



Bear River Semi-Autonomous Salmon Enumeration Fence - 2021

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ABSTRACT

The Bear River is a major tributary to the Skeena River, in Northern British Columbia, and a significant producer of wild sockeye, Chinook and coho salmon. Enumeration of returning spawning salmon to the Bear River Watershed is expensive, challenging and of unknown accuracy due to the remoteness of the area and the fact that an unknown proportion of the sockeye are lake spawners.

This report describes the activities undertaken during year two of a four years project which has an overall objective to provide accurate census counts of sockeye, coho and Chinook that enter the Bear River Watershed, using a customized autonomous salmon enumeration technology integrated into a fence installed in the middle reach of the Bear River.

In 2021, the autonomous fish enumeration technology developed and tested in 2020 was successfully installed and operated at the location identified in 2020 on the Bear River. The next phase of the project is to continue operating the fence and the autonomous fish enumeration equipment on the Bear River in 2022.

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INTRODUCTION

The Bear River is a major tributary to the Upper Skeena River (Figure 1). It drains an area of approximately 452 km² (Gottesfeld & Rabnett, 2008) including Bear Lake, which covers approximately 1,961 ha. The Bear River watershed is a significant producer of wild sockeye, Chinook and coho salmon (from here, sockeye, Chinook and coho). All three species of salmon originating from the Bear River Watershed are harvested in commercial, recreational and Aboriginal fisheries in Canada and Alaska. Establishing robust fish stock status assessment programs for these species is important to monitor their abundance, to preserve diversity, and ultimately to maintaining future First Nations, recreational and commercial salmon fisheries. As described in Canada's Wild Salmon Policy, the Bear River system is considered critical habitat within the Skeena River watershed for the spawning and rearing of Bear River sockeye, coho and Chinook.

Current salmon enumeration in the Bear River consists of low-precision visual enumeration techniques (i.e. aerial surveys) to estimate escapement for sockeye, coho and Chinook. These techniques most likely significantly under-estimate sockeye escapement estimates to the Bear Lake system as a large proportion of the sockeye returning to this system are lake spawners, which are known to be challenging to enumerate during aerial surveys as they may stage and spawn at great depths. In addition, the accuracy of aerial surveys to estimate the abundance of spawning coho and Chinook in the Bear River has never been tested.

This report describes the activities undertaken during year two of a four-year project for which the overall objective is to provide accurate census counts of sockeye, coho and Chinook that enter the Bear River system. The method chosen to achieve this objective is a customized autonomous salmon enumeration technology integrated into a fence installed in the middle reach of the Bear River (Figures 1 and 2). Doire and Fernando (2021) describe the activities undertaken during year one (2020) of the project, including the development and testing of the customized autonomous fish enumeration technology and the identification of the most appropriate location to install the semi-autonomous fence on the Bear River.

The specific objective for the second year of this project was:

1. To install and operate the semi-autonomous salmon enumeration fence on the Bear River and enumerate the full migration of sockeye, Chinook and coho (if possible).

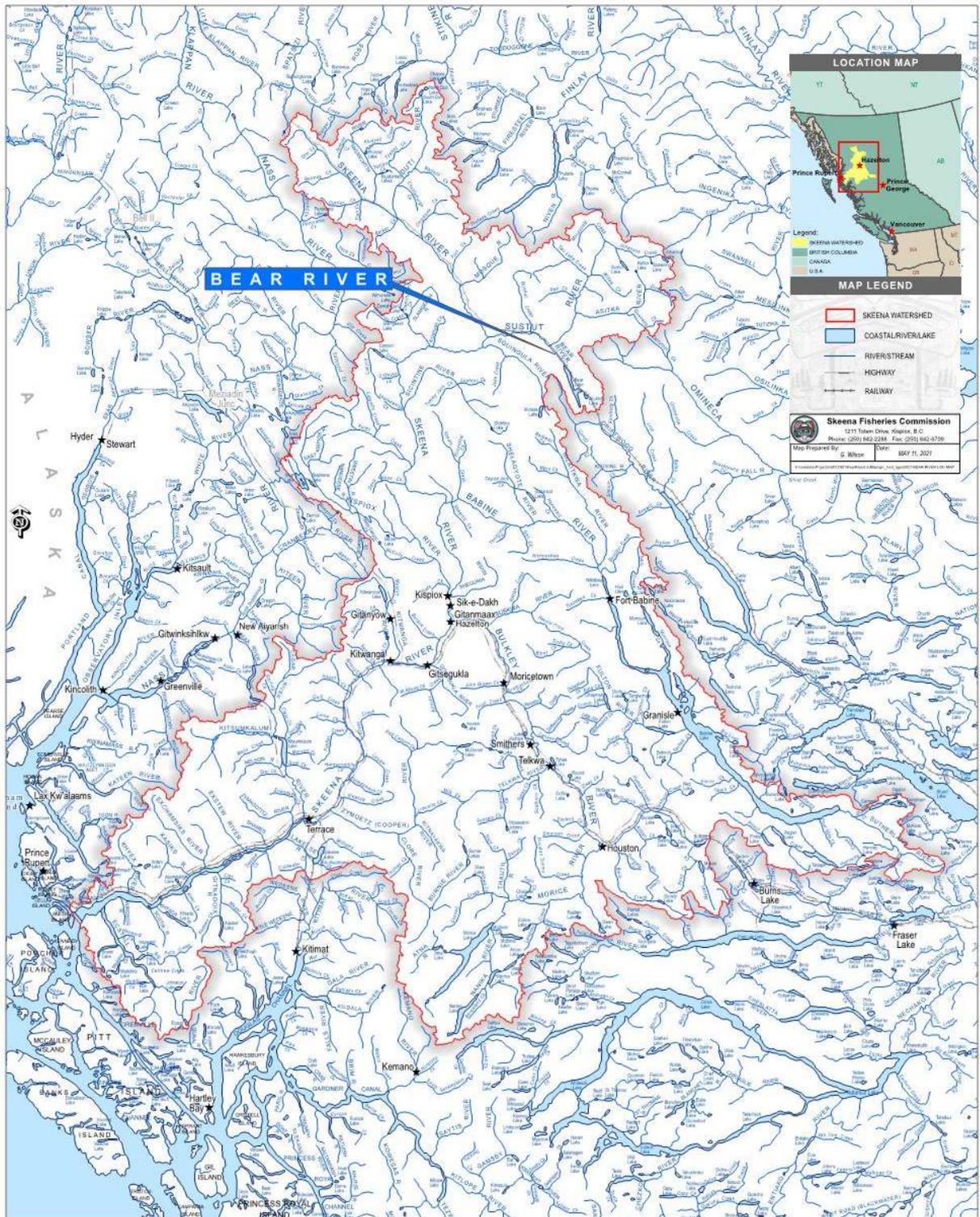


Figure 1. Location of the Bear River within the Skeena River Watershed.

