Appendix J

2020 Fish Passage Summary

FISH PASSAGE CENTER

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November 4, 2020

Mr. Daniel Turner
U.S. Army Corps of Engineers
Northwestern Division
PO Box 2870
Portland, OR 97208-2870

Dear Mr. Turner:

As per our agreement, we are providing a copy of our *Gas Bubble Trauma Monitoring and Data Reporting for 2020* to you and Ms. Claire McGrath of NOAA Fisheries. This report summarizes data collected during the 2020 juvenile salmonid migration.

Please feel free to contact us if you require any additional information.

Sincerely,

Michele DeHart
Fish Passage Center Manager

CC: Claire McGrath, NOAA Fisheries
Laura Hamilton, USACE
Julie Ammann, USACE

Gas Bubble Trauma Monitoring and Data Reporting for 2020

Overview

The objective of the juvenile salmonid gas bubble trauma (GBT) monitoring program is to provide a measure of the exposure to harmful levels of total dissolved gas (TDG) experienced by migrating juvenile salmonids. The monitoring assesses both the incidence and severity of exposure and provides an "early warning" of potentially harmful levels of TDG. The data are reported to the fisheries management entities and the water quality agencies of Washington and Oregon, and are available to other interested parties through Fish Passage Center weekly reports and daily postings to the FPC website during the season (http://www.fpc.org/smolt/gasbubbletrauma.html). The fisheries management entities review the data in-season to determine if modifications to spill are necessary based on the GBT monitoring.

The monitoring of juvenile salmonids in 2020 for GBT was conducted at Upper Columbia, Middle Columbia, and Snake River sites, as part of the Smolt Monitoring Program (SMP). Fish were collected and examined for signs of GBT at Rock Island Dam (RIS) on the Upper Columbia River, and at Bonneville Dam (BON) and McNary Dam (MCN) on the Middle Columbia River. The Snake River monitoring sites were Lower Granite (LGR), Little Goose (LGS), and Lower Monumental (LMN) dams. The goal of the GBT monitoring program was to sample 100 salmonids each day of sampling at each site. The proportion of each species sampled (limited to Chinook and steelhead) was dependent upon their prevalence at the time of sampling. Yearling Chinook and steelhead dominated the samples in the spring, with samples gradually shifting to subyearling Chinook predominance in the summer through the end of August, unless an adequate sample could not be collected. Sampling at some sites was terminated prior to the end of August because of high temperatures and/or lack of ability to reach target sample sizes (more detail on these instances is provided below). A daily sample size of 100 fish is necessary to assure that the sample observation accurately represents the population incidence of signs of gas bubble trauma.

Since fish held at shallow depths for long periods of time may exhibit bubbles even at low TDG levels and would not be representative of the migrating population (Weitkamp 2000), the GBT monitoring program is designed to minimize the holding time prior to examining fish. Fish to be examined were netted off the bypass separator bars (at LGR, LGS, LMN, and MCN) or removed from the sample tank or other sampling apparatus (at RIS and BON). Due to the configuration of the collection systems at BON and RIS, sampling at the separator is not possible. Therefore, fish for the GBT sample can be held for prolonged periods at these sites, particularly at RIS where fish may be held for up to 24-hours. Over the years, SMP personnel at BON have minimized the amount of time that GBT sample fish are held in the sample tank prior to examination. However, due to continued limitations at RIS, data from this site should be evaluated within the context of the sampling procedure(s) used. Since the values can be biased high, the results are evaluated independently of the other monitoring locations. In an attempt at minimizing the impact of prolonged holding periods, the FPC and RIS staff continued to implement a

modified sampling protocol in 2020. Details of this protocol and an evaluation of past data are provided below in a separate discussion.

Once collected, fish are anesthetized and examined using a modified examination tray. The tray is equipped with a siphon tube that delivers anesthetic water over the fish's gills allowing fish to be continually anesthetized during the GBT examination. Sampling occurred two days per week at the Columbia River sites and one day a week at each of the Snake River sites throughout the spring and summer spill programs. Table J-1, below, provides the frequency, duration, and method of collection for the GBT Monitoring Program, under the current protocol.

Table J-1
Summary of GBT Monitoring sampling schedule in spring and summer, 2020

Region	Site	Frequency of Sampling	Duration of Sampling	Method of Collection
Snake	LGR	Once per week	April-June	Separator
	LGS	Once per week	April-August	Separator
	LMN	Once per week	April-August	Separator
Middle Columbia	MCN	Twice per week	April-August	Separator
	BON	Twice per week	April-August	Sample Tank
Upper Columbia	RIS	Twice per week	April-August	Sample Tank/Entering Trap

Examinations of fish were conducted using variable magnification (6x to 40x) dissecting scopes. The eyes and unpaired fins (e.g., dorsal, caudal, and anal fins), were examined for the presence of bubbles. The bubbles present were quantified using a ranking system based on the percent area of the fins or eyes covered with bubbles (USGS 1997) (Table J-2). Additional information was recorded for each fish during the examination, including species, age, fork length, fin clips, and tags present.

