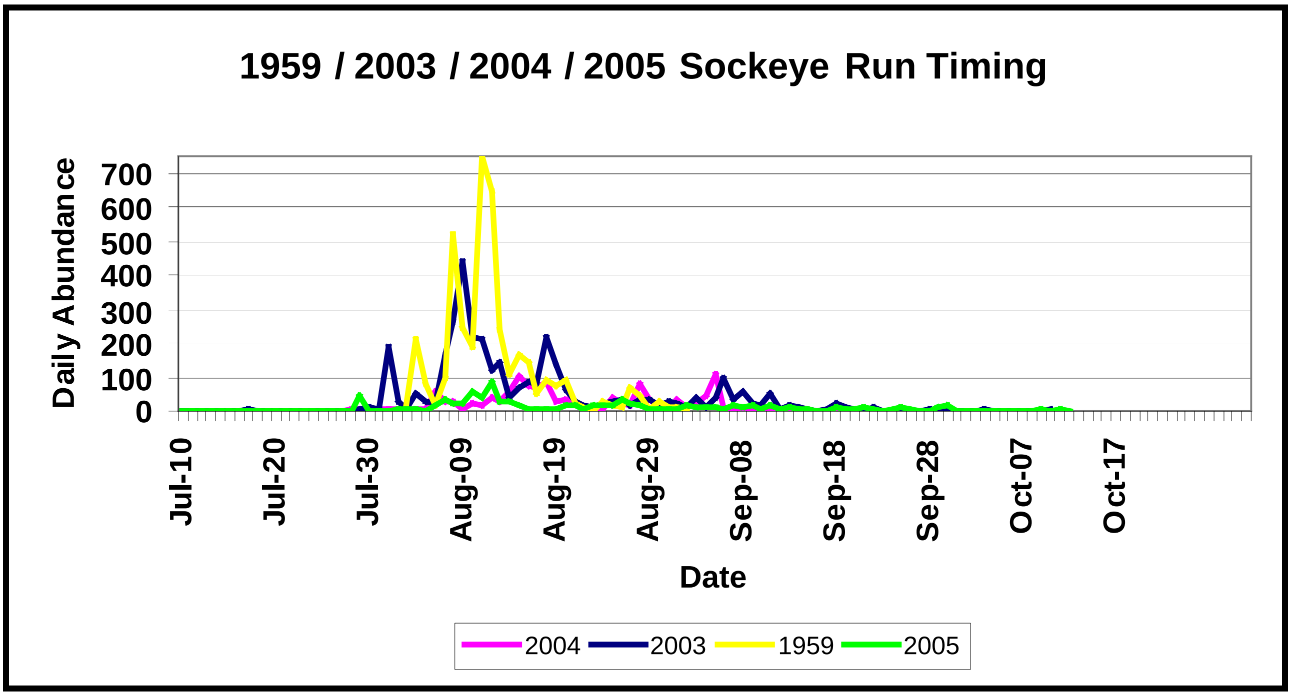


Figure 7: Kitwanga sockeye run timing near the confluence of the Kitwanga River in 1959, 2003, 2004 and 2005.

Recent Escapements

In 2000 the GFA initiated an adult enumeration program on Kitwanga sockeye and accurate counts of sockeye have been collected ever since. Recent escapements have been lower than observed in the early 1900's, despite the fact that the Gitanyow and the Gitwangak have not fished the stock for almost 40 years. In 2000, 2001 and 2002 sockeye were enumerated at a temporary fence in the upper reach of the Lower Kitwanga River, approximately 4 km downstream of Gitanyow Lake (Cleveland et. al. 2001, Cleveland 2002, Kingston et. al. 2003). In 2003, 2004 and 2005 sockeye were enumerated at the Kitwanga Enumeration Facility (KEF) located approximately 4 km from the confluence of the Kitwanga and Skeena Rivers (Cleveland 2004, Cleveland 2005, Kingston 2006). The temporary fence and the KEF allowed the GFA to accurately determine Kitwanga sockeye escapement for the past 6 years (Photograph #14 & #15).

In 2000 and 2001 Kitwanga sockeye escapements were extremely low, yielding returns of less than 300 fish during both seasons. This is similar to the BC16 estimates for all but one year since 1960. The years between 2002 – 2005 yielding escapements between 937 and 3,377 sockeye (Figure 8).

Photograph #14: Aerial view of temporary fence 2001.

Photograph #15: Aerial view of Kitwanga River Salmonid Enumeration Facility 2003.

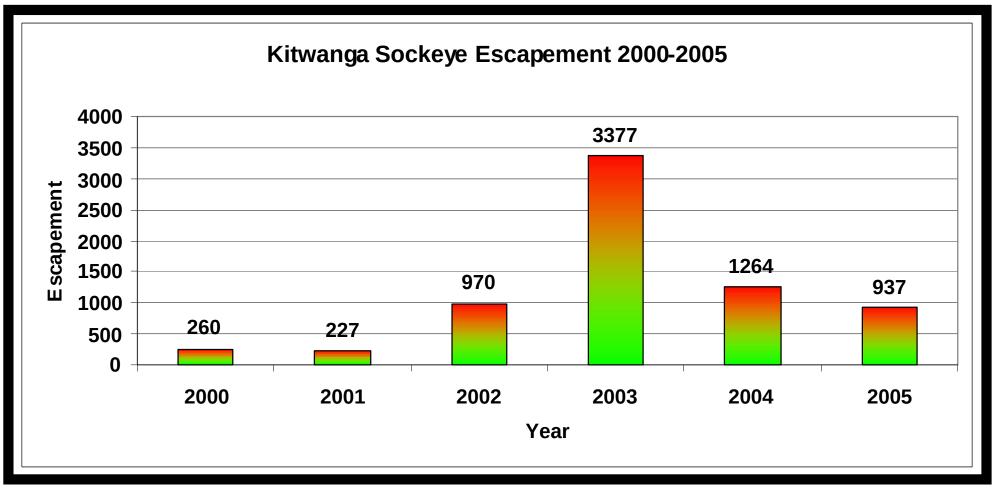


Figure 8: Kitwanga sockeye escapement from 2000 – 2005.

FISHERIES

Evidence of Skeena salmon exploitation by aboriginal fisheries dates back more than 5,000 years (Wood 2001). Prior to European contact salmon were relied heavily upon by the Aboriginal Peoples that inhabited the Skeena, and sockeye in particular were caught all along their migratory routes from the ocean to the headwaters of the river. Sockeye were the staple of the First Peoples diets, and an intricate management system was implemented by the various House groups to protect the resource for future generations. However, this fisheries management regime changed significantly in 1878 with the implementation of the Fisheries Act beginning an effective Canadian control of fisheries management (Harris 2002).

The incursion of Euro-Canadians brought change, a time where sockeye salmon became one of the most valued resources in North America. Because the Skeena River produced millions of sockeye a year, the stocks were extremely conducive to the establishment of commercial production. Commercial fishing for Skeena sockeye yielded average catches in the first half of the 20th Century of almost 1 million fish per year, which employed a multitude of fishers and processors who would flock to the coast every summer. The industry grew quickly as investors developed the fishery. In 1907 there were fourteen canneries at the mouth of the Skeena that were supplied with fish from 870 boats (Rabnett et. al. 2001). However, these intensive fishing efforts quickly depleted the Skeena sockeye runs and between 1910 and 1955 the overall catch declined by 50% (Figure 9).

