Gitksan Watershed Authorities

2001 Upper Kispiox Sockeye Stock Assessment

Stephens Creek Adult Weir

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Executive Summary

The Gitxsan Watershed Authorities (GWA) is an organization committed to the preservation of salmon stocks in the Skeena Watershed. Since 1992, when operating as the Gitksan and Wet'suwet'en Watershed Authorities (GWWA) this organization has been monitoring and collecting extensive data on habitat quality, escapement and juvenile salmonid populations within the Middle and Upper Skeena Watershed. Most recent efforts have been concentrated on the coho populations within the Kispiox Watershed. In 2001, the GWA undertook a project to study the Upper Kispiox River sockeye, in particular the sockeye stocks that return to their natal streams in the Swan and Stephens Lake Watershed.

This project: *The 2001 Upper Kispiox Stock Assessment,* focused on the enumeration of sockeye stocks within the Swan and Stephens Lake Watershed and the suitability of the methods used to carry out this task. To successfully achieve the objectives of this project the GWA constructed an adult fish weir on Stephens Creek, the inlet to the Swan Lake Watershed. The weir enumerated most of the Swan Lake sockeye and provided an efficient method of capturing sockeye for tagging and biological data collection purposes. Between July 12 and September 28, 2001, 10,109 sockeye and 1,998 coho were counted through the weir.

Enumerations of spawning areas in the Swan Lake Watershed were carried out through two methods – Foot and Aerial surveys with the intention to calibrate these two methods and determine their accuracy when compared with the total number of fish counted through the weir.

Three Foot and Air surveys were carried out at 14-15 days apart on most streams within the watershed. It was determined that the counts carried out by aerial surveys were within 5% ± 2% of the counts obtained through ground surveys. From the ground surveys, an Area-Under-The-Curve (AUC) estimate was calculated for each surveyed spawning area in the Swan and Stephens Lake system. The cumulative ground survey AUC estimates for all streams enumerated in 2001 in the Swan and Stephens Watershed accounted for 99.6 % of the sockeye that were enumerated at the Stephens Creek Weir. The cumulative aerial survey AUC estimates for Club Creek and Falls Creek accounted for 88.7 % of the sockeye enumerated at the Stephens Creek Weir.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

The Skeena River is one of three major sockeye producing systems in British Columbia; within the watershed at least 70 distinct spawning sites and 27 lakes are utilized by sockeye. Among the sockeye bearing systems in the Skeena, the Babine Lake is the largest in terms of size and sockeye production, accounting for up to 95% of the total Skeena sockeye salmon escapement (DFO 1999). The remaining 5% of sockeye escapement is produced by smaller tributaries of the Skeena River. The Kispiox River (Watershed Code 470 (WSC)) is one of the tributaries considered important for the production of sockeye that utilize smaller systems within the Skeena River Drainage.

Within the Kispiox River Drainage the primary sockeye, production occurs in the Swan and Stephens Watershed (WSC 470-657200). A number of stream type sockeye populations are also present in the Kispiox River Drainage. Little background knowledge exists about the specific biology of the Swan-Stephens Lake sockeye stocks. Most of the sockeye research in the Skeena River system has focused on the more abundant enhanced Babine Lake (Pinkut and Fulton) stocks, due to their importance as the targeted stocks of the Skeena River commercial salmon fishery. However, with the forthcoming Wild Salmon Policy by Fisheries and Oceans Canada (FOC) it has been recognized that the emphasis of research should be placed on the wild stocks rather than enhanced stocks. This change in policy will allow the integrity of small system stocks and the biodiversity of the Skeena River as a whole to be protected. In light of this policy, the wild sockeye population in the Swan Lake system has been recognized as an important component of sockeye biodiversity in the Skeena watershed.

Within the Skeena River, drainage the Kispiox River (Watershed Code 470) is a medium sized watershed with a catchment area of 2082 square kilometres. The watershed supports spawning populations of five species of Pacific salmon (spp. *Oncorhynchus*) as well as steelhead trout (*Oncorhynchus mykiss*) which have been monitored since 1992 by the Gitxsan Watershed Authorities (GWA) with an ongoing focus towards rebuilding the Kispiox River salmon and steelhead escapements to historical levels.

In 2001, the GWA undertook a project that focused on the enumeration of sockeye salmon (*O. nerka*) in the Swan-Stephens Watershed.

Sockeye spawning in the Swan-Stephens watershed occurs in eight known areas of varying spawning substrate composition. The spawning substrate ranges from boulder sized material located in Club Creek, to gravel in other small streams where nests are easily excavated. The realization that the sockeye in Club Creek are biologically distinct and maintaining a significant sized population in these unusual spawning areas can be attributed to the fact that “the sockeye salmon exhibits the greatest diversity in adaptation to a wide variety of spawning habitats” (Groot 1998).

Historically the Swan-Stephens Lake area salmon have been mostly enumerated in aerial surveys (for consistency) by FOC staff. In 1992, 1993 and 1999, the GWA performed ground based counts of these areas. DFO historically recorded escapements to the Swan-Stephens system averaging from 3200 to 7250 between 1950 and 1992. The 1992 ground survey by the GWA recorded 22,767 sockeye. In 2000, the GWA did not monitor the main sockeye escapement to the Swan-Stephens system but concentrated on the

monitoring of Swans-Stephens coho populations. Nevertheless, when the coho surveys were carried out 194 sockeye were also counted. These fish are recruits from the 1995 run with an escapement of 5900 (Rutherford 1999).

In 2001, the GWA constructed a counting weir on Stephens Creek with the purpose of enumerating the entire sockeye escapement. GWA staff also carried out a series of spatially separated ground and aerial counts on the sockeye spawning areas in the Swan-Stephens Watershed with the purpose of correlating these two methods with the weir counts. The known sockeye spawning areas (figure 3) of the Swan-Stephens Watershed are as follows:

1. Lower Club Creek
2. Upper Club Creek
3. Falls Creek
4. Barnes Creek
5. Jackson Creek
6. Unnamed 1 Creek
7. Unnamed 2 Creek, and
8. Stephens Creek

This report covers the activities of the GWA Swan-Stephens watershed sockeye enumeration project from July 2001 to October 2001.

2.0 Objectives

The general objectives of this project were to attain an accurate estimate of the number of sockeye returning to spawn in the Swan-Stephens watershed and evaluate the effectiveness of three (aerial, fence, stream walks) methods of escapement estimation. The specific project objectives are as follows:

1. Enumerate returning sockeye salmon in the Swan-Stephens watershed with a counting weir.
2. Collect biological data (length, sex, age and tissue samples for DNA)
3. Carry out a series of ground surveys on the eight known sockeye spawning areas.
4. Carry out aerial surveys of the spawning areas.
5. Collect temperature, stage, and discharge data for Stephens Creek.
6. Collect GPS data to determine spawning area size and the location and length of streams used.
7. Provide jobs for unemployed and displaced fishers.

These objectives were achieved and the data collected will provide insight as to the status of the Upper Kispiox River sockeye populations in addition to determining the accuracy of ground and aerial surveys.

3.0 Background and Study Area

3.1 Background

The returns of salmon and steelhead to Kispiox River traditionally supported a number of Gitksan villages. The Swan and Stephens Lake area is also of high cultural significance since this area is the traditional territory of the Gitksan and Gitanyow First Nations. The following Gitksan and Gitanyow house group territories encompass the area:

Gitksan

- Geel
- Antgulilbix
- Tsiibaasa

Gitanyow

- Malii
- Haizimsques

The area was traditionally used as a place for hunting, fishing, trapping and food gathering by these house groups. The Gitksan village site of Lax Dit'ax was situated adjacent to Stephens Creek on the Kispiox River. Given the historical escapements to the area, Lax Dit'ax was an important part of the Gitksan fishery that occurred on Stephens Creek near the outlet of Stephens Lake.

> *This was a well settled area, as Gardner noted: "Wednesday (July) 14: Laugh-Na-Taugh is very pretty place on the south side of the Kyspyox river it is a nice dry meadow of about 40 acres with Indian Houses in the middle of it the Indians have their fishery on the stream that runs out of lake 'Mandan.'"* (Sterritt 1998)

This excerpt is from Gardner's survey through the area in 1874, "*Mandan*" is Stephens Lake. More recently, the Swan and Stephens area has been utilized by hunting guides and outfitters for trophy hunting of grizzly bears and moose. There are a number of tree stands located on Stephens Creek, Club Creek and Falls Creek that were used by hunters for shooting and photography of the concentrations of grizzly bears seen during the salmon spawning season.

The most recent activity with regards to the protection of the area is the declaration of the Swan Lake Wilderness Area by Order in Council in 1991 (MoF 1996) acknowledging the unique flora and fauna values as well as the historical importance of the area.

The use of the main spawning areas within the Swans-Stephens system is highly variable. In one of the main spawning areas of the system (Lower Club Creek), consistent spawning utilization escapements have been recorded since the start (ca. 1904) of the Fisheries Resource Board of Canada (FRBC) efforts to enumerate spawner areas. Falls Creek had high escapements in the 1950's and Upper Club Creek attained high spawner densities in the 1960's through to the 1990's. Stephens Creek had significant escapement only in the 1960's and 1970's. Small populations of spawners are found in three small tributaries of Swan Lake other than Falls Creek.

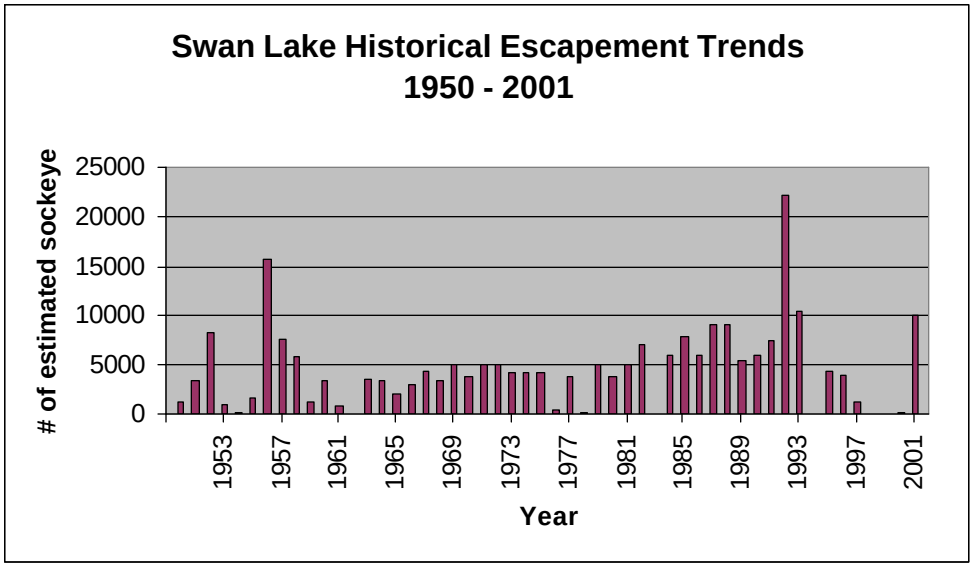


Figure 1. Historical escapement estimates to Swan-Stephens System

Figure 1 shows the historical escapement estimates for the Swan-Stephens system. Estimates prior to 1992 were based primarily on Club Creek (Upper and Lower). In 1992, the GWA included Jackson and Barnes Creeks and in 2001, the GWA enumerated all known spawner areas in the Swan-Stephens Lake system, including Club Creek. The whole system has been monitored consistently since circa 1904, but observations were not recorded numerically until the 1950's. Prior to the 1950's escapement, estimates for spawning areas were recorded as light, medium and heavy by different observers for different years. Due to a lack of standardization or calibration of the terms "light, medium and heavy" in this context and possible inconsistencies introduced by the various observers a numerical estimate has not been placed on these observations (Spilsted 2002).