Table J-2
Ranking criteria used in monitoring for signs of gas bubble trauma.

Rank	Sign
0	no bubbles present
1	up to 5% of a fin area or eye covered with bubbles
2	6% to 25% of a fin area or eye covered with bubbles
3	26% to 50% of a fin area or eye covered with bubbles
4	> than 50% of a fin area or eye covered with bubbles

To standardize handling and reporting practices among sites and to provide accounting for Endangered Species Act permitting purposes, the FPC modified the handling protocol for the GBT program in 2015. Monitoring in 2020 followed the same protocol that was issued in 2015. For more detailed information on the examination

procedure, the 2020 GBT Monitoring Protocol is available on the FPC website (FPC 2020a).

Pilot GBT Monitoring Program for Non-salmonids

In addition to the salmonid GBT Monitoring program that is conducted under the SMP, we conducted a pilot GBT Monitoring Program for non-salmonids at the five FCRPS projects where GBT monitoring for salmonids occurred (LGR, LGS, LMN, MCN, and BON). This pilot program was implemented in response to the new 125% tailrace total dissolved gas (TDG) standard in the Snake and Mid-Columbia rivers for the spring spill season. Specifically, non-salmonid GBT monitoring was added to the new 125% tailrace TDG standard for both state water quality agencies. Although the water quality standards specified that the non-salmonid monitoring program did not need to be implemented until 2021, this pilot program was implemented in order to provide information on what can be accomplished, in terms of non-salmonid GBT Monitoring, under the current GBT Monitoring program for salmonids.

Under this pilot program, GBT Monitoring personnel at the FCRPS projects were instructed to collect and examine any non-salmonid fish species that they encountered during the period when salmonids were being collected and examined for GBT. Each GBT sample ended once the target sample size of salmonids had been met, or the allotted time for salmonid monitoring had run out, regardless of how many non-salmonids were encountered and examined. SMP crews were instructed to follow the same protocols for collection, handling, anesthetizing, examination, and release as they did for salmonids. Detailed instructions for SMP personnel on this pilot study were included in the 2020 GBT Sampling Protocol (FPC 2020a). It is worth noting that the pilot GBT Monitoring program was not conducted at RIS, as the PUD projects in the Upper Columbia continued to operate under the 115%/120% TDG standard and, therefore, GBT monitoring of non-salmonids was not necessary.

2020 Water Conditions and Spill Operations

The runoff volume (January–July) for the 2020 water year was average in the Middle Columbia River and near average in the Snake River. Runoff (January–July) was 100% of average (1981–2010) at The Dalles Dam and 92% of average at Lower Granite Dam. To put the runoff volumes into perspective, the 2020 January–July runoff volumes at The Dalles and Lower Granite were ranked 49th and 53rd, respectively, over the last 92 years (1929–2020).

In 2020, runoff in the Snake River followed a more typical in shape (Figure J-1). Flows in March and April were mostly below average but by early May flows had increased to average or above average levels. There were four distinct spikes in flows throughout the month of May and into early June (May 2nd, May 13th, May 21st, and June 1st; Figure J-1). Daily average flows at Lower Granite Dam peaked on June 1st, at approximately 166 Kcfs. Given the new 125% tailrace TDG standard that was implemented in the spring, the peak flows in 2020 were not sufficiently high to warrant

spill in excess of the estimated 125% TDG spill cap (i.e., uncontrolled spill). Soon after peaking on June 1st, flows at Lower Granite Dam began to decrease rapidly and even dropped below the current ten-year average by June 5th. In general, summertime flows at Lower Granite Dam were at to slightly above the current ten-year average (Figure J-1).

Runoff in the Middle Columbia was also more typical in shape. However, like the Snake River, flows in March and April were generally below average (Figure J-2). By early May, flows in the Mid-Columbia River had increased to average to above average levels. Flows at McNary Dam peaked on June 2nd, at nearly 400 Kcfs. Given the new 125% tailrace TDG standard that was implemented during the spring, peak flows in 2020 were not sufficiently high to warrant spill in excess of the estimated 125% TDG spill cap (i.e., uncontrolled spill). Soon after peaking on June 2nd, flows at McNary Dam began to decrease. However, summer flows at McNary Dam remained above average through early July (Figure J-2). By July 4th, flows at McNary Dam were close to the current ten-year average, where they remained for the rest of the summer spill season.