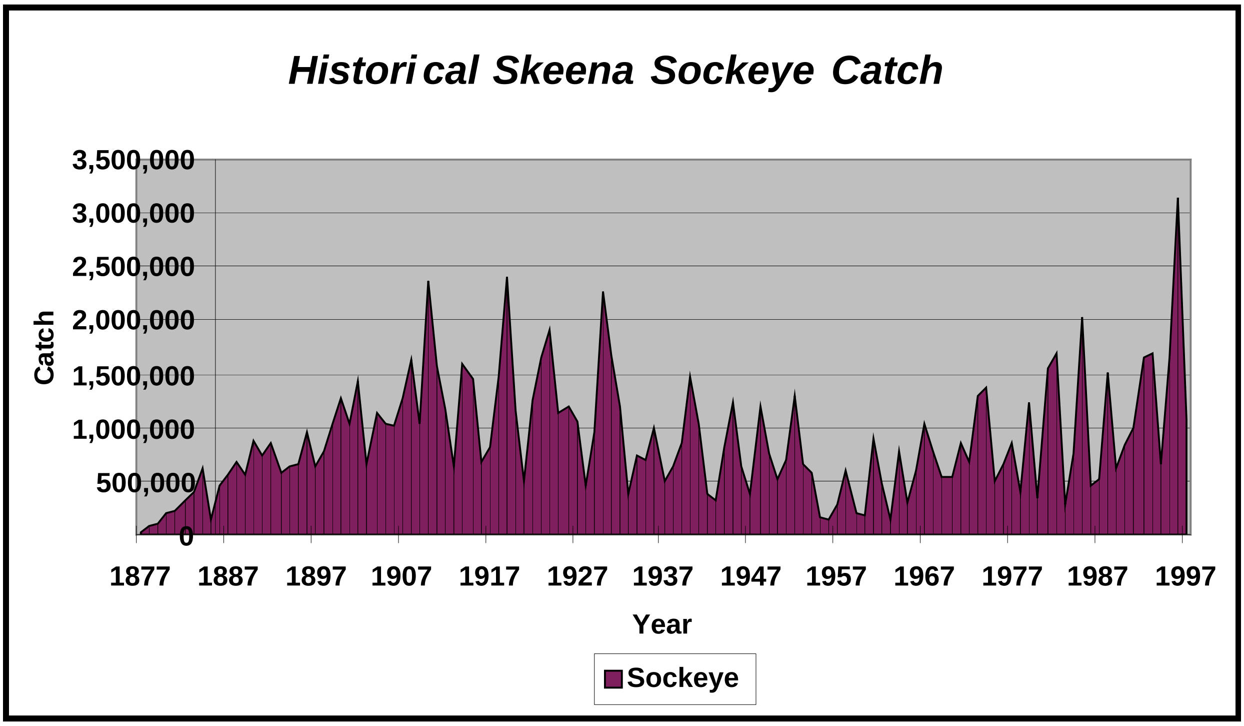


Figure 9: Historical aggregate Skeena sockeye catch between 1877 and 1997 (Groves 2003).

The decline in Skeena sockeye production fuelled management efforts to boost sockeye production once again, and between the 1960's and early 1970's the development of an enhancement facility became a priority to maintain the processing plants at the coast. This enhancement facility was located on Babine Lake and consisted of the construction of two large spawning channels located on Pinkut Creek and the Fulton River. This project essentially boosted sockeye production in the Skeena to the point that enhanced Babine sockeye now represents at least 90% of the overall aggregate run of sockeye salmon in the Skeena River. In contrast, prior to the enhancement works Babine sockeye represented less than 80% of the overall Skeena sockeye aggregate (Wood et al 1998).

With increased Babine production, harvest of Skeena sockeye at the coast was able to steadily increase, giving the impression that exploitation rates were sustainable. However, over time although these historical fishing pressures may have been sustainable for the aggregate (made-up of mostly enhanced Babine sockeye), it was not the case for many of the wild non-enhanced sockeye stocks of the Skeena River. Post enhancement, exploitation rates on the sockeye aggregate have average almost 60%, reaching as high as 74% in some years (Figure 10). In most cases exploitation of this magnitude are not sustainable, especially on wild stocks where natural freshwater habitats can have much greater variability. This legacy of over fishing Skeena sockeye has precipitated conservation concerns for various wild Skeena sockeye stocks, which includes the sockeye populations that inhabit the Kitwanga River.

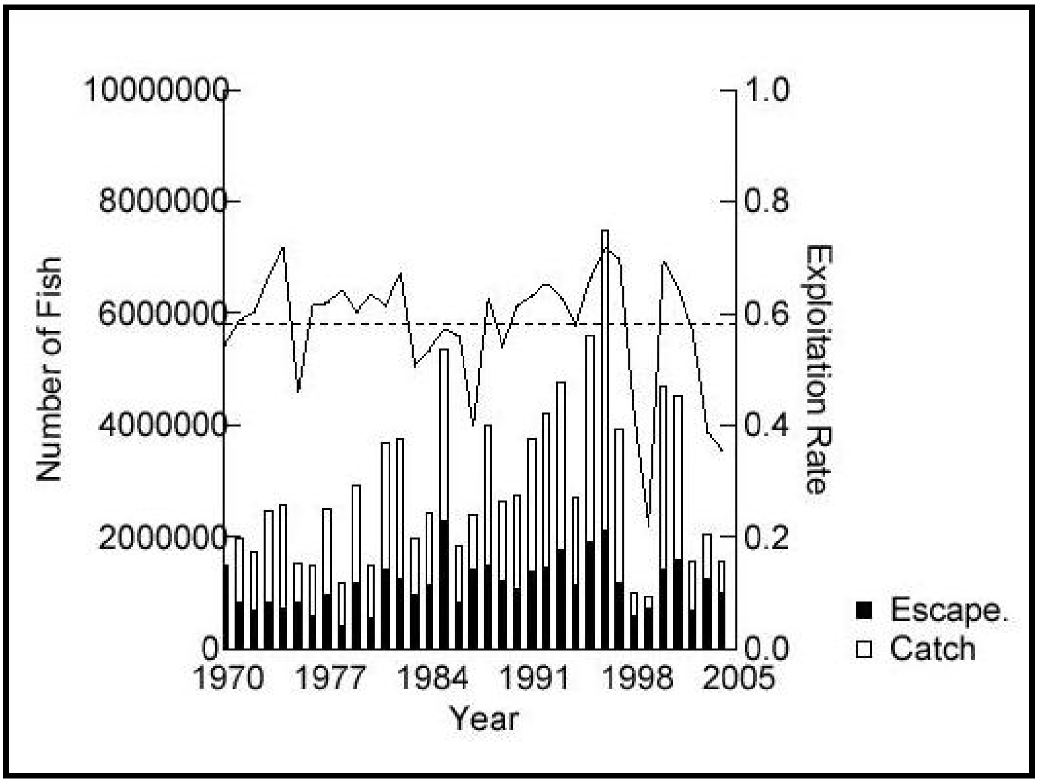


Figure 10: Post enhancement total catch and percent exploitation of Skeena sockeye (Cox-Rogers 2004)

First Nations Fisheries

Tsimshian and Gitksan First Nations harvest Kitwanga sockeye in mixed-stock Food, Social, and Ceremonial fisheries in the adjacent ocean areas and on the lower and middle Skeena River below the inflow of the Kitwanga River. No direct estimates of historic in-river First Nations exploitation on Kitwanga sockeye exist at the present time, although a fishery model is now being used to estimate in-river impacts. In an average year First Nations along the Skeena River below Kitwanga are estimated to harvest approximately 5% of the total returning Skeena sockeye stock and it is assumed that Kitwanga sockeye are harvest at similar rates (Cox-Rogers 2004). The one exception to the rule is thought to occur in the Skeena River at the mouth of the Kitwanga. Here Kitwanga sockeye may be susceptible to higher exploitation rates for part of the season as they may congregate for some weeks before migrating up the Kitwanga River to Gitanyow Lake. During these holding episodes, harvest of Kitwanga sockeye might be significant. In order to address this problem GFA and Gitksan Watershed Authorities (GWA) in partnership with the DFO initiate a fishing closure at the mouth of the Kitwanga River. This closure has been in effect since 2002 and to date has been very well accepted by both Aboriginal and sport fishers (Hamelin 2004).

Terminal sockeye fishing by First Nations has not occurred in the Kitwanga Watershed since the early 1970's (Jacobs et. al. 1999), although historic terminal fisheries are well documented (Rabnett et. al. 2002).

Alaskan Commercial Fisheries

Kitwanga sockeye migrate homeward through Southeast Alaska and a proportion of the total run is harvested in Alaska gillnet and seine fisheries. Given the later run-timing of this stock, Alaskan commercial fisheries are likely exerting exploitation rates on Kitwanga sockeye that are similar to the later-timed Babine River stocks. Current American exploitation of Kitwanga sockeye are thought to be approximately 5% per year, this compares to historical exploitations of 10 – 15% (Cox-Rogers et. al. 2004). The Pacific Salmon Treaty limits catch in some Alaskan fisheries directed at Skeena sockeye salmon, but other interceptions occur as incidental harvests in Alaskan pink and chum fisheries.

Canadian Commercial Fisheries

The commercial fishery on Skeena River sockeye began with the first cannery operations in 1877 (Wood et. al. 2001). Sockeye salmon were harvested predominantly by gillnets in the Skeena River until the 1930's when powered vessels moved out to ocean fishing areas. A seine fishery was introduced in the 1950's and grew rapidly through the next two decades. The fishery typically ran from late-June through mid-August but in recent years, the fishery has been confined to the mid-July to early August time period to reduce incidental catches of coho, steelhead, and earlier migrating non-Babine sockeye. Effort levels in recent years, from gillnet and seine boat-days, are substantially reduced compared to historic levels. Still, exploitation rates on Kitwanga sockeye in marine fisheries are substantial given their highly overlapped run-timing with Babine Lake sockeye.

Annual catch data for Kitwanga sockeye are not available and annual escapement records are incomplete or of variable accuracy except for more recent fence counts (now in place). As such, exploitation rates on this stock cannot be directly calculated. Instead, exploitation rates are modeled using weekly sockeye harvest rates in Canadian fisheries, run-timing curves for the wild stocks, and add-on exploitation for U.S. and in-river First Nations fisheries (Cox-Rogers et al 2004). Figure 11 summarizes estimated exploitation rates for Kitwanga sockeye since 1970. Decadal mean marine exploitation is estimated to have been 0.480 from 1970-79, 0.460 from 1980-89, 0.471 from 1990-99, and 0.493 from 2000 through 2003. Decadal mean marine + FSC exploitation is estimated to have been 0.530 from 1970-79, 0.520 from 1980-89, 0.531 from 1990-99, and 0.510 from 2000 through 2003. These exploitation rates are considered maximums and may be biased high because exploitation rates for the Skeena River aggregate stock caught in Southeast Alaska have been used as a surrogate for the later-timed Kitwanga sockeye stock, and FSC exploitation rates within the Skeena River are for the aggregate stock captured below Hazelton which may not apply to the later-timed Kitwanga sockeye stock. On-going DNA-based stock identification analyses of commercial and FSC fisheries may help to quantify exploitation rates on Kitwanga sockeye.

Exploitation to achieve maximum sustained yield (MSY) has been estimated at 0.34 for Kitwanga sockeye based on updated lake trophic status assessments and current production characteristics of Gitanyow Lake.

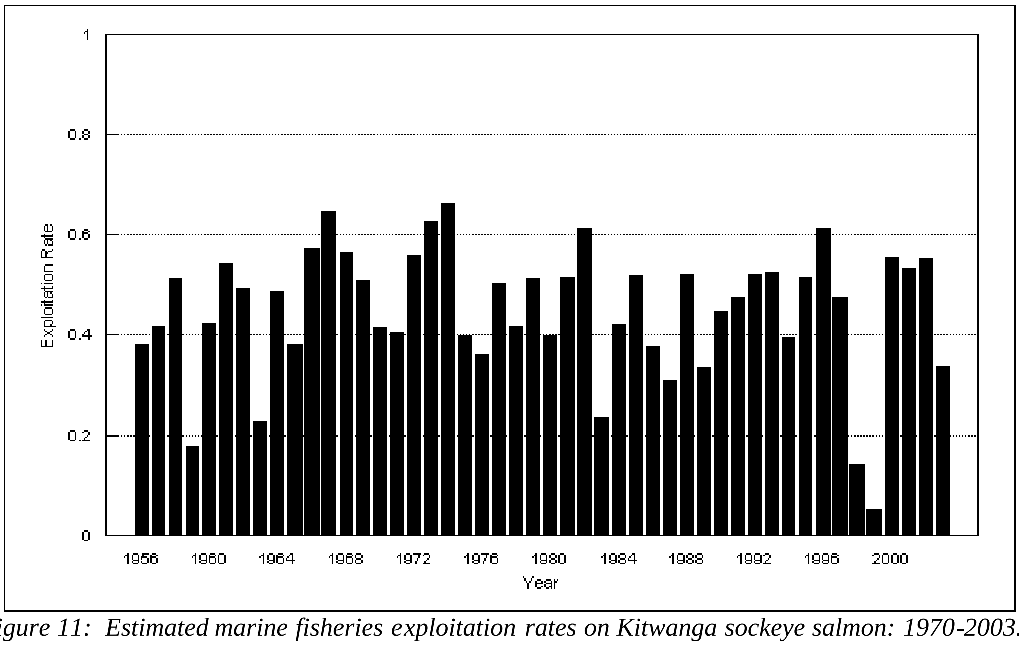


Figure 11: Estimated marine fisheries exploitation rates on Kitwanga sockeye salmon: 1970-2003.

Recreational Fisheries

Opportunities for sport fishing on sockeye salmon in the Skeena River have been provided in recent years. However, the recreational fishery remains extremely limited with catches estimated to be only a few thousand fish, usually representing an exploitation of less than 1% per year (Cox-Rogers 2004).

Stock Status Outlook

Based on recent escapement data collected on Kitwanga sockeye it would appear that the stock has stabilized at an all time recorded low of approximately 1000 fish per year (2000-2005 average). These returns are much lower than historical escapements to the Kitwanga River. As recent as 50 years ago Kitwanga sockeye escapements were thought to average 4,000 - 5,000 per year even after the Gitanyow and Gitwangak had harvested Kitwanga sockeye in-river for sustenance purposes. In-river Kitwanga sockeye harvest continued until the early 1970's harvests averaging 4,000 fish per year had been documented in fisheries records as recent as 1945 (Cleveland 2000).

Presently, Kitwanga sockeye appear to be in a bottleneck, recruiting adults at only 5% of system capacity (Cox-Rogers et. al. 2003). If adult recruitment is not increased over the short term the stock could be at risk of collapse (e.g. returns of less than 150 females in 2000 and 2001).