3.2 Study Area

The Swan Lake Wilderness Area is located near the headwaters of the Kispiox River approximately 100 kilometres northwest of Hazelton, BC (Figure 2). Figure 3 shows the Swan Lake system and drainage area; the Swan Lake drainage encompasses an area of 144 km^2 (14,497.51 hectares).

Figure 2. Kispiox Watershed Map

Figure 3. Swan Lake Watershed Map

4.0 Scientific Equipment and Methods

4.1 Scientific Equipment

The following scientific equipment was used to monitor water and air quality parameters:

- Level Logger air temperature and barometric pressure recording data loggers
- Level Logger water temperature and stage recording data loggers
- Metric stage gauge

4.2 Methods

4.2.1 Adult Weir Construction

Figure 4. Stephens Creek adult fence w/floating live boxes

To successfully determine the number of sockeye salmon returning to the Swan-Stephens system an adult counting weir (Figure 4) was constructed on Stephens Creek 400 meters from the outlet of Stephens Lake (Figure 3). The weir was constructed in approximately 2 meters of water with a low rate of flow and spanned 18 meters across the creek channel.

Crews constructing the weir used a berth log that spanned the width of the stream to support the structure. To construct the panels 19.05 mm (¾") outer diameter and 12.7 mm (½") inner diameter conduit (EMT) and 5.08cm x 10.16cm (2"x4") lumber with 20mm holes drilled 25mm apart to insert the EMT.

To construct the fence the berth log was placed across the stream and positioned at right angle to the flow, then a GWA crewmember with diving certification removed any large woody debris from the underwater fence area. Subsequently fence panels were constructed out of the wooden frame and the conduit then installed leaning at a 50° downstream angle with the aid of the diver. To allow fish to enter the live box a large entrance structure was constructed (see Figure 5) out of a wooden support frame and the 20mm conduit.

The two live boxes with dimensions of 91.44cm x 91.44cm x 243.84cm (3' x 3' x 8'), pre-fabricated at the Kispiox Hatchery, were floated into place and connected to accommodate the fish entering.

Figure 5. Entrance leading into floating live boxes.

In order to successfully enumerate the whole migration period of the Swan Lake sockeye, the fence was made operational on July 12, 2001 just before the anticipated beginning of the run.

4.2.2 Enumeration of Adult Salmonids

Counting Weir

Sockeye

To ensure that the whole run of sockeye salmon to the Swan-Stephens system would be enumerated crews surveyed lower Club Creek one of the main spawning areas upstream of the weir and Stephens Creek upstream and downstream from the weir for the presence of spawning sockeye salmon. This preliminary survey determined that no sockeye were present in Lower Club Creek or Stephens Creek and therefore it is assumed that no sockeye salmon were present in the whole Swan-Stephens system prior to the installation of the adult counting weir.

Once the weir was erected crews visited the site two to four times daily, and the live boxes were inspected for the presence of sockeye salmon. If sockeye were present in the live boxes crews tagged a predetermined sample of adult sockeye (50 if >50 sockeye in live box and 25 if ≤ 50 sockeye) from the live boxes then counted and released the remaining immigrating sockeye to continue in their migration upstream. At the time the sockeye were tagged the sex of each individual fish was identified, its length was measured and age and tissue samples were collected.

During most of the sockeye run at Stephens Creek crews monitoring the weir counted the fish in the live boxes three times per day (morning, afternoon and evening). This monitoring schedule was chosen for two reasons: First, when the fish were tagged and released, any fish holding below the fence would scatter and retreat downstream and not return for several hours and second to avoid excessive crowding in the live boxes. Early morning inspections, prior to 07:00hrs, established that the fish in this system were not moving through the weir until later in the morning.

Coho

As the beginning of the 2001, coho run to the Swan – Stephens system overlapped with the end of the returning sockeye run, the GWA also enumerated the early portion of the coho run while the fence was still in place.

The GWA crewmembers tagged a sample number of coho each day (this was dependant on the number of coho observed in the live box) to allow for the possibility of mark/recapture estimation of the escapement numbers by carrying out stream surveys later in the season. The remaining numbers of coho were released without tagging. At the time the coho were tagged the sex of each individual fish was identified, its length was measured and age and tissue samples were collected.

Spawning areas

The primary objective of the Swan-Stephens project was to calibrate the accuracy of aerial surveys with foot surveys and the count obtained at the weir. The information obtained will be useful in future counts within this system as well as other streams of similar habitat within the Skeena Drainage Basin.

A minimum of three counts during the survey period must be conducted in order to obtain an acceptable Area-Under-the-Curve (AUC) estimate. The GWA carried out three surveys at 14-day intervals over the study period. Reasons for choosing to survey three times was to ensure that the start, peak and end of the spawning period would be covered. The following methods were used to enumerate sockeye on the individual spawning areas:

Foot Surveys – During the study period, three foot surveys were conducted at 14 day intervals on each of the following streams in the Swan-Stephens Watershed.

- Upper Club Creek
- Barnes Creek
- Unnamed Creek 1
- Unnamed Creek 2
- Lower Club Creek
- Falls Creek
- Jackson Creek

Crews of 2 to 4 people would begin their survey at the mouth of each stream and would walk upstream to search for live and dead sockeye as well as excavated spawning redds. The surveyed stream length in each stream was dependent on changes in physical stream parameters (velocity, channel and substrate composition) and the distribution of the sockeye. If no sockeye were observed for two to four hundred meters and the habitat was not suitable for spawning, it was assumed that no spawning would occur upstream and the survey was concluded. In addition to fish numbers, GPS coordinates for the start and end of the survey transects were collected.

Aerial Surveys – aerial surveys are particularly useful for obtaining counts of spawners quickly and efficiently in areas where ground access to the spawning grounds is difficult (Cousens 1982). As suggested in the "DFO Review of Salmon Escapement Estimation Techniques" the helicopter was flown at low speeds and altitude to allow the observer time to enumerate individual as well as schools of sockeye in the spawning areas.

Aerial surveys were conducted on all streams surveyed by foot and were carried out simultaneously to the creek walks to ensure that fish numbers at any given day were comparable to allow an accurate calibration of the aerial surveys and foot surveys.

Usually two surveyors with different roles conducted aerial counts. The primary observer who had considerable experience in aerial surveys focused on enumeration while the second observer recorded and verified the counts made by the primary observer.

Factors that may have affected the accuracy of the aerial surveys are: sunlight reflections, shade, in stream vegetation, rain, water turbidity and fish spooked from the helicopter flying overhead.

4.2.3 Area-Under-the-Curve

The Area-Under-the-Curve (AUC) estimator is a spreadsheet calculator that provides an escapement estimate based on a series of spatial ground or aerial surveys of the spawning grounds.

For this report, the data collected by ground and aerial surveys was used individually in the AUC calculator to determine secondary estimates of the escapement to the Swan Lake system. The primary estimate being the number of sockeye enumerated at the Stephens Creek Weir.

The numbers estimated by the AUC method for individual spawning areas were used to determine the distribution of the returning sockeye population throughout the system in relation to the actual weir count. Factors taken into account when calculating AUC estimates for each stream were as follows:

- Observer efficiency (visibility based on crew experience, stream dynamics and in stream cover).
- Fish stream residence time based on best estimates of the time that the fish entered the spawning area to the time that they spawned.

4.2.4 Collection of biological and water parameter data

Biological Data Collection

In addition to the morphological measurements, additional data collected is tissue samples (upper caudal punches) for DNA analysis to determine genetic variability in the Swan Lake sockeye population and scale samples for aging.

Five scale samples were taken from the preferred area of the fish as suggested by in Sjolund 1974, and then transferred into a scale sample book. Figure 6 shows GWA technicians collecting DNA and scale samples from a Swan lake system sockeye.

Figure 6. GWA technicians collecting tissue and scale samples.

Weather/Water Parameter Data

Water parameter data collection was a pertinent aspect to this project, as it allowed for a correlation of run timing with weather and changes in stream flow.

Data collected was as follows:

- Air temperature
- Water temperature
- Water stage

To collect this data, Level Loggers were installed. These data loggers measured changes in barometric pressure, air temperature and changes in water temperature and stream stage.

5.0 Results

5.1 Stephens Creek Weir

The Stephens Creek weir was in operation from July 12, 2001 until September 28, 2001. Since there was no obvious failure of the fence a complete count of the run was conducted and subsequently an estimate through the mark and recapture effort was not carried out. It should be noted that GWA fisheries technicians spent considerable time searching for possible by passes through or around the fence. The fence was also successful in gathering data on the early portion of the 2001 Swan Lake coho escapement.

Data collected at the fence site is as follows:

- Total sockeye salmon escapement and run timing to the Swan Lake system
- Sample of coho salmon escapement and run timing to the Swan Lake system
- Sex of the tagged sockeye
- Length of tagged sockeye
- Sexual maturity of tagged sockeye
- Sex of the tagged coho
- Length of tagged coho
- Sexual maturity of tagged coho

5.2 Sockeye escapement and run timing to the Swan Lake system

The number of sockeye that migrated through the fence was 10,109 over a period of 79 days.

Figure 7 shows the total sockeye escapement and run timing for the Stephens Creek weir.

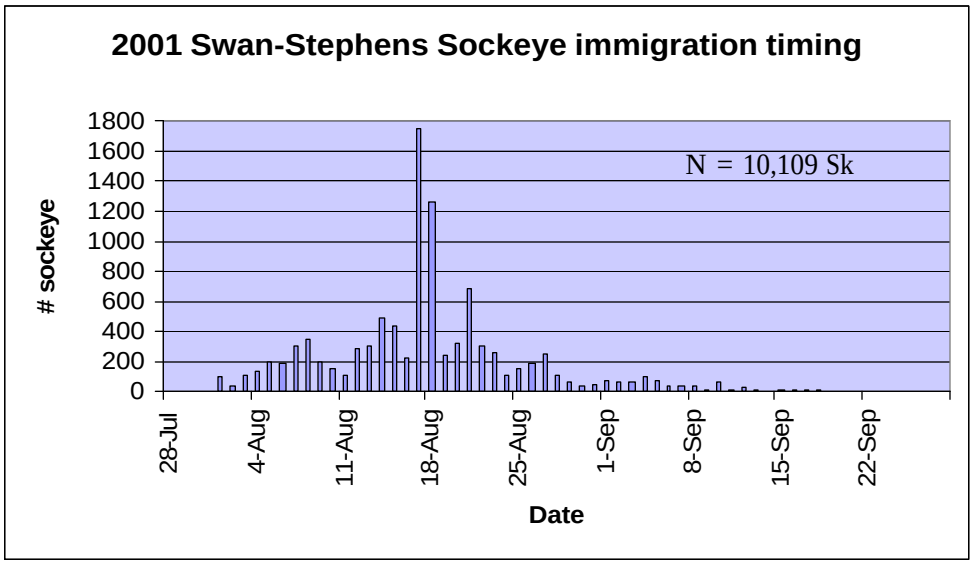


Figure 7. Swan –Stephens Creek sockeye immigration timing.

From July 12 to July 27, 2001 or the first 16 days of operation, no fish were observed migrating upstream through the weir. This changed on July 28 when the first fish were observed at the weir. From August 1 on, the first significant number of adults migrated through the weir daily with peak migration between August 14 and August 22. From then on sockeye numbers started to decline until the end of the weir operation (Figure 7).

The maximum number of fish, after tagging a sample, counted and released at one time from the two live boxes was 689 on August 21. However, the peak numbers of fish recorded for a given day were 1753 and 1262 sockeye on August 17 and 18 respectively. The reason for these high numbers is that technicians opened the door on the live box and visually counted the number of sockeye passing through the fence after they had tagged a portion earlier in the day. This procedure was only used on two days during the peak of the sockeye run. A direct visual count of fish migrating through the weir was possible because of water clarity and the absence of water surface disturbance. This made for extremely high visible of fish at the weir site. Figure 8 shows sockeye at a depth of approximately 240cm.

Figure 8. Swan Lake sockeye at the Stephens Creek Weir

5.3 Stephens Creek water parameters vs. sockeye timing

Determining run timing and physical factors that may influence run timing of the Swan Lake sockeye was a key component of the study. By installing data loggers in Stephens Creek two factors that may influence fish migration from the Kispiox River into the Swan-Stephens system were collected.

Figure 9 indicates that sockeye do not wait for stable or rising stage levels before immigration into the Stephens system.

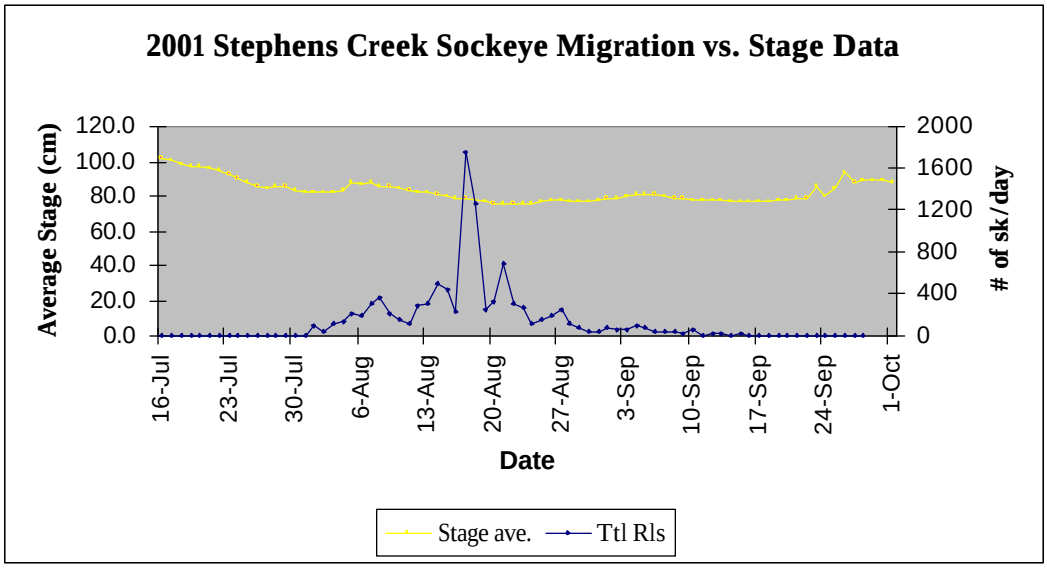


Figure 9. Stephens Creek sockeye migration vs. stage levels.

Water temperature may play a more significant role in the timing of the sockeye migration through Stephens Creek to the deeper waters of Stephens, Club and Swan Lake. Figure 10 shows that the rise in the Stephens Creek water temperature corresponds with peak sockeye run timing.

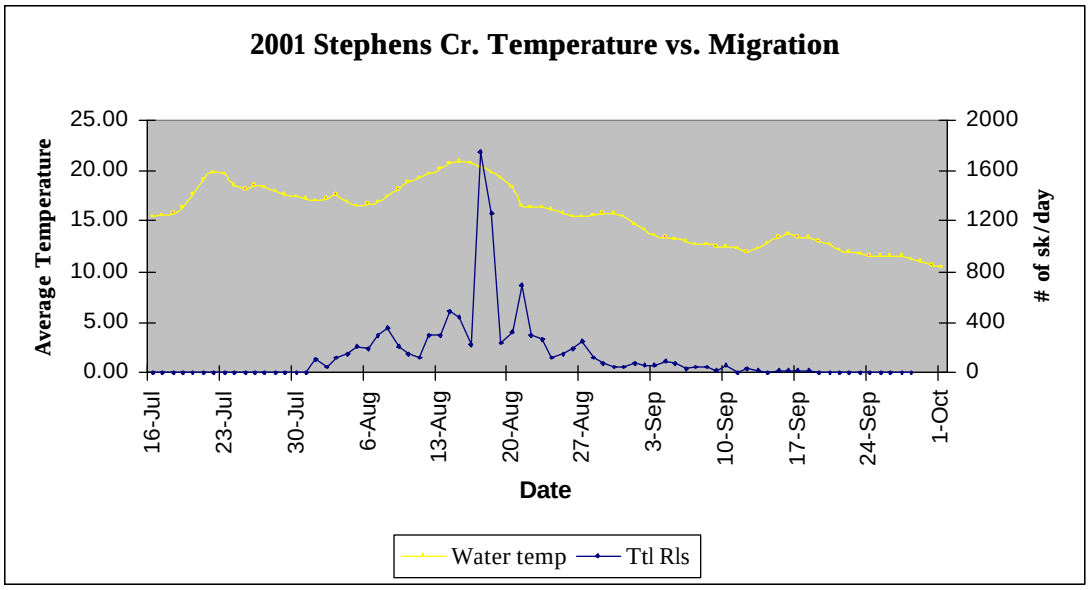


Figure 10. Stephens Creek H_2O temperature versus sockeye immigration timing.

5.4 Coho escapement and run timing to the Swan Lake system

The number of coho counted is 1,998 coho salmon that migrated through the fence over the 79 days of fence operation.

Figure 11 illustrates the sample of coho escapement and run timing data collected from the Stephens Creek weir.

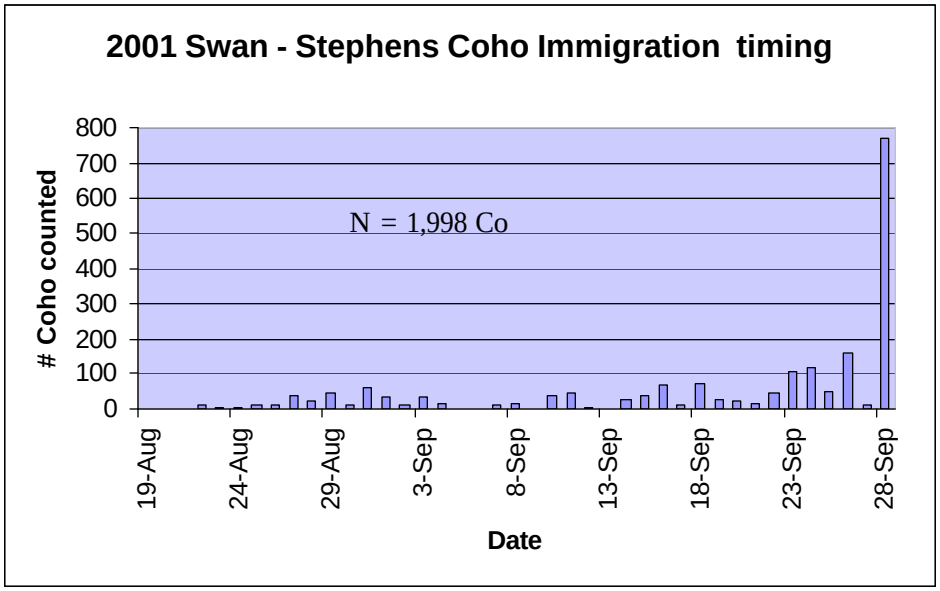


Figure 11. Stephens Creek Weir Coho Timing and Escapement.

The first coho salmon entered the Stephens Creek Weir on August 19, 2001 and numbers of coho migrating through the weir steadily increased throughout the remaining period of weir operation. Lapses in the immigration numbers can be attributed to the weather and stage conditions at Stephens Creek. On September 28 774 coho moved past the fence site just after the fence had been removed and the crew continued to monitor the numbers of coho migrating upstream. The berth log was used as a visual reference point for the enumeration of upstream migrating coho after the fence was removed. Fish that returned below the fence site were also enumerated and subtracted from the total to avoid inflating the number of coho seen migrating upstream.

5.5 Sex Composition

Sockeye – Previous studies recorded 44% and 66% females on Club Creek in 1988 and 1994 respectively (Rutherford 1999).

In 2001, 54% females were recorded among all of the fish that were tagged and released from the fish weir.

Figure 12 illustrates the relative length frequency of sockeye by sex.

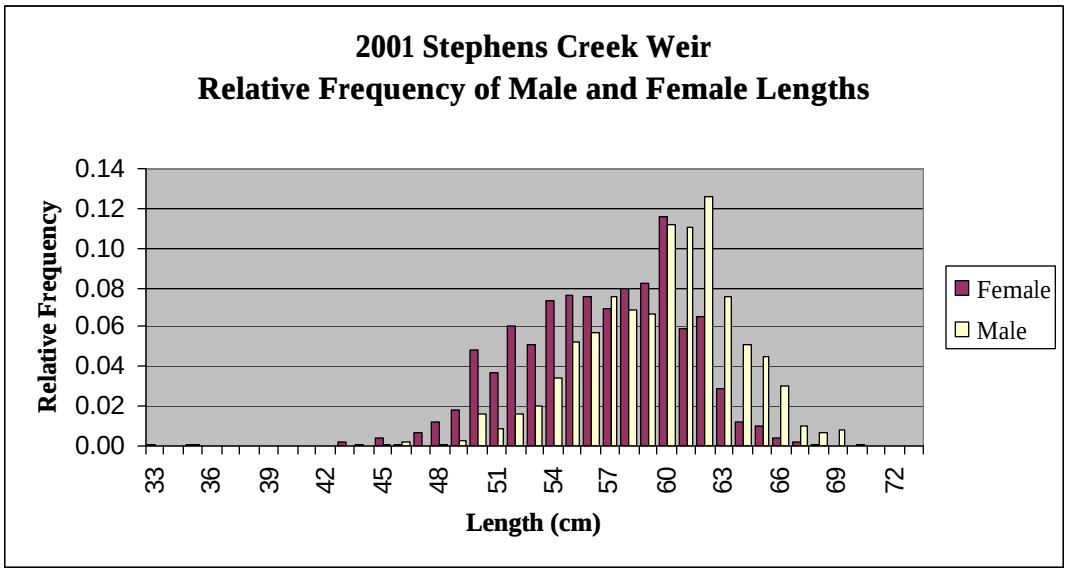


Figure 12. Stephens Creek weir sockeye relative frequency.

Coho - In this study, the GWA crews recorded 51% females within the coho salmon that were tagged and released out of the live boxes.

Figure 13 illustrates the relative length frequency of coho by sex.

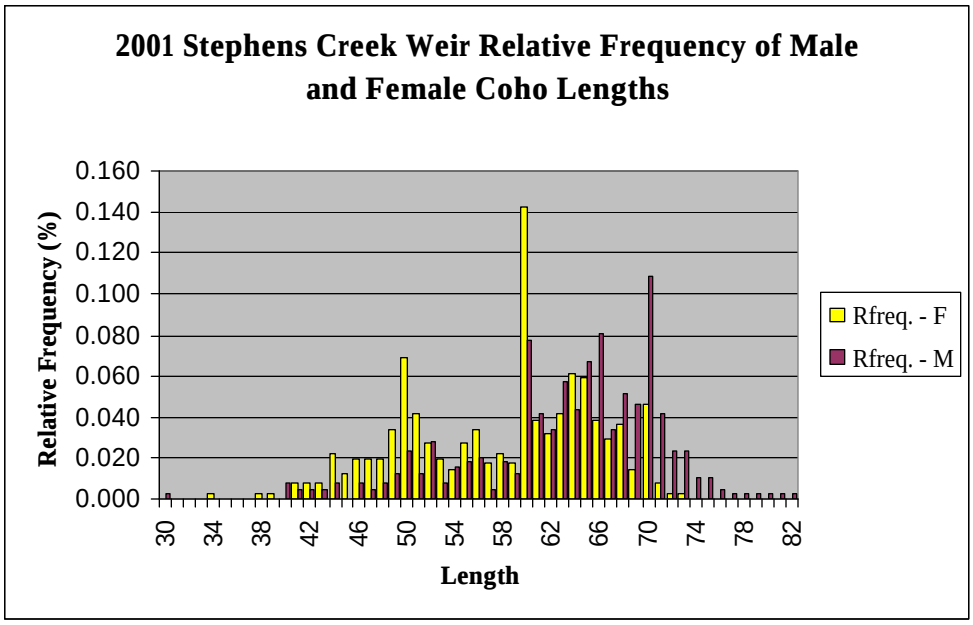


Figure 13. Stephens Creek weir coho relative frequency.

5.6 Sockeye Length Frequency

Figure 14 illustrates the length frequency of all sockeye tagged between July 28 and September 28, 2001.

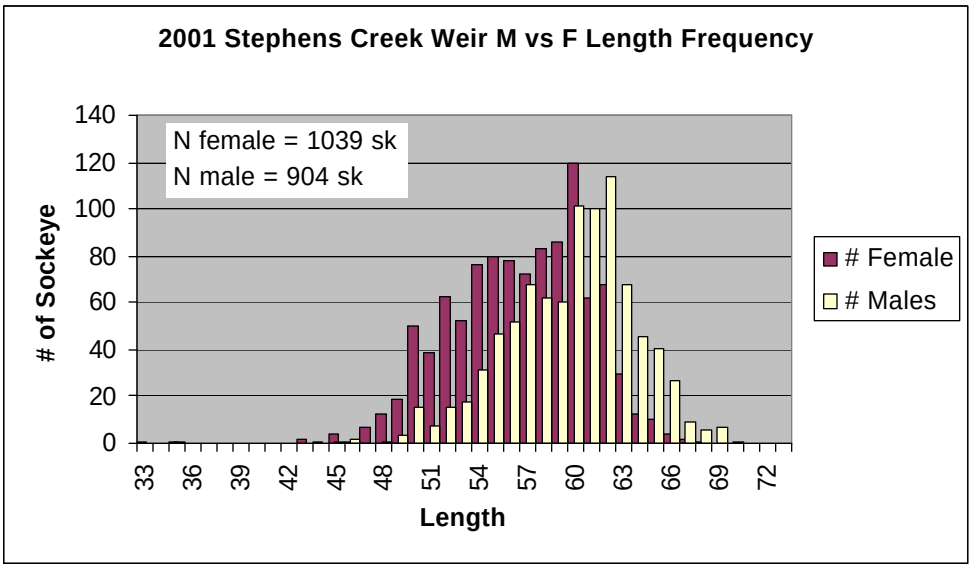


Figure 14. 2001 Stephens Creek male vs. female length frequency.

Because no scale samples have been analyzed to determine the average sockeye age for the 2001 Swan Lake returns, it cannot be assumed that the length frequency histogram (figure 14) illustrates a single age class for this population of returning sockeye. For the

purposes of this report, the sockeye may be classified into two categories, adults and Jack sockeye. Mature fish usually return to spawn after 2-3 years at sea, when they range from 410 to 610 mm in length (Weatherley 1995). Precocious males are usually less than 410 mm in length and less frequent in their abundance when compared with fish that stayed in the ocean for more than one summer. It should also be noted that Jack sockeye due to their small size might have been able to find their way through the weir without being counted.

Figure 15 illustrates the Stephens Creek weir length frequency for male sockeye. Note that very few male sockeye captured at the weir that were less than 410 mm. this may indicate that precocious males managed to push their way through the weir without being counted.

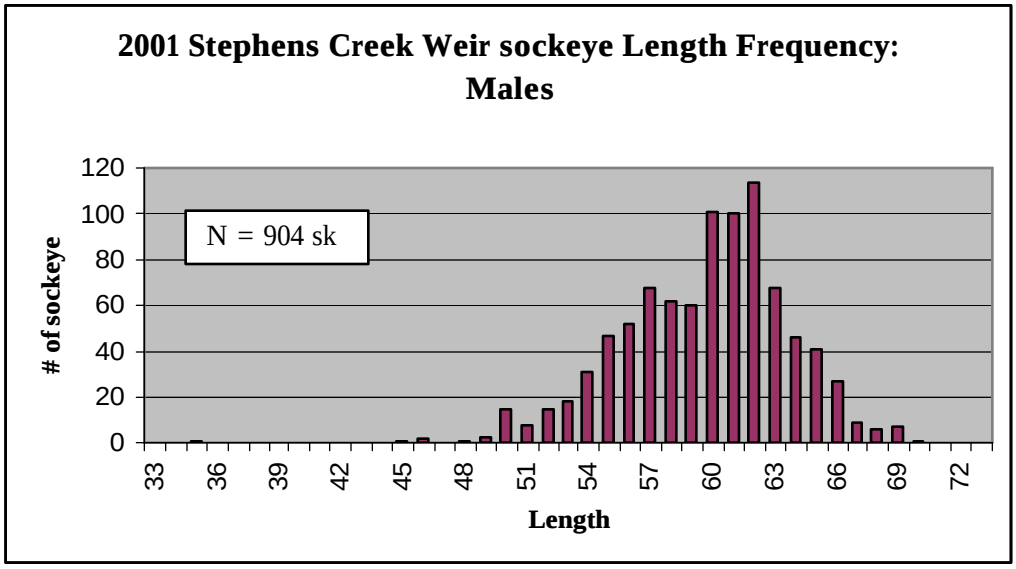


Figure 15. 2001 Stephens Creek weir male sockeye length frequency.

Figure 16 illustrates the length frequency of female sockeye returning to the Swan Lake system and shows that two sockeye were less than 410 mm. These sockeye may have been misidentified and were possibly "precocious males". Male (Figure 15) and female sockeye salmon (Figure 16) show similar length frequency distributions.

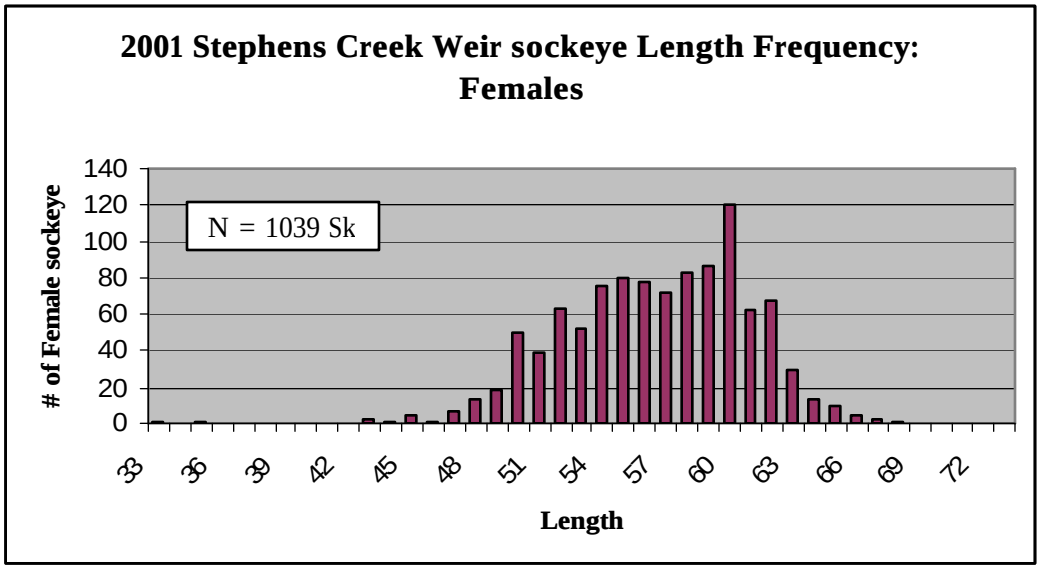


Figure 16. 2001 Stephens Creek weir female sockeye length frequency.

5.7 Coho Length Frequency

Figure 17 illustrates the male coho length frequency distribution for the Stephens Creek Weir for coho tagged between July 28 and September 28, 2001.