Figure J-1.
Average daily flows at Lower Granite Dam in 2020, 2019, and the 10-year average

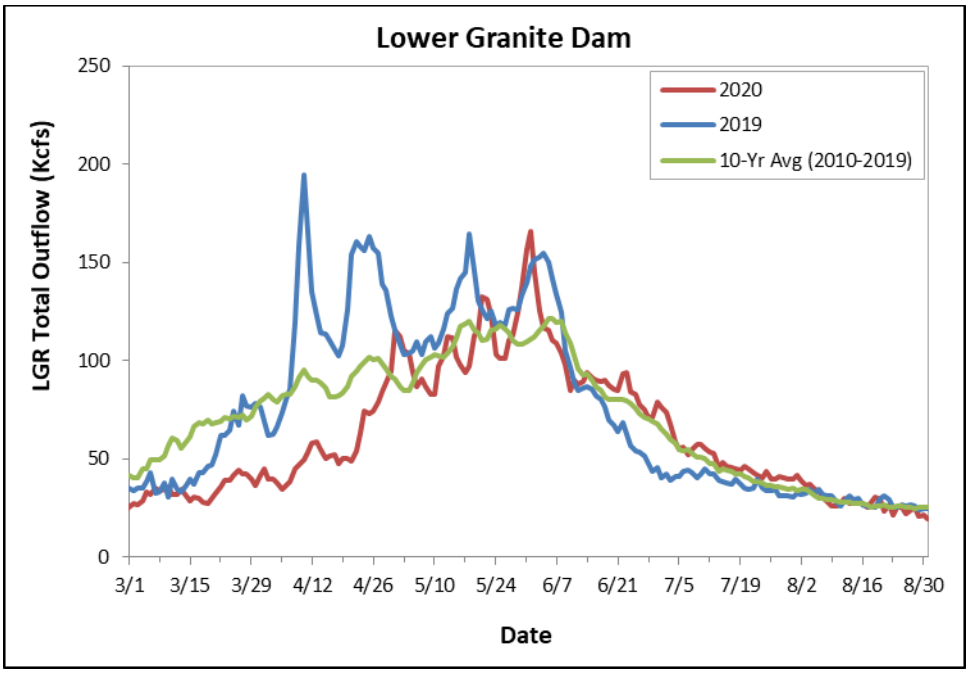
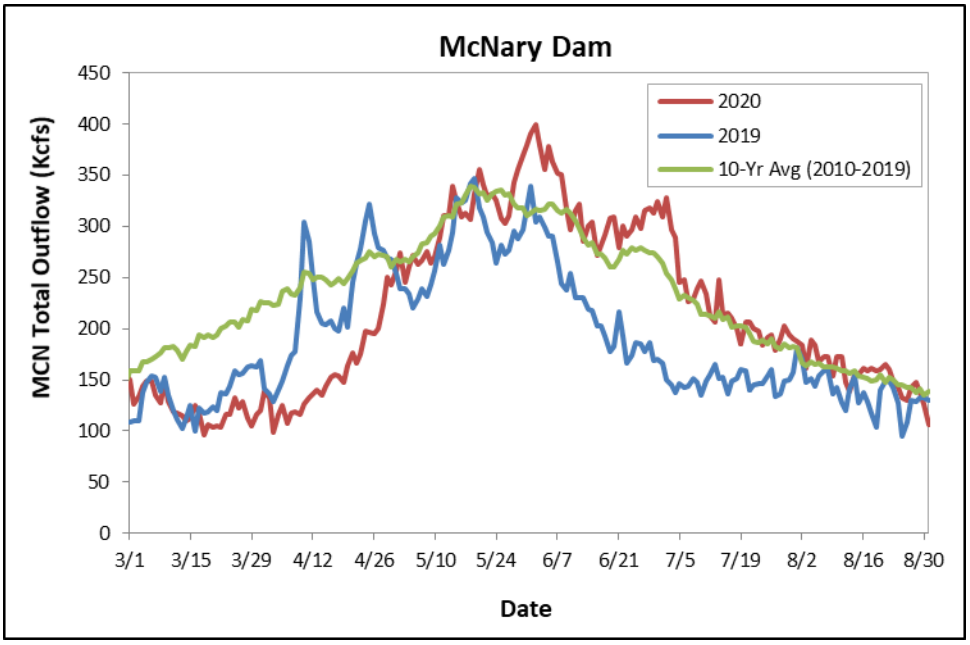


Figure J-2
Average daily flows at McNary Dam in 2020, 2019, and the 10-year average



In December of 2018, the Action Agencies (Bonneville Power Administration, the U.S. Army Corps of Engineers, and the U.S. Bureau of Reclamation) signed an agreement with the states of Oregon and Washington and the Nez Perce Tribe for 2019-2021 Spill Operations. The spill operations under this agreement are referred to as "Flex Spill". Under the 2020 Flex Spill Agreement, many FCRPS projects were to spill to the estimated 125% tailrace total dissolved gas (TDG) spill caps for sixteen hours per day and "performance standard" spill for eight hours per day during the spring spill season (Table J-3). The three exceptions to this were John Day, The Dalles, and Bonneville dams. John Day Dam was to spill to a "Max FOP" spill volume for sixteen hours per day and performance standard spill (32% of instantaneous flows) for eight hours per day. At John Day, this "Max FOP" spill volume was the estimated daily 120% tailrace TDG spill cap. The Dalles Dam was to spill 40% of instantaneous flows, 24-hours per day. Finally, Bonneville Dam was to spill a "Max FOP" spill volume of 150 Kcfs for sixteen hours per day and performance standard spill (100 Kcfs) for eight hours per day. At all projects with a "Flex Spill" operation, the eight hours of "performance standard" spill would occur in up to two blocks per calendar day, an AM block and a PM block.

