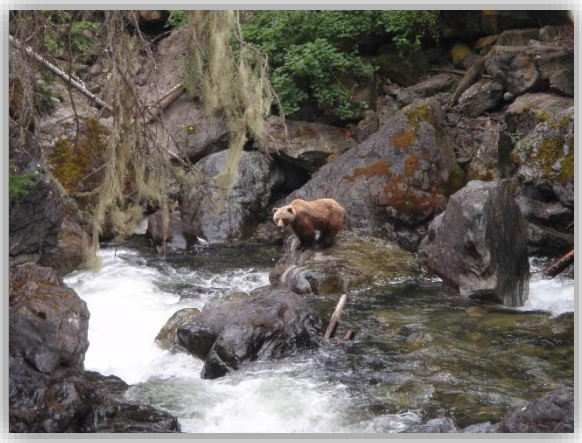
Kuthai Lake sockeye review -2015



Final Report

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Prepared by:

Taku River Tlingit Fisheries

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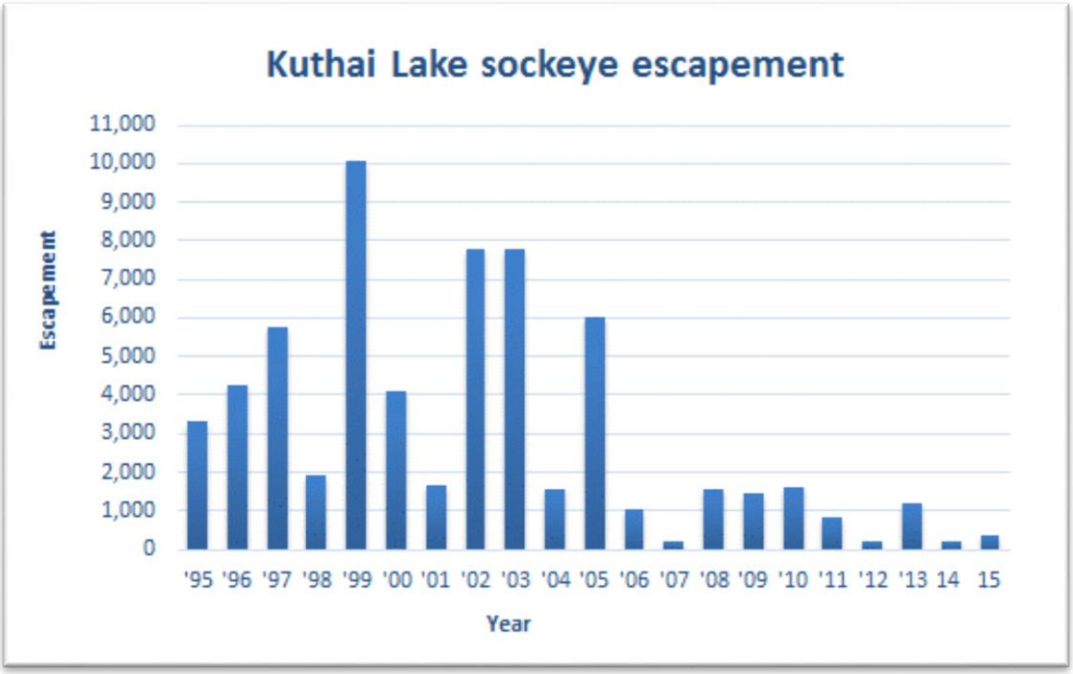
INTRODUCTION

Background:

Kuthai sockeye escapement has been low for numerous years and does not seem to be recovering. The 10-year average escapement from 2005-2014 was 1,423 while the previous period from 1995-2004 it was 4,818. Sockeye escapement to the lake in 2015 was 341. Although run-sizes and escapements are known to fluctuate over the longer-term, during the last 9 years we have not seen a rebound in the cycle. Also, within that period there have been 3 years of escapements in the range of about 200 fish. Such a low level of escapement has not been observed prior to 2007.

Figure 1: Yearly Kuthai Lake sockeye escapement



Like all of the sockeye lakes in the Taku drainage, there is currently no explicit sockeye escapement goal for Kuthai Lake. As such, there is no formal management trigger within existing TBR PST arrangements to prescribe management action. Therefore it will largely fall upon the TBR Technical Committee (with guidance and / or support from the TBR Panel) to direct a management response regarding the Kuthai sockeye decline. Given that currently the specific factor(s) contributing to decline in Kuthai sockeye abundance were unknown, it was considered prudent to investigate such in 2015. This way, informed actions can take place in a timely manner regarding further assessment needs or restoration activities.

Although the Kuthai stock is only a moderate contributor to the overall Taku sockeye run, it does comprise the earliest run component and is harvested in both US and CAN fisheries. As

well, *Ghàt âyi* (Kuthai) Lake is considered very important to the First Nation in terms of proximity to the community and associated Traditional Use.

Objectives and scope:

This project was an investigation into why Kuthai Lake sockeye escapement has dramatically declined and remains low. The focus was upon evaluating migration access for the Kuthai stock, along with estimating relative abundance and stock proportions for Kuthai and co-migrating early run main-stem sockeye.