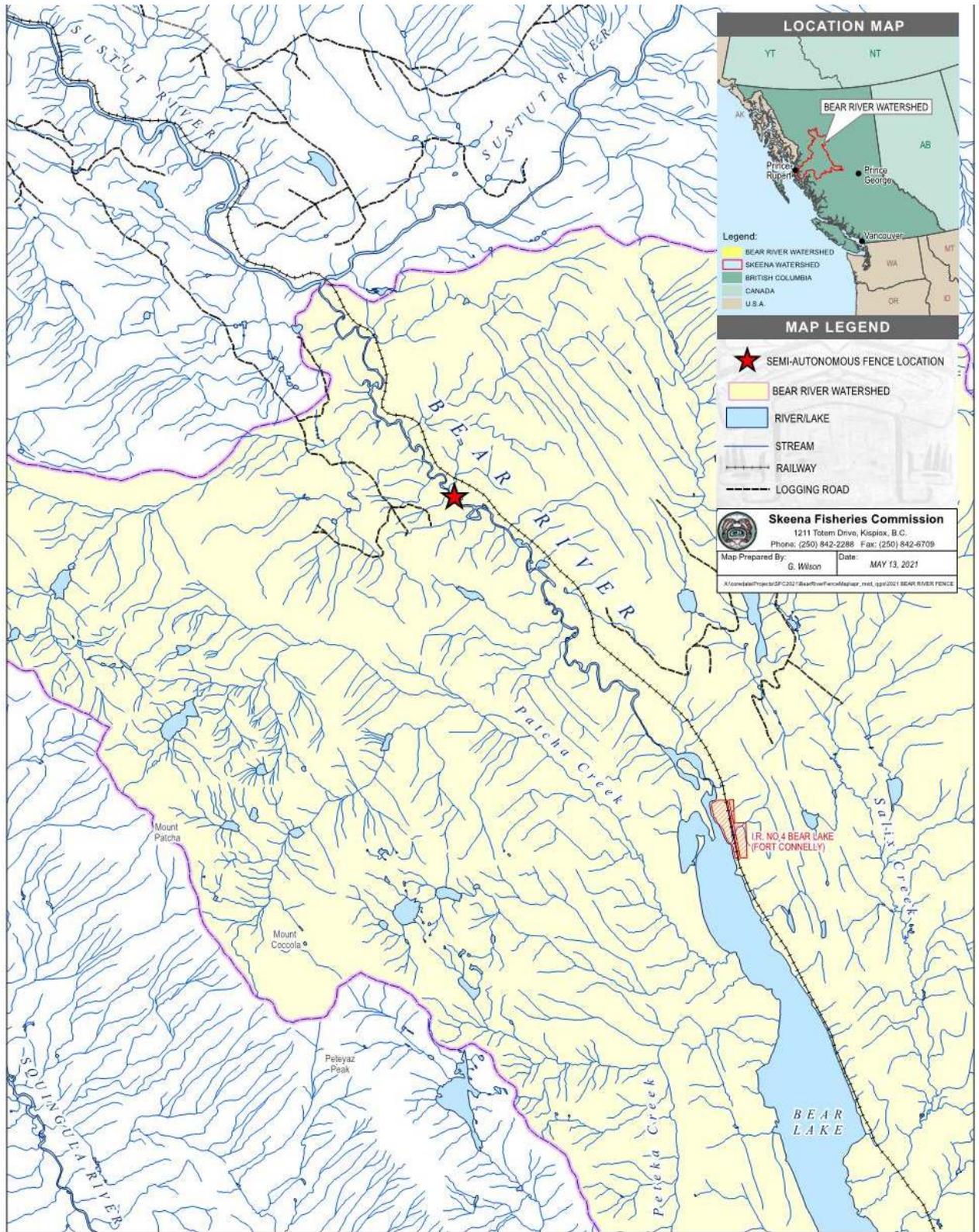


Figure 2. Map of the Bear River showing the location of the Bear River semi-autonomous salmon enumeration fence.

METHODS

The installation of the semi-autonomous salmon enumeration fence was completed during two trips to the Bear River. During the first trip in early June 2021, the solar power and satellite communications systems were mobilized and installed at the site identified in 2020 (Figures 2 and 3). Following observations made during winter 2020-2021 at the Kitwanga smolt fence site, the height of the solar structure was increased to over 10' to prevent accumulating snow from shading the solar panels during winter (Figure 3). All remote monitoring systems were made operational during this trip (Figure 4).



Figure 3. Photo of the installation of the solar power and satellite communications systems structure on the Bear River. June 3, 2021.



Figure 4. Photo of the solar power and satellite communications systems structure with the Bear River in the background. Photo taken remotely on June 4, 2021.

