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Seattle City Light

MAY 31, 2018

LINDSY ASMAN
U.S. FISH AND WILDLIFE SERVICE
CONSERVATION AND HYDROPOWER PLANNING
510 DESMOND DRIVE SE
LACEY, WA 98503

Dear Lindsy,

On July 13, 2013, the Federal Energy Regulatory Commission (FERC) issued an Order Amending License and Revising Annual Charges for Seattle City Light's (City Light) Skagit River Hydroelectric Project (FERC No. 553). The Order states that the Skagit River Project (Project) is subject to the reasonable and prudent measures and terms and conditions of the Incidental Take Statement (ITS) in the Biological Opinion filed by the U.S. Fish and Wildlife Service (USFWS) on February 12, 2013 and included as Appendix B of the Order. Appendix B requires City Light to report annual incidental take of bull trout (*Salvelinus confluentus*) to the USFWS by March 31st.

Due to unusually heavy snowfall and cold weather early this year at the Skagit Hydroelectric Project and the resulting lack of access to acoustic receivers in Ross Lake, we submitted a letter to USFWS and FERC on March 22, 2018 requesting an extension for filing the annual Incidental Take Report for bull trout. The revised date for submitting this report is May 31, 2019.

City Light's sixth annual Take Statement for bull trout under the amended license for the Skagit River Hydroelectric Project is enclosed. It covers calendar year 2018 and is based on the results of monitoring conducted by City Light to estimate turbine entrainment and the calculations used to estimate dam spillway mortality. An extended maintenance project (generator rewind) at the Diablo Project resulted in an unusually high number of spill days at Diablo Dam during 2018. As a result, the 2018 annual take estimate for spillway mortality at this dam was substantially higher than that reported from 2013 through 2016. The spillway take estimate for 2018 was slightly higher than that reported for 2017, which also had a high number of spill days because of the same generator maintenance project.

The number of days of spill observed at Ross and Gorge dams in 2018 was similar to that reported in previous years. There were no maintenance activities conducted in 2018 that required reservoir drawdowns that would have impacted bull trout. The total estimated incidental take from the Project for 2018 is 59 bull trout, all from spillway mortality.

If you have any questions about the information provided in this annual take report, please contact Ed Connor, Senior Skagit Fisheries Biologist, at (206) 684-8417 or ed.connor@seattle.gov.

Sincerely,

Colleen McShane
Director, Natural Resources and Hydro Licensing Division
Seattle City Light

CC: FERC Secretary
D. Johnson, FERC PRO
T. Romanski, USFWS
A. Bearlin
E. Lowery

Annual Incidental Take Report for 2018 – Bull Trout
Skagit River Hydroelectric Project (FERC 553)
Seattle City Light

Prepared by: Ed Connor, Aquatic Ecologist

May 31, 2019

Introduction

The U.S. Fish and Wildlife Service (USFWS) issued a Biological Opinion (BO) and Incidental Take Statement (ITS) (Reference Number O1EWFW00-2012-F-0302) for the Skagit River Hydroelectric Project (FERC Project No. 553) on February 12, 2013. The ITS was issued under the terms of sections 7(b)(4) and 7(o)(2) of the Endangered Species Act (ESA), which provides that taking incidental to, and not intended as part of the agency action, is not considered prohibited, provided that such taking is in compliance with the terms and conditions of the ITS. The ITS requires that Seattle City Light (City Light) submit a take report for bull trout (*Salvelinus confluentus*) on an annual basis.

This Take Report for 2018 summarizes the monitoring methods used by City Light to estimate the annual incidental take of bull trout from the ongoing operations and maintenance of the Skagit River Hydroelectric Project (Project). The results of the monitoring are then used to provide an estimate of bull trout take from the following operational and maintenance activities and events:

- Turbine entrainment at Ross, Diablo, and Gorge dams
- Spillway entrainment at Ross, Diablo, and Gorge dams

Bull Trout Monitoring for Estimating Incidental Take

In 2018, City Light continued the acoustic monitoring program in the three Project reservoirs (Ross, Diablo, and Gorge) to estimate the number of bull trout entrained into the power tunnel intakes at the dams, and subsequently passing through the turbines of the power plants. This monitoring program was initiated in early 2013 following the issuance of the ITS by USFWS. Vemco VR2W acoustic receivers installed in all three reservoirs were used to monitor the movement of bull trout, to detect the entrainment of fish surgically implanted with acoustic transmitter tags into the power tunnel intakes, and to determine whether any entrained fish survived passing from the power tunnels through the turbines. City Light and their consultant, R2 Resource Consultants, maintained and periodically uploaded tag detection data from these receivers throughout the 2018 monitoring period.

Ross Lake Receivers

A total of 24 acoustic receivers were active in Ross Lake during the 2018 monitoring period, with the majority of these (14) in the forebay, the deep basin area of the reservoir immediately upstream of Ross Dam (Figure 1; Table 1). The monitoring effort was greatest in Ross Lake compared to the other two Project reservoirs because it supports higher numbers of bull trout due to its large size and extensive drainage area.

The Ross Lake forebay acoustic receiver array was designed specifically to track the movement of tagged bull trout in the area of the reservoir where entrainment of fish into the power intakes and spillways would occur. The configuration of forebay receivers allows for an accurate assessment of the vulnerability of bull trout in Ross Lake to both power intake and spillway entrainment. Two of the receivers, RFB11 and RFB 12, are located immediately in front of the Ross Dam intake structure to monitor the entrainment of bull trout into the two power tunnel intakes. The power intake tunnels are located about 185 ft below the surface of the reservoir at full pool. These two receivers, along with receivers situated at the Ross Boat House (RFB10) and along the shore just north of the intake facility (RFB15), were used to monitor the area of the forebay where bull trout would be vulnerable entrainment into the power intakes. Any fish entrained into the power intakes would subsequently pass through the turbines, and then into Diablo Lake from the Ross Powerhouse tailrace. Three receivers, RFB08, RFB09, and RFB10, were located immediately in front of Ross Dam to monitor the entrainment of fish into the spillways during spill events. Based upon range testing of the Vemco acoustic tags used in this study within Ross Lake, the probability of detecting a bull trout passing through the forebay into the power intakes was determined to be 100 percent.

Four receivers were used to monitor the movement of bull trout in the middle area of the forebay: RFB05, RFB06, RFB07, and RFB14. Finally, four receivers were also used to monitor fish in the outer forebay area: RFB01 and RFB02 located near Ross Lake Resort, and RFB03 and RFB04 located on a long boom located at the far outer forebay area. For the 2018 monitoring period, the Ross Dam forebay receivers were downloaded in April 2018, October 2018, and May 2019.

In addition to the forebay receiver array, four receivers were stationed near the mouths of major tributaries to Ross Lake to detect the movement of tagged bull trout in these streams for spawning (Figure 2). Receivers were located outside of the mouth of Ruby Creek (RLK01) in the Ruby Arm section of the reservoir, in Big Beaver Creek (RLK02), and in Lightning Creek (RLK04). A tributary receiver (RLK05) was stationed in the upper Skagit River, British Columbia, approximately 0.8 miles upstream of the reservoir.

We added five additional receivers in late 2017 in upper Ross Lake (Figure 2; Table 1) to provide coverage for tagged bull trout in the upper area of the reservoir. Receivers were placed in the reservoir near Skymo Creek (RLK06), Desolation Trail (RLK07), Little Beaver Creek (RLK08), Jack Point (RLK09), and Silver Creek (RLK10). We also deployed a receiver in lower Ruby Creek (RLK11) in October 2018 to improve tracking bull trout into and out of this spawning tributary.