The main objectives for the project included:

1. To evaluate migration access (or success) for the Kuthai stock;
2. To estimate relative abundance and stock proportions for Kuthai and co-migrating early run main-stem sockeye;
3. Working with the TBR Technical Committee regarding planning and implementation;
4. Presenting project results to the TBR agencies and the First Nation for consideration;
5. Submission of a final written report which details project methods and results.

Project area description:

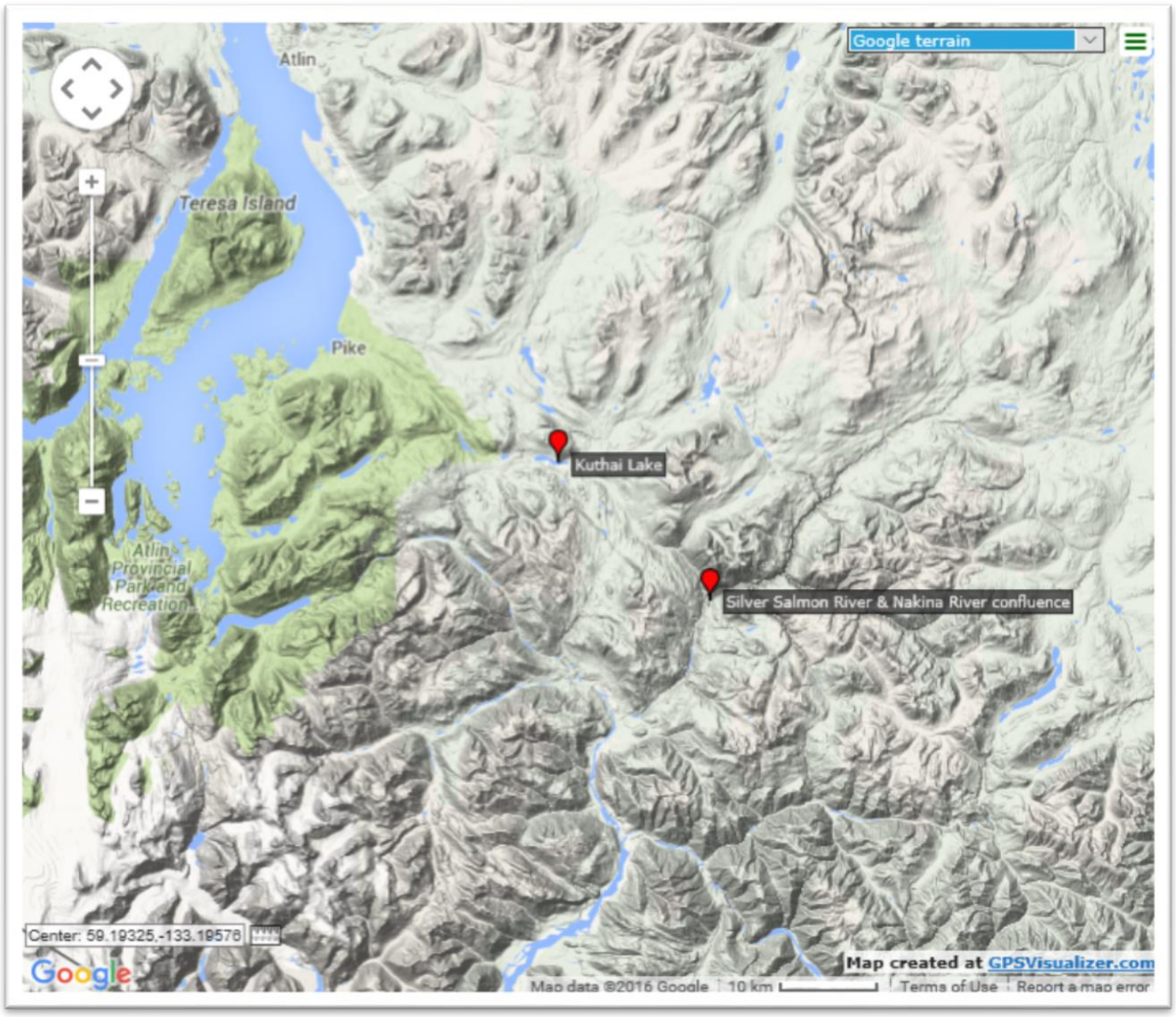
Kuthai Lake is located 45 km southeast of the community of Atlin in northwestern BC. (See Figure 2 below.) This oligotrophic lake is 724 m above sea level with a surface area of 154.2 ha and mean and maximum depths of 7.42 and 16.7 m respectively.

Kuthai Lake is utilized by spawning and rearing sockeye salmon as well as rainbow trout and pike. (Rainbow trout, Dolly Varden and the odd Chinook salmon have been observed in the creek just below the lake outlet.)

Kuthai Lake drains into the Silver Salmon River, 23 kilometers upstream of the confluence with the Nakina River. Silver Salmon River is a 5th order stream with a total length of 48 km. The upper portion of Silver Salmon Creek is slow, meandering and surrounded by wetlands. The immediate lower portion, approximately 1 km above the Nakina River confluence has a steep gradient within a confined canyon with large boulders and cascades, creating a series of jumps that may provide challenges to migrating adult sockeye.

Primary access to the lake is by floatplane although a four wheel drive road leads to the lake from the Warm Bay road. Since 1971 an enumeration weir for adult sockeye salmon has been operated at the outlet of Kuthai Lake.

Figure 2: General location of project sites



The map in Figure 3 is a delineation of the Silver Salmon watershed with a preliminary set of reach breaks broken out based on site geomorphology. Nakina River is at the bottom of the map and Sloko River is to the west. The Silver Salmon watershed covers an area of approximately 430 km² in the lee of the Coast Range Mountains. Hydrologically the watershed is transitional between the wet Coastal Mountains zone and the drier Yukon Plateau region. The east side of the watershed is more mountainous with peaks up to 1,800 meters while the west side is more topographically subdued with considerably more open plateau and lower relief. Major sub-basins include the Silver Salmon main stem, and the Tawina Lake and Katina basins.

Overall the watershed has considerable hydrologic storage between the seasonal snow pack, plateau wetlands and oxbows and small lakes in all sub-basins. This suggests that there is good potential for low flow augmentation during the summer and winter periods and strong

flood attenuation during peak runoff events. Watershed areas of the major sub-basins are shown in Table 1 below.

Figure 3: Watershed map of the Silver Salmon River

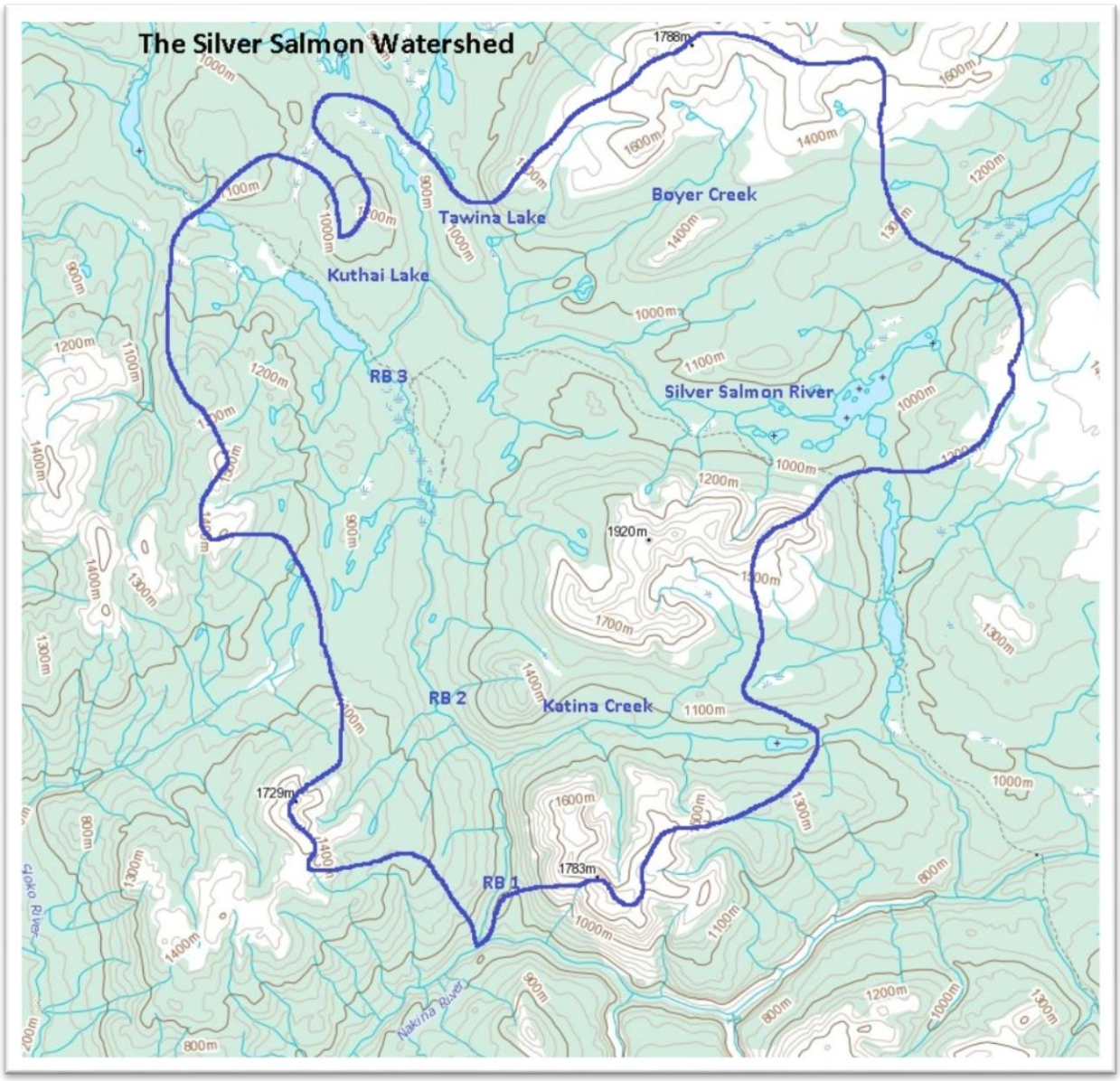


Table 1: Silver Salmon watershed major sub-basins

Watershed	Area
Silver Salmon above Kuthai	202 km²
Katina Creek	59 km²
Silver Salmon Total	430 km2

METHODS

Radio telemetry:

A total of 100 radio telemetry tags were purchased for application on early run sockeye captured on the lower Taku River. The intent was to provide information on the success of Kuthai sockeye migration, spatial distribution of early run Taku sockeye, and some further indication of stock proportions.

This portion of the project involved collaboration with ADF&G staff working on a Chinook radio telemetry project. Fish were captured and tagged during the annual mark-recapture experiments on the lower Taku River. Tracking of the applied sockeye tags was mainly done opportunistically during regular ADF&G Taku Chinook aerial index surveys.

Genetic sampling:

During stat weeks 23-28 (June 1st to July 11th) of 2015 there were 800 genetic samples collected from early run sockeye captured in the Canyon Island fish wheels on the Lower Taku River. The intent here was for mixed stock analysis that would allow for the delineation of stock proportions between the Kuthai Lake sockeye and those that are early run main-stem stocks. The samples were to be analyzed at DFO's Pacific Biological Station in Nanaimo, BC.

Field surveys:

From July 9th – 12th, 2015 field surveys of the Silver Salmon River were conducted to assess potential barriers to adult migration up the Silver Salmon River. The crew included a Hydrologist, Biologist and TRT Fisheries Manager, who all stayed at the Nakina Carcass weir camp.

A ground survey was conducted in Reach 1 of the Silver Salmon River. The crew hiked up into the canyon and looked for evidence of sockeye being held back or trying to navigate this section. Stream gauging of flows and discharge were performed on the Nakina River (at the weir site), on the Silver Salmon (just above the Nakina confluence), and at the outlet of Kuthai Lake (below the weir).

The field assessment also included an aerial survey of the entire Silver Salmon River (from the Nakina to Kuthai Lake). This allowed for the capture video imagery of channel characteristics and the evaluation of fish access through beavers dams in the upper reaches.