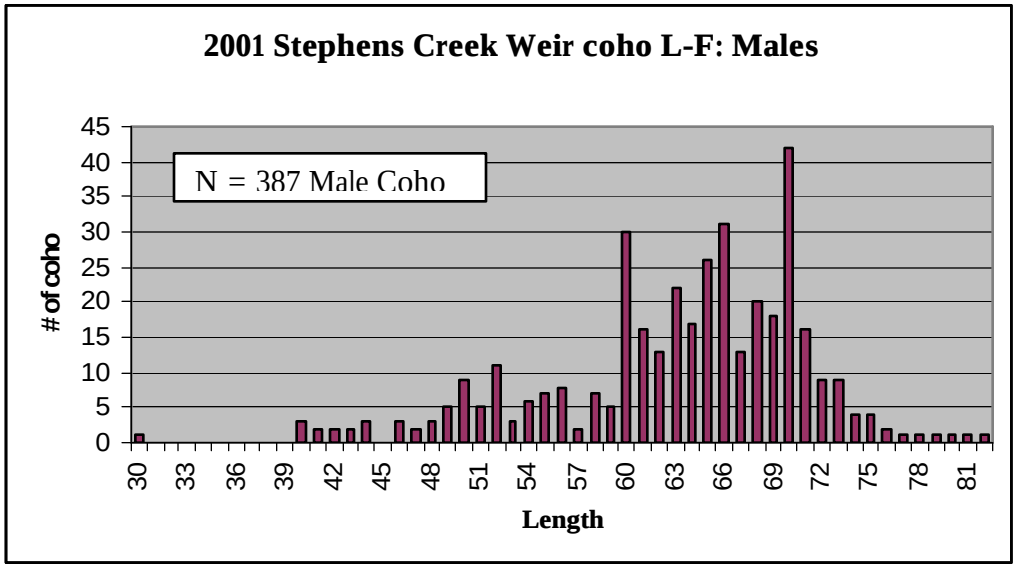


Figure 17. 2001 Stephens Creek male coho length frequency.

Figure 18 illustrates the female coho length frequency for the Stephens Creek Weir.

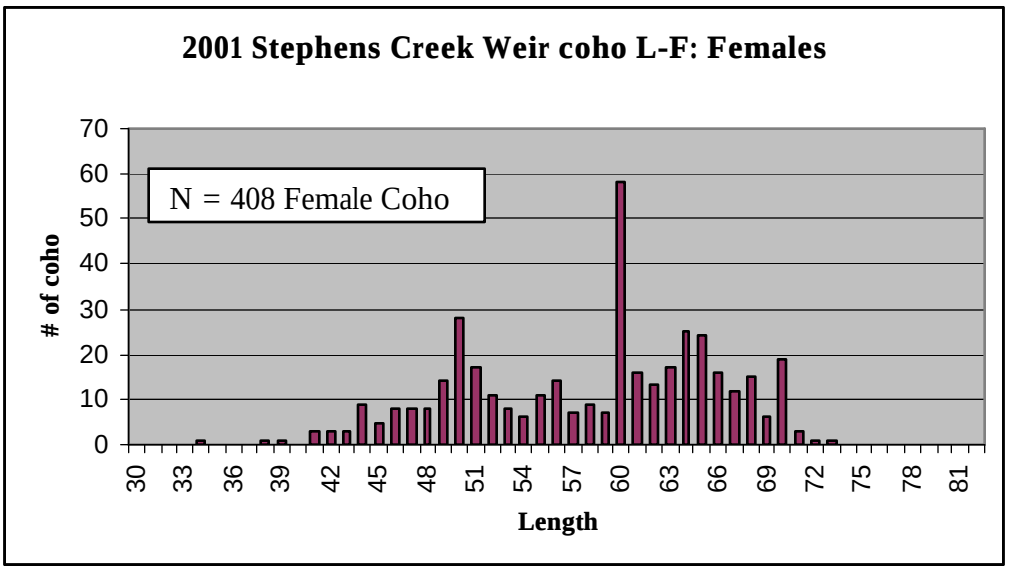


Figure 18. 2001 Stephens Creek female coho length frequency

5.8 Swan – Stephens Spawning Area aerial and ground enumeration

5.8.1 Sockeye

The primary objective of the project was to calibrate the accuracy of aerial surveys with the known accuracy of foot surveys and the count obtained at the Stephens Creek Weir. Table 1 shows the overall results and comparisons of foot and aerial surveys on the individual streams.

Table 1. 2001 Aerial vs. Foot Survey data

Results for the 2001 Swan - Stephens sockeye project			
Stephens Creek Weir - 10,109 sockeye			
Stream	**Foot**	**Aerial**	**AUC**
Lower Club Creek	5068	5490	8054
Upper Club Creek	125	205	250
Falls Creek	665	420	1069
Jackson Creek	88	n/o*	139
Barnes Creek	196	n/o*	290
Unnamed 1 Creek	n/o	n/o	n/o
Unnamed 2 Creek	46	n/o	258
Total	**6188**	**6115**	**10060**
* observed holding in lake		n/o - none observed	

Club Creek – Club Creek (WSC 470-657200-22900) is host to the majority of returning adult spawning sockeye in the Swan Lake – Stephens Lake system. The stream is

partitioned into Upper Club Creek and Lower Club Creek. Upper Club Creek is approximately 100m long and is the connector between Swan Lake and Club Lake. Lower Club Creek starts at the outlet of Club Lake and ends at the inlet to Stephens Lake; it includes several the small lakes.

Figure 19. Lower Club Creek and inlet to Stephens Lake.

Figure 19 shows the spawning area utilized by sockeye and coho at the inlet to Stephens Lake. Most of the stream substrate composition in the foreground area is large cobble and boulders (20 – 30 cm) as seen in Figure 20. The densities of spawning sockeye in this stream section were the highest of all the spawning areas located on Club Creek.

2001 GWA observations of spawning sockeye in Club Creek indicated that the sockeye spawn in large boulder type material and that the eggs are deposited in interstitial between the boulders. Foerster noted in 1968 that the fractured bedrock areas that comprise most of the spawning material of Club Creek seemed like a most unusual and extraordinary type of spawning area. Foerster therefore suggested that this stock must be uniquely adapted to this location to maintain itself (Foerster 1968)

The numbers of spawning sockeye salmon that have been counted in Club Creek have historically been high. In 1992 the Git<u>x</u>san and Wet'suwet'en Watershed Authorities (GWWA) enumerated an estimated 21,600 sockeye spawning in 5 identified reaches (GWWA 1992). In 1993 the GWWA enumerated 7,108 sockeye spawning in the same areas (GWWA 1993). In 2001, Lower Club Creek at the outlet to Stephens Lake hosted a concentration of spawning sockeye in the Swan – Stephens system that is similar to historical observations.

Figure 20 illustrates the substrate composition of Club Creek and the average size of spawning material utilized by the salmon species that spawn in Club Creek.

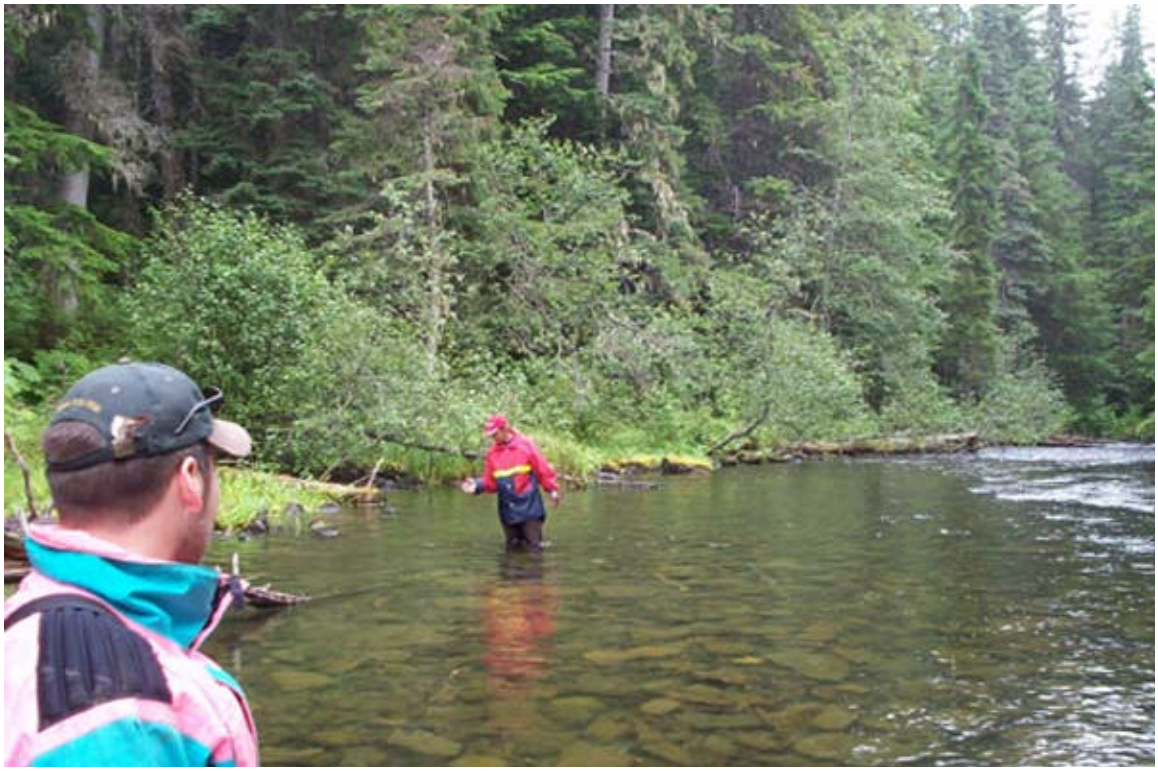


Figure 20. GWA Technicians examining Lower Club Creek spawning areas.

Foot Surveys – Lower Club Creek

Foot Surveys of Lower Club Creek were carried out on August 30, September 13 and October 01, 2001.

The numbers of sockeye observed via foot surveys are as follows:

1. August 30, 2001 – 367 sk.
2. September 13, 2001 – 4045 sk.
3. September 28, 2001 – 656 sk.

Factors that may have affected accuracy of the foot surveys of Lower Club Creek are the deep waters of the small lakes that intersect the creek. Several sockeye were observed in these areas and were counted but the exact numbers that may have been holding in these lakes prior to moving into the spawning areas is unknown. It should be noted that sockeye in these lakes were for the most part visible from the air.

Aerial Surveys

The total observed number of sockeye salmon in Club Creek from the air was 5,490. This number is similar to the number of sockeye that were independently counted by foot (5068 sk). It should be noted that crews carrying out the foot surveys did not offer any indication of the foot survey results to the aerial survey crew prior to the aerial surveys. The number of sockeye observed via aerial surveys is as follows:

1. August 31,01 – 390 sk
2. September 14,01 – 4400 sk
3. September 28,01 – 700 sk

Table 2 shows the comparison of foot survey and aerial survey data for lower Club Creek and the percent difference between aerial observations and the foot surveys.

Table 2. Lower Club Creek aerial survey and foot survey data

Lower Club Creek Aerial vs. Foot Survey Data					
Date	**Fence Data To Date**	**Foot Data**	**Aerial Data**	**Aerial % Comparison with foot**	**% Foot vs. aerial (+/-)**
30-Aug		367			
31-Aug	9440		390	94%	6%
13-Sep		4045			
14-Sep	605		4400	92%	8%
28-Sep		656			
01-Oct	64		700	94%	6%
				average	average
Total	**10109**	**5068**	**5490**	**93%**	**7%**

Based on the average difference in aerial and foot survey data, under optimal stream and weather conditions an observer experienced in aerial survey counts can obtain estimates within 7% of foot survey data.

Upper Club Creek – Club Creek (see Swan Watershed Map) is located at the outlet of Swan Lake. This stream is a trunk or connector stream between Swan Lake and Club Lake and is approximately 100 meters in length.

Historically, Upper Club Creek has had escapement counts of 200 sockeye in 1992 (GWWA 1992) and an estimated count of 580 spawners in 1993 (GWWA 1993). The Fisheries Research Board of Canada Manuscript Report Series, reports escapements to Upper Club Creek ranging from 400 sockeye in 1951 to 1500 sockeye in 1964 (Smith 1966). The average annual escapement to Upper Club Creek between 1951 and 1965 is 478 sockeye (Smith, 1966).

A visual point sampling technique was employed to estimate the Upper Club stream bottom substrate using the Modified Wentworth Substrate Classification (Murphy and Willis, 1996). With this technique the substrate composition of Upper Club Creek is 3.3% fines, 10% gravel, 20% pebble-sized material, 43.3% cobble sized material and 23.3% boulders (fractured rock up to 400mm). Figure 21 is a photograph of the spawning substrate typical of Upper Club Creek.

Figure 21. Upper Club Creek spawning substrate

Foot Surveys

A foot survey was carried out on this section of Club Creek on September 19 and 125 sockeye were observed to be spawning in this area at this time. Reasons for not carrying out additional foot surveys of this stream are the lack of time and the fact that this stream is easily enumerated from the air.

Aerial Surveys

A total of 216 sockeye were observed during three aerial surveys of Upper Club Creek. These numbers are as follows:

August 31 –	30 sk
September 14 –	136 sk
September 28 –	50 sk

Falls Creek – Falls Creek (WSC 470-657200-45000) is located on the east side of Swan Lake (UTM coordinates N 6184715, E 0522335) north of Club Creek. Falls Creek hosts the second largest return of adult sockeye spawning populations to the Swan Lake system. Although the spawning area is only 400 meters in total length, it is extremely productive.

Historical escapement estimates for Falls Creek were 7,500 sockeye in 1956 (DFO 2001). The GWA obtained an escapement estimate of 450 sockeye in 1993 (GWWA 1993).

The stream substrate of Falls Creek is composed of small to medium sized gravel intermixed with coarse sand. Figure 22 illustrates the section of Falls Creek adjacent to the inlet to Swan Lake and shows the sockeye that are spawning in this area.

Figure 22. Falls Creek habitat and the sockeye spawners.

Figure 23 shows the barrier that limits the spawning area of Falls Creek to the first 400 meters upstream from Swan Lake. During the study, GWA crews conducting a foot survey of the stream witnessed an adult sockeye spawner trying to navigate the second set of falls above the ones in the foreground and observed that each witnessed attempt was unsuccessful. It should also be noted that no spawning sockeye have been observed above the falls by the GWA in the past.

Figure 23. Impassable barrier to the upper reaches of Falls Creek.

Although not obvious, the falls are approximately 2 to 3 meters high and above the large boulder in the middle of the photo, another set of falls of approximately the same height but steeper gradient was observed.

Foot Surveys

Foot Surveys of Falls Creek were carried out on August 31, September 14 and September 28, 2001.

The numbers of sockeye observed via foot surveys are as follows:

1. August 31, 2001 – 306 sk.
2. September 14, 2001 – 337 sk.
3. September 28, 2001 – 22 sk.

Predation by bears was observed to be high in Falls Creek judging by the large number of carcasses or dead pitch observed on its bank. The number of dead pitch observed during the three foot surveys is as follows:

1. August 31, 2001 - 0 sk
2. September 14, 2001 - 201 sk
3. September 28, 2001 - 57 sk

Figure 24 is a graphical representation of the foot survey data that was collected on Falls Creek.

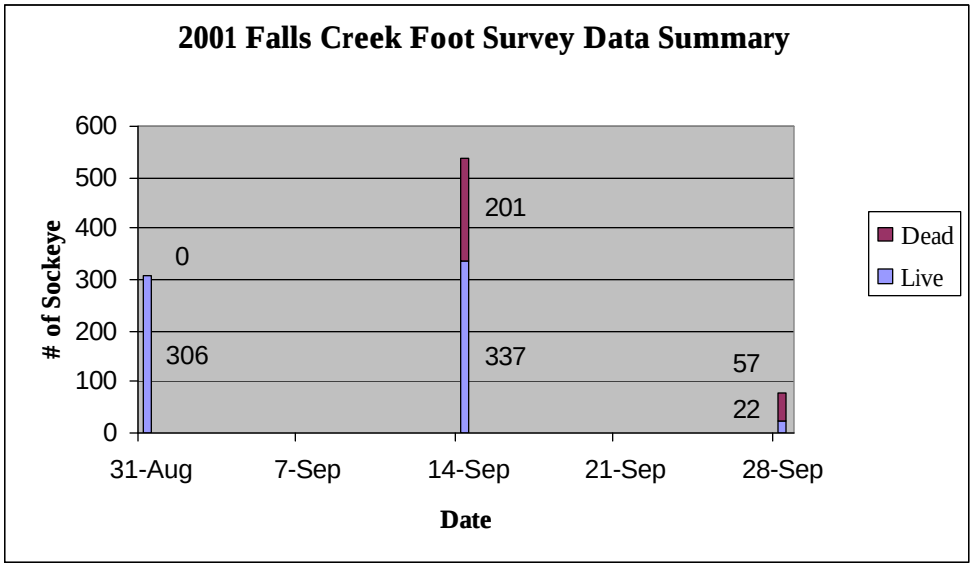


Figure 24. 2001 Falls Creek foot survey summary.

Aerial Surveys

A total of 420 sockeye were observed during three aerial surveys conducted on Falls Creek:

1. August 31 - 220 sk
2. September 14 - 200 sk
3. September 28 - 0 sk

The fact that 200 m above the mouth of Falls Creek alders and dense forest cover the stream may explain why the numbers of fish observed by aerial surveys were lower than the numbers observed during foot surveys.

Table 3. Falls Creek Aerial Survey vs. Foot Survey Data.

Falls Creek Aerial vs. Foot Survey Data					
Date	Fence Data **To Date**	**Foot Survey Data**	**Aerial Survey Data**	**Aerial % Comparison with foot data**	**% Difference foot/aerial (+/-)**
31-Aug	9440	306	220	72%	28%
14-Sep	605	337	200	59%	41%
28-Sep	64	22	0	100%	100%
Total	**10109**	**665**	**420**	**77%**	**56%**

It is important to note that for the 200 m section of Falls Creek that it was possible to count by helicopter the number of fish counted by foot and aerial surveys were similar for all three survey dates.

Barnes Creek – Barnes Creek (WSC 470-657200-52600) is located at the Northeast end of Swan Lake (UTM Coordinates – N 0519754, E 6185461). The total effective spawning area is approximately 500 meters in length with the spawning population spread over this length of stream. 800 meters of the stream was surveyed and no spawning activity was observed beyond 500m.

The stream substrate is composed of small to medium sized gravel intermixed with coarse sand.

Foot Surveys

Foot Surveys of Barnes Creek were carried out on August 31, September 14 and September 28, 2001. Figure 25 shows the summary of the foot survey data collected.

The numbers of sockeye observed via foot surveys are:

1. August 31, 2001 – 69 sk.
2. September 14, 2001 – 111 sk.
3. September 28, 2001 – 16 sk.

Bears were deemed the main predator of sockeye in Barnes Creek. A large number of carcasses or dead pitch were observed during the September 14 survey. The number of dead pitch observed for the three foot surveys are:

1. August 31, 2001 - 14 sk
2. September 14, 2001 - 100 sk
3. September 28, 2001 - 14 sk

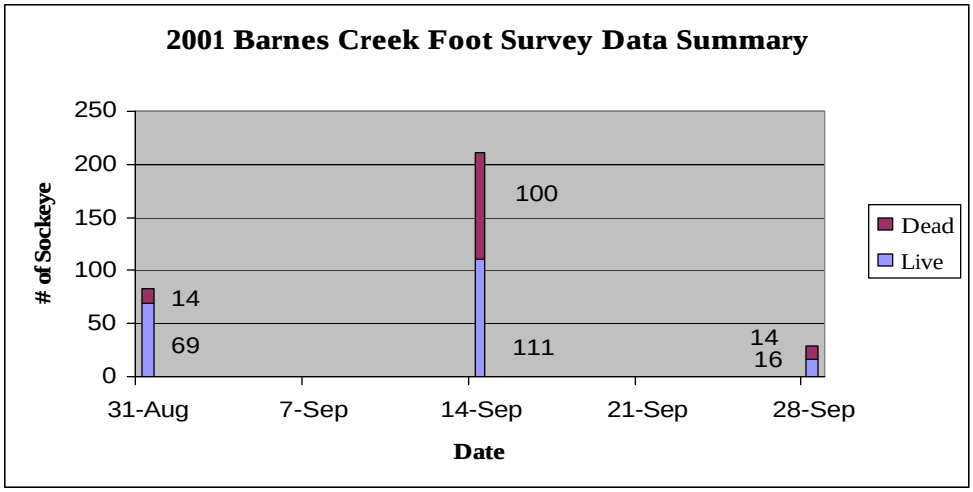


Figure 25. Barnes Creek foot survey summary.

Aerial Surveys

Aerial surveys were carried out each time a foot survey was conducted on Barnes Creek and no sockeye were observed during these aerial surveys.

Since the banks of Barnes Creek are densely vegetated, it was not surprising that no fish were counted during aerial surveys.

Jackson Creek – Jackson Creek (WSC 470-657200-54100) is located at the Northwest end of Swan Lake (UTM Coordinates – N 6185512, E 0519088). The total effective spawning area is approximately 400 m in length with the spawning population spread over this length of stream. 700 m of the stream was surveyed and no spawning activity was observed beyond the initial 400 m.

Prior to 1992 there are no records of sockeye observed in Jackson Creek, however observations by the Gitksan and Wet'suwet'en Watershed Authorities (GWWA) in 1992 recorded 377 spawning sockeye in a survey that investigated the first 200 meters above Swan Lake (GWWA 1992). In 1993, the GWWA inspected Jackson Creek as a follow up to the previous year however; the survey was suspended at 50 meters because a beaver dam had been constructed. The number of sockeye observed in 1993 was 12 in the first 50 meters(GWWA 1993).

Foot Surveys

Foot Surveys of Jackson Creek were carried out on August 31, September 14 and September 28, 2001. The numbers of sockeye observed via foot surveys are:

1. August 31, 2001 – 45 sk.
2. September 14, 2001 – 29 sk.
3. September 28, 2001 – 14 sk.

Bears were deemed the main predator of sockeye in Jackson Creek. A large proportion of carcasses or dead pitch was observed during the September 14 survey. The number of dead pitch observed for the three foot surveys is as follows:

1. August 31, 2001 - 2 sk
2. September 14, 2001 - 7 sk
3. September 28, 2001 - 2 sk

The data collected is summarized in figure 26.

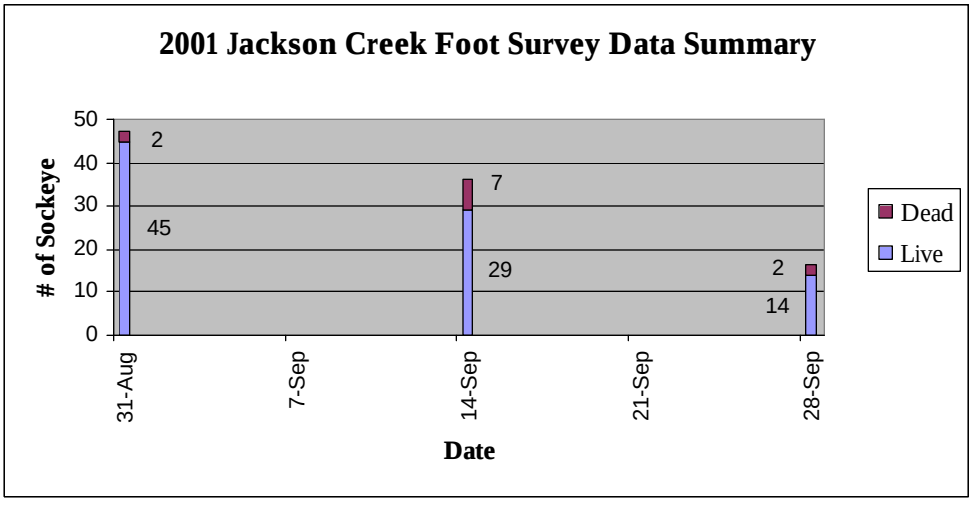


Figure 26. Jackson Creek foot survey summary.

Aerial Surveys

Aerial surveys were carried out each time a foot survey was conducted on Jackson Creek and no sockeye were observed during these aerial surveys.

Again, dense vegetation blocked the view from above in Jackson Creek and made aerial surveys impossible.

Unnamed 1 Creek – Unnamed 1 Creek is located in the Southwest end of Swan Lake. One survey, 2500 meters in length, was carried out on this stream in 2001 and no sockeye were observed. This stream is slow moving and the sediment build up was considered too extensive to be a productive spawning area in 2001.

No sockeye were observed in this stream by the GWWA in 1992 and 1993.

Unnamed 2 Creek – Unnamed 2 Creek is located in the Southeast end of Swan Lake (UTM Coordinates – N 6178667, E 0524440). The total effective spawning area is approximately 700 m in length with the spawning population spread over this length of stream.

No sockeye were observed in this stream by the GWWA in 1992 and 1993.

Foot Surveys

Foot Surveys of Unnamed 2 Creek were carried out on August 31, September 14, September 19 and September 28, 2001. September 19 was added to the counts because crews abandoned the survey after 400m on September 14 due to high bear activity in the area.

The numbers of sockeye observed via foot surveys are:

1. August 31, 2001 – 13 sk.
2. September 14, 2001 – 23 sk.
3. September 19, 2001 - 8 sk.
4. September 28, 2001 – 14 sk.

Bears were deemed the main predator of sockeye in Unnamed 2 Creek. A large number of carcasses or dead pitch was observed during the September 14 survey. The number of dead pitch observed for the three-foot surveys are:

1. August 31, 2001 - 0 sk
2. September 14, 2001 - 59 sk
3. September 19, 2001 - 128
4. September 28, 2001 - 1 sk

The data collected on Unnamed 2 Creek is summarized in figure 27.

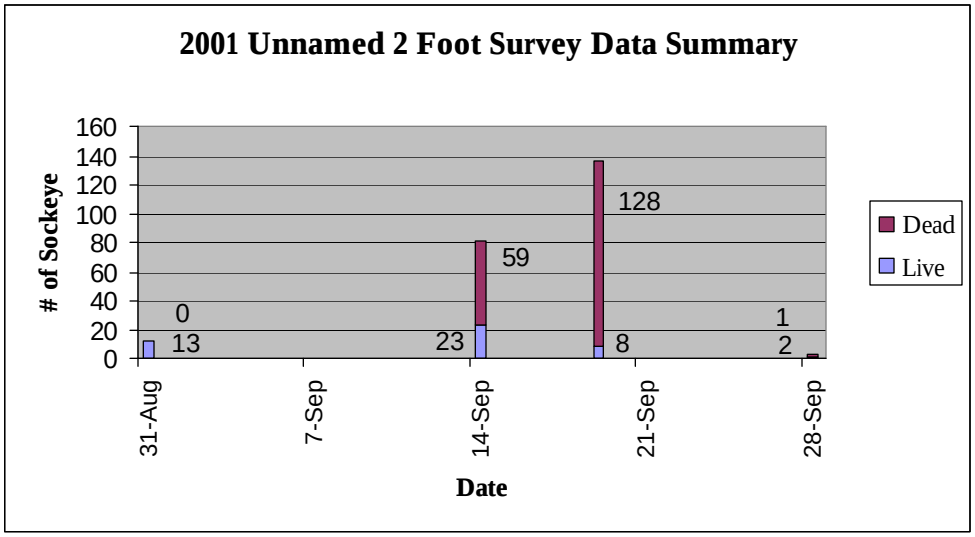


Figure 27. 2001 Unnamed 2 foot survey summary.

Aerial Surveys

Aerial surveys were carried for the August 31 and September 14 and 28, but not for September 19. No sockeye were observed during these aerial surveys.

Again, dense vegetation obstructed the view from above and made aerial surveys impossible.

Stephens Creek - Stephens Creek was also inspected periodically, however, no sockeye were observed to be spawning in this stream.

5.8.2 Coho

Coho were not the focus of this project, however, efforts were made to collect as much data as possible on the numbers, timing and biological data that have been aforementioned in this report. Data collection also included coho observed in streams that ground and aerial surveys were carried out.

Generally few coho were observed in the six streams during the sockeye surveys however, the GWA carried out an aerial survey of the Kispiox River main stem on October 25, 2001 and expanded this survey to include coho ground surveys in the Swan Lake Watershed. Table 4 summarizes the ground survey data that was collected and shows the AUC estimate for coho returning to this watershed.

Table 4. Swan Lake coho escapement summary.

2001 Swan Lake Coho Escapement Summary		
Stream	**Foot/aerial**	**AUC est.**
Falls Cr.	98	253
Jackson Cr.	5	5
Barnes Cr.	12	30
Unnamed 2 Cr.	343	500
Upper Club Cr.	0	0
Lower Club Cr.	36	1370
Stephens Cr.	370	617
Total	864	2775

The data contained in Table 4 includes the aerial count of Stephens Creek, which was not subject to spatial ground surveys by GWA crews.

Figure 28. Sockeye Spawning Distribution.

5.9 Area-Under-the-Curve Analysis

In order to determine the distribution of the sockeye enumerated through the fence on Stephens Creek an AUC estimate was calculated for each stream. These estimates were made based on the foot survey data that was collected for each stream. The total AUC estimate (10060 sockeye) is consistent with the number of sockeye that were enumerated at the fence (10,109 sockeye), which suggests that the parameters used in the AUC calculation (observer efficiency of 80% and stream residence time of 10 days) are adequate for local conditions. AUC estimates are illustrated in Figure 28, which shows a map of the Swan Lake Watershed.

5.9.1 Foot Survey AUC

The AUC estimates for each stream in the Swan Lake Watershed, with the percentage (%) of the run that returned to the stream, based on the fence count, are as follows:

Lower Club Creek - Based on 349, 4211 and 656 fish observed during the three foot surveys an AUC estimate of 8054 sockeye was calculated for Lower Club Creek. This represents 79.7 percent of the total weir count on Stephens Creek.

Upper Club Creek – The Upper Club Creek escapement estimate was made based on the number of observed fish obtained by a single foot reconnaissance survey to the site on September 21, 2001 and two aerial surveys that were carried out (N= 30, 125 and 50 respectively). The 2001 escapement estimate to the Upper Club Creek is 250 sockeye, which represents 2.5% of the weir count.

This generates an AUC estimate for the entire Club Creek of 8304 sockeye, which represents 82.1% of the weir count for 2001.

Falls Creek - For the purposes of AUC calculations the numbers of fish observed during three foot surveys were used (N=306, 337 and 22 respectively). The total number of sockeye residing in Falls Creek in 2001 calculated by an AUC estimate is 1069 sockeye or 10.6% of all of the sockeye that migrated through the weir.

Barnes Creek - For the purposes of AUC calculations the numbers of fish observed during three foot surveys were used (N = 70, 100 and 16 respectively). The AUC calculated 2001 Barnes Creek escapement estimate is 290 sockeye or 2.9% of all sockeye salmon that migrated through the weir.

Jackson Creek - For the purposes of AUC calculations the fish numbers counted during three foot surveys were used (N = 45, 29 and 14 respectively). Based on these numbers an AUC escapement estimate of 139 sockeye or 1.9% of all sockeye that migrated through the weir for was calculated Jackson Creek in 2001.

Unnamed Creek 2 - For the purposes of AUC calculations the results from the Unnamed 2 Creek foot surveys of August 31, September 14, September 19 and September 28, 2001 were used. The calculations were made based on a sample of 13, 23, 8 and 2 respectively for these surveys. The 2001 AUC estimate for Unnamed 2 Creek is 258 sockeye, which represents 2.5% of the 2001 total weir count.

The following table summarizes the total Area-Under-the-Curve estimates for the Swan and Stephens area for the year 2001. These estimates account for a cumulative 99.6 % of the weir count.

Table 5. 2001 AUC summary for Swan Lake watershed.

2001 Area-Under-the-Curve Summary for the Swan Lake Watershed by Stream		
Stream		**AUC estimate**
Lower Club Creek		8054
Upper Club Creek		250
Falls Creek		1069
Barnes Creek		290
Jackson Creek		139
Unnamed 2 Creek		258
Unnamed 1 Creek		n/o
Total AUC estimate		**10060 Sk**

5.9.2 Aerial Survey AUC

As the primary focus of this project was to determine the accuracy of aerial surveys within the Swan Lake Watershed, further AUC estimates were calculated based on aerial counts. These aerial AUC estimates are compared with the foot survey AUC estimates to determine the effectiveness of aerial surveys. The total aerial AUC estimate is consistent with the total AUC foot survey escapement estimate for the Swans-Stephens system, which suggests that the parameters used in the AUC calculation (observer efficiency of 85% and stream residence time of 10 days) were adequate.

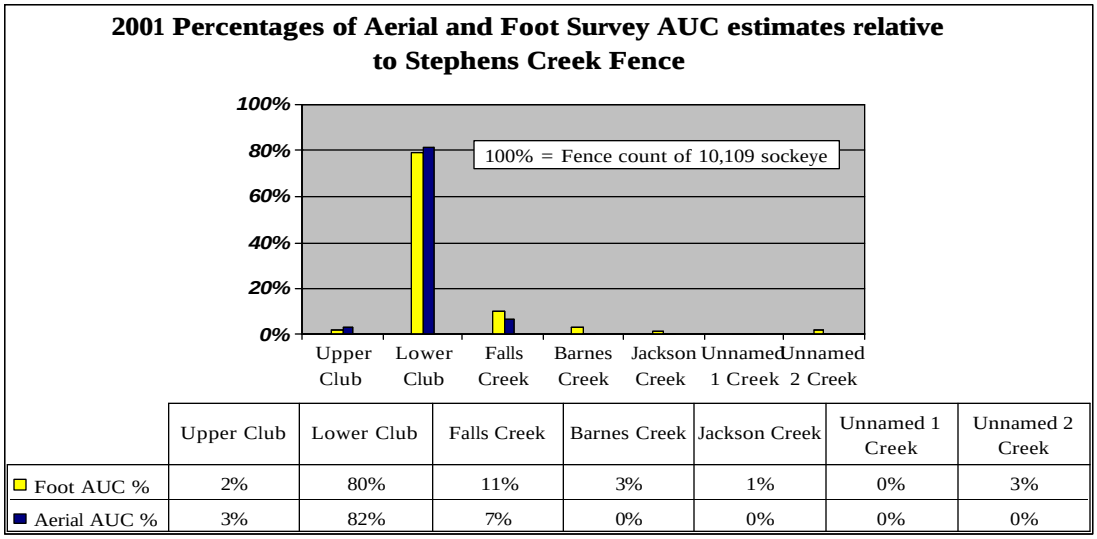
Falls Creek - For the purposes of AUC calculations the results from the Falls Creek aerial surveys of August 31, September 14 and September 28, 2001 were used. Based on the 220, 200 and 0 sockeye observed during these surveys an aerial AUC estimate of 680 sockeye was calculated for Falls Creek. This number represents 6.7 percent of the total weir count on Stephens Creek. The reasons for the aerial AUC estimate being lower than the foot survey AUC (1068 sk) is that only approximately 200 meters of Falls Creek can be surveyed from the air, while the full 400m of spawning area could be surveyed by foot.

Lower Club Creek - For the purposes of aerial AUC calculations the results from the Lower Club Creek aerial surveys of August 31, September 14 and September 28, 2001 were used. Based on observed numbers of 390, 4400 and 700 fish an aerial AUC estimate of **8285 sockeye** was made for Upper Club Creek. This represents 82.0 percent

of the total weir count on Stephens Creek. The reasons for the aerial AUC estimate being greater than the foot survey AUC (8054 sk) is that the visibility of Lower Club Creek is likely better from the air as the observer can see the sockeye in the wider sections and deeper pools.

Upper Club Creek –The results from the August 31(30 fish), September 14 (136 fish) and September 28 (50 fish), 2001 surveys were used to calculate an aerial AUC estimate of 321 sockeye for Upper Club Creek. This represents 3.3 percent of the total weir count (see figure 29).

No further AUC estimates were made for the Swan Lake system as no spawners could be observed in the remaining streams from the air due to streamside vegetation. Figure 29 illustrates the percent of the escapement estimates for each stream in relation to the Stephens Creek Weir sockeye count.



	Upper Club	Lower Club	Falls Creek	Barnes Creek	Jackson Creek	Unnamed 1 Creek	Unnamed 2 Creek
Foot AUC %	2%	80%	11%	3%	1%	0%	3%
Aerial AUC %	3%	82%	7%	0%	0%	0%	0%

Figure 29. Swan Lake streams percent shared escapement in relation to the weir

6.0 Discussion

The Swan and Stephens System sockeye have been enumerated by inadequate spawner area observations since 1904. The enumeration effort carried out by the GWA in 2001 represents the first comprehensive enumeration study carried out on this stock. Most returns to the Swan and Stephens system have been consistent over the years with returning sockeye numbers averaging between 5,000 to 10,000 sockeye per year. However, during an inspection of the area in 2000 approximately 160 sockeye were enumerated, which caused some concern as to the status of this stock. With 10,109 sockeye being enumerated in 2001, it is evident that this stock is maintaining its stability but may be subject to pressure from commercial fisheries, and the native food fishery occurring along the Skeena Rive below the Kispiox River confluence.

For this project to be successful, it was vital that the entire sockeye run was enumerated at a strategic point (Stephens Creek Weir). Using the data that was collected on the weir site in comparison with data that was collected on the spawning streams allowed the GWA to calculate the percentage of sockeye that utilize each individual area. Knowing this percent usage for each spawner area in the Swan and Stephens system will allow for an accurate escapement estimate in the future based on aerial and ground surveys and as well analyze any fluctuations in the usage of these spawner streams.

The determination of the accuracy of aerial counts was another focus of this project. The GWA has demonstrated that in streams, which are easily visible from the air, the accuracy of data collected from aerial counts is consistent with data obtained during ground surveys. In the Swan and Stephens system, annual data that is collected from the air in visible and partially visible streams can be used in conjunction with ground surveys of streams not visible from the air to estimate an escapement for the system. In addition, knowing the accuracy of the GWA aerial surveys will also aid in the escapement estimates for other known spawner areas in the Skeena River Drainage Basin. Areas that are visible from the air could be accurately enumerated with minimal error. It should also be noted that the aerial survey AUC estimate for Lower Club Creek was considerably higher than the foot survey AUC, this is more than likely due to higher visibility from the air in the deeper pools and the observer efficiency of this stream could possibly be increased to 90 percent.

Also supporting the accuracy of the aerial surveys are the Area-Under-the-Curve estimates. Based on the data collected at the fence and during the spawning area surveys the GWA can accurately estimate the total escapement for this system using the AUC escapement estimator and ground survey data. The total AUC sockeye escapement estimate for the Swan and Stephens system is 10,060 fish while the number of sockeye counted at the weir was 10,109 fish. For aerial counts, the escapement estimate has been calculated to be within 11% of the total weir count using the streams that aerial surveys could be carried out.

Although coho were not the focus of this project, it was plausible to enumerate the fish at the fence site and record the numbers of coho spawners observed when carrying out sockeye spawner area surveys. The data that was collected in early surveys were used in conjunction with surveys carried out later in the year to generate escapement estimates for the Swan and Stephens coho using Area-Under-the-Curve estimates of 2775 coho for 2001.

Historically, Lower and Upper Club Creek were the only spawning areas enumerated by Fisheries Officers employed by the Fisheries Research Board of Canada. Later Falls Creek was included due to high spawner densities observed in the area. In 1992, the GWWA included the remaining four streams (Jackson Cr., Barnes Cr., Unnamed 1 and 2 Creeks) in the area after witnessing spawning sockeye and coho in these streams. These streams continue to be monitored when the Club and Falls Creeks were enumerated to monitor their productivity and to maintain best escapement estimates for whole the Swan and Stephens Watershed.

Where run timing is concerned Figure 9 shows that water levels are not a key factor in the immigration of sockeye to the Swan-Stephens system and figure 10 illustrates that sockeye are likely to immigrate into the Swan Stephens system starting approximately 30 days prior to entering the spawning areas. A likely explanation for this run timing-water temperature correlation may be that sockeye move into the system before air temperature increases surface water temperatures in the lakes (known as summer heat income) to levels that are potentially lethal for sockeye salmon. Once in the lakes sockeye salmon can seek the colder water masses below the thermocline. Fish migration has also been reported to be linked to rising water temperatures by (Hach 1996-2001).

Evidence suggests that high water temperatures in rivers which are used by sockeye salmon for migration and spawning can cause appreciable mortality of unspawned individuals (Foerster 1968). Moreover fish in the Northern Hemisphere experience stress when exposed to temperatures between 15°and 20°C for prolonged periods of time while temperatures above 20°C are often lethal (Rosberg 2001). As indicated in Figure 10, water temperatures in Stephens Creek exceeded 15°C for a prolonged period and did reach 20°C for a short period during the peak run timing.

It is also known that fish seek suitable water conditions by searching for water where temperatures are closer to their requirements. Fish usually are attracted to warm water during the fall, winter and spring and to cool water in the summer and have the ability to detect slight temperature differences (Hach 1996-2001).

7.0 Conclusions

Although the Swan – Stephens system sockeye have been enumerated numerous times in the past, through ground surveys of spawning areas, 2001 is the first time that the Swan – Stephens sockeye escapement has been enumerated through three different survey methods at the same time. From July 12 to September 28, 2001, the Stephens Creek weir was successful in allowing the GWA to enumerate returning sockeye (N=10,109 sk) to this area of the Kispiox River Watershed. For coho, the early part of the run was enumerated (N=1998 fish)

This project was successful in accomplishing the following objectives:

1. The enumeration of returning sockeye salmon in the Swan-Stephens watershed with a counting fence.
2. The collection of biological data.
3. The enumeration of spawning areas via a series of ground surveys on the six known sockeye spawning areas.
4. The enumeration of spawner areas via aerial surveys.
5. The collection of temperature, stage, and discharge data for Stephens Creek.
6. The collection of GPS data to determine area of the spawning grounds and the location and length of streams used.
7. Provision of jobs for unemployed and displaced fishers.

The main objective of determining the accuracy of aerial surveys will also allow the GWA to quickly enumerate streams, that are time consuming to enumerate on foot, with a measurable degree of accuracy.

The data collected from this project provides a better understanding of the Swan Lake sockeye. The GWA now has a baseline escapement that historical and future sockeye escapements to the Swan-Stephens system can be compared. A summary of the escapement estimates for each individual stream enumerated in the Swan Lake Watershed is outlined in Table 6.

Table 6. Sockeye Escapement Summary

2001 Swan Lake/Club Creek Sockeye Escapement Summary	
Stream	**Escapement**
Stephens Creek Weir	10,109
Club Creek	8,056
Falls Creek	1,069
Barnes Creek	290
Jackson Creek	139
Unnamed 1 Creek	N/O
Unnamed 2 Creek	258

8.0 Recommendations

Based on the results and scope of the 2001 Swan – Stephens system sockeye project and the importance of maintaining the vitality of this small system stock, the recommendations are as follows:

1. Continue to enumerate the spawner areas of Swan Lake and Club Creek via foot or aerial surveys seasonally.

2. Continue to enumerate the spawner areas of Swan Lake and Club Creek at least three times throughout the spawner period.

3. Establish an electronic counter on Stephens Creek that would allow for the collection of yearly system escapement numbers to the area. This would provide minimal impact to the environment as opposed to setting up a camp.

4. Carry out a juvenile sockeye study and habitat analysis of the Swan Lake system.

5. Determine carrying capacity of the spawning and rearing areas of the Swan Lake system for sockeye and coho.

6. Use the biological data and scale analysis to determine the age composition of the 2001 returning adults.

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