HABITAT STATUS

Habitat Setting

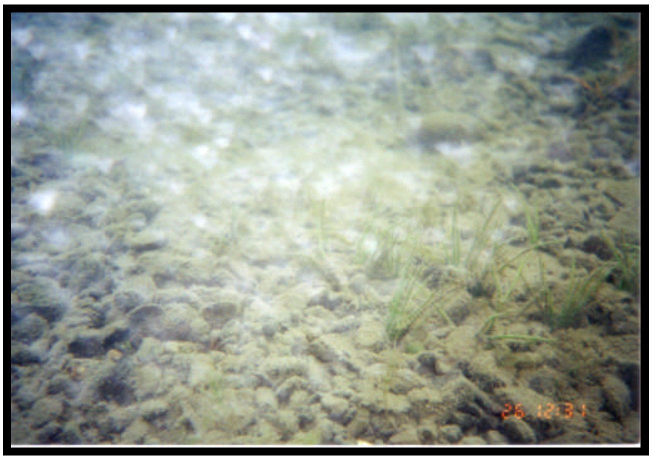
The Kitwanga Watershed is a fifth order drainage with a catchment area of approximately 833 km^2. Elevation ranges from 2,096 m in the Kispiox Range to 172 m at the Skeena River confluence. The Kitwanga River peak discharges typically occur in May and June due to spring snowmelt, then decrease until September when fall rains and early snowmelt increase stream flows through October. Stream flows decrease starting in November and continuing through the winter when precipitation falls as snow. Annual low flow happens 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; however, Gitanyow Fisheries Authorities (GFA) has recently installed stream-gauging stations above and below Gitanyow Lake and close to the mouth of Kitwanga River. Air and water temperatures, as well as stage correlated to discharge have been collected continuously since 2001. The highest in river temperatures are observed at the lake outlet between mid June and mid August of every year. It is not uncommon to see daily average temperatures exceeding 20°C (Kingston 2005). To date the highest discharge recorded on the Kitwanga River was 93.0 m^3/s, on October 11, 2004 near the mouth of the river. It is estimated that the 2004 fall flood had a recurrence interval of 1 in 12 years (Kingston 2005).

Gitanyow Lake is the predominant feature of the upper watershed. It supports Kitwanga sockeye for almost all of their freshwater residence. It is mesotrophic and relatively clear with a euphotic zone that extends to the bottom of most of the lake. It is shallow with an average depth of only 5 m, and a maximum depth of 15 m (Shortreed et. al. 1998). A pronounced thermal stratification is evident during much of the summer and the average thermocline depth is approximately 6 m. When the lake is thermally stratified it is common to see cool temperatures and low oxygen levels in the hypolimnion and elevated temperatures (>18ºC) in the epilimnion (Cleveland 2000, Kingston 2004). It is slightly alkaline with a constant pH of approximately 7.46 and a relatively low seasonal average of total dissolved solids (TDS) of 68 mg/L (Shortreed et. al. 1998). Seasonal averages in total alkalinity for the lake are considered moderately buffered, while nitrate concentrations are low for most or all of the growing season. Photosynthetic Rates (PR) for the lake are extremely high, so high that it can be rated as one of the most productive sockeye nursery lake in BC. Macrozooplankton biomass is also high in the lake. Biomass peaks of 3,000 mg/m^2 are seen in June, declining to 1,500 mg/m^2 in July and slowly declining further to 1,000 mg/m^2 by October. Gitanyow Lake's planktonic biomass is composed of mostly *Daphnia longispina* (63%). Large pelagic invertebrates are also present which include *Leptodora kindtii* and chironomid larvae (Shortreed et. al. 1998).

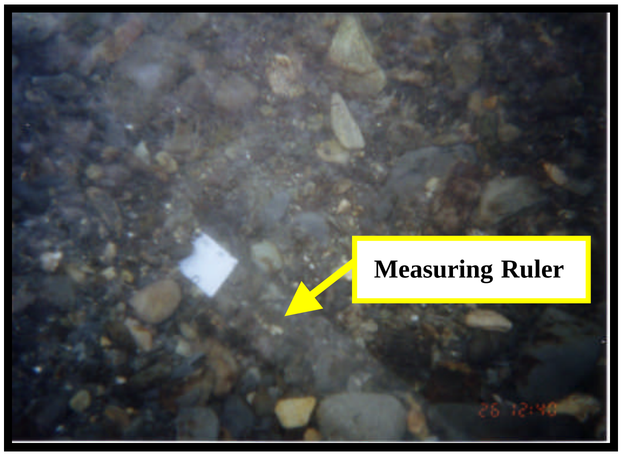
Gitanyow Lake has a shoreline perimeter of 22 km made up of areas with fine sediments and areas of gravels. Much of the shoreline is over grown with rooted aquatic vegetation, and in 2002 it was noted that approximately 60% of the shoreline was covered with these aquatics (Cleveland 2003). Macrophytes were found throughout the lake and a total of twenty plant species were identified. Canadian waterweed (*Elodea canadensis*), northern water milfoil (*Myriophyllum sibiricum*) and variable pondweed (*Potamogeton gramineus*) dominated the

littoral zone of Gitanyow Lake (Cleveland 2003). The most abundant plant species was Canadian waterweed, representing 55% of the area covered by plants (Photograph #16). .
Potential sockeye spawning substrate can be found along 21% of the Gitanyow Lake shoreline. It was estimated in 2002 that ***"good"*** spawning gravels encompass an area of approximately 32,000 m² or 8% of the shore, while ***"moderate"*** spawning gravels could be found over 51,000m². To date sockeye spawners have only been observed utilizing areas classed as *"good"* where aquatic vegetation is only present in low densities (Cleveland 2003). Even the areas classed as good spawning grounds appeared to be impacted by sedimentation. Upon examination of spawning areas it is easily discernable where sockeye have spawned in a particular year, because nest digging activities free the surface area of fine sediments that cover the bottom of the lake in most areas (Photograph # 17 and 18). Intragravel dissolved oxygen and temperature levels adjacent to active sockeye spawning areas have been studied in some detail over the last few years. Temperatures was not determined to limit embryo survival at any site, while dissolved oxygen levels may have adversely effected incubating eggs in some isolated locations (Cleveland 2003).

Photograph #16: Elodea canadensis sample (by Maryland DNR).



Photograph #17: Unused lakeshore sockeye spawning area.



Photograph #18: Used lakeshore sockeye spawning area.

Kitwanga Sockeye Habitat Requirements

Kitwanga sockeye are anadromous, dividing their life cycle into fresh water and ocean phases with different environmental variables. Freshwater habitats provide spawning, embryo incubation, fry rearing and smolt migration, while the marine habitat accommodates the young migrants physiological adaptation to salinity and allows ocean rearing and in-out migration corridors common to northeast Pacific sockeye.

This sockeye recovery plan relates to freshwater and estuarine habitats, particularly habitats that are critical to the sustenance and survival of Kitwanga sockeye. Critical habitat is defined as *"the minimum extent and arrangement of habitat elements throughout the estuarine and freshwater life history of Kitwanga sockeye that are necessary to provide an acceptable probability for the survival or recovery and that are identified as critical habitat in this recovery plan."*

Critical habitats for sustaining and recovering Kitwanga sockeye populations include:

- Migratory routes between the ocean and Gitanyow Lake for smolt and pre-spawning adults. This critical habitat requires a route clear of obstructions, appropriate water temperatures, flows, cover and healthy conditions in the estuary, Skeena River, and Kitwanga River.

- Gitanyow Lake, where mature sockeye hold for several weeks to two months before moving onto lakeshore spawning grounds. It is critical that the lake maintains adequate low temperature zones with adequate dissolved oxygen (D.O.) concentrations to sustain fish and minimize the chances of pre-spawning mortality.

- Gitanyow Lake shores support spawning Kitwanga sockeye. It is critical that spawning gravels stay free of sediment and intrusion of rooted aquatic vegetation. Water percolation through nesting areas must also be maintained to sustain incubating embryos. Spawning and incubation habitat is believed to be one of the limiting factors affecting Kitwanga sockeye production in the Gitanyow watershed.

- Kitwanga sockeye fry and parr rear in the lake for one year to two years utilizing a variety of lake areas. It is important that temperatures, D.O. levels and food sources remain suitable to sustain nursing juveniles.

Kitwanga Sockeye Habitat Status

Gitanyow Lake is one of the larger sockeye producing lakes in the Skeena Watershed. Historically, the lake produced tens of thousands of sockeye, but in the last 50 years production has fallen to where in some years only a few hundred fish make it back to spawn. Presently, the system is substantially under-utilized and the stock is of great conservation concern. Likely production bottlenecks are a lack of adult recruitment and the deterioration of spawning and rearing grounds. Recruitment limitations are linked to excessive exploitation rates of the stock in the commercial fishery for over 125 years. The deterioration of spawning and rearing areas are believed to be linked to 45 years of poor forest harvesting practices that have left the Kitwanga Watershed with many impacts.

Logging Development in the Kitwanga Watershed

Logging began with agricultural clearing by settlers who arrived 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 by the demand for lumber. Independent cedar 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.

Up until about 1960 logging was predominantly selective with a moderate proportion of residual timber left standing, particularly in the southeastern portion of the Kitwanga 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 Gitanyow 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 silviculture system of choice. 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. 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 Gitanyow 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 Village and around Gitanyow 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 (Figure 12).

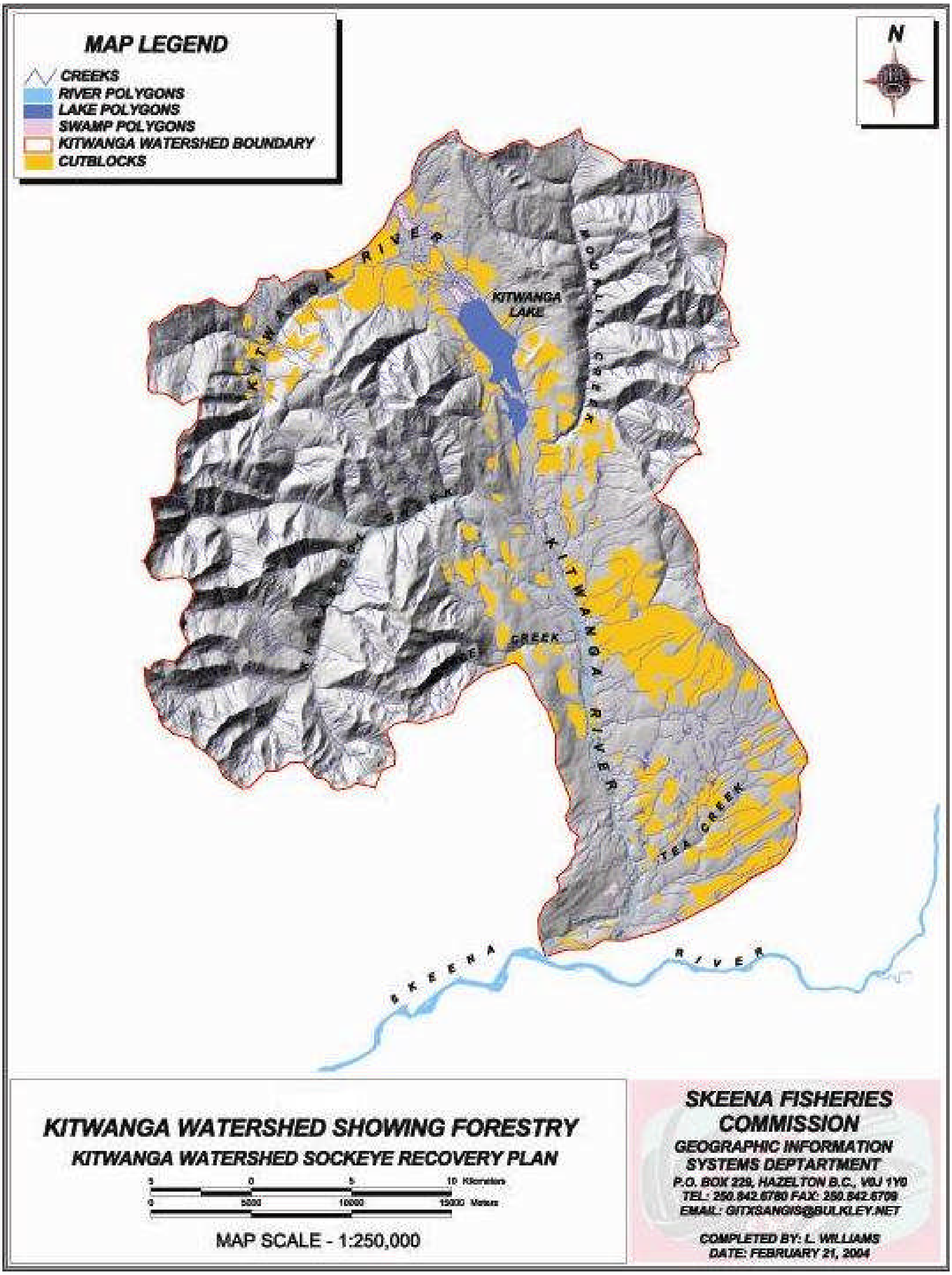


Figure 12: Map showing extent of clearcut areas in the Kitwanga Watershed.

In the early 1990s, logging activities raised fish and fish habitat concerns with First Nation peoples, local residents, and fish conservation interests. Between 1995 and 1999, the Watershed Restoration Program was involved in assessing the forestry related impacts and upslope sediment-producing areas in relation to fish and fish habitat (Wildstone 1995). Watershed health has benefited from road deactivation, riparian, in-stream, and off-channel site works to a certain degree. Habitat restoration activities, conducted under the Watershed Restoration Program, include culvert backwatering, placement of LWD, and riparian site works (McElhanney 2001). McElhanney (2001) summarized the twelve assessment and site works projects conducted in the watershed since 1995, and concluded that approximately $731,000 of logging related, prioritized restorative work is still needed. To date none of these works have taken place.

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

Current Kitwanga Sockeye Habitat Setting

Critical to the review and understanding of fish habitat is the study of water quality. The Kitwanga Watershed generally has good water quality; however, during flood events or stream bank failures, waters become turbid due to the many high elevation and steep drainages, which easily erode. Topographic, geologic, and climatic factors control rates of sediment transfer in the Kitwanga Watershed. Sediment transfer out of the mountainous portions of the watershed into Gitanyow Lake and the mainstem is further complicated by significant geomorphic events that trigger major episodic pulses of sediment through the sediment system.

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 of the system (Beak and Aquafor 1999). How water quality is affected in relation to land use activities, particularly forest development, is not well understood or documented for the watershed. 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 Gitanyow Lake has yet to be established. Cumulative effects on water quality from logging operations have not been quantified. Major concerns include the integrity and importance of small streams, hydrologic change, temperature change, sedimentation, and changes to the stream's physical structure.

Gitanyow Lake acts as a major storage site in the cascading sediment system of the Kitwanga Basin. The trap efficiency of Gitanyow Lake is a function of the lake size and shape, location of inflows and outflow, volume of water throughput, and the character of the sediment. The trap efficiency is unknown but it is probably high because of the two basins with a shallow and narrow connection. 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).