For the 2018 monitoring period, the Ross Lake receivers were downloaded in April and October 2018, and in May 2019. The Lightning Creek receiver (RLK04) was lost due to a cut anchor line in late 2018, so data from this receiver was not available for the latter part of the year.

Diablo Lake Receivers

A total of 15 acoustic receivers were present in Diablo Lake in 2018 (Table 2; Figure 3). Two of these receivers (DL01 and DLK09) are located at the Diablo Dam spillways, and one of the receivers (DLK10) is located adjacent to the Diablo Dam power intakes which are located on the north end of the dam. Based upon the results of tag range testing we conducted, these receivers should be able to detect 100 percent of bull trout passing into the intakes or overall the spillways. Three additional receivers were added to the Diablo Lake array in 2018 (DLK11 in Buster Brown Cove, DLK12 in Diablo Canyon, and DLK13 in the southwest corner of the reservoir) to improve the detection of bull trout in this reservoir.

The two Thunder Arm receivers are important for monitoring the movement of bull trout into Thunder Creek, which is the largest bull trout spawning area in the Diablo basin. An additional receiver (DLK14) was also placed at the mouth of Thunder Creek in August 2018 to detect fish migrating into and out of this tributary. The most upstream receiver (DLK06) is located at the tailrace of Ross Powerhouse. This receiver is used to detect any tags implanted in Ross Lake bull trout that were entrained into the Ross Dam power tunnel intakes and through the turbines into Diablo Lake, as well as tags that passed over the Ross Dam spillways.

For the 2018 monitoring period, detection data from the Diablo Lake receivers were downloaded in April, August, and October 2018, and in May 2019.

Gorge Lake Receivers

A total of 11 receivers were deployed in Gorge Lake during the 2018 monitoring period (Table 3; Figure 4). We added three new receiver sites in Gorge Lake in 2018, including a receiver at the Highway 20 Bridge (GLK09) which divides the upper and lower halves of the reservoir, a receiver in lower Gorge Lake (GLK10), and a finally a receiver at the Gorge Dam intakes (GLK11). The most downstream of the receivers in Gorge Lake (GLK01 and GLK11) are

positioned so they can detect 100 percent of bull trout passing into the power intakes and spillways of Gorge Dam.

One of the receivers in the Gorge Lake array is next to the Diablo powerhouse tailrace (GLK06). The purpose of this receiver is to detect any bull trout that were tagged in Diablo Lake, and subsequently pass into the power intakes and through the turbines into Gorge Lake. Two other receivers were deployed in 2017 - one in the upper area of the reservoir at Reflector Bar (GLK07) to detect any tagged fish that had passed over the Diablo Dam spillways and another at the lower end of Stetattle Creek (GLK08) to monitor the movement of bull trout into and out of this tributary, which is the only spawning stream located in the Gorge Lake basin.

Finally, a receiver (SKG01) is located in the Skagit River immediately downstream of the Gorge Powerhouse tailrace (Table 3) to detect tagged bull entrained into the power tunnel intakes or pass over the spillways of Gorge Dam into the Skagit River.

For the 2018 monitoring period, the tag detection data from the Gorge Lake receivers were downloaded in April, August, and October 2018, and in May 2019.

Acoustic Tagging

Adult bull trout from all three reservoirs have been captured using hook-and-line and surgically implanted with Vemco V13 acoustic tags. Fish are captured and tagged each year to replace those with expired tags. The collection and handling of bull trout and surgical implantation of acoustic tags is conducted following the methods described in City Light's current USFWS scientific collection permit for an ESA-listed species (Permit TE 005885-4).

A detailed animal care protocol for the capture, handling, and surgical implantation of acoustic tags for bull trout was submitted to the National Park Service's (NPS) national program veterinarian (Fort Collins, Colorado) in March 2018. An Animal Research Project Approval (PWR_NOCA_2018.A3) for the bull trout tagging program protocols was issued by the National Park Service's Institutional Care and Use Committee (IACUC) on May 10, 2018.

The goal for the annual incidental take monitoring program is to maintain 30 active tags in Ross Lake, 10 in Diablo Lake, and 10 in Gorge Lake. An application to the NPS for a research permit to cover this capturing and tagging bull trout was submitted in April 2018; the research permit was issued on December 1, 2018. Thus, the ability to capture and surgically implant bull trout with acoustic tags was limited to one month. This resulted in only 20 active tags in Ross Lake during 2018. Enough fish were able to be captured in Diablo Lake in December 2018 to increase the number of active tags in this reservoir to 11. There were a sufficient number of tags implanted in bull trout in Gorge Lake from 2014 through 2016 to provide 10 active tags in this

reservoir in 2018. The current research permit extends through the end of August 2019, additional bull trout will be tagged in the three reservoirs during over the summer month to meet or exceed the goals for these reservoirs.

The acoustic tags currently implanted in bull trout at the Skagit Hydrolectric Project reservoirs have a lifespan ranging from 1130 to 1583 days (3.1 to 4.3 years). Temperature and depth sensor tags have a 3.1-year lifespan, while the non-sensor "pinger" tags have a lifespan of 4.3 years. Bull trout have lifespans that can exceed 10 years, which means that a tagged bull trout can be tracked for several years.

Range testing of the acoustic tags was conducted in the forebay of Ross Dam in 2013 and 2014 using the fixed array of 14 receivers. The distance of test tags to each the receivers in the forebay area was then calculated, and the percentage of "pings" (digitally coded tag transmissions) successfully detected by the receivers determined at various distances. The receivers detected 100 percent of the pings at 300 meters, 50 percent of the pings at 600 meters, and 15 percent of the pings at 900 meters. The detection efficiency of the array was determined to be 100 percent for bull trout moving through the forebay into the intake area next to the dam. The detection rate of tags moving through the Diablo and Gorge dam forebay and power intake areas was similarly determined to be 100 percent based upon the results of our 2013 and 2014 range tests.

A total of 20 tags were active in Ross Lake during the 2018 monitoring period (Table 4). These tags were implanted in bull trout during 2015 and 2017. These tags will remain active through 2020 and 2021 (Table 4) based upon the battery life expectancy provided by the tag manufacturer (Vemco). Most of the acoustic tags (16) used in Ross Lake were temperature and pressure (TP) sensor tags. The pressure sensors in these tags provide the ability to track the depths used by bull trout, as well as the temperature regimes used by the fish in this thermally stratified reservoir. This is especially useful for detecting and monitoring fish that swim close to the Ross power tunnel intakes, which are located 185 ft below the surface of the reservoir at full pool elevation. Three bull trout were implanted with non-sensor "pinger" tags that transmit a unique identification code for each fish.

A total of 11 tags were active in Diablo Lake during the 2018 monitoring period (Table 5). Seven of the tags used in Diablo Lake were "pinger" tags. We added four temperature-pressure sensor tags in Diablo Lake for the 2018 monitoring period. The results of genetic analysis conducted by the Washington Department of Fish and Wildlife's (WDFW) genetics lab suggest that most native char in Diablo Lake are Dolly Varden, which are substantially smaller in size than bull trout. All of the native char captured and tagged in Diablo Lake were bull trout based upon their large size. The WDFW Molecular Genetics Lab (Olympia) has confirmed that all the fish tagged to date were bull trout.