For the spring spill season, the COE estimated the 125% tailrace TDG and/or "Max FOP" spill caps for each FCRPS project on a daily basis. Where applicable, projects were operated to these estimated 125% tailrace TDG and/or "Max FOP" spill caps for the 16-hours of gas cap or "Max FOP" spill. The daily 125% tailrace TDG and "Max FOP" spill caps were published on the TMT website (http://pweb.crohms.org/tmt/documents/ops/spill/caps/).

There was no "Flex Spill" in the summer spill season, as all spill operations were 24-hours per day. However, under the 2020 Flex Spill Agreement, summer spill operations were broken into two period. The first period consisted of a single spill operation from the beginning of the summer spill season (June 16 in the Mid-Columbia River and June 21 in the Snake River) to August 14th. The second period consisted of a different spill operation from August 15th through August 31st (Table J-3).

Table J-3

2020 spring and summer spill operations at Snake and Mid-Columbia FCRPS projects under the 2020 Flex Spill Agreement and Fish Operations Plan.

Project	Spring "Flex Spill" (Snake: Apr. 3-June 20) (Mid-Columbia: Apr. 10-June 15)		Summer Spill (Snake: June 21-Aug. 31) (Mid-Columbia: June 15-Aug. 31)	
	Gas Cap Spill (16 hrs/day)	Perf. Standard Spill (8 hrs/day)	Prior to Aug. 15	Aug. 15-Aug 31
LGR	120% Gas Cap	20 Kcfs	18 Kcfs	SW of ~7 Kcfs
LGS	120% Gas Cap	30%	30%	SW of ~7 Kcfs
LMN	120% Gas Cap	30 Kcfs (bulk pattern)	17 Kcfs	SW of ~7 Kcfs
IHR	120% Gas Cap	30%	30%	SW of ~8.5 Kcfs
MCN	120% Gas Cap	48%	57%	20 Kcfs
JDA	120% Gas Cap	32%	35%	20 Kcfs
TDA	120% Gas Cap	40%	40%	30%
BON	120% Gas Cap	100 Kcfs	95 Kcfs	50 Kcfs

For the 2020 Flex Spill operations, the states of Oregon and Washington modified their TDG water quality standards for FCRPS projects in the Snake and Mid-Columbia rivers. For the spring spill season, TDG was managed to a 125% tailrace TDG standard where the 12-hour average TDG could not exceed 125%. In addition, the state of Oregon had a 2-hour average TDG standard of 127% while Washington had a 2-hour standard of 126% TDG. As part of their new 125% tailrace TDG standard, the Washington Department of Ecology (DOE) and Oregon Department of Environmental Quality (DEQ) specified that a minimum sample size requirement of 50 salmonids and 50 non-salmonids must be examined for GBT Monitoring, per week, per zone (i.e., Snake Zone vs. Mid-Columbia River Zone). In addition, Washington adopted the methodology of calculating the 12-hour average TDG based on the 12 highest hourly TDG measurements in a single calendar day (not necessarily consecutive). This methodology for estimating the 12-hour average TDG was applied in both the spring and summer spill seasons. Finally, when summer spill began in June, the State of Washington's 115% forebay TDG requirement was reinstated and the tailrace TDG standard was reduced to 120% for both states.

Results

In all, 12,297 juvenile salmonids were examined for GBT between April and August of 2020 (Table J-4). The fish were collected and examined as part of the Smolt Monitoring Program. In addition, 36 total non-salmonids were samples as part of the pilot program (Table J-5). These 36 non-salmonids spanned 14 different species, the most common of which were yellow perch, smallmouth bass, and peamouth.

Table J-4

Number of juvenile salmonids examined for signs of GBT at dams on the Lower Snake River and on the Columbia River from April to August 2020 as part of the Smolt Monitoring Program.

Species	BON	MCN	LMN	LGS	LGR	RIS	Total
Chinook Subyearlings	1,750	1,900	680	361	0	1,463	6,144
Chinook Yearlings	1,099	1,181	299	307	445	775	4,106
Steelhead	163	302	377	441	293	471	2,047
Total	3,012	3,383	1,356	1,099	738	2,709	12,297

Table J-5

Number of non-salmonids examined for signs of GBT at dams on the Lower Snake and Mid-Columbia rivers during the 2020 spring spill Season as part of the pilot GBT Monitoring program for non-salmonids.

Species	BON	MCN	LMN	LGS	LGR	Total
Pacific Lamprey Ammocoete	0	0	0	0	1	1
Smallmouth Bass*	1	3	2	1	0	7
Bridgelip Sucker	0	0	1	0	0	1
Channel Catfish*	0	1	0	0	0	1
Chiselmouth	0	0	0	0	1	1
Carp*	0	1	0	0	0	1
Crappie*	0	1	0	0	0	1
Mountain Sucker	0	1	0	0	0	1
Mountain Whitefish	1	0	0	1	0	2
Yellow Perch*	1	6	0	0	0	7
Peamouth	6	0	0	0	0	6
Sculpin	0	1	0	0	0	1
Three-spine Stickleback	3	0	0	0	0	3
Sucker Sp.	2	1	0	0	0	3
Total	**14**	**15**	**3**	**2**	**2**	**36**

* indicates non-native species

Fin signs were found in 193 or 1.57% of the total salmonids sampled at all sites (Table J-6), with 119 of those detections occurring at Rock Island Dam. Of the 193 salmonids that had signs of fin GBT in 2020, 181 (93.8%) had a maximum fin ranking of 1, where less than 5% of a fin area was occluded with bubbles. Eleven total salmonids (5.7%) had a maximum fin ranking of 2, where 6-25% of the fin area was occluded with bubbles. Finally, one salmonid (0.52%) had a maximum fin ranking of 3, where 26-50%

of the fin area was occluded with bubbles. This was the only salmonid with severe (i.e., ≥26% of a fin area occluded with bubbles) signs of GBT in 2020. Among the 36 non-salmonids that were collected and examined for GBT, zero signs of fin GBT were observed. A more detailed breakdown of GBT exams and signs for 2020 can be found in Tables J-7 through J-12.

Table J-6

Number of juvenile salmonids found with fin GBT at dams on the Lower Snake River and on the Columbia River from April to August 2020 as part of the Smolt Monitoring Program.

Species	Fin GBT by Site						Grand Total
	BON	MCN	LMN	LGS	LGR	RIS	
Chinook Subyearlings	6	0	12	9	0	64	91
Chinook Yearlings	9	5	4	8	0	50	76
Steelhead	2	6	9	4	0	5	26
Total	17	11	25	21	0	119	193

The action criteria for GBT is established as 15% of fish showing any signs of fin GBT, or 5% of the fish showing severe signs of fin GBT. Signs of fin GBT are deemed severe when ≥26% of an unpaired fin is covered with bubbles (i.e., Rank 3 or 4). Voluntary spill may be reduced, if possible, when one or both action criteria are met. These action criteria were developed based on lab studies that indicated that significant mortality did not occur until 60% of the exposed population exhibited signs of GBT or 30% exhibited severe signs in their unpaired fins. The action levels were set at 15% with any signs and 5% with severe signs to provide a large margin of safety, primarily because the results from the lab studies indicated some level of uncertainty between fin bubble percentage and the onset of mortality (FPC 2007b).

The 15% criterion was met once in 2020, in the Snake River but was not met in the Mid-Columbia or Upper Columbia Rivers. However, the single instance in the Snake River was based on a very small sample, where only five salmonids were examined and one exhibited signs of GBT. Total dissolved gas was well below the 115%/120% TDG criteria that were in place at the time of this exam. For more discussion on this instance, see the LGS results section below. The criterion of 5% severe GBT was never met in 2020.

Lower Granite Dam (LGR)

The 12-hour average TDG in the Dworshak Dam (DWR) tailrace exceeded the 110% Environmental Protection Agency (EPA) standard on two occasions in 2020, June 11th and June 12th (Figure J-3). However, it is unclear why the 12-hour average TDG exceeded 110% on these two days, as there was no spill at DWR on either day. It is possible that the 12-hour average TDG reported on these two days was the result of a gauge malfunction. In addition, TDG in the LGR forebay never exceeded 110% in 2020. In fact, the maximum 12-hour average TDG in the LGR forebay in 2020 was 107%. GBT sampling at LGR is typically used to provide a background level of GBT for migrating

juvenile salmonids that are first entering the hydrosystem. Sampling at LGR in 2020 began on April 10th and ran through June 5th. SMP personnel at LGR attempted to conduct a GBT sample on June 12th but were unable to collect any target salmonids or non-salmonids in the time allotted. GBT sampling at LGR was officially terminated after the failed attempt on June 12th, as subyearling Chinook pre-dominated the salmonid collections and meeting sample size requirements with yearling Chinook and/or steelhead was not possible.

In all, nine total GBT samples were conducted at LGR in 2020, from April 10th to June 5th. Among the nine GBT samples that were conducted at LGR in spring 2020, 738 total salmonids were examined and zero had signs of fin GBT (Figure J-3, Table J-7). The target sample size of 100 salmonids examined per GBT sample was met in all but three of the GBT samples at LGR. The three samples that did not meet this target sample size were the first sample on April 10th (with 60 total salmonids examined) and the last two samples on May 29th and June 5th (with 50 and 23 total salmonids sampled, respectively). The DOE and DEQ minimum sample size requirement of 50 salmonids per week was met in all but one week. The one week that did not meet this requirement was the last week (June 5th), where only 23 total salmonids were collected and examined for GBT.

Non-salmonids were only encountered at the separator on two occasions at LGR, May 8th and May 29th. In each of these two occasions, only one individual non-salmonid was encountered and examined. One Pacific lamprey ammocoete was examined in the sample from May 8th and one chiselmouth was examined in the sample from May 29th. Neither of these two non-salmonids had signs of fin GBT (Figure J-3, Table J-7). The DOE and DEQ minimum sample size requirement of 50 non-salmonids per week was never met at LGR in 2020.

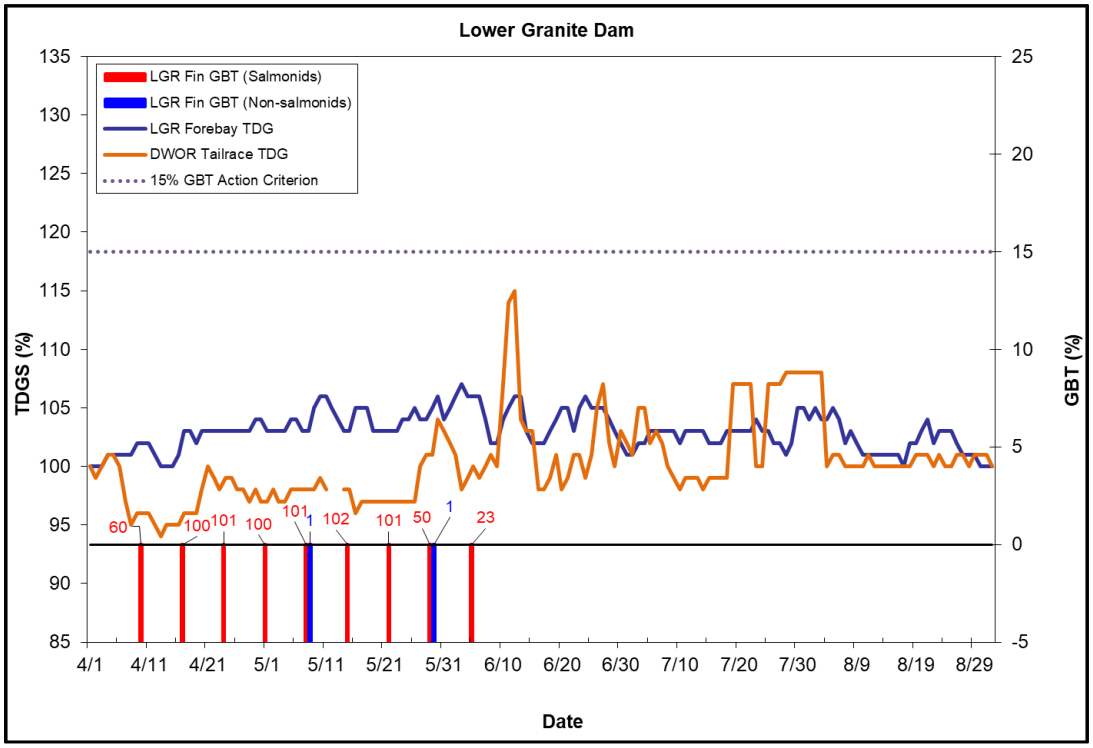
Table J-7

Detailed breakdown of GBT exams and signs of fin GBT at Lower Granite Dam in 2020. Shaded columns indicate non-salmonid samples.

	Salmonid Samples			Non-Salmonid Samples			
Sample Date	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Species Sampled
4/10	60	0	0.0%	0	---	---	
4/17	100	0	0.0%	0	---	---	
4/24	101	0	0.0%	0	---	---	
5/1	100	0	0.0%	0	---	---	
5/8	101	0	0.0%	1	0	0.0%	Pacific lamprey ammocoete
5/15	102	0	0.0%	0	---	---	
5/22	101	0	0.0%	0	---	---	
5/29	50	0	0.0%	1	0	0.0%	Chiselmouth
6/5	23	0	0.0%	0	---	---	

Figure J-3

Percent GBT observed in the salmonid (red bars) and non-salmonid (blue bars) samples at Lower Granite Dam and 12-hour TDG at the Dworshak tailrace and Lower Granite forebay in 2020.



Notes: 1) the y-axis for GBT incidence rate starts at -5% in order to display all GBT sample data, including days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) red and blue numbers over the bars indicate the total salmonids (red) and non-salmonids (blue) examined for GBT.

Little Goose Dam (LGS)

GBT sampling at LGS occurred from April 6th to July 27th. Sampling at LGS was terminated after the sample on July 27th due to decreasing numbers of fish in the sample that precluded the examination of an adequate sample size. During the spring spill season (Apr. 3-June 20), TDG levels in the LGR tailrace exceeded the 125% criteria a total of 5 times in 2020. These exceedances included a three-day period from May 21st to May 23rd and a two-day period at the end of May (May 29th and 30th) (Figure J-4). During the summer spill period (June 21-August 31), TDG levels in the LGR tailrace never exceeded the 120% tailrace TDG standard and the 115% forebay standard was only exceeded for the first few days of summer spill, as TDG from the "flex spill" operation at LGR moved downstream to the LGS forebay.

Seventeen total GBT samples were conducted at LGS in 2020. Among the 17 GBT samples at LGS, 1,099 total salmonids were examined for GBT and 10 GBT samples had at least one salmonid exhibiting signs of fin GBT (Figure J-4, Table J-8). The highest GBT incidence rate at LGS in 2020 occurred on July 20th, where 20% of the examined fish exhibited signs of fin GBT. However, it should be noted that this GBT incidence rate was

based on only five salmonids examined, one of which exhibited signs of fin GBT. Total dissolved gas in the LGR tailrace and LGS forebay had been well below 120% and 115% TDG standards during this time (Figure J-4). The second highest GBT incidence rate at LGS occurred on June 8th, when 6.3% of the GBT sample exhibited signs of fin GBT. It should be noted that 64 total salmonids were examined for this GBT sample. This was below the target sample size of 100 fish examined but was above the DOE and DEQ minimum sample size requirement of 50 salmonids examined. This sample had one individual with Rank 3 signs of fin GBT (26-50% of the fin occluded with bubbles), which is considered severe GBT. The incidence rate for severe GBT on this date was 1.6%, which is below the action criterion of 5% severe fin GBT. The 12-hour average TDG in the LGR tailrace had been 125% or greater over the entire week preceding this June 8 sample (Figure J-4). Among the remaining 8 GBT samples where signs of fin GBT were present, GBT incidence rates ranged from 1.0% to 4.0% and zero had signs of severe GBT. The target sample size of 100 salmonids examined per GBT sample was met in only 7 of the 17 total samples at LGS. The DEQ and DOE minimum sample size requirement of 50 salmonids per week was met in all but 5 samples. The 5 samples that did not meet these minimum sample size requirements were the first sample (April 6th), the samples on June 29th and July 6th, and the last two samples (July 20th and July 27th) (Table J-8).

Table J-8

Detailed breakdown of GBT exams and signs of fin GBT at Little Goose Dam in 2020. Shaded columns indicate non-salmonid samples.

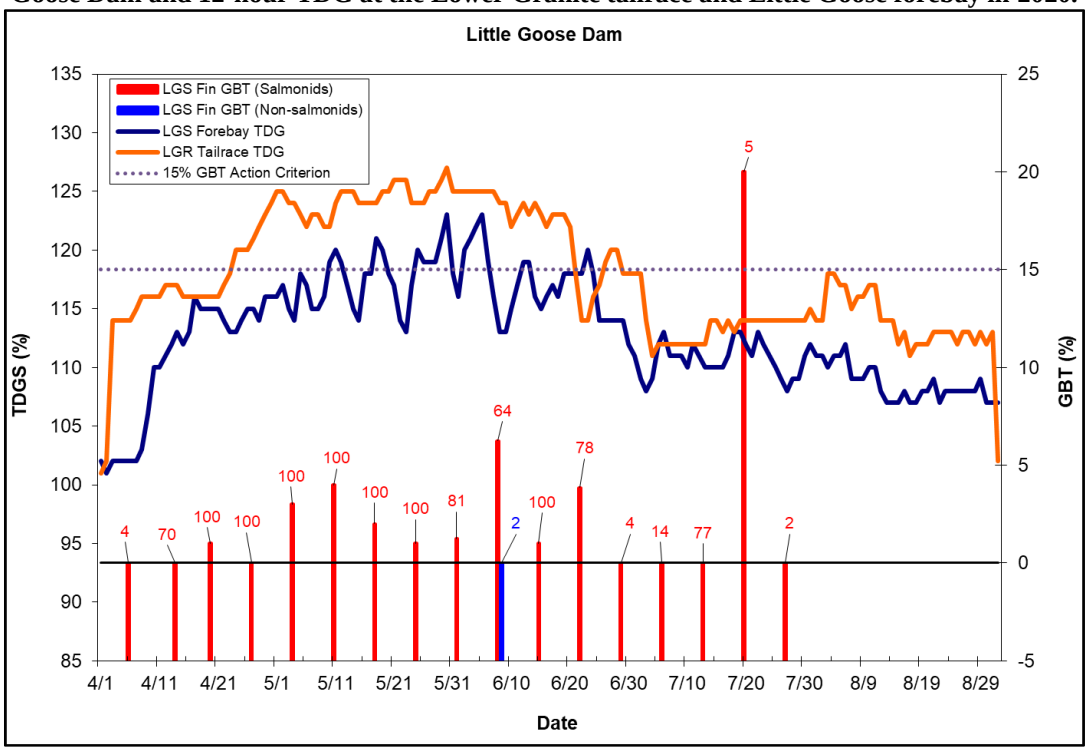
	Salmonid Samples			Non-Salmonid Samples			
Sample Date	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Species Sampled
4/6	4	0	0.0%	0	---	---	
4/14	70	0	0.0%	0	---	---	
4/20	100	1	1.0%	0	---	---	
4/27	100	0	0.0%	0	---	---	
5/4	100	3	3.0%	0	---	---	
5/11	100	4	4.0%	0	---	---	
5/18	100	2	2.0%	0	---	---	
5/25	100	1	1.0%	0	---	---	
6/1	81	1	1.2%	0	---	---	
6/8	64	4	6.3%	2	0	0.0%	Mountain whitefish, Smallmouth bass*
6/15	100	1	1.0%	0	---	---	
6/22	78	3	3.8%	---	---	---	
6/29	4	0	0.0%	---	---	---	
7/6	14	0	0.0%	---	---	---	
7/13	77	0	0.0%	---	---	---	
7/20	5	1	20.0%	---	---	---	
7/27	2	0	0.0%	---	---	---	

* indicates non-native species

Among the 11 GBT samples that were conducted during the spring spill season (April 3-June 20) at LGS, non-salmonids were only encountered at the separator on one occasion, June 8th (Table J-8). On this occasion, two total non-salmonids were encountered and examined, one smallmouth bass and one mountain whitefish. Neither of these individuals exhibited signs of fin GBT (Figure J-4, Table J-8). The DOE and DEQ minimum sample size requirement of 50 non-salmonids per week was never met at LGS in 2020.

Figure J-4

Percent GBT observed in the salmonid (red bars) and non-salmonid (blue bars) samples at Little Goose Dam and 12-hour TDG at the Lower Granite tailrace and Little Goose forebay in 2020.



Notes: 1) the y-axis for GBT incidence rate starts at -5% in order to display all GBT sample data, including days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) red and blue numbers over the bars indicate the total salmonids (red) and non-salmonids (blue) examined for GBT.

Lower Monumental Dam (LMN)

GBT sampling at LMN occurred from April 8th to August 5th. Sampling was terminated after the sample on August 5th due to decreasing numbers of fish in the sample that precluded the ability to meet sample size requirements, increasing temperatures, and generally low TDG at this time. Total dissolved gas levels in the LGS tailrace exceeded the 125% standard on six total occasions in the spring of 2020. These six occasions encompassed a six-day period in late May and early June when the 12-hour average TDG in the LGS tailrace was 126% (Figure J-5). During the summer spill period (June 21-August 31), TDG levels in the LGS tailrace exceeded the 120% tailrace TDG standard on one occasion (June 28th), where the 12-hour TDG was 121%. In addition, the 115% forebay standard was exceeded for much of the first 10 days of summer spill, as TDG from the "flex spill" operation at LGS moved downstream to the LMN forebay.

In all, 18 total GBT samples were conducted at LMN in 2020. Of these 18 GBT samples at LMN, 1,356 total salmonids were examined for GBT and 10 GBT samples had at least one salmonid exhibiting signs of fin GBT (Figure J-5, Table J-9). The highest GBT incidence rate in 2020 at LMN was 4.3%, which occurred on June 10th. It should be noted that 47 total salmonids were examined for this GBT sample. This was below the target sample size of 100 salmonids examined and just below the DOE and DEQ minimum sample size requirement of 50 salmonids examined. Total dissolved gas in the LGS tailrace had been in the 124%-126% range over the week preceding this June 10 GBT sample (Figure J-5). Among the remaining nine GBT samples where signs of fin GBT were present, GBT incidence rates ranged from 1.1% to 4.0%. No signs of severe GBT were observed at LMN in 2020. In fact, all 25 salmonids that exhibited signs of GBT at LMN in 2020 were Rank 1. The target sample size of 100 salmonids examined per GBT sample was met in only 50% of the GBT samples at LMN. The nine samples that did not meet this target sample size were the first three samples in April (April 8th, April 16th, and April 22nd), the samples on June 10th and June 17th, the sample on July 8th, and the last three samples (July 22nd, July 29th, and August 5th). The DOE and DEQ minimum sample size requirement of 50 salmonids per week was met in all but five samples in 2020. The five samples that did not meet this requirement were the first two samples (April 8th with 15 total examined and April 16th with 42 total examined), the samples on June 10th and June 17th (with 47 and 8 salmonids examined, respectively, and the last sample (August 5 with 40 salmonids examined) (Figure J-5, Table J-9).

Among the 11 GBT samples that were conducted during the spring spill season (Apr. 3-June 20) at LMN, non-salmonids were only encountered at the separator on two occasions, June 3rd and June 10th (Table J-9). Over these two occasions, a total of three individual non-salmonids were encountered and examined: one smallmouth bass on June 3rd and one smallmouth bass and one bridgelip sucker on June 10th. None of these non-salmonids exhibited signs of fin GBT (Figure J-5, Table J-9). