



Gitanyow *Fisheries*
Authority



Kitwanga Sockeye Salmon Radio Telemetry Project, 2017



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Appendix II - 2017 Telemetry Final Locations River – PDF Map

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1. INTRODUCTION AND BACKGROUND

The purpose of the 2017 Kitwanga sockeye salmon (*Oncorhynchus nerka*) radio telemetry project was:

- To identify sockeye spawning locations,
- To determine how long it takes Kitwanga sockeye to travel from the Kitwanga River Salmon Enumeration Facility (KSEF) to spawning areas,
- To determine if there is any on route mortality, and
- To determine residency timing from lake entry to the time when actual spawning occurs.

Funding for this project was provided by Fisheries and Oceans, Canada (DFO) under the Fish Habitat Restoration Initiative (FHRI).

The Kitwanga River is one of the most productive fish bearing streams in the Skeena Watershed. It supports all five species of Pacific salmon and steelhead, several resident salmonid species, along with numerous coarse fish species:

- 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*)

The GFA initiated a “The Kitwanga River Sockeye Salmon Rebuilding Program” in 1999 when Kitwanga sockeye stocks were noticeably depressed compared to historical numbers. Kitwanga River sockeye salmon abundance had drastically declined for about 40 years prior to 1999, which has raised concerns for the stock (Cleveland et al. 2006). DFO BC16 records between 1919 and 1950 estimate the average Kitwanga sockeye escapement into the system was between 5,000 – 10,000 fish annually, not including the harvest of Aboriginal food and commercial fisheries (Gottesfeld et al. 2002). Since the 1960’s and into the 1990’s, sockeye escapement to the river

were estimated to average less than 500 fish per year, and was deemed as at-risk of collapse (Cleveland and McCarthy 2003).

Since 2000, the Gitanyow Fisheries Authority's *Kitwanga River Sockeye Salmon Rebuilding Program* includes major landmarks. One key component has been the annual enumeration of both adults sockeye (since 2000) entering the Kitwanga River system through the Kitwanga River Salmon Enumeration Facility (KSEF) and smolts out-migrating estimates (2000) collected annually from Gitanyow Lake through mark/recapture studies (2000-2007) and then through the operation of the Kitwanga Smolt Facility (2008-2017, KsF – Figure 1). The enumeration facilities provide complete fish counts, and random subsample data for size, age and sex distribution. Other rebuilding works include the evaluation and rehabilitation of Gitanyow Lake sockeye spawning grounds (2006-2008) and a two-year cohort hatchery program (2006-2008). The Kitwanga sockeye salmon telemetry project in 2017 adds valuable data to this aspect of the sockeye rebuilding program. This report presents the important findings of the 2017 telemetry study including in-river / lake residency time, final spawning ground destinations, and tagging mortality.

2. METHODS

The primary objectives of the Kitwanga sockeye telemetry study were to confirm and identify current spawning locations and dates, determine in-river and lake residency time, and assess the survival rate of radio-tagged fish. In 2017, GFA applied 22 gastro-intestinal radio tags to Kitwanga sockeye salmon, which involves inserting a radio tag into the stomach via the mouth and esophagus through a non-harmful applicator tube (Figure 2).

Tags were applied at the KSEF from August 18th to September 8th, 2017 to track them from the site (~4km upstream from the confluence of the Kitwanga/Skeena Rivers) to known spawning areas approximately 30km upstream in Gitanyow Lake (Table 1). All tagged fish were in good condition and in the early stage of their run timing (silver/chrome color). Tags were subsequently tracked throughout the Kitwanga River and Gitanyow Lake weekly following tag application. The GFA's intent was to apply 30 tags evenly across the run, but only 22 tags were applied. This was due to the tagging station at the KSEF sustaining damage during a flooding event on September 11th, 2017, forcing it to shut down early for the season.



Figure 1: Google Earth image of the Kitwanga Watershed including insert photo's of KSEF, KsF and Gitanyow Lake.

Table 1: Inventory of gastro-intestinal radio tags applied to 22 Kitwanga sockeye salmon at the KSEF from August 18th to September 8th, 2017.

Sample	Date	Frequency	Channel	Code	Fish ID	Fork Length (cm)
1	18-Aug-17	150.540	5	43	5-43	57
2	18-Aug-17	150.460	1	131	1-131	55
3	18-Aug-17	150.700	13	128	13-128	57
4	18-Aug-17	150.760	16	93	16-93	60
5	21-Aug-17	150.700	13	66	13-66	56
6	22-Aug-17	150.560	6	52	6-52	57
7	22-Aug-17	150.780	17	163	17-163	62
8	22-Aug-17	150.620	9	87	9-87	51
9	22-Aug-17	150.540	5	211	5-211	60
10	22-Aug-17	150.540	5	1	5-1	56
11	29-Aug-17	150.640	10	93	10-93	52
12	29-Aug-17	150.600	8	78	8-78	58
13	29-Aug-17	150.640	10	94	10-94	59
14	29-Aug-17	150.640	10	41	10-41	59
15	30-Aug-17	150.640	10	92	10-92	54
16	30-Aug-17	150.700	13	123	13-123	55
17	30-Aug-17	150.740	15	140	15-140	59
18	01-Sep-17	150.720	3	133	3-133	57
19	01-Sep-17	150.600	14	80	14-80	57
20	01-Sep-17	150.600	8	76	8-76*	61.5
21	07-Sep-17	150.560	6	5	6-5	59
22	08-Sep-17	150.600	8	76	8-76	51

**Note: Tag 8-76 was initially applied on Sept. 1 but the fish regurgitated the tag and it recovered shortly thereafter and redeployed on Sept.8 in another fish.*



Figure 2: Photos showing gastro-intestinal radio tags applied to sockeye at the KSEF by the GFA crew.

Radio tagged sockeye were tracked using two Lotek SRX400 radio receivers, one set-up as a mobile unit and the other as a stationary unit at the KsF site (Figure 3). Mobile tracking was performed a total of 11 times by vehicle and boat (Table 2). Stationary receiver information was collected for the entire study period from August 28 to November 5, 2017 and downloaded weekly.

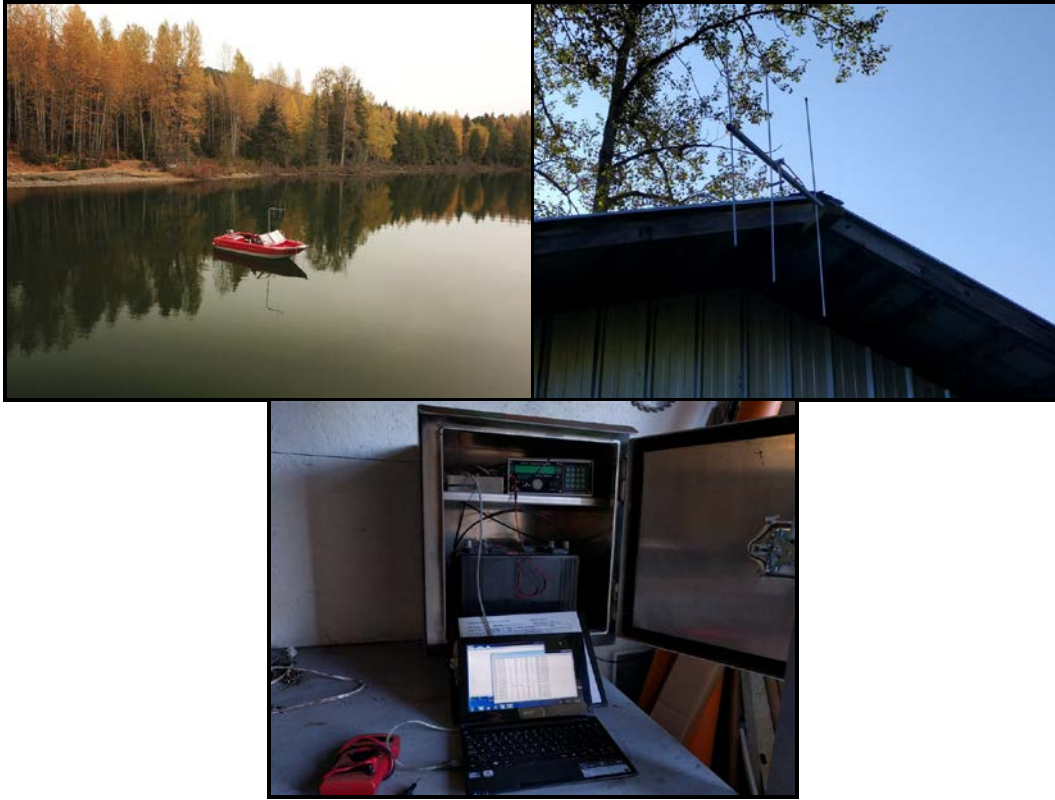


Figure 3: Photo series showing the mobile tracking system mounted to a boat (upper left), and the stationary tracking system installed at the KsF (upper right and bottom).

Table 2: Summary of Mobile Radio Tracking Efforts.

Date	Method	Locations Tracked (moving in an upstream direction)
28-Aug	Truck	KSEF to KsF
05-Sep	Truck	KSEF to KsF
12-Sep	Truck	KSEF to KsF
19-Sep	Truck	KSEF to KsF
27-Sep	Boat/Truck	Mills FSR to Gitanyow Lake
29-Sep	Truck	Mills FSR to KsF
04-Oct	Boat/Truck	Gitanyow Village to Gitanyow Lake
11-Oct	Boat	Gitanyow Lake
18-Oct	Boat	Gitanyow Lake
25-Oct	Truck	KSEF to KsF
05-Nov	Boat	Gitanyow Lake

For the most part, much of the Kitwanga River was easily accessible by tracking crews, except for a section known locally as the Kitwanga River canyon, which extends for about 4km from about 6km to about 10km upstream of the KSEF. Once tagged fish bypassed the canyon tracking was conducted from Highway 37 North, and various access points through to the KsF and into Gitanyow Lake. Significant tracking points references in relation to the Kitwanga River are:

- Mills Lake Forest Service Road Bridge - ~14km upstream from KSEF,
- Gitanyow Village (access road) - ~22km upstream from KSEF,
- Gitanyow North Access Rd - ~22.3km upstream from KSEF,
- Kitwancool FSR - ~23km upstream from KSEF,
- KsF - 600m DS of Lake.

3. RESULTS

A total of 22 Kitwanga sockeye were tagged in the Kitwanga River telemetry study in 2017. Twenty were tracked throughout the Kitwanga River/Gitanyow Lake system and their final destinations referenced using GPS (Table 3). The other two-tagged fish were only tracked in the immediate vicinity of the KSEF tagging location because one fish had regurgitated its radio tag and another fish died shortly after tagging.