A total of 10 active tags were assumed to be present in the reservoir during the 2018 monitoring period (Table 6). These tags were implanted from 2014 through 2016 and will remain active between 2019 and 2021 based upon battery life expectancy. All of the tags in Gorge Lake were "pinger" tags. An additional two active tags (A69-1601-58468 and A69-9006-15670/15671) were found present in Gorge Lake in 2018 from tagged bull trout that migrated through the Diablo Dam power intakes and powerhouse turbines in 2016 and 2018. These fish survived turbine passage and remained active in Gorge Lake during 2018 based upon the movement of fish evident from the tag detection data.

Ross Lake Tagging Results

In Ross Lake, 16 of 20 bull trout with active acoustic tags were detected in 2018 (Table 7). Ross Lake has a very large volume (1.4 million acre-ft) and tributary drainage network (1,000 sq-miles) compared to the two smaller Project reservoirs, and detecting all the tagged fish in this system is challenging. Never-the-less, the Ross Lake receiver array detected the 80 percent of the bull trout with active tags during the year. This improved detection efficiency in 2018 (compared 51 percent for 2017) was likely the result of additional receivers that were deployed in north half of Ross Lake for the 2018 monitoring year.

A total of 660,221 unique detections of tagged bull trout were recorded by the Ross Lake acoustic receiver array during 2018, resulting in an average of 41,264 data points for each of fish detected. This detection rate was substantially greater than that observed during the 2017 monitoring period, which is likely the result of the expanded receiver array used in this large reservoir in 2018.

Of 20 bull trout with active tags in Ross Lake in 2018, a total of 13 (65 percent) were found to have used the forebay area of Ross Dam during the monitoring period (Table 7). This is the same forebay use level observed in 2016 (65 percent), but substantially greater than the forebay use level observed in 2017 (19 percent). This implies that the forebay was an important foraging and habitat area for bull trout in 2018.

A total of 523,288 detections were recorded by the receivers deployed in the forebay, accounting for 79 percent of all the detections observed in the Ross Lake during 2018 (Table 7). This percentage of detection in the Ross Dam forebay was greater than that observed in 2016 (68 percent), and much greater than that observed in 2017 (18 percent). The majority of detections in the forebay were from two bull trout that had appear to have established foraging territories near Ross Lake Resort and the Ross Lake Boathouse in 2018.

Nine (9) of the 20 tagged bull trout (45 percent) were detected within the power intake zone of the forebay during 2018 (i.e., detected by receivers RFB10, RFB11, RFB 12, or RFB14). The 131,220 detections observed in the power intake zone of Ross Dam accounted for 20 percent of the detections observed in Ross Lake during 2018. The bull trout tag detections in the intake zone represented 25 percent of the detections in the forebay area. The number of tags and percentage of detections observed in the intake zone in 2018 was higher than that observed during the preceding two years. This means that bull trout were more susceptible to entrainment into the power intakes in 2018 compared to 2016 and 2017.

Diablo Lake Tagging Results

Four (4) of 11 bull trout implanted with tags in Diablo Lake were detected during the 2018 monitoring period (Table 8). Of these four fish, two were found to have migrated into Gorge Lake presumably through the power intakes of Diablo Dam and through the powerhouse turbines. Thus, two of the tagged bull trout found in Gorge Lake in 2018 were fish that were originally captured and tagged in Diablo Lake.

A total of 93,807 detections of tagged bull trout were recorded in Diablo Lake during 2018, representing an average of 31,269 detections per fish for the three active tags remaining in the reservoir during this monitoring period (Table 8). A total of 42,431 of these detections (45 percent) were observed in area of the reservoir near the spillways in 2018. This is considerably greater than the 1.8 percent of detections observed in the spillway area in 2017. A total of 25,317 detections were observed in the reservoir near the Diablo Dam intakes, accounting for 27 percent of the detections observed in Diablo Lake during 2018. The higher percentage of detections observed in the spillway and power intake areas of Diablo Dam indicate that bull trout were more vulnerable to spillway and power intake entrainment during 2018 compared to 2016 and 2017.

One of the bull trout tagged in Diablo Lake in 2018 (A69-9006-15672/15673) was entrained into the Diablo Dam power intakes and survived passage through the turbines. This fish was last observed in Diablo Dam in September, and later observed to be present in Gorge Lake in October. A total of 3,425 tag detections were recorded from this fish in Diablo Lake, and 16,899 detections were later recorded from the same fish in Gorge Lake later in 2018. Analysis of movement patterns among different acoustic receivers indicate that this fish is alive and actively foraging in Gorge Lake in the vicinity of the Diablo Powerhouse tailrace. This is the second tagged bull trout that was observed to have successfully passed through the power intakes, penstocks, and turbines from Diablo Lake to Gorge Lake. The first fish (A69-1601-58467) was observed to have migrated from Diablo to Gorge in December 2016. This fish remains active in Gorge Lake, with 12,835 detection recorded in 2018 (Table 8). These findings suggest that bull trout can survive passage through the Diablo Dam power intakes and turbines.

Only 4 of the 11 bull trout tagged in Diablo Lake were detected during the 2018 monitoring year. Three of these were detected in Diablo Lake during 2018, and one was detected in Gorge Lake during this year (i.e., tagged and migrated from Diablo and Gorge reservoir in late 2016). Of the seven fish that were not detected, five were captured and tagged late in the monitoring period (December 2018). Data collected during the 2019 monitoring year will be important for determining the status of these non-detected fish given their late tagging date in 2018.

Gorge Lake Tagging Results

In Gorge Lake, only 2 of 10 the bull trout tagged in this reservoir (20 percent) were detected in 2018 (Table 9). A total of 38,269 detections were recorded in this reservoir during this monitoring period, not including detections from the two bull trout that originated from Diablo Lake. An average of 19,134 detections were recorded per tagged fish tags in 2018. None of the tagged bull trout were detected in the forebay and intake areas of Gorge Dam during the year. Most bull trout detections were recorded in the Diablo Powerhouse tailrace area of the reservoir (receiver GLK06), with the remainder recorded in the deep pool areas of the reservoir immediately downstream and upstream of the tailrace (receivers GLK05 and GLK07). The tailrace area has been consistently the highest use area by bull trout in Gorge Lake since monitoring commenced in 2013. This is likely a result of the excellent foraging opportunities provided in this area. No fish were detected by the Stetattle Creek receiver in 2018.

The percentage of acoustic tags detected in Gorge Lake in 2018 was the lowest measured since the incidental take monitoring project commenced in 2013. The tags present in Gorge Lake were all implanted in bull trout during 2014, 2015 and 2016, meaning that these were older tags yet still active. The battery expiration dates for these tags range from March 2019 through March 2021. However, it is evident that many of these tags are no longer present in the reservoir. Tags from dead fish would still be detectable throughout most of the reservoir given the high concentration and spacing of acoustic receivers in Gorge Lake. Any tagged bull trout migrating upstream into Stetattle Creek should have been detected by the receiver located at the mouth of this stream. Further, any bull trout entrained into the spillway or power turbines of Gorge Dam should have been detected by the receivers located in the lower reservoir (including those located in the forebay and adjacent to the power intakes).

It is difficult to know why there were so many missing tags from Gorge Lake. Fishing and predation are two possibilities. The number of active tags implanted in bull trout in 2019 will be increased so that a minimum of 10 tags are detected in the reservoir.