In late July 2021, a second trip to the Bear River was made to install the salmon enumeration fence (Figure 5), the fish/camera box (see Doire and Fernando 2021 for details) and the autonomous fish enumeration system (see Doire and Fernando 2021 for details). The enumeration fence is a modular resistance board design (Figure 6). It consists of fourteen (14) 5'x10' welded aluminum square tubing frames with 10' PVC pickets through aluminum stringers (Figure 7). The fence sill is made of 9' heavy steel I-beams (Figure 7) bolted together across the river. The fence panels are attached to the fence sill using a combination of eye-bolts, shackles, and galvanized steel cable running through tabs along the I-beams sill (Figure 8). The steel I-beam fence sill was anchored into the riverbed using duckbill anchors and chains (Figure 9) and the fence panels were locked together using pieces of bent rebar. The resistance boards to lift the fence panels using the water current were constructed of 4'x4' pieces of 1/2" plywood. Burlap sandbags were positioned in front of the fence sill to prevent erosion under the sill (Figure 8). The fence was fish tight on July 28, 2021 (Figure 10). The fish box housing the high definition underwater camera and the LED light was integrated into one panel of the fence, where the greatest depth was observed (Figure 11). The fish box was anchored using two duckbill anchors and two threaded metal rods and nuts driven into the riverbed (Figures 11 and 12). The autonomous video fish enumeration system and the remote monitoring system were fully operational on July 29, 2021 (Figures 13 to 15). An electric fence was installed around the solar power and communications systems structure to deter animals from getting too close to the structure and potentially causing damages (Figure 14).



Figure 5. Photo of the fish enumeration fence installation on the Bear River. July 28, 2021.

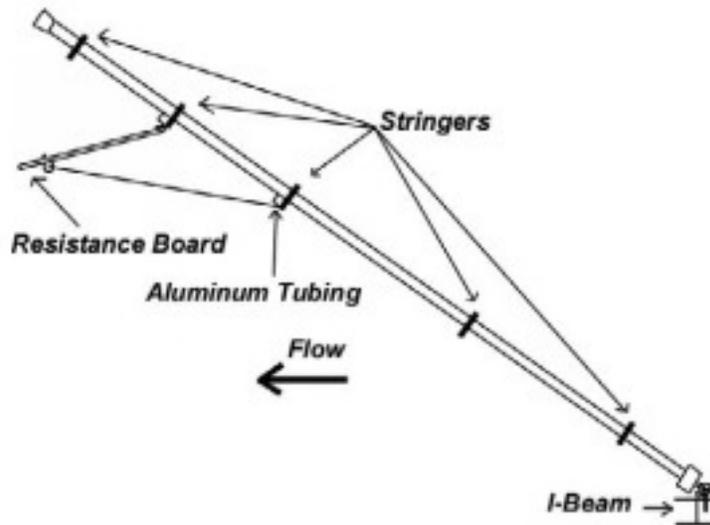


Figure 6. Side view schematic of a resistance board fence panel with aluminum frame/stringers, PVC pickets and steel I-beam sill. From Scace *et al.* 2007.



Figure 7. Photo of one of the fence panels (top) and one of the heavy steel I-beams (bottom) used at the Bear River.



Figure 8. Photo showing how the fence panels are attached to the fence sill using a galvanized cable running through tabs along the fence sill, shackles and eye-bolts. Sandbags in front of the sill protect from erosion. The chain ties the fence sill to a duckbill anchor.



Figure 9. Photo of a duckbill anchor cable, turn buckle and chain anchoring the fence sill.



Figure 10. Photo of the assembled salmon enumeration fence, and solar power and satellite communications systems structure on the Bear River. July 29, 2021.



Figure 11. Photo of the fish/camera box integrated into the enumeration fence at the Bear River. July 29, 2021.