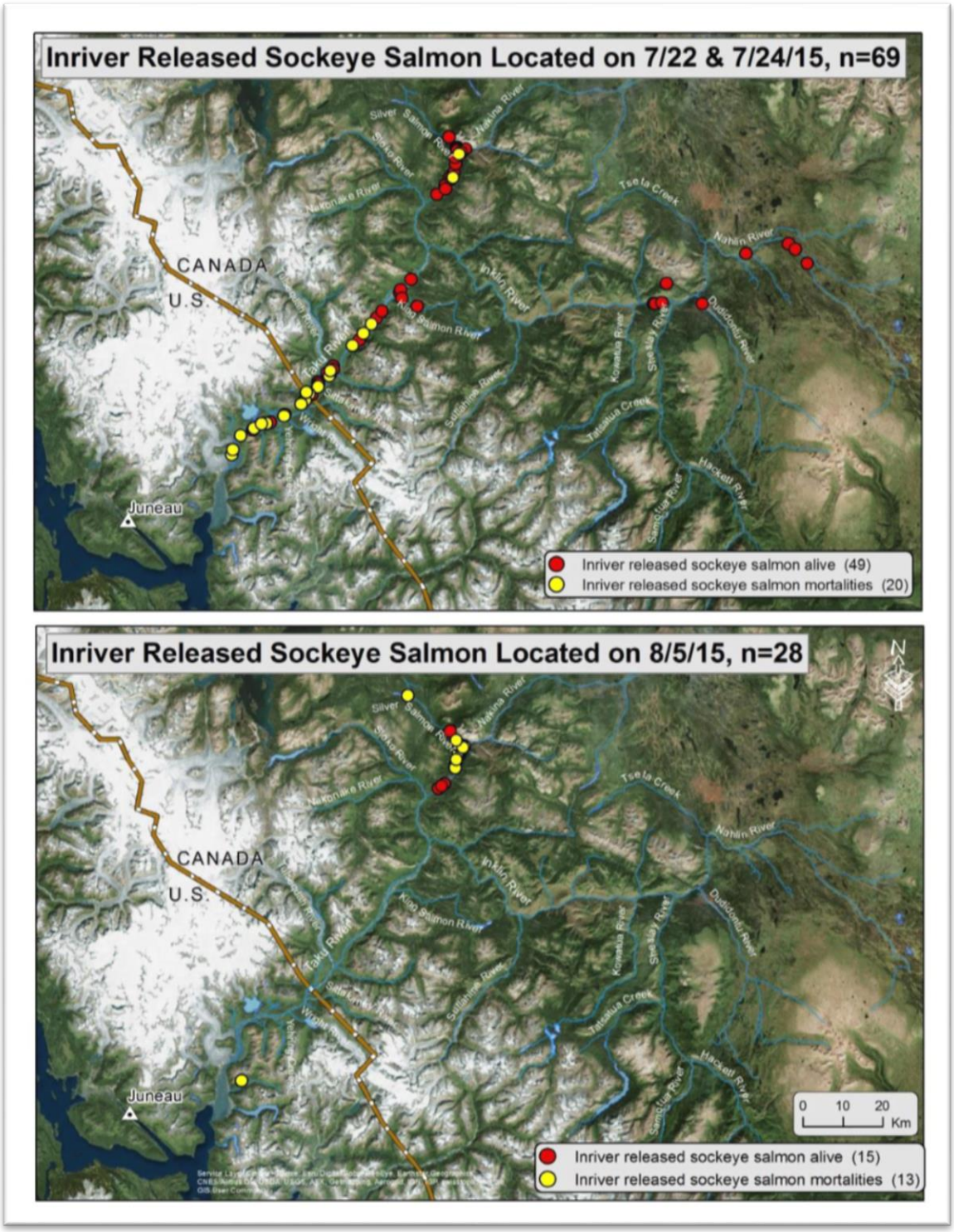
RESULTS

Radio telemetry:

The 100 radio tags were applied from June 13th to July 4th, 2015 on the Lower Taku River. It was apparent that a substantial proportion of the 100 radio tags (at least 25% but likely more)

were heading up Nakina or Silver Salmon Rivers. Estimates from the overall telemetry include: 23 did not proceed upstream (were likely mortalities); 27 were located at the Nakina/Silver Salmon confluence; and 1 was located at Kuthai Lake.

Figure 4: Sockeye radio tag locations



During the August 8, 2015 radio telemetry flight there was only 1 live sockeye tracked in the Silver Salmon River, and 2 mortalities there. (See Figure 4 above.) Lower down, at the Silver Salmon / Nakina confluence there were 14 live sockeye and 10 mortalities tracked. Historically at that time, approximately 77% of Kuthai sockeye have already made it to the lake. This indicates a potential migration barrier in the canyon area of the lower the Silver Salmon River (upstream of its confluence with the Nakina River.)

Based upon radio tag proportions, it is roughly estimated that 3,000 to 5,000 sockeye (27 tags) went up the Nakina River to the Silver Salmon River, and about 1,000 to 2,000 sockeye (12 tags) were stuck in the canyon area on the lower Silver Salmon River.

Genetic sampling:

Unfortunately, the 800 sockeye genetic samples were mistakenly left at the ADF&G Canyon Island camp after demobilization in October of 2015. It has been indicated that in March of 2016 the samples will be opportunistically picked up and delivered to the ADF&G office in Juneau. Then they will be shipped to the PBS lab in Nanaimo, however at this time genetic analysis and subsequent results are still pending.

Aerial survey and reach break summary:

The reach break summary is described by the following:

- **Reach 1:** This is the section of channel between the confluence of Nakina River up to the top of the canyon section. This reach is approximately 900 meters long and has the major potential migration barriers in a steep step pool morphology. Reach 1 has instream boulder clusters near the Nakina confluence and at the top of the reach that form the most complex and highest jump height obstacles. The boulder clusters include individual clasts that range in size up to approximately 10 meters in diameter. The boulders are poorly embedded with minimal alluvial gravel which leaves large voids between the individual clasts. This results in extremely high interstitial flow volumes that reduces the area of water surface area and the dimensions of staging and holding pools. The middle of reach 1 is more of a alluvial step pool / cascade sub-reach with fewer obvious jump height obstacles.

Photo 1: Aerial view of Reach 1 on the Silver Salmon River.
(The Nakina River is on the far right of the photo.)

Photo 2: Aerial view of Reach 2.

(Showing the step pool morphology and one of several active sediment sources.)

- **Reach 2:** This is the approximately 8 km section of channel upstream of the canyon that is characterized by lower gradient, less confinement and a cascade morphology. This reach has several relatively large sediment sources providing bedload input to the canyon reach that is likely important in maintaining the canyon pools and infilling between the boulders.

- **Reach 3:** This is the 13 km meandering riffle / pool section of Silver Salmon River channel that traverses the plateau area in the center of the watershed. Lower gradient and abundant glacial fluvial sediments create a channel with sinuous meanders, ox-bow cutoff channels, and extensive areas of riparian wetlands. This reach provides excellent beaver habitat as evidenced by the series of main stem and off channel beaver dams and lodges in various stages of repair. Although fairly numerous beaver dams were observed in Reach 3, all but one appeared to be open or breached, and no sockeye salmon were observed holding below the dams.

Photo 3: Aerial view of Reach 3.
(Showing the meandering channel and riparian wetlands characteristic of this reach.)

- **Reach 4**: This is the 400 meter section of channel upstream of the confluence with Tawina Creek up to Kuthai Lake. This reach is a meandering channel with a reduced channel cross section due to the lower flows coming from the lake.