Turbine Entrainment and Mortality

None of the tagged bull trout in Ross Lake were detected in Diablo Lake or Gorge Lake (Table 7), indicating that none passed through the Ross Dam intakes and powerhouse turbines. Of the 16 bull trout detected in the reservoir during 2018, none were last detected at the two receivers (RFB11 and RFB12) located in front of the Ross Dam power intakes, or at the two other receivers (RFB10 and RFB 15) located adjacent to the intake area (Table 7). Any bull trout that would have been last detected near the Ross Dam power intakes would be assumed to have been entrained into the power intakes and then passed through the turbines. All the tagged bull trout were last detected other locations, either at the outer areas of the dam forebay (RFB02), or at receivers located near the mouths of Ruby Creek (RLK01), Big Beaver Creek (RLK02) and in the upper reservoir (RLK06). Any tag passing through the Ross Powerhouse turbines, including the tag of a dead fish, would have been detected by a receiver (DLK06) located immediately downstream of the Ross Powerhouse tailrace.

As mentioned previously, one of the bull trout tagged in Diablo Lake was entrained into the power intakes of Diablo Dam during the 2018 monitoring period (Table 8). Based upon the analysis of the detection data, this fish survived passage through the turbines and now resides in Gorge Lake. These data indicates that this fish, which was last detected on May 19, 2019, is alive based upon frequent movements of this individual between receivers. Neither of the other bull trout tags in the Diablo Lake were last detected at the receiver located adjacent to the Diablo Dam power intakes (DLK10). These fish were last detected within and near the Thunder Arm area of the reservoir.

No tagged bull trout were entrained into the Gorge Dam power intakes during the 2018 monitoring period based upon our receiver detection data. Of 12 bull trout with active tags present in Gorge Lake during this period (including two fish originating from Diablo Lake), none were detected in the forebay and intakes areas of the reservoir during 2018 (Table 9). In addition, no tags were detected in the Gorge Powerhouse tailrace area (receiver SKG01) during the year. Any tagged bull trout passing through the Gorge Powerhouse turbines would likely be detected at this location. Of the bull trout tags detected in 2018, all were last observed in in the upper half of Gorge Lake (Table 8 and 9). Any fish that was entrained into the power intakes or spillways would have been last detected in the lower half of Gorge Lake by receivers GLK01, GLK02, GLK03, and GLK10, and especially at receiver GLK11 which is located adjacent to the power intakes and spillways of Gorge Dam.

In conclusion, the results of acoustic monitoring conducted in 2018 found that none of the tagged bull trout in Ross Lake, Diablo Lake, and Gorge Lake were entrained into the power intakes of the dams and through the powerhouse turbines. *Therefore, the total Incidental Take for bull trout turbine mortality at the Skagit Hydroelectric Project for 2018 was determined to be* ***zero****.*

Spillway Mortality

No tagged bull trout were detected passing over the spillways of the three Skagit dams in 2018. Any fish passing over the spillways would likely first be detected in the forebay areas of the three dams, with the tags then detected later by receivers located in the tailrace areas downstream of these dams. Therefore, our estimate of spillway injury and mortality based upon tagged bull trout is zero.

However, the 2013 Biological Opinion and ITS for bull trout at the Skagit Hydroelectric Project also requires the estimation of spillway mortality based upon the number of days of spill that are recorded during the year at each dam. This provides an estimate of take that provides greater levels of protection to bull trout. This method for estimating take is prudent since the passage of tagged fish over a spillway may be sometimes difficult to detect during periods of high spill.

There were zero days of spill at Ross Dam in 2018 (Figure 5). Spills at this dam are rare due to the large storage capacity of Ross Lake, with an average of three days of spill per year from 2013 through 2016.

The number of days of spill at Diablo Dam was much higher in 2018 than previous years due to an extended maintenance outage at Diablo Powerhouse. Generator Unit 32 was taken offline throughout the 2018 monitoring period for a long-term maintenance and a major generator rewind. This unit provides approximately 45 percent of the generating capacity at Diablo Powerhouse. Due to the reduced generation capacity of Diablo Powerhouse, spills at Diablo Dam occurred between January 2 and December 30 (Figure 5). Major spilling (greater than 1,000 cfs) at Diablo Dam occurred between January 6 and March 19 due to high inflows from winter storms. Major spilling also occurred between May 21 and June 11, and between July 13 and July 18, during periods of high inflow caused by snowmelt runoff.

As a result of the generator maintenance outage, spill was recorded for a total of 203 days at Diablo Dam in 2018. In comparison, Diablo Dam spilled during 195 days in 2017 when Generation Unit 31 at Diablo Dam was undergoing a major rewind. The number of spill days in both 2017 and 2018 was much higher than the number observed from 2013 to 2016, which averaged 37 days of spill per year. Starting in 2019, the frequency of spills at Diablo Dam should be reduced to the normal levels observed between 2013 and 2016 since the two-year generator rewind project will have been completed.

At Gorge Dam, spills were associated with a large Pacific storm system that resulted in high inflows between February 21 and March 12, 2018 (Figure 5). Short periods of spill also occurred between May 9 and May 18 due to high inflows from snowmelt runoff, and between

August 5 and 15 for project maintenance. Gorge Dam spilled for a total of 35 days in 2018, which is slightly higher than the average 27 spill days observed per year observed from 2013 to 2017.

The BiOP for the Skagit Hydroelectric project (USFWS 2013) describes the method for calculating spillway mortality of bull trout based upon the percent of time that spill occurs during the year at each of the three dams.

For Ross Dam, this method estimates an annual take of 1 bull trout (fish entrained by the spillways and subsequently killed), assuming that the dam spilled on average 0.6 percent of the time on an annual basis. Adjusting for the spills observed at Ross Dam in 2018 (zero days during the year), the annual take estimate for spill at this dam would be **zero** bull trout.

For Diablo Dam, this method estimates an annual take of 6 bull trout (fish entrained by the spillways and subsequently killed), assuming that the dam spilled, on average, 6.2 percent of the time on an annual basis. Adjusting for the spills observed at Diablo Dam in 2018 (55.6 percent of the days during the year), the annual take estimate for spill at this dam would be **54** bull trout.

Finally, for Gorge Dam, this method estimates an annual take of 6 bull trout (spillway passage mortality) assuming that spills occur on average 5.5 percent of days on an annual basis. Based on the observed spill rate at Gorge Dam in 2018 (9.6 percent of the days during the year), the annual estimated take would be **5** bull trout.

*Combining spill mortalities estimated at the three dams, the total estimated Incidental Take for spillway mortality at the Skagit Hydroelectric Project for 2017 is therefore **59** bull trout.*

Total Incidental Take Estimate for 2018

The total estimated Incidental Take of bull trout attributed to the ongoing operation of the Skagit Hydroelectric Project (including the Ross, Diablo, and Gorge power facilities) for 2018 can be summarized as follows:

- Turbine mortality – zero
- Spillway mortality – 59 fish (assumed to be adults)

The total annual Incidental Take at the Skagit Hydro Project is therefore estimated to be **59** bull trout.

Figure 1. Acoustic receiver array in Ross Lake forebay for 2018.