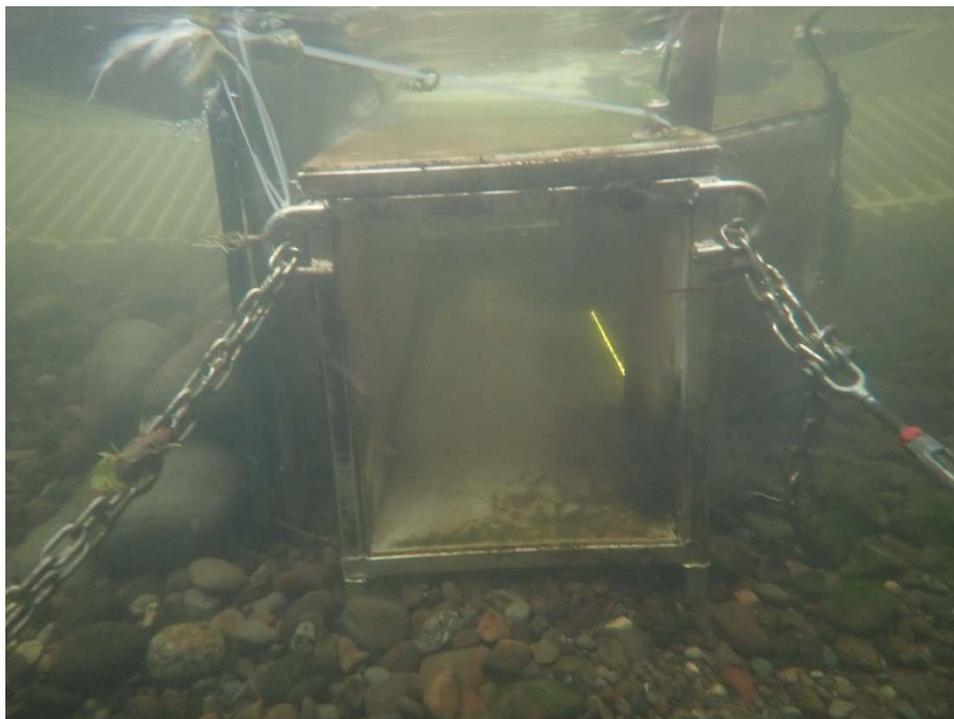


Figure 12. View of the upstream opening of the fish/camera box integrated into the enumeration fence at the Bear River. Note the LED light.

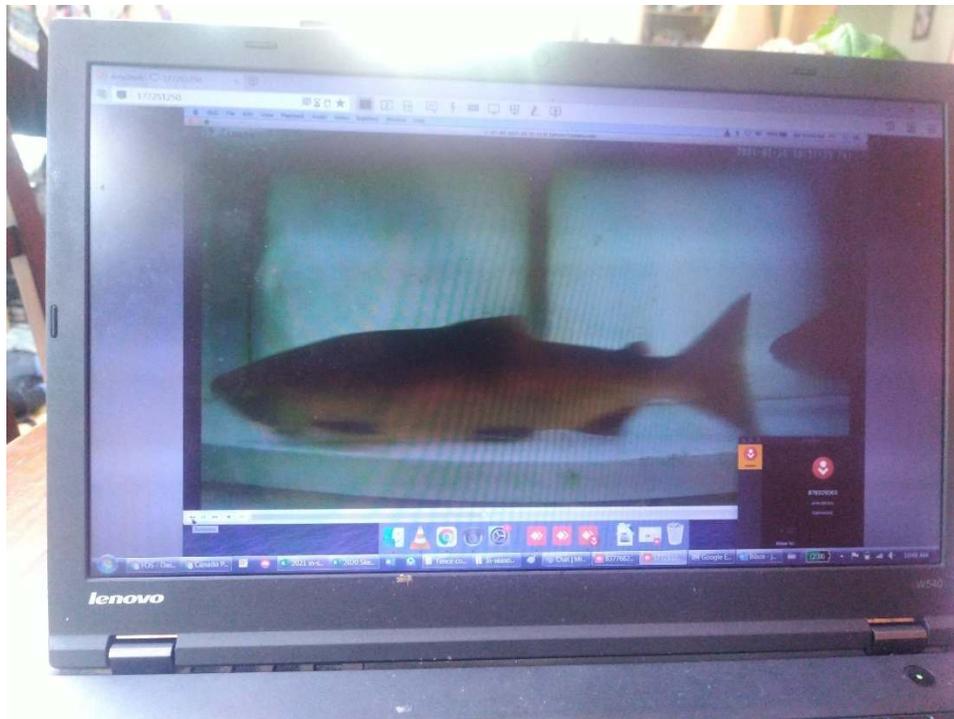


Figure 13. Photo of a sockeye swimming through the fish box at the Bear River viewed on a laptop computer in Smithers, BC via remote communications. July 31, 2021.



Figure 14. Photo of the fish enumeration fence, fish box, and solar power and satellite communications systems structure taken remotely. August 31, 2021.