Potential Limiting Factors

Most of the freshwater habitat required to successfully produce sockeye in the Kitwanga Watershed appear to be present in one form or another. However detailed studies conducted by GFA and the DFO have identified a number of potential limiting factors to sockeye production. They will be discussed in further detail below:

1. Elevated In-river Water Temperatures

If adult sockeye are stressed by high water temperature they are more susceptible to disease and parasites, and may even die un-spawned. Optimum water temperatures for migrating sockeye salmon are documented to be between 7-15°C with the upper limit for migration occurring at 21°C (US Army Corps of Engineers 1991). As a rule of thumb temperatures above 18°C can be considered elevated for salmonids. Kitwanga River temperature records collected at various locations show temperatures exceeding the optimum range for sockeye migration from July until September in some years. Temperatures above the upper migration limit of 21°C were recorded at the outflow of Gitanyow Lake in 2004 (Figure 12).

Figure 13: Water Temperature comparison between the KEF and the Kitwanga River directly below Gitanyow Lake in 2003 and 2004 (GFA Aquarod data).

Elevated summer water temperatures appear to affect the migration of Kitwanga sockeye adults in some years by delaying their movement into Gitanyow Lake (personal observations). However, no significant pre-spawning mortality of

Kitwanga sockeye has even been recorded. The effects of these elevated temperatures on Kitwanga sockeye survival are not well understood. It is possible that Kitwanga sockeye avoid the stresses of elevated water temperatures through local adaptations such as staying below the confluence of Moonlit Creek until temperatures are more tolerable (Moonlit Creek cold water input to the Kitwanga River).

2. Spawning Ground Limitation

The quality of Kitwanga sockeye spawning areas are thought to be limiting production. In the past sockeye spawned in diverse areas of Gitanyow Lake where spawners could be seen all along the western and northern shorelines and even in the river below the Lake. In the last 7 years (1999-2005) spawners have only been observed in an area along the western shoreline at the lake narrows. Current spawning locals likely reflects the presence of gravel with the most intragravel effluent flow.

Investigations by GFA in 2002 showed that many of the historical spawning areas north of the narrows have been covered in sediment and had been over taken by macrophyte growth, while current spawning locals remain in better shape. It is likely that the extreme southern end of the north basin (narrows area) has less silt since most of the silt would have settled out at the head of the lake as it entered from the Upper Kitwanga River (Ewert, 2006). It is also likely that logging in the 1980s negatively influenced water flow regimes to the west side of Gitanyow Lake. For example Biolith reported that the west side of Gitanyow Lake historically received water from 2nd and 3rd order streams that are now de-watered in the portions closest to the lake. It was also noted that many of the streams were exposed to riparian logging, leaving them with unstable channels and extensive bank erosion (Biolith 1999).

Increased siltation is believed to have caused increased macrophyte growth along the littoral area of Gitanyow Lake. Twenty plant species in all have been identified in the littoral zone covering approximately 60% of the shoreline. The most abundant species are Canadian waterweed (*Elodea canadensis)*, northern water milfoil *(Myriophyllum sibiricum)*, and variable pondweed *(Potamogeton gramineus)* (Cleveland 2003). This compares to McConnell accounts in 1946 of Gitanyow Lake where he reported shallow shelves at the northern and southern lake ends and several bays with extensive areas of reeds and horsetails. He went on to say that the lake outlet contained a moderate growth of pondweed, water lilies, and water milfoil and that the rooted aquatic vegetation covered about 18% of the total area of the lake.

3. Sockeye Fry Nursing Area Limitations

Shortreed et. al. (1998) raised the possibility that summer rearing area temperatures potentially limit fry production in Gitanyow Lake. Shortreed et. al. predicted that because Gitanyow Lake was so shallow it may not allow sockeye fry to seek refuge from elevated water temperatures in late summer. This concept supposes an epilimnion with elevated temperatures and a hypolimnion with anoxic conditions leaving juveniles with no suitable habitat for summer survival. Therefore, summer water quality conditions was studied in Gitanyow Lake by GFA in 2000 and 2001 to test the Shortreed et. al. theory.

The limnological data collected from Gitanyow Lake showed that summer water temperatures in the epilimnion did exceed optimum levels and that the very bottom of the hypolimnion was anoxic for the same sampling periods. Despite these unfavourable conditions there always appeared to be an area where juveniles could seek refuge, ruling out any obvious constraints on the survival of Kitwanga juvenile sockeye (Figure 14) (Kingston 2004). However, the limnological conditions described above may cause other adverse effects that are not as well understood, such as restriction of food supply.

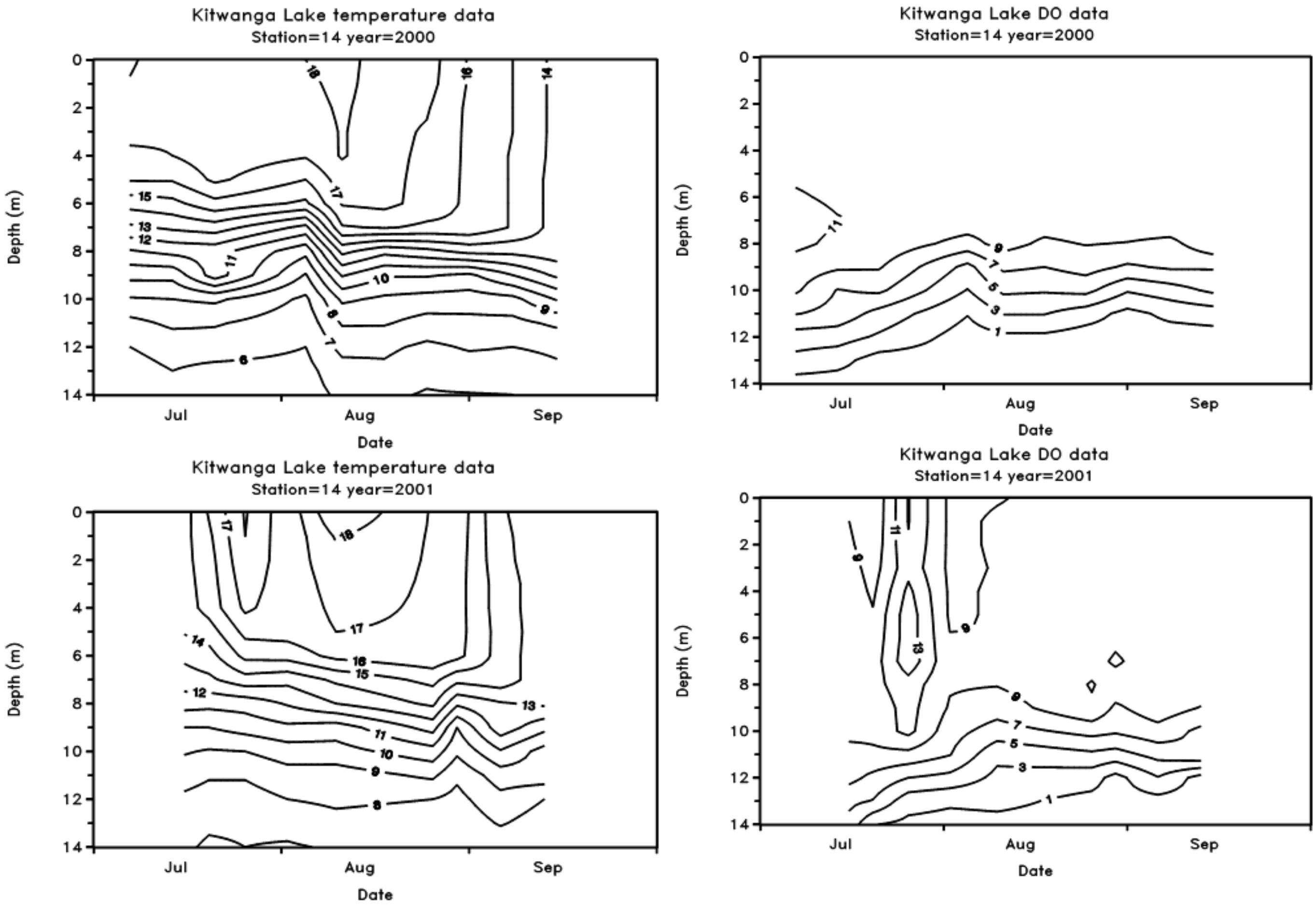


Figure 14: Gitanyow Lake (Kitwanga Lake) temperature / dissolved oxygen data presented by depth for the months of July, August and September of 2000 and 2001.

Kitwanga Sockeye Habitat Trends

Future habitat issues might involve one or more of the three critical habitat components: smolt and pre-spawning adults migratory routes between the ocean and Gitanyow Lake, Gitanyow Lake habitat quality for pre-spawning & spawning adults and Gitanyow Lake rearing habitat for sockeye fry and parr.

Habitat trends involving smolt and pre-spawning adult migratory passage need to consider the uncertainties around proposed coastal finfish farm operations, the mixed stock fishery the mouth of the Skeena River, potential increased stream temperatures affected by global climatic change and proposed coastal industrial developments such as oil and gas.

Given the documented effects of past forest utilization and that most commercially available stands have been logged, it is unlikely that future forest development activities in the Kitwanga Watershed will continue at rates similar to past activity. As immature forests stands become commercially viable, the nature and extent of logging of second growth forests will again become an issue.

The probability and extent of future impacts relating from past logging, for example, elevated stream temperatures or lateral channel movement that increases sediment delivery, is unknown. Potential increases to beaver impoundments are also unknown.

The growth of *Elodea canadensis* in Gitanyow Lake has recently been noted and it appears to be steadily increasing. The Gitanyow people in particular are concerned about how *Elodea* growth will affect water quality and the fisheries value of the lake. Factors affecting *Elodea* growth are not well known, and the exact link between the *Elodea* infestation and sediment and nutrient inputs to the lake is currently unclear.

The relationship between *Elodea* and sockeye is not well understood, so the possibility that excessive plant growth may inhibit sockeye production should be considered. An *Elodea* infestation can affect the food chain in the lake by displacing algal primary producers and potentially limit sockeye production. As well, decomposition of *Elodea* during the winter may cause harmful oxygen deficits. In 2005 GFA conducted an initial investigations on the suitability of winter dissolved oxygen concentrations in Gitanyow Lake. D.O. Levels were found to be suitable throughout most of the lake (Kingston 2006a).

Habitat restoration or rehabilitation of degraded spawning and egg incubation areas will depend on the availability of committed funding. In addition, it is generally unknown how existing and proposed strategic policies, programs, and regulations will affect the Kitwanga sockeye recovery approach.

RECOVERY STRATEGY

Feasibility of Recovery

The Kitwanga sockeye population is depressed but recovery appears to be both biologically and technically feasible if certain threats to its viability can be addressed. The intent of recovery is to bring this population back to viable status by targeting the threats that have contributed to its decline. For Gitanyow Lake, the available assessment data indicates that degraded spawning habitat is a ***major*** threat affecting sockeye recruitment into the lake and initial recovery efforts should focus on this threat. Other threats, such as *Elodea* infestation will need further evaluation. Fisheries exploitation must remain below the estimated MSY equilibrium in all years if the stock is going to be able to rebound in an effective, timely manner. The list of threats potentially affecting recovery of Kitwanga sockeye can be summarized as follows:

Life Stage: Egg to Alevin

- Random loss of genetic variation due to low spawning abundance in the Gitanyow Lake (known threat, high risk)
- Past, current, and continued human activity, especially in the form of forest harvesting activities in and around Gitanyow Lake, especially along the western shorelines near the narrows between the northern and southern lake basins (known threat, high risk)

Life Stage: Fry/Parr

- In-lake predation (presumed threat, low risk)
- In-lake food competition (presumed threat, low risk)
- In-lake macrophyte infestation (potential threat, unknown risk)
- Altered lake water quality due to human activity (forestry development) around Gitanyow Lake (known threat, moderate risk)
- Altered lake productivity, including that resulting from climate change (potential threat, unknown risk)
- Animal activity (beavers) and habitat alteration above Gitanyow Lake resulting in additional warming of lake water (presumed threat, moderate risk)

Life Stage: Smolt

- In-river predation (presumed threat, unknown risk)
- Estuarine predation (presumed threat, low risk)
- Estuarine development such as the establishment of open net fin-fish farms (potential threat, unknown risk)

Life Stage: Marine Growth

- Altered ocean productivity, including that resulting from climate change (potential threat, unknown risk)
- Finfish aquaculture (potential threat, unknown risk)

- Predation (presumed threat, low risk)
- Fisheries mortality (known threat, high risk)

Life Stage: Spawner

- Reduced access to Gitanyow Lake lakeshore spawning areas due to further sedimentation and macrophyte encroachment (known threat, moderate risk)
- Elevated water temperatures in the Kitwanga River and Gitanyow Lake (presumed threat, moderate risk)
- Further loss of inter-gravel water flow along the west side of Gitanyow Lake in Lakeshore spawning areas (known threat, moderate risk)
- Disease (presumed threat, low risk)

Goals and Objectives

In the sections below, goals and objectives are identified and various recovery approaches for meeting objectives are established. For each recovery approach, a list of specific projects is presented and prioritized from most urgent to least urgent to ensure resources are directed to where they are needed most. Finally, an action plan showing how and when each recovery project will be implemented, what each project will cost, and how each project will be monitored, is presented.

The biological goals, objectives, and approaches for recovery of Gitanyow Lake sockeye need to be both realistic and feasible. As Gitanyow Lake is fry-recruitment limited and is producing sockeye well below capacity, the most immediate biological need is to reverse this trend by improving ***natural*** production. The ***goals*** of Kitwanga sockeye recovery are to therefore:

1) *Stop and reverse the decline of Kitwanga sockeye salmon.*

2) *Ensure that the natural bio-diversity and genetic integrity of this population is maintained.*

Recovery *objectives* to meet these goals need to consider the nature of the various threats affecting sockeye production in Gitanyow Lake as well as the watershed's current and future capacity to support increased salmon production. An additional consideration is the time frame for recovery given that some threats can be addressed now and some may require further assessment. As such, the *immediate* and *long-term* **objectives** of Kitwanga sockeye recovery are to:

Immediate (within 1 cycle or 4 years)

1) *Reduce the exploitation of adult sockeye in the commercial and in-river fisheries at least below recommended MSY equilibrium point to help boost natural production and preserve genetic variability in the stock.*

2) *Halt further loss of critical (major) sockeye spawning habitat in Gitanyow Lake.*

3) *Identify and, where feasible, begin restoring lost critical (major) sockeye spawning habitat in Gitanyow Lake.*

Long Term (within 3 cycles or 12 years)

4) *Examine and, where feasible, reduce potential threats to sockeye recruitment into Gitanyow Lake caused by other factors (macrophyte loading, juvenile predation, fisheries exploitation, etc).*

5) *Achieve upward and sustained growth in annual sockeye fry-recruitment into Gitanyow Lake relative to lake-rearing capacity.*

6) *Achieve upward and sustained growth in annual adult sockeye returns into Gitanyow Lake relative to spawning and rearing capacity.*

7) *Monitor, and where feasible, reduce potential threats to critical rearing habitat for Gitanyow Lake sockeye outside of the Kitwanga Watershed.*

Recovery Approaches

Recovery of Kitwanga sockeye will focus on four coincident recovery approaches to achieve the above objectives:

1) *Maintenance and restoration of critical spawning habitat.*

2) *Strategic enhancement (fry outplanting) in key lakeshore spawning areas.*

3) *Assessments of juvenile and adult stock status coupled with population viability analysis (PVA).*

4) *Assessments of other factors affecting Kitwanga sockeye production.*

Some of the projects associated with each recovery approach could provide results rather quickly (e.g. strategic enhancement) and will be important for enhancing remaining habitats and stabilizing the population. Other projects will produce results over the long term and will support population recovery over time (e.g. habitat restoration). As resources may be limited and the time and effort needed to implement some projects could be substantial, it is important to establish priorities.

To date, technical evaluations by First Nations, federal and provincial agencies have determined which protection and restoration projects have the greatest potential to contribute to recovery of Kitwanga sockeye. Priorities have been assigned based on the information contained and referenced in this report as well as on the success or failure of similar conservation efforts in other watersheds.

Prioritized Project List

Appendix Tables 1 through 3 outline the prioritized habitat, enhancement, and stock assessment projects designed to recover Kitwanga sockeye salmon. Recovery of Kitwanga sockeye will be a feedback learning process starting with the smaller, logistically tractable projects and moving towards the larger, logistically difficult projects over time. To meet the most ***immediate*** objective of improving fry recruitment as quickly as possible, the fry out planting pilot projects have good potential and are highly recommended for implementation starting in 2006. Several of the longer-term habitat restoration projects on the major spawning lakeshores should also be started in 2006. Stock assessment activities are essentially on going and will be maintained through 2006 and beyond. One ongoing and key stock assessment activity will be modeling future population size given the range of recovery approaches being considered.

As recovery proceeds, the duration and scope of each recovery project will need to remain flexible to changing priorities as project results and new information becomes available. For example, habitat degradation of Gitanyow Lakeshore spawning areas is thought to be severe and it may prove difficult to reverse past or future disturbances without substantial cost, effort, additional resources, and/or different approaches. For this reason, the initial schedule and sequence of recovery projects will require commitment to adjusting and supplementing approaches and projects as needed over time.

A final but important component of recovery implementation will be informing and educating the local community and other stakeholders about the recovery planning process and encouraging them to become involved. It is anticipated that the Gitanyow and the Gitwangak will play a key role in the implementation of the recovery strategy as wells as local stewardship groups as they become interested.

ACTION PLAN

This section of the recovery plan details how the recovery projects listed in Appendix Tables 1 through 3 will be implemented, what the proposed timelines are, and how each project will be monitored and evaluated.

Implementation

Specific details for implementation of this recovery plan have and continue to be developed. Some projects have been implemented to address some of the known threats to this population (Appendix Tables 1 through 3).

Monitoring and Evaluation

Monitoring will be critical for detecting and evaluating the response of Kitwanga sockeye to recovery activities. The success of this recovery strategy will be dependent upon the measures implemented and a review will be conducted every subsequent 4 to 5-years. Monitoring and Evaluation will incorporate, where appropriate, the following components into all recovery of the projects listed in Appendix Tables 1-3.

- Statistical designs for gathering data
- Specific indicators of recovery that can be measured over time
- Standardized sampling protocols
- Logistic procedures for data collection that are consistent (quality control)
- Generation of data that is accessible and can be shared.
- Stable and appropriate funding.
- Summary analyses that will help integrate monitoring information into the recovery process.
- Inclusion of the public through stewardship initiatives that help protect critical habitats and restore impacted habitats.
- Community awareness through information programs developed with local stakeholder and community groups
- Partnerships with public and industry for specific stewardship projects.

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APPENDIX

APPENDIX TABLE 1. Prioritized list of HABITAT restoration projects for sockeye recovery in the Kitwanga Watershed

Project Description and Priority	Status	One time $	Ann. $
Highest Priority			
Pilot Gitanyow Lakeshore Spawning Ground Restoration Small scale substrate cleaning, gravel addition to know lakeshore spawning locals	Funded for 2006	$85,000	
Gitanyow Lakeshore Spawning Ground Restoration Large scale substrate cleaning, gravel addition to know lakeshore spawning locals (build upon the lessons learned in 2006)	Proposed	$150,000 for 3 years	
Restoration of natural streams flow around Gitanyow Lake Re-channalization and reforestation of streams flowing into Gitanyow Lake	Proposed	$100,000	
Beaver Plan Implementation for Upper Kitwanga Beaver control in the Upper Kitwanga River to maintain constant flow (reduce lake temperatures, increase flushing factor).	Ongoing		$25,000
Reforestation of the Upper Kitwanga Valley adjacent to the Kitwanga River Reconnaissance and Feasibility Study	Proposed	$100,000 for 5 years	
Monitoring of Sediment input into Gitanyow Lake Annual program to monitor sedimentation of spawning gravels	Proposed		$35,000
Moderate Priority			
Removal of the 26-Mile FSR Restore natural water flow in the Upper Kitwanga River	Proposed	$500,000	
Monitoring of Macrophyte growth Annual program to monitor macrophyte growth in Gitanyow Lake	Proposed		$35,000
River Temperature Monitoring Program Continue to record Kitwanga River temperature data / assess effects on adult migration.	Ongoing		$10,000
Groundwater mapping of Gitanyow Lakeshore Groundwater input determination to potentially identify locations for spawning channel construction	Proposed	$40,000	

APPENDIX TABLE 2. Prioritized list of ENHANCEMENT restoration projects for sockeye recovery in the Lakelse Lake Watershed

Project Description and Priority	Status	One time $	Ann. $
Highest Priority			
Pilot Satellite Sockeye fry-outplanting utilizing an existing Enhancement Facility Fry planting program for Gitanyow Lake with Kispiox Hatchery	**Funded for 2006**		$90,000
Moderate Priority			
Spawning Channel(s) Development Feasibility Study - Back-up option in the event that lakeshore spawning restoration is ineffective	**Proposed Back-up**		$30,000

APPENDIX TABLE 3. Prioritized list of ASSESSMENT projects for sockeye recovery in the Lakelse Lake Watershed

Project Description and Priority	Status	One time $	Ann. $
Highest Priority			
Annual Sockeye Smolt Enumeration Program Smolt trapping initiative to determine longterm Smolt output trends	Underway		$30,000
Construction of a Permanent Sockeye Smolt Trap	Proposed	$50,000	
Annual Adult Enumeration Program Operation of the Kitwanga River Salmonid Enumeration Facility to determine adult recruitment and ocean survival.	Underway		$100,000
Annual (over winter) egg incubation and survival assessments Incubation and embryo survival assessment in Gitanyow Lake.	Underway		$15,000
Exploitation rate assessment updates for Kitwanga sockeye Historic review and updated modeling of recent fisheries exploitation rates	Underway		$5,000
Moderate Priority			
Sockeye River Spawning Survey Investigations Mapping and distributional surveys of potential sockeye river spawning sites	Underway		$10,000
Juvenile Growth assessments Juvenile growth monitoring throughout the growing season to identify presence of food availability (summer check theory)	Proposed		$40,000
Lower Priority			
Sockeye predation monitoring in Gitanyow Lake Assessment of juvenile sockeye predation rates in Gitanyow Lake	Proposed		$40,000