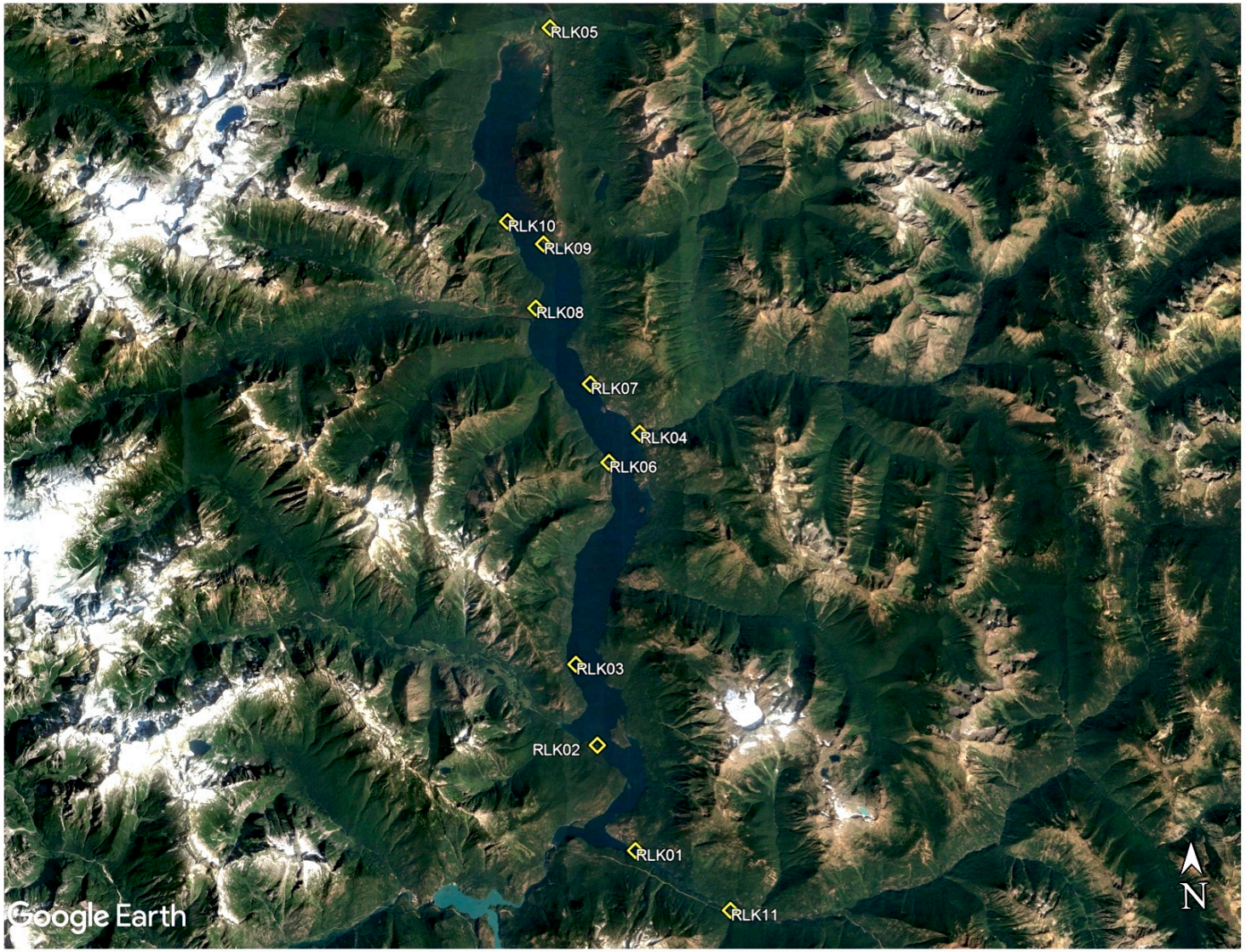

Figure 2. Acoustic receiver array in Ross Lake outside the forebay for 2018.

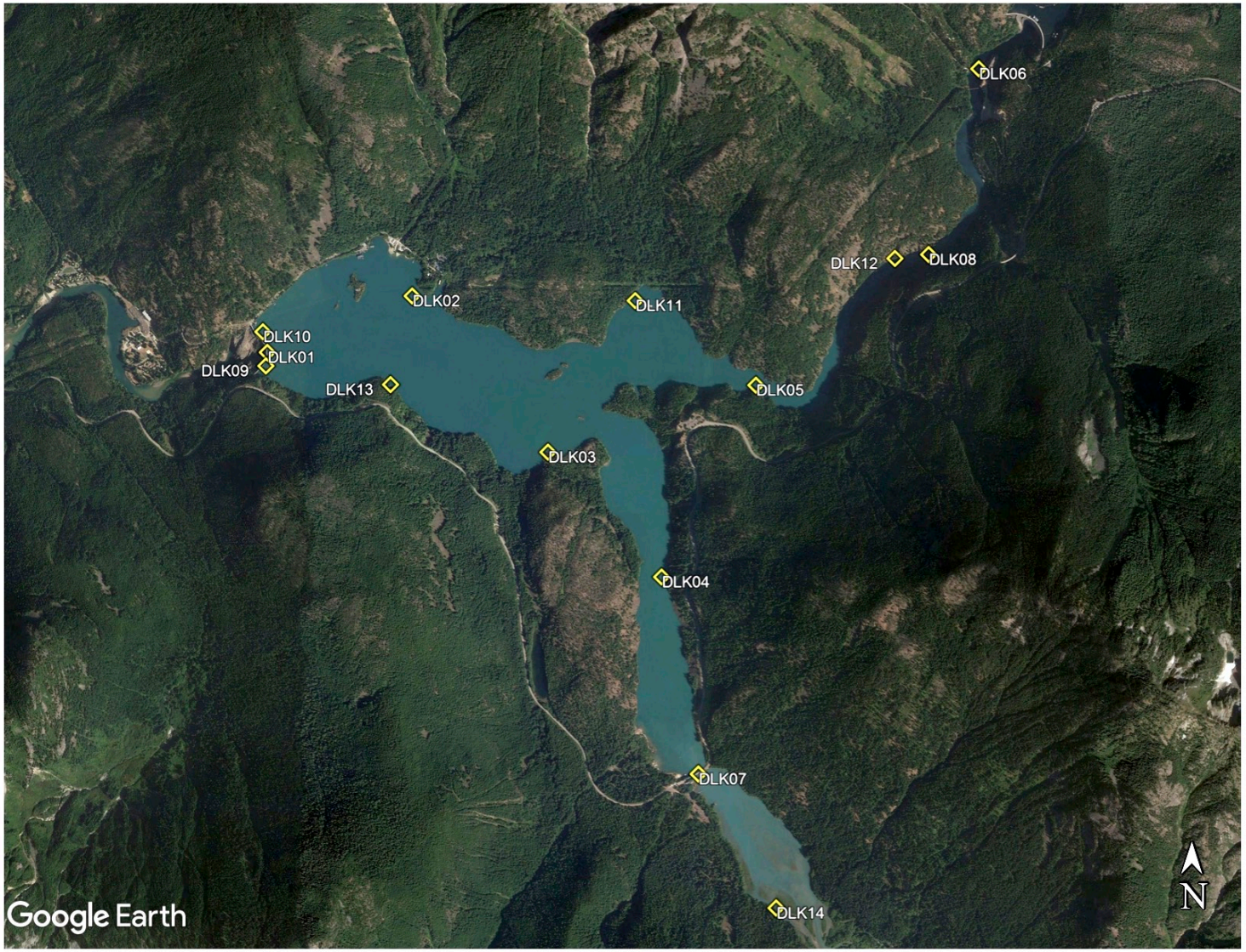

Figure 3. Acoustic receiver array in Diablo Lake for 2018.

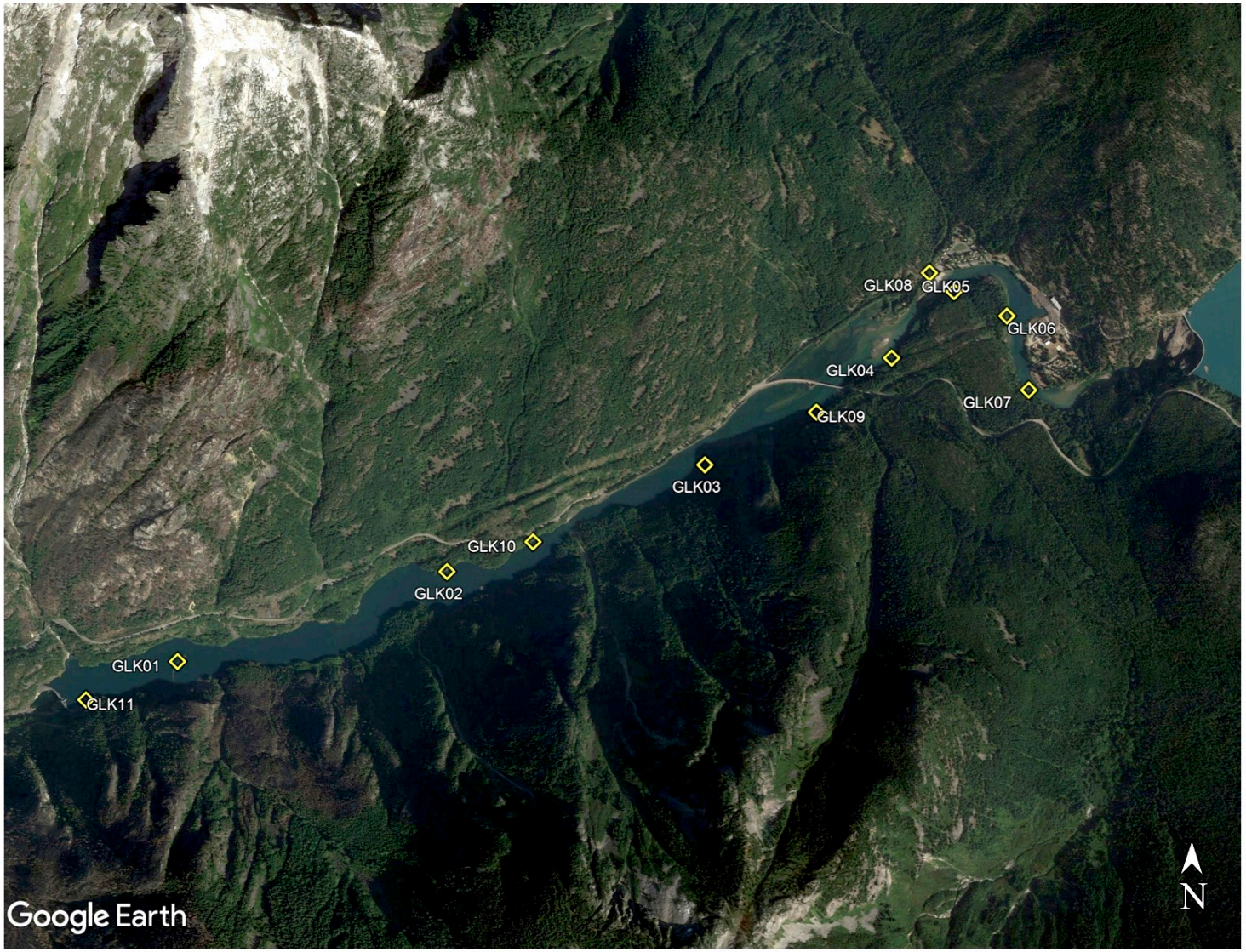

Figure 4. Acoustic receiver array in Gorge Lake for 2018.

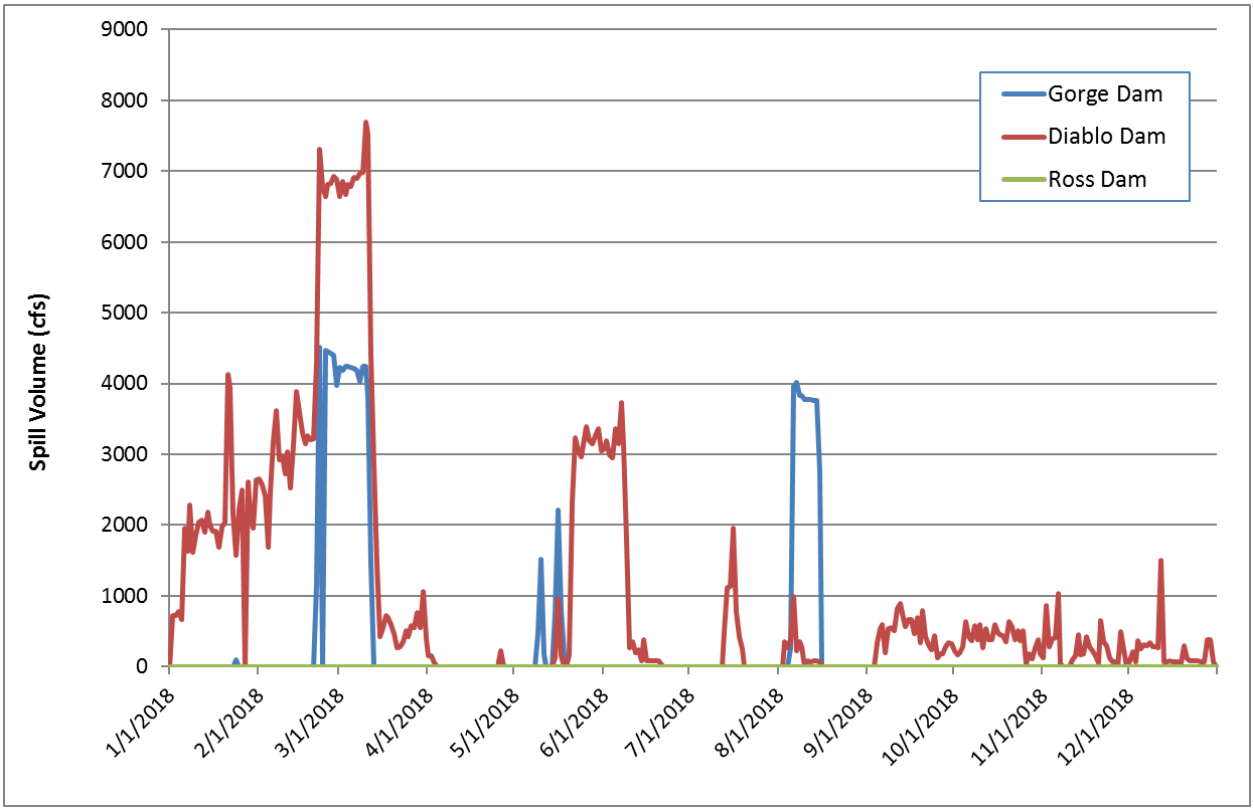

Figure 5. Spill timing and spill volumes at Ross, Diablo, and Gorge dams in 2018.

Table 1. Acoustic receivers deployed in Ross Lake during 2018 monitoring period.

Receiver	Location	Station	Deployment Date	Latitude	Longitude
VR2W-105049	Resort Boom West	RFB01	2/23/2012	48.73759	-121.06577
VR2W-105034	Resort Boom East	RFB02	2/23/2012	48.73890	-121.06072
VR2W-122250	Outer Boom North	RFB03	2/23/2012	48.73764	-121.05405
VR2W-122843	Outer Boom South	RFB04	2/23/2012	48.73670	-121.05563
VR2W-105035	Inner Boom South	RFB05	2/23/2012	48.73449	-121.06480
VR2W-105037	Inner Boom Middle	RFB06	2/23/2012	48.73470	-121.06595
VR2W-105045	Inner Boom North	RFB07	2/23/2012	48.73419	-121.06817
VR2W-102681	Dam Boom North	RFB08	2/23/2012	48.73283	-121.06866
VR2W-105671	Ross Boathouse North	RFB09	2/23/2012	48.73254	-121.06784
VR2W-105044	Ross Boathouse South	RFB10	10/20/2011	48.73236	-121.06760
VR2W-101961	Ross Dam Intakes West	RFB11	2/23/2012	48.73168	-121.06695
VR2W-105046	Ross Dam Intakes East	RFB12	2/23/2012	48.73180	-121.06638
VR2W-102788	Ross Resort Shoreline	RFB14	3/19/2013	48.73420	-121.06863
VR2W-122857	Ross Dam Intake Shoreline	RFB15	3/19/2013	48.73276	-121.06527
VR2W-104295	Ross Lake Ruby Arm	RLK01	2/7/2013	48.73004	-121.02532
VR2W-104779	Ross Lake Big Beaver	RLK02	2/7/2013	48.76682	-121.04427
VR2W-101602	Lightning Creek	RLK04	2/7/2013	48.87482	-121.01878
VR2W-101960	Upper Skagit River, B.C.	RLK05	10/10/2012	49.01927	-121.06065
VR2W-102681	Ross Lake Skimo Cr.	RLK06	11/9/2017	48.86489	-121.03531
VR2W-105048	Ross Lake Desolation Trail	RLK07	11/9/2017	48.89389	-121.04398
VR2W-104662	Ross Lake Little Beaver Cr.	RLK08	11/2/2017	48.91887	-121.07317
VR2W-105042	Ross Lake Jack Point	RLK09	11/2/2017	48.94310	-121.06933
VR2W-105043	Ross Lake Silver Cr.	RLK10	11/2/2017	48.94838	-121.08508
VR2W-122285	Ruby Creek	RLK11	10/16/2018	48.70866	-121.97593

Table 2. Acoustic receivers deployed in Diablo Lake during 2018 monitoring period.

Receiver	Location	Station	Deployment Date	Latitude	Longitude
VR2W-105039	Diablo Dam Center	DLK01	3/2/2012	48.71376	-121.13133
VR2W-122251	Diablo Lake North	DLK02	3/2/2012	48.71690	-121.11940
VR2W-103973	Diablo Lake South	DLK03	11/14/2013	48.70840	-121.10806
VR2W-102780	Middle Thunder Arm	DLK04	10/17/2012	48.70165	-121.09862
VR2W-105038	Lower Diablo Canyon	DLK05	3/2/2012	48.71213	-121.09091
VR2W-104781	Ross Powerhouse Tailrace	DLK06	3/2/2012	48.72961	-121.07244
VR2W-105036	Thunder Arm Bridge	DLK07	3/19/2015	48.69101	-121.09552
VR2W-102787	Middle Diablo Canyon	DLK08	11/17/2017	48.71935	-121.07662
VR2W-105036	Diablo Dam South Spillway	DLK09	11/17/2017	48.71302	-121.13143
VR2W-101959	Diablo Dam Intakes	DLK10	11/17/2017	48.69110	-121.09548
VR2W-122854	Buster Brown Cove	DLK11	8/28/2018	48.71672	-121.10093
VR2W-122855	Middle Diablo Canyon	DLK12	10/11/2018	48.71912	-121.07941
VR2W-102789	Diablo Forebay South	DLK13	10/16/2018	48.71204	-121.12111
VR2W-104296	Thunder Creek Mouth	DLK14	8/22/2018	48.68384	-121.08912

Table 3. Acoustic receivers deployed in Gorge Lake during 2018 monitoring period.

Receiver	Location	Station	Deployment Date	Latitude	Longitude
VR2W-105047	Gorge Dam Logboom	GLK01	12/7/2011	48.69951	-121.20055
VR2W-103974	Gorge Lake Right Bank	GLK02	12/7/2011	48.70361	-121.18240
VR2W-105041	Gorge Lake Left Bank	GLK03	12/7/2011	48.70845	-121.16502
VR2W-104300	Davis Ranch	GLK04	12/5/2013	48.71327	-121.15244
VR2W-102680	Gorge Lake Hollywood	GLK05	12/7/2011	48.71625	-121.14826
VR2W-102682	Diablo Powerhouse Tailrace	GLK06	12/7/2011	48.71518	-121.14468
VR2W-122848	Reflector Bar	GLK07	11/17/2017	48.71188	-121.14317
VR2W-122853	Stetattle Creek	GLK08	8/3/2017	48.71708	-121.14993
VR2W-102785	Highway 20 Bridge	GLK09	10/23/2018	48.71083	-121.15751
VR2W-104293	Lower Gorge North Shore	GLK10	10/23/2018	48.70496	-121.17660
VR2W-122847	Gorge Dam Intakes	GLK11	10/23/2018	48.69777	-121.20672
VR2W-104294	Skagit River Newhalem	SKG01	12/7/2011	48.67210	-121.24653

Table 4. Active acoustic tags in Ross Lake during 2018 monitoring period (TP = temperature/depth sensor tag; PING = pinger tag).

Tag Number	Tagging Site	Sensor	Tagging Date	Tag End Date	Sex	Length (mm)	Weight (g)
A69-1601-58455	Big Beaver Cr	PING	11/12/2015	3/13/2020	m	570	1800
A69-1601-58456	Big Beaver Cr	PING	11/12/2015	3/13/2020	m	473	1050
A69-1601-58457	Big Beaver Cr	PING	11/12/2015	3/13/2020	m	448	950
A69-1602-29255	Ruby Creek	PING	12/7/2017	4/9/2022	m	355	800
A69-9006-15674/15675	Ruby Creek	TP	12/7/2017	1/10/2021	m	481	1120
A69-9006-15676/15677	Ruby Creek	TP	12/7/2017	1/10/2021	m	592	1180
A69-9006-15678/15679	Big Beaver Cr	TP	10/26/2017	11/29/2020	m	490	1350
A69-9006-15680/15681	Big Beaver Cr	TP	10/26/2017	11/29/2020	m	500	1280
A69-9006-15682/15683	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	510	1230
A69-9006-15684/15685	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	530	1420
A69-9006-15686/15687	Big Beaver Cr	TP	10/17/2017	11/20/2020	m	510	1300
A69-9006-15688/15689	Big Beaver Cr	TP	10/26/2017	11/29/2020	m	650	2280
A69-9006-15690/15691	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	565	1500
A69-9006-15692/15693	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	531	1240
A69-9006-15694/15695	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	550	1360
A69-9006-15696/15697	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	480	1200
A69-9006-15698/15699	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	500	1280
A69-9006-15700/15701	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	540	1560
A69-9006-15702/15703	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	540	1480
A69-9006-15704/15705	Big Beaver Cr	TP	10/11/2017	11/14/2020	m	560	1650

Table 5. Active acoustic tags in Diablo Lake during 2018 monitoring period (TP = temperature/depth sensor tag; PING = pinger tag).