Figure 15. Aerial photo of the semi-autonomous Bear River salmon enumeration site. September 19, 2021.

The Bear River semi-autonomous salmon enumeration fence and related systems were operated almost full time until October 30, 2021 and required little on-site maintenance during operation. There were very few debris accumulating on the fence, however algae growing inside the fish box needed to be scrubbed every 10-14 days as it's movement triggered the motion sensing software and diminished the video image quality. A couple of other incidents occurred during the month of August, which resulted in 94 hours without video data during the main period of salmon migration through the Bear River. The first incident was a power cable that became disconnected, leading in the loss of power to the light inside the fish passage/camera box, which resulted in the loss of video data for four consecutive nights (28 hours) from August 11th to August 15th. The second incident was when the camera inside the fish box ceased working likely because a large animal may have got tangled in the cable. Unfortunately, the weather was too poor for flying to the site and quickly replace the camera. This resulted in two and a half days (66 hours) without video data from late on August 26th to mid-day on August 29th. The 94 hours of missing data were individually infilled using the average for the specific hour being infilled during the three days prior and after the outages.

Other instances of missing data occurred when the fish enumeration and communications systems had to be preventively shutdown to save power during the middle/end of

October, when shorter days combined with extended periods of overcast skies resulted in the solar panels not producing enough power. Fortunately, relatively few salmon migrated through the Bear River salmon enumeration fence in mid to late October. For this reason, we did not attempt to infill for the missing data in October as it was considered not significant.

Finally, a major rain event led to significantly high water levels in the Bear River in early October (Figure 16). Despite this significant event, the fence appeared to remain fish tight, and the salmon enumeration and communications systems remained operational.

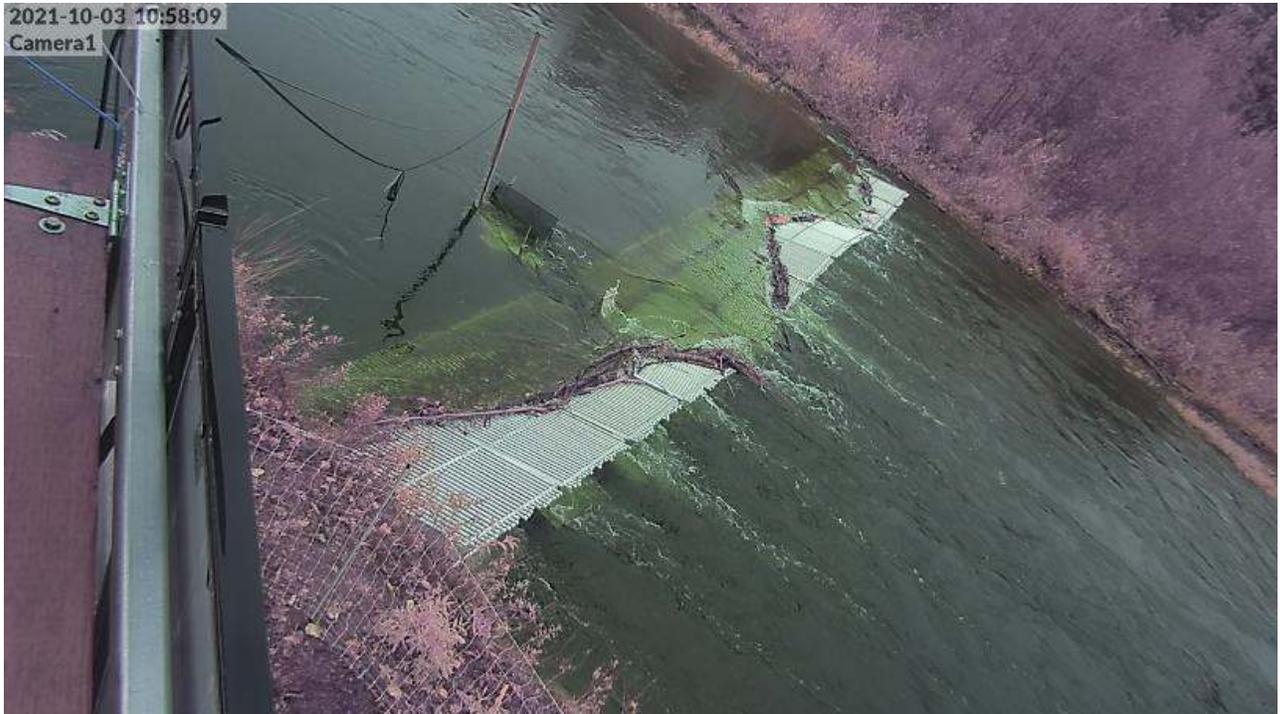


Figure 16. View of the Bear River autonomous salmon enumeration fence during the high-water event in early October 2021. Photo taken remotely on October 3, 2021.

The enumeration fence panels were removed from the Bear River on October 30, 2021 in preparation for the winter (Figure 17). Only the steel I-beam fence sill remained in the river. The solar power and communications systems structure was also left in place for the winter and remained operational to monitor the voltage of the battery bank over-winter. The only modifications that were made to the structure were the vertical positioning of the solar panel to better shed snow (Figure 18), and the addition of insulation foam to protect the battery bank from the cold.



Figure 17. View of a crew removing the Bear River enumeration fence panels. Photo taken remotely on October 30, 2021.



Figure 18. View of the solar power and communications systems structure at the Bear River during winter. Photo taken remotely on January 13, 2022.

RESULTS AND DISCUSSION

The Bear River semi-autonomous salmon enumeration fence recorded the passage of sockeye salmon (Figure 13), large and jack Chinook salmon (Figure 19), pink salmon, coho salmon, steelhead, bull trout, rainbow trout, pigmy white fish and lamprey between July 29th and October 30th, 2021. This report focuses on salmon and steelhead, however total enumeration counts for the other species are presented in Appendix I. Figure 20 shows the daily counts for the salmon species and steelhead. A relatively small number of salmon were enumerated during the first few days of the semi-autonomous salmon enumeration fence operation (Figure 20), suggesting that very few salmon may have migrated through the fence site prior to the installation of the fence. Most of the sockeye migrated over a period of two months, between early August and late September, with two peaks on August 14th and August 25th, however sockeye were also observed in late October (Figure 20). The migration of large Chinook and pink was more constrained in time, with most of the two species recorded within a month, between mid-August and mid-September (Figure 20). Peaks in large Chinook migration were observed on August 14th, August 25th and September 4th. Most coho were observed between mid-August and early October, with a peak on September 21st (Figure 20) Most steelhead were recorded in September and few in October (Figure 20). Finally, Table 1 presents the total enumeration counts for the salmon species and steelhead.



Figure 19. View of a large Chinook migrating through the fish/camera box at the Bear River semi-autonomous salmon enumeration fence. September 1, 2021.

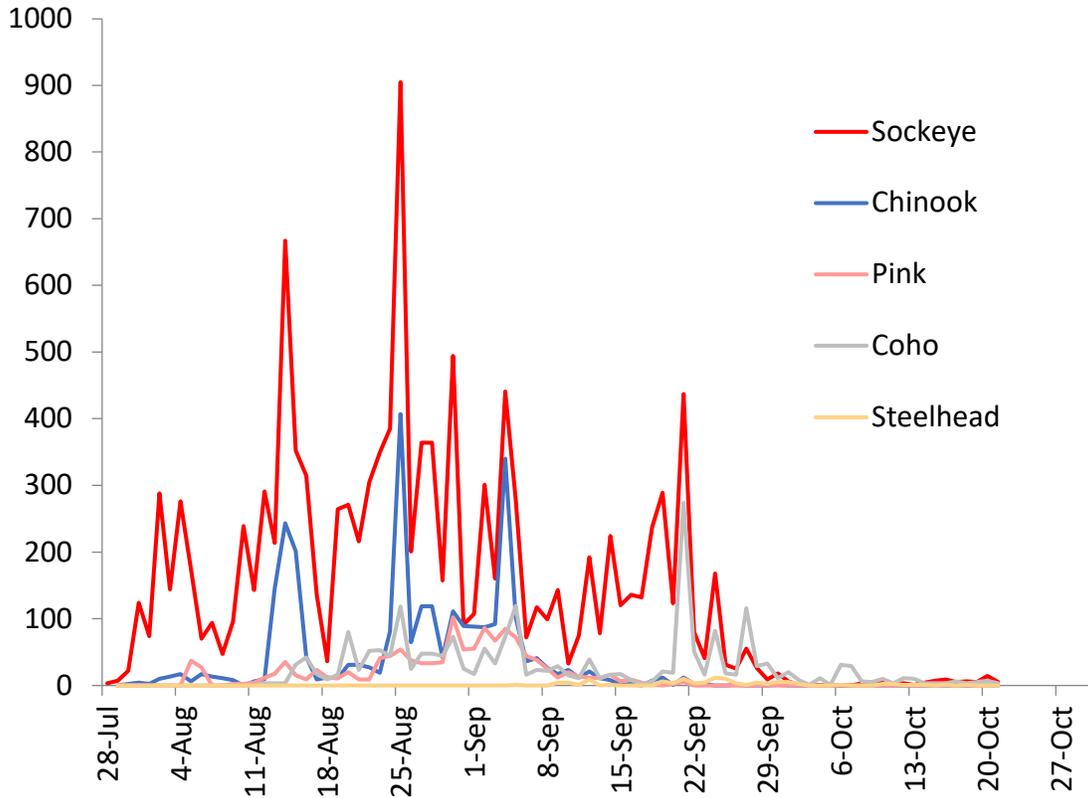


Figure 20. Daily counts of sockeye, Chinook (large), pink and coho salmon, and steelhead through the Bear River semi-autonomous salmon enumeration fence in 2021.

Table 1. Total enumeration counts of sockeye, Chinook (large and jack), pink, coho and steelhead at the Bear River semi-autonomous salmon enumeration fence in 2021.

Species	Sockeye	Chinook (large)	Chinook (jack)	Pink	Coho	Steelhead
Total	12,504	2,868	1,404	1,261	2,134	100

DFO and the Gitksan Watershed Authorities conducted aerial surveys over the Bear River Watershed to estimate the escapement of sockeye and Chinook. The aerial survey estimates for sockeye and Chinook were 2,015 and 2,301, respectively. The discrepancy between the sockeye fence count and the sockeye aerial survey estimate is significant and appears to confirm the presence of a large lake-spawning sockeye population in the Bear River system. The number of those lake-spawning sockeye is impossible to estimate during aerial surveys. The aerial survey Chinook estimate is closer to the count of large Chinook through the Bear River semi-autonomous salmon enumeration fence, however if jack Chinook are included in the total Chinook fence count, the Chinook fence is almost

double the aerial survey estimate. No aerial survey estimates are available for pink, coho, or steelhead.

CONCLUSIONS AND RECOMMENDATIONS FOR 2022

2021 was the second year of a four years project with the objective to enumerate sockeye and Chinook salmon returning to the Bear River Watershed to spawn. During this second year, the semi-autonomous salmon enumeration fence system tested in 2020 on the Kitwanga River was mobilised, installed, and operated on the Bear River from late July to late October 2021. Practically, the total runs of sockeye, Chinook, pink, coho and steelhead through the Bear River were enumerated in 2021, going above and beyond the objectives set for this project.

We will continue this project in 2022, building on the success achieved in 2021 and implementing the following recommendations:

- Install a remote-start generator to provide backup power to prevent shutdown due to low power during periods of persistent overcast skies and/or short days;
- Find ways to reduce algae growth inside the fish/camera box and/or develop and install a remote-controlled mechanism to remove algae;
- Bury all cables as much as possible to prevent disturbance by animals or environmental conditions'
- Install a measuring device inside the fish/camera box.

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APPENDIX I

Total enumeration counts of pigmy whitefish, juvenile salmonid, lamprey, bull trout and rainbow trout at the Bear River semi-autonomous salmon enumeration fence in 2021.

Species	Pigmy whitefish	Juvenile salmonid	Lamprey	Bull trout	Rainbow trout
Total	274	127	88	271	36