Of the 20 radio-tagged fish that left the immediate vicinity of the KSEF site, 14 (70%) entered Gitanyow Lake and moved to two sockeye spawning areas along the westerly shoreline of the lake. The remaining 6 fish (30%) did not make it to Gitanyow Lake and are all thought to have died on route, in-river. Appendix I shows individual tracking records for the tagged 14 spawners that successfully made it to Gitanyow Lake. Data showed that Kitwanga sockeye can vary in terms of migration and holding times and locations, while ripening and spawning. This will be expanded on in the following sections.

Table 3: UTM coordinates (Zone 9U) and final destinations for 20 radio tagged sockeye found in Gitanyow Lake and the Kitwanga River (not including 1 regurgitated tag and 1 tagged fish that died at KSEF).

Fish ID #	Easting	Northing	Final Destination
10-92	555697	6135676	Lake
10-94	555712	6135866	Lake
1-131	555718	6135900	Lake
13-128	555717	6135756	Lake
13-66	555677	6135679	Lake
16-93	556110	6134950	Lake
17-163	555653	6135610	Lake
3-133	555704	6135799	Lake
5-1	555697	6136011	Lake
5-211	555696	6136006	Lake
5-43	555688	6135670	Lake
8-76	555686	6135668	Lake
8-78	555697	6135602	Lake
9-87	555669	6135521	Lake
10-41	557690	6128596	River
10-93	559558	6124761	River
13-123	561721	6114142	River
15-140	557766	6128143	River
6-5	558659	6107444	River
6-52	560414	6121097	River

Most (n=13) of the tagged fish that were tracked to Gitanyow Lake were found congregated at one location (Figure 4; see Appendix I “2017 Telemetry Final Locations Lake” for better clarity). This location was within 50m of the shoreline just north of an area known locally as the narrows in the north basin. None of these fish could be observed actively spawning as they were located at depths of between 3-6m, but it is likely that this area made up most of the active spawning area in 2017. This site extended over a distance of approximately 600m along the shoreline. One other tagged sockeye was tracked to another known spawning area in the lake just south of the narrows, but once again could not be seen because it was actively moving around at a similar 3-6m depth that prevented visual observations of active spawning.

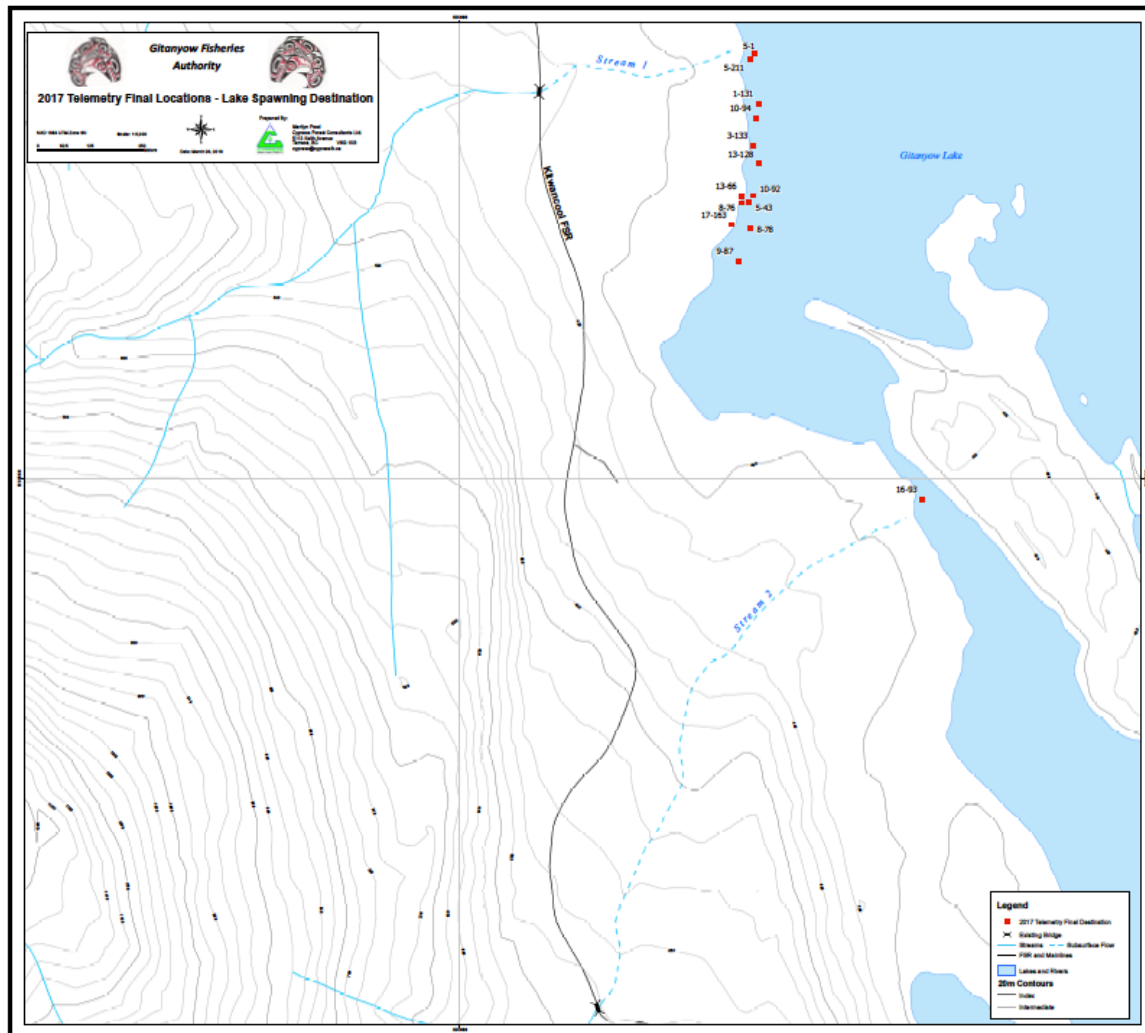


Figure 4: Overview map of Gitanyow Lake spawning sites showing 13 fish concentrated along the west shoreline in the north basin and 1 site just south of the narrows on west shoreline in the south basin.

Of the 14 tagged sockeye that entered the lake, it took on average 23 days to travel the 30km between the KSEF and Gitanyow Lake based on the information collected by the stationary tracker set-up at the KsF (Table 4). A wide range of in-river residency times were observed, with the quickest fish taking 10 days and the longest taking 56 days to pass the KsF and enter the lake. More specifically, it took:

- 4 fish tagged on Aug. 18th - 13, 16, 23, and 34 days to reach the lake,
- 1 fish tagged Aug. 21st - 12 days,
- 4 fish tagged Aug. 22nd - 10, 19, 20, and 56 days,
- 2 fish tagged Aug. 29th - 12 and 30 days,

- 1 fish tagged Aug. 30th - 42 days,
- 1 fish tagged Sept. 1st - 11 days, and
- 1 fish tagged Sept. 8th - 23 days.

By excluding the four slowest fish (30 to 56 days in-river residency, or 29% of the tagged lake arrivals) the average time between tagging at the KSEF and lake entry was about 16 days. The reason for the extended in-river residency time of these 4 fish is unknown. Initially it was thought that these fish may have been held up by the KsF after it was set-up on Sept. 11. However, upon further investigation it was found that all 4 fish spent most of their time many kilometers (>6km) downstream of the KsF and they had never ventured up to the KsF and moved back down, according to the stationary receiver recordings. Therefore, it was determined that the installation and presence of the KsF was not likely a influencing factor in why these fish preferred to stay in the river rather than traveling into the lake like many of the other spawners.

The average date to first noticed arrival to the spawning grounds was October 14th. The two earliest tracked tagged fish arrived at the main spawning grounds in the north basin on the same day, September 27th, and the last on November 5th, 2017. Note that tracking was conducted weekly on Gitanyow Lake, so fish could have arrived anytime between tracking dates.

GFA attempted to correlate in-river tracking/movement data with river and lake temperatures however no patterns were detected. River temperatures at the KSEF were consistently between 12° and 11° C during the tagging dates between August 18th and September 8th. Gitanyow Lake surface temperatures recorded by GFA from August 16th to October 19th, 2017 cooled from 19.6°C to 9.6° C (recorded weekly in August, biweekly in September / October). The average date for first arrival to the spawning grounds was October 14th and the nearest recorded lake surface temperature was on October 19th, which was 9.6° C.

A wide variation was also observed in the time spent at the KsF before moving into the lake ranging from about ½ hour to 24 days (Table 4). This was due to the installation of the KsF on Sept 11th for use as an adult counting fence after the KSEF became inoperable, which slowed the normal movement of some migrating fish. For example, seven tagged fish that entered the lake prior to September 11 only took an average of 28 minutes (range from 20 to 41 minutes) to traverse the KsF and move into the lake. These seven fish ripened in the lake for an average of

31 days (range from 17 to 48 days) before first noticed arrival to their spawning grounds (Table 5). In contrast the other seven-tagged fish that arrived after the KsF was installed took an average of 13.5 days (range from 0.5 to 24.4 days) to traverse the KsF and move into the lake. Also in contrast is that these seven later timed fish ripened in the lake for an average of only 7.6 days (range from 1 to 13 days) before first noticed arrival to their spawning grounds. The KsF delayed sockeye movement through the site but survivals did not seem to be adversely effected because all of the sockeye that arrived at the KsF once it was installed all eventually moved through and successfully proceeded to their respective lakeshore spawning grounds.

Table 4: In-river time spent from KSEF to Gitanyow Lake for all 14 tagged sockeye that made it to the lake in 2017.

Date Tagged	Channel	Code	First Detected at KsF		Last Detected at KsF		Time Spent between KSEF and KsF	Time Spent at KsF (holding DS)
			Date	Time (hr:min)	Date	Time (hr:min)	Days	Days
18-Aug	5	43	31-Aug	3:37	31-Aug	4:09	13	0.02
18-Aug	16	93	03-Sep	4:02	03-Sep	4:27	16	0.02
18-Aug	13	128	10-Sep	2:43	10-Sep	3:16	23	0.02
18-Aug	1	131	21-Sep	21:29	23-Sep	19:57	34	1.94
21-Aug	13	66	02-Sep	0:12	02-Sep	0:41	12	0.02
22-Aug	5	211	01-Sep	3:33	01-Sep	3:58	10	0.02
22-Aug	9	87	10-Sep	0:48	10-Sep	1:29	19	0.03
22-Aug	17	163	11-Sep	20:31	06-Oct	5:47	20	24.39
22-Aug	5	1	17-Oct	2:57	17-Oct	16:08	56	0.55
29-Aug	8	78	10-Sep	1:11	10-Sep	1:31	12	0.01
29-Aug	10	94	28-Sep	10:37	06-Oct	1:36	30	7.62
30-Aug	10	92	11-Oct	7:16	23-Oct	16:19	42	12.38
01-Sep	3	133	12-Sep	5:35	05-Oct	21:07	11	23.65
08-Sep	8	76	01-Oct	1:26	24-Oct	17:17	23	23.66
Avg							23	5.44
Min							10	0.01
Max							56	24.39

Table 5: Arrival timing to lakeshore spawning grounds for 14 tagged sockeye in 2017.

Tagging Date	Fish ID#	Last date detected at KsF	Tracking Date for First Arrival to Spawning Grounds*	Elapse Time from Lake Entry to Spawning Grounds (days)*	Elapsed Time to Spawning Grounds Since Tagged (days)*
18-Aug	5-43	31-Aug	18-Oct	48	61
	16-93	3-Sep	11-Oct	38	54
	13-128	10-Sep	27-Sep	17	40
	1-131	23-Sep	27-Sep	4	40
21-Aug	13-66	2-Sep	11-Oct	39	51
22-Aug	5-211	1-Sep	4-Oct	33	43
	9-87	10-Sep	27-Oct	47	66
	17-163	1-Sep	27-Oct	56	66
	5-1	17-Oct	18-Oct	1	57
29-Aug	8-78	10-Sep	4-Oct	24	36
	10-94	6-Oct	11-Oct	5	43
30-Aug	10-92	23-Oct	5-Nov	13	68
1-Sep	3-133	5-Oct	11-Oct	6	40
8-Sep	8-76	24-Oct	5-Nov	12	58
Average		20-Sep	14-Oct	25	52
Minimum		31-Aug	27-Sep	1	36
Maximum		24-Oct	5-Nov	56	68

Note: Tracking in Gitanyow Lake was conducted weekly, therefore tracking dates and associated elapse time presented in the table above could be off by as much as 7 days.

A total of 8 fish (from original 22 tagged) did not reach the lake after tagging at the KSEF (Figure 5; see Appendix II “2017 Telemetry Final Locations River” for better clarity). Of the 8 fish, one tag was regurgitated immediately after being applied (found ~5m upstream of the KSEF site) and one tagged fish died and washed up on the fence within a couple of days. One fish dropped downstream of the KSEF site and was last tracked near the Kitwanga / Skeena River Confluence (Note: this tagged fish moved downstream during the flooding event that occurred on September 11th). The 5 remaining tagged sockeye were tracked into the Kitwanga River actively moving for several weeks before the tags became stationary. More specifically, two-tagged sockeye were found halfway to the lake (one carcass recovered on the river bank, another in a log jam), another two two thirds the way to the lake , one found trapped in off-river habitat (beaver ponds) adjacent to the river (likely accessed at high water), the other in-river and the last one in the Kitwanga River canyon less than a third of the way to the lake. All of these tagged fish were presumed to have died on-route and did not contribute to spawning in 2017. More detailed individual fish movements and associated tracking records for fish that did not make it to Gitanyow Lake can be found in Table 6.

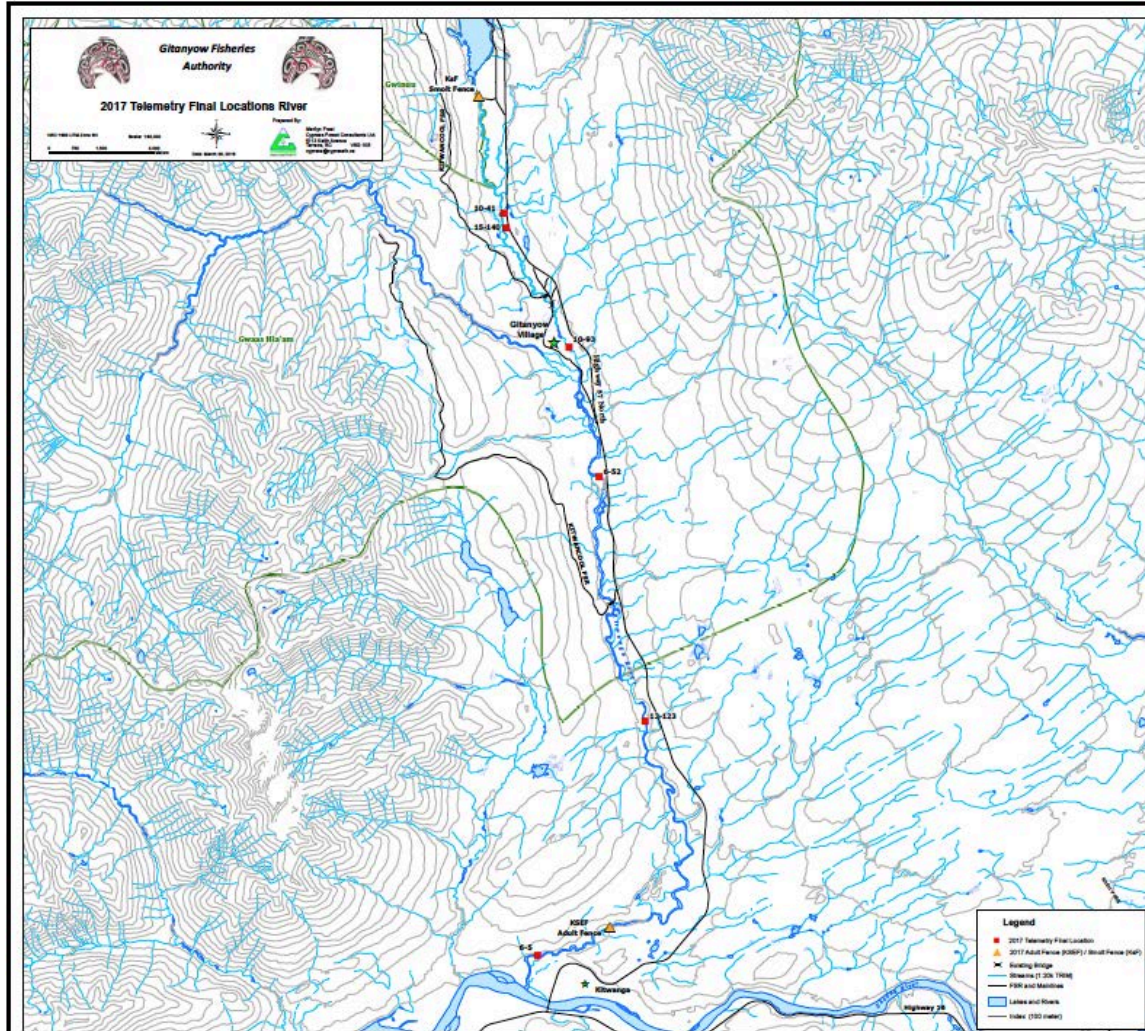


Figure 5: Overview map of final tracking locations for the six fish tracked in river that did not make it to Gitanyow Lake.

Table 6: List of tagged fish that did not make it to Gitanyow Lake by November 5, 2017 after tagging at the KSEF.

Date Tagged	Channel	Code	Comments
22-Aug-17	6	52	Tracked to a logjam ~5km downstream of the Gitanyow Village on Sept. 12. Sockeye did not move from this site (likely pre-spawn mortality).
29-Aug-17	10	93	Died in river. Tag recovered by Gitanyow Village on Sept. 29. Fish was in advanced stages of decomposition, died days before recovery (likely pre-spawn mortality).
29-Aug-17	10	41	Found dead in swamp adjacent to the river. Tracked to swamp (~24km upstream of KSEF) on Sept. 12 during river flooding event. Remained in the swamp (likely got trapped when river receded). No spawning gravels present in pond (likely pre-spawn mortality).
30-Aug-17	13	123	Tracked: Sept. 5 ~2km upstream of KSEF, Oct. 25 ~5km upstream of KSEF (canyon area). Sockeye did not move from this site (likely pre-spawn mortality)
30-Aug-17	15	140	Tracked: Sept. 5 & 12 ~2km upstream of KSEF, Sept. 27, ~20km upstream from KSEF, Oct. 4 ~22km upstream of KSEF, Oct. 25 ~24km upstream from KSEF. Sockeye did not move from this site (likely pre-spawn mortality).
01-Sep-17	14	80	Died at KSEF, tag recovered. Pre-spawn mortality.
01-Sep-17	8	76	Regurgitated tag at KSEF. Deleted from study.
07-Sep-17	6	5	Tracked Sept. 12 downstream of KSEF near Skeena River. Likely moved downstream during Sept. 11 flooding event. Tagged not picked-up again (likely pre-spawn mortality).

4. DISCUSSION

The Kitwanga Sockeye Telemetry Project, 2017 was successful in identifying critical spawning habitat in Gitanyow Lake. Many of the radio-tagged fish managed to reach their spawning grounds and tracking data showed a high concentration of spawners along 600m of the west shoreline in the north basin of the lake. GFA documented several other spawning sites in past investigations within close proximity to the 2017 locations (Kingston 2009). However, only one radio-tagged fish was found in one of these sites (just south of the narrows along the west shoreline in the south basin). No non-tagged sockeye were observed in the other known spawning sites in 2017 but spawners may have been too deep to view. Also of note is that the 2017 overall Kitwanga sockeye return was very small, estimated at only 375 individuals. This compares to a more recent average return of Kitwanga sockeye of 4,580 (2003-2016), maximum return of 20,804 in 2010 and minimum return of 240 in 2007. Therefore, ideally the study would be repeated when more fish are available to track and more fish are present on the spawning grounds to see if the results are different.

GFA suspects that the active 2017 spawning grounds maybe associated with ground-water upwelling from a stream that flows into the lake from the west that could be attracting spawning sockeye (Figure 4; see Appendix I “2017 Telemetry Final Locations Lake” for better clarity). This stream is actively avulsing (changing direction regularly due to rock debris torrents) between the Kitwancool Forest Service Road (located ~500m upslope) and the lake (McCarthy 2009) where spawners were found in 2017, and immediately to the south in previous years. GFA hopes to study this area in more detail in 2018 to assess if upwelling is contributing to the high concentration of spawning sockeye.

Similarly, the single fish observed just south of the narrows and observed by GFA in relatively large numbers in the past may be drawn to upwelling from another stream flowing from the west (Figure 4; see Appendix I “2017 Telemetry Final Locations Lake” for better clarity). Another known spawning site located just north of the narrows may also be associated with upwelling by this stream. GFA hopes to also study this area in more detail in 2018 to assess if upwelling is attracting spawning sockeye.

The tagged sockeye that entered the lake took on average 23 days to travel the 30km between the KSEF and Gitanyow Lake. The quickest fish made it in 10 days and the longest took 56 days. However, by excluding four seemingly slow sockeye, GFA assumes that the average time in-river before reaching Gitanyow Lake is about 2 weeks. This wide variability seemed to be skewed because some fish decided to hold in river to ripen while other held in the lake. These two strategies may be an adaptive strategy utilized by Kitwanga sockeye, but given the tagging sample size was low it is not possible to tell from these initial observations. Furthermore, temperatures between the river and the lake did not seem to influence this behaviour, but enhanced study designs that put more emphasis on temperature profiling in-river verses the lake may identify parameters not identified in this initial study. It is recommended that the study be repeated with a larger tag group to see if these two migration strategies persist in future broodyear cohorts and better temperature profiling be undertaken while tracking is being conducted.

Multiple tracking locations for all fish were recorded before the final fate destinations were identified for all fish tracked. From the fish that entered the lake and moved to lakeshore spawning areas, lake holding time varied greatly between an average of 25 days, to a minimum of 1 day and a maximum of 56 days. However, overall it would appear that most fish require approximately 6-8 weeks total before they are ready to spawn after Kitwanga River entry. GFA intends to better qualify this information in a future tagging program.

Also of note is on-route mortality was very high, estimated at 36% for the 22-tagged sockeye in 2017. Even if we discount the two fish that did not migrate very far from the KSEF tagging location, and the one that left the system shortly after tagging, the mortality was still fairly high at 26%. Elevated water temperatures can be one of the usual factors that contribute to on-route mortality, but temperatures in the Kitwanga Watershed in 2017 when sockeye were in the system did not seem to be limiting. Therefore, it is not clear what other factors could be contributing to the loss. Additional well designed tracking studies could help answer some of these unknowns. GFA proposes that the radio-tracking program be continued during the 2018 sockeye spawning cycle. Methods would be similar to the 2017 program, however GFA hopes to increase the sample size to 40 or more fish coupled with a detailed water temperature monitoring program for the Kitwanga River and Gitanyow Lake. Given the 2017 results, GFA may now anticipate that a portion of tagged fish will perish in-river, therefore a larger sample size will provide better numbers of active spawners for better account of spawning sites in use. This data also provides important information on in-river residency time, actual spawning dates, and baseline information to look at the interaction between climate change (i.e. water temperature) and Kitwanga River sockeye salmon.

5. REFERENCES

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6. SUPPLEMENTARY APPENDIX FOLDER

Appendix I - 2017 Telemetry Final Locations Lake – PDF Map

Appendix II - 2017 Telemetry Final Locations River – PDF Map

Appendix III

Individual tracking data for sockeye tagged at the KSEF on August 18th, 2017 sorted by time to reach the KsF. Note that the arrival dates to the KsF and spawning grounds are highlighted in bold.

Tagging Date	Fish ID#	Tracking Date	Tracking Location in Kitwanga Watershed	Elapsed Time Since Tagged (days)
18-Aug	5-43	28-Aug	About 1km upstream of Kitwancool FSR bridge.	10
		31-Aug	Arrival at KsF; 0.5 hours holding at fence before passing through.	13
		5-Sep	Near Gitanyow Lake boat launch in southeast bay in north basin.	18
		4-Oct	Moved to south basin along westerly shoreline.	47
		11-Oct	Moved to lake narrows.	54
		18-Oct	First tracked arrival to primary spawning grounds in north basin.	61
		5-Nov	Remained in primary spawning grounds in north basin.	79
	16-93	28-Aug	About 150m upstream of Gitanyow North Access Road bridge.	10
		3-Sep	Arrival at KsF; 0.5 hours holding at fence before passing through.	16
		5-Sep	South end of south basin.	18
		4-Oct	Mid-lake in north basin.	47
		11-Oct	First tracked arrival to lake narrows at secondary spawning grounds.	54
		18-Oct	Remained at lake narrows.	61
	13-128	28-Aug	At Gitanyow Village behind Gas bar/Totem Pole Site/Museum.	10
		10-Sep	Arrival at KsF; 0.5 hours holding at fence before passing through.	23
		27-Sep	First tracked arrival to primary spawning grounds in north basin.	40
		4-Oct	Remained at primary spawning grounds in north basin.	47
		11-Oct	Remained at primary spawning grounds in north basin.	54
		18-Oct	Remained at primary spawning grounds in north basin.	61
		5-Nov	Remained at primary spawning grounds in north basin.	79
	1-131	28-Aug	About 400m downstream of Mill Lakes FSR bridge	10
		5-Sep	About 300m upstream of Kitwancool FSR bridge.	18
		12-Sep	About 400m upstream of Kitwancool FSR bridge.	25
		21-Sep	Arrival at KsF; 46 hours holding at fence before passing through.	34
		27-Sep	First tracked arrival to primary spawning grounds in north basin.	40
		4-Oct	Remained at primary spawning grounds in north basin.	47
		11-Oct	Remained at primary spawning grounds in north basin.	54
		18-Oct	Remained at primary spawning grounds in north basin.	61
		5-Nov	Remained at primary spawning grounds in north basin.	79

Appendix III continued: Individual tracking data for sockeye tagged at the KSEF on August 21st and 22nd, 2017 sorted by time reach the KsF. Note that the arrival dates to the KsF and spawning grounds are highlighted in bold.

Tagging Date	Fish ID#	Tracking Date	Tracking Location in Kitwanga Watershed	Elapsed Time Since Tagged (days)
21-Aug	13-66	28-Aug	About 1km upstream of Kitwancool FSR bridge.	7
		2-Sep	Arrival at KsF; 0.5 hours holding at fence before passing through.	12
		5-Sep	South end of south basin.	15
		27-Sep	Moved to lake narrows.	37
		4-Oct	Remained just south of lake narrows.	44
		11-Oct	First tracked arrival to primary spawning grounds in north basin.	51
		18-Oct	Remained at primary spawning grounds in north basin.	58
		5-Nov	Remained at primary spawning grounds in north basin.	76
22-Aug	5-211	1-Sep	Arrival at KsF; 0.5 hours holding at fence before passing through.	10
		5-Sep	South end of south basin.	14
		4-Oct	First tracked arrival to primary spawning grounds in north basin.	43
		11-Oct	Remained at primary spawning grounds in north basin.	50
		18-Oct	Remained at primary spawning grounds in north basin.	57
		5-Nov	Remained at primary spawning grounds in north basin.	75
	9-87	28-Aug	About 100m downstream of Mill Lakes FSR bridge.	6
		5-Sep	About midway between Gitanyow Village and KsF.	14
		10-Sep	Arrival at KsF; 0.7 hours holding at fence before passing through.	19
		27-Oct	First tracked arrival to primary spawning grounds in north basin.	66
		11-Oct	Remained at primary spawning grounds in north basin.	50
		18-Oct	Remained at primary spawning grounds in north basin.	57
		5-Nov	Remained at primary spawning grounds in north basin.	75
	17-163	28-Aug	About 300m upstream of Mill Lakes FSR	6
		11-Sep	Arrival at KsF; 24 days holding at fence before passing through.	20
		6-Oct	Remained shortly upstream of KsF	45
		27-Oct	First tracked arrival to primary spawning grounds in north basin.	66
		5-Nov	Remained at primary spawning grounds in north basin.	75
	5-1	5-Sep	About 80m upstream of Gitanyow North Access Road bridge.	14
		12-Sep	About 3km upstream of Kitwancool FSR bridge or about 3.5km downstream of KsF.	21
		19-Sep	Remained about 3km upstream of Kitwancool FSR bridge or about 3.5km downstream of KsF.	28
		27-Sep	Remained about 3km upstream of Kitwancool FSR bridge or about 3.5km downstream of KsF.	36
		29-Sep	Remained about 3km upstream of Kitwancool FSR bridge or about 3.5km downstream of KsF.	38
		4-Oct	Remained about 3km upstream of Kitwancool FSR bridge or about 3.5km downstream of KsF.	43
		17-Oct	Arrival at KsF; 13 hours holding at fence before passing through.	56
		18-Oct	First tracked arrival to primary spawning grounds in north basin.	57
		5-Nov	Remained at primary spawning grounds in north basin.	75

Appendix III continued: Individual tracking data for sockeye tagged at the KSEF on August 29th, 30th and September 1st and 8th, 2017 sorted by time reach the KsF. Note that the arrival dates to the KsF and spawning grounds are highlighted in bold.

Tagging Date	Fish ID#	Tracking Date	Tracking Location in Kitwanga Watershed	Elapsed Time Since Tagged (days)
29-Aug	8-78	5-Sep	At Kitwancool FSR bridge.	7
		10-Sep	Arrival at KsF; 0.3 hours holding at fence before passing through.	12
		4-Oct	First tracked arrival to primary spawning grounds in north basin.	36
		17-Oct	Remained at primary spawning grounds in north basin.	49
		18-Oct	Remained at primary spawning grounds in north basin.	50
	10-94	12-Sep	At Gitanyow Village behind Gas bar/Totem Pole Site/Museum.	14
		19-Sep	About 1km upstream of Kitwancool FSR bridge.	21
		28-Sep	Arrival at KsF; 7.6 days holding at fence before passing through.	30
		6-Oct	Still in Gitanyow Lake outlet	38
		11-Oct	First tracked arrival to primary spawning grounds in north basin.	43
		18-Oct	Remained at primary spawning grounds in north basin.	50
		5-Nov	Remained at primary spawning grounds in north basin.	68
30-Aug	10-92	12-Sep	About 300m downstream of Gitanyow North Access Road bridge.	13
		19-Sep	Remained about 100m upstream of Gitanyow North Access Road bridge	21
		27-Sep	Remained about 100m upstream of Gitanyow North Access Road bridge	29
		6-Oct	Remained about 100m upstream of Gitanyow North Access Road bridge	38
		11-Oct	Arrival at KsF; 12.4 days holding at fence before passing through.	43
		23-Oct	Still in Gitanyow Lake outlet	55
		5-Nov	First tracked arrival to primary spawning grounds in north basin.	68
1-Sep	3-133	5-Sep	About 1km upstream of Mill Lakes FSR bridge.	4
		12-Sep	Arrival at KsF; 23.67days holding at fence before passing through.	11
		5-Oct	Still holding below KsF.	34
		11-Oct	First tracked arrival to primary spawning grounds in north basin.	40
		23-Oct	Remained at primary spawning grounds in north basin.	52
		5-Nov	Remained at primary spawning grounds in north basin.	65
8-Sep	8-76	12-Sep	About 3.5 km upstream of KSEF. Likely slowed down from Sept. 10-11 rainstorm event.	4
		19-Sep	At Gitanyow North Access Road bridge.	11
		29-Sep	About 3.5km upstream of Kitwancool FSR bridge or about 3km downstream of KsF.	21
		1-Oct	Arrival at KsF; 23.7 days holding at fence before passing through.	23
		24-Oct	Still holding below KsF.	46
		5-Nov	First tracked arrival to primary spawning grounds in north basin.	58