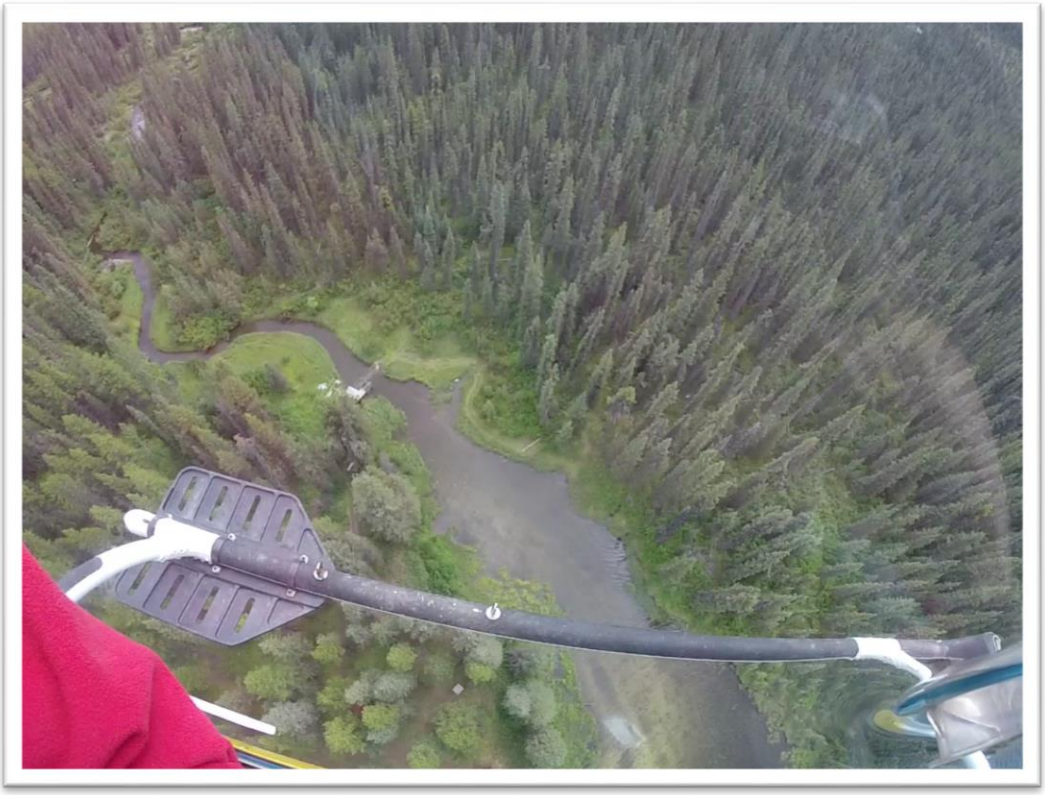


Photo 4: Areal view of Reach 4 just below the lake.
(The adult weir can be seen at the outlet of the lake. Stream gauging was conducted immediately below the weir.)

Ground survey and barrier assessments:

A ground survey barrier assessment was conducted in Reach 1 on July 10th and 11th, 2015. A detailed physical survey of canyon jump heights and staging pool depths was not possible given safety issues relating to navigating the canyon at that time. There were water and rock hazards along with a high prevalence of site occupation by grizzly bears.

The crew hiked to the two most problematic jump height obstacles at the top and bottom of Reach 1 for inspection. The first of those is immediately above the Nakina River and consists of a boulder cluster jump height obstacle. This obstacle was complex with jump height, turbulence and staging pool depth issues.

It was difficult to see into the pools due to depth and turbulence. However, some sockeye salmon were observed visually or by underwater camera.

The second obstacle that was ground surveyed was at the top of the canyon in Reach 1. Similar to the lower obstacle this location has several boulder cluster jump height challenges with turbulence and potentially staging pool depth issues.

Photo 5: Migration obstacle immediately above the Nakina confluence.
(View from water level.)

Photo 6: Staging pool underwater view with holding sockeye.

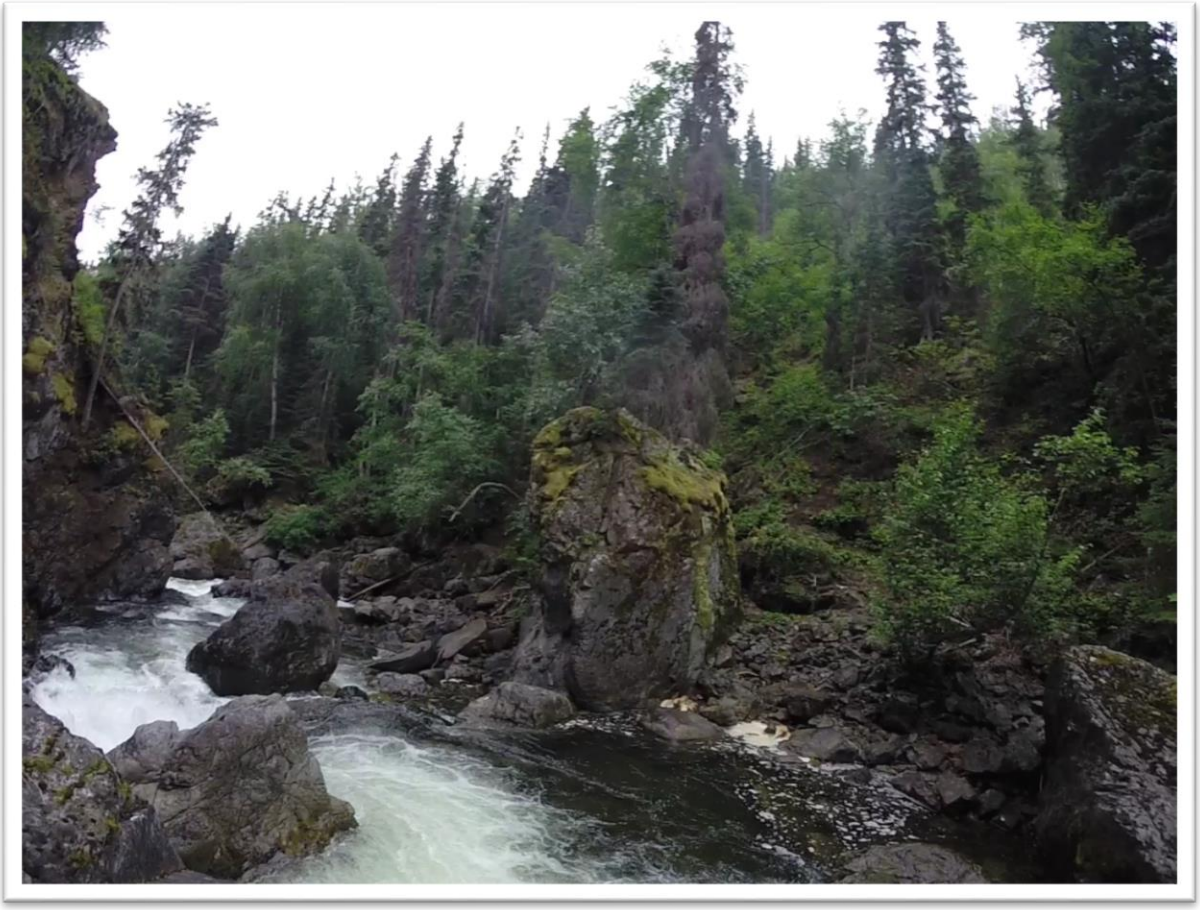


Photo 7: The migration obstacle at the top of the Canyon in Reach 1.

Hydrometric gauging:

Stream flows were gauged at three locations to capture baseline hydrometric data for future analysis. The stage at the time of survey was very low which provides a valuable low flow estimate. Flow was measured in panels with a Swoffer 2100 flow meter using the mid-section method. A summary of the flow gauging is included in Table 2 below.

Table 2: Summer 2015 Stream Gauging summary

Site	Flow	X-section width	Watershed Area
Nakina River	15.22 m^3/sec	40.1 meters	1950 km^2
Silver Salmon River	2.57 m^3/sec	10.5 meters	430 km^2
Kuthai Lake Outlet	0.16 m^3/sec	6.0 meters	45 km^2

CONCLUSIONS

Discussion:

The reconnaissance surveys conducted in 2015 indicate that a complex set of migration obstacles exist between Nakina River and Kuthai Lake. Reach 1 has two areas with complex obstacle geometries involving boulder cluster jump height obstacles in series with multiple step cascades. Reach 2 doesn't have any obvious migration obstacles based on the aerial survey results. Reach 3 has a number of beaver dams that may be obstacles in some years. Reach 4 also didn't have any obvious obstacles, although flow depths near the lake could be quite shallow in low flow years. While some channel spanning LWD jams were noted in Reaches 1, 2 and 3 they didn't appear to be barriers, however the Reach 1 jams were not assessed on the ground.

With respect to the complex boulder cluster / cascade obstacles in Reach 1 there are a number of factors that should be considered in the assessment of potential migration barriers. These factors are:

- Jump heights observed were, in places, about 2 meters in height which taken alone may not be problematic but may be an issue in concert with inadequate staging pool depths. A general rule of thumb is that a ratio of 1:1.25 (obstacle height: staging pool depth) is optimal to achieve maximum jump heights. Staging pools in reach 1 may not be achieving this;
- Velocity effects can be problematic in steep channels and extended cascade flow leading to fish refusal or exhaustion;
- Extreme freshet flows in 2007 and high rates / depths of scour during that event may have resulted in more interstitial flow in the bedrock clusters and reduced pool depths making passage more difficult. If bedload sediment loading is insufficient to infill the interstitial spaces and prevent the loss of pool volumes or generate adverse subsurface flow patterns then the problem may persist or worsen. This is more likely in situations with large boulder morphologies that have large interstitial voids and low boulder to boulder contact. A number of bedload sediment sources were noted in Reach 2 during the aerial survey which suggests potential bedload source areas that could eventually mitigate any possible channel degradation that has occurred during extreme high flow events;
- Supercritical flow and air entrainment in cascades can reduce swimming performance and achievable jump heights; and
- Stage dependency is often a factor in steep channels where extreme low and high flows are less passable resulting in an optimal average range of stage and velocity combinations that supports better fish passage.

The escapement trends to Kuthai Lake have been consistently low since 2007 which suggests that some physical change in the channel may have occurred that has reduced passage through Reach 1. Since a number of fish were noted holding below the first barrier it would seem that this is a priority candidate for passage restoration. In 2007 there was a regionally exceptional freshet peak with many areas experiencing calculated recurrence interval peak flows on the order of 1:100 years. This type of extreme peak flow often exceeds the shear stress required to modify channel morphologies and rearrange smaller boulders that may have been stable for long periods. Extreme "channel forming flows" in 2007 may have altered the channel alluvium resulting in more interstitial flow and adverse changes to staging pools or, more likely, have mobilized medium sized boulders into the staging pools. Staging pool hydraulics could have been altered by boulder recruitment to reduce total depth which limits the achievable jump heights. Optimally, staging pool hydraulic geometry should have sufficient depth and width to allow the formation of a hydraulic circulation cell that enhances achievable jump heights. This may not be the case if boulders have been recruited directly below the plunge location.

Recommendations:

Based on results of the 2015 project, it is recommended that additional field surveys be conducted with the following main objectives:

1. Further assessment of potential migration barriers in Reach 1 of the Silver Salmon River for the Kuthai sockeye stock. This should involve a physical survey of the channel, staging pool dimensions, jump heights cascade lengths and instream velocity measurements;
2. Collection and analysis of hydrology data for the Silver Salmon River and Kuthai Lake to assess the potential for correlation between stage / flow and the passage success of migrating sockeye; and
3. Investigation and development of conceptual plans mitigation options to improve fish passage.

The preliminary fish access mitigation options proposed at this point includes the following (in order of priority / achievability):

1. The highest priority should be clearing of staging pool clasts that may be impeding the pool hydraulics and limiting achievable jump heights. This could be a staged process starting with the obstacle at the Silver Salmon / Nakina confluence and progressing upstream. Performance criteria would rely on the escapement results. Boulders removed from the staging pool could be placed to enhance the backwater effect at the tail-spill of the pool which would reduce jump heights and improve staging pool hydraulics;
2. Investigate the potential for implementation of a steep pass fishway at the Nakina / Silver Salmon confluence obstacle that could be put in place during the migration

window. This approach has been applied successfully in other locations like Frazer Lake on Kodiak Island Alaska. This would need to be a low tech, manually removable structure to avoid damage from freshet flows and to be logistically manageable. It would also have to be relatively "bear proof";

3. To develop a water storage scenario at Kuthai Lake and / or above the canyon to store water for release during the adult sockeye migration window. This mitigation option requires some baseline hydrology and an understanding of the correlation between river stage and the timing / success rate of sockeye passage through the canyon. If passage success is observed to be correlated with stage, then augmenting flows from storage should be explored. The objective is to maintain staging pool and channel depths within the optimal range. A secondary objective is to provide depth cover in channel resting pools to reduce bear predation. It may be possible to conduct a rapid beaver dam breach program during the migration window to generate a minor flood wave to test the theory.
4. To investigate the feasibility of breaking up some of the large boulders on the Lower Silver Salmon River, which are likely influencing migration access at certain water levels. This would require some more detailed engineering / assessment to ensure that such wouldn't produce a nick point in the channel that could migrate upstream and generate new barriers, obstacles and channel instability.

In order to further investigate mitigation options and plans to improve fish passage, methods and tasks proposed for the future 2016 project are:

1. Installation of two hydrometric stations to collect baseline flows;
2. Develop a water balance for the lake and look at some water storage scenarios;
3. Create a surrogate hydrologic data set to run scenarios;
4. Estimate the amount of storage required to improve passage (i.e. flow rate x flow duration);
5. Investigate the potential for installation of a low head check dam at Kuthai Lake as well a second one further down, just below the wetland. (The existing bathymetric map would be utilized to calculate a water balance for the lake.) The concept of developing these dams would be to store some of the freshet water in-lake, and release it during the sockeye migration window to mitigate the stage dependant barrier below;
6. Look at known Kuthai sockeye run timing in order make temporal comparisons to hydrology and asses the stage dependence of passage through Reach 1; and
7. Conduct a full survey of lower Silver Salmon River during low water (likely late fall / early winter). This will allow for the measurement of jump heights and staging pool dimensions for a more detailed passage assessment. From such, the feasibility of designing a steep pass structure, clearing smaller boulders from the staging pools and potentially breaking up some of the large boulders could be assessed.

PROJECT PERFORMANCE REVIEW

Below is a list of the measures for project success from the original proposal. After each is a brief review of post-project performance.

1. Providing meaningful evaluation of migration access for the Kuthai stock.
    - The ground survey and radio telemetry results both clearly indicated that stage dependent migration barriers existed for the Kuthai stock in the canyon area on the lower section of the Silver Salmon River.
2. Effectively estimating relative abundance and stock proportions for Kuthai sockeye, as distinguished from co-migrating early run main-stem sockeye.
    - This aspect of the project is has not been completed as yet. The genetics samples were collected, however analysis is still pending. (See genetic sampling results on page 7).
3. Providing recommendations in regard to further assessment needs and/or restoration strategies.
    - A preliminary list fish access mitigation options was identified, from which specific methods and tasks proposed for 2016 were developed.
4. Collaboration and communication with the TBR Technical Committee during the project.
    - There was communication with the TTC throughout the project. Preliminary results were discussed in the context of reviewing the 2016 project proposal.
5. Effective reporting of results, and not exceeding the original budget.
    - Results were efficiently conveyed within this report. The original budget was not exceeded, however it is anticipated that a request will be made to carry over the genetic analysis portion of the funding.