Tag Number	Tagging Site	Sensor	Tagging Date	Tag End Date	Sex	Length (mm)	Weight (g)
A69-1601-22793	Thunder Arm	PING	2/19/2015	6/21/2019	m	555	1650
A69-1601-58460	Ross Powerhouse	PING	11/17/2016	3/19/2021	m	507	1350
A69-1601-58467	Thunder Arm	PING	4/17/2017	8/17/2021	m	640	2500
A69-1601-58468	Ross Powerhouse	PING	12/2/2016	4/3/2021	m	505	1250
A69-1602-29251	Thunder Arm	PING	12/4/2018	4/6/2023	m	590	2500
A69-1602-29252	Thunder Arm	PING	12/8/2017	4/10/2022	m	410	1250
A69-1602-29253	Thunder Arm	PING	12/4/2018	4/6/2023	m	455	1480
A69-9006-15666/15667	Thunder Arm	TP	12/4/2018	1/7/2022	m	650	3400
A69-9006-15668/15669	Thunder Arm	TP	12/4/2018	1/7/2022	m	680	3550
A69-9006-15670/15671	Ross Powerhouse	TP	12/8/2017	1/11/2021	m	550	2100
A69-9006-15672/15673	Ross Powerhouse	TP	12/4/2018	1/7/2022	m	518	1500

Table 6. Active acoustic tags in Gorge Lake during 2018 monitoring period (PING = pinger tag).

Tag Number	Tagging Site	Sensor	Tagging Date	Tag End Date	Sex	Length (mm)	Weight (g)
A69-1601-22788	Diablo PH Tailrace	PING	11/4/2014	3/6/2019	m	750	3250
A69-1601-22789	Diablo PH Tailrace	PING	11/4/2014	3/6/2019	f	535	1900
A69-1601-22791	Diablo PH Tailrace	PING	2/19/2015	6/21/2019	m	558	1675
A69-1601-22794	Diablo PH Tailrace	PING	2/19/2015	6/21/2019	f	480	1150
A69-1601-58454	Diablo PH Tailrace	PING	11/13/2015	3/14/2020	m	755	3250
A69-1601-58458	Diablo PH Tailrace	PING	11/6/2015	3/7/2020	f	760	4400
A69-1601-58459	Diablo PH Tailrace	PING	11/13/2015	3/14/2020	f	563	2400
A69-1601-58461	Diablo PH Tailrace	PING	11/18/2016	3/20/2021	m	670	3500
A69-1601-58462	Diablo PH Tailrace	PING	11/18/2016	3/20/2021	f	520	1600
A69-1601-58463	Diablo PH Tailrace	PING	11/18/2016	3/20/2021	m	438	1100

Table 7. Acoustic tag detection summary for bull trout tagged in Ross Lake during 2018 monitoring period (ND = no detections).

Tag Number	Tagging Date	Last Detection Date	Last Detection Site	Ross Lake	Ross Dam Forebay	Ross Dam Intakes	Diablo Lake	Gorge Lake
A69-1601-58455	11/12/2015	ND	ND	0	0	0	0	0
A69-1601-58456	11/12/2015	ND	ND	0	0	0	0	0
A69-1601-58457	11/12/2015	ND	ND	0	0	0	0	0
A69-1602-29255	12/3/2018	5/16/2019	RLK01	73	46	0	0	0
A69-9006-15674/15675	12/3/2018	5/16/2019	RLK01	5,099	538	0	0	0
A69-9006-15676/15677	12/3/2018	4/29/2019	RLK02	4.251	32	0	0	0
A69-9006-15678/15679	10/26/2017	12/31/2018	RLK02	266,387	254,793	124,134	0	0
A69-9006-15680/15681	10/26/2017	5/5/2019	RLK02	6,132	3,651	36	0	0
A69-9006-15682/15683	10/11/2017	5/16/2019	RLK01	18,629	498	2	0	0
A69-9006-15684/15685	10/11/2017	8/11/2018	RLK06	8,423	0	0	0	0
A69-9006-15686/15687	10/17/2017	ND	ND	0	0	0	0	0
A69-9006-15688/15689	10/26/2017	7/23/2018	RLK01	37,551	30,821	2,483	0	0
A69-9006-15690/15691	10/11/2017	7/24/2018	RLK06	11,182	96	0	0	0
A69-9006-15692/15693	10/11/2017	7/25/2018	RLK02	27,725	878	178	0	0
A69-9006-15694/15695	10/11/2017	5/16/2019	RFB02	229,098	217,697	1,056	0	0
A69-9006-15696/15697	10/11/2017	7/21/2018	RLK02	3,937	515	29	0	0
A69-9006-15698/15699	10/11/2017	5/15/2019	RLK02	9,137	0	0	0	0
A69-9006-15700/15701	10/11/2017	4/23/2019	RLK02	15,936	0	0	0	0
A69-9006-15702/15703	10/11/2017	11/16/2018	RLK02	11,678	11,119	2,676	0	0
A69-9006-15704/15705	10/11/2017	10/21/2018	RLK02	4,973	2,604	626	0	0
TOTAL DETECTIONS				660,211	523,288	131,220	0	0

Table 8. Acoustic tag detection summary for bull trout tagged in Diablo Lake during 2018 monitoring period (ND = no detections).

Tag Number	Tagging Date	Last Detection Date	Last Detection Site	Diablo Lake	Diablo Dam Spillways	Diablo Dam Intakes	Gorge Lake
A69-1601-22793	2/19/2015	ND	ND	0	0	0	0
A69-1601-58460	11/17/2016	ND	ND	0	0	0	0
A69-1601-58467	4/17/2017	2/24/2018	DLK04	9,464	0	0	0
A69-1601-58468	12/2/2016	4/30/2018	GLK07	0	0	0	12,835
A69-1602-29251	12/4/2018	ND	ND	0	0	0	0
A69-1602-29252	12/8/2017	5/10/2019	DLK03	80,918	42,259	25,203	0
A69-1602-29253	12/4/2018	ND	ND	0	0	0	0
A69-9006-15666/15667	12/4/2018	ND	ND	0	0	0	0
A69-9006-15668/15669	12/4/2018	ND	ND	0	0	0	0
A69-9006-15670/15671	12/8/2017	5/19/2019	GLK06	3,425	172	111	16,899
A69-9006-15672/15673	12/4/2018	ND	ND	0	0	0	0
TOTAL DETECTIONS				93,807	42,431	25,317	29,734

Table 9. Acoustic tag detection summary for bull trout tagged in Gorge Lake during 2018 monitoring period (ND = no detections).

Tag Number	Tagging Date	Last Detection Date	Last Detection Site	Gorge Lake	Gorge Dam Forebay	Gorge Powerhouse Tailrace
A69-1601-22788	11/4/2014	ND	ND	0	0	0
A69-1601-22789	11/4/2014	ND	ND	0	0	0
A69-1601-22791	2/19/2015	ND	ND	0	0	0
A69-1601-22794	2/19/2015	ND	ND	0	0	0
A69-1601-58454	11/13/2015	ND	ND	0	0	0
A69-1601-58458	11/6/2015	ND	ND	0	0	0
A69-1601-58459	11/13/2015	ND	ND	0	0	0
A69-1601-58461	11/18/2016	6/25/2018	GLK06	25,948	0	0
A69-1601-58462	11/18/2016	ND	ND	0	0	0
A69-1601-58463	11/18/2016	6/24/2018	GLK07	12,321	0	0
TOTAL DETECTIONS				38,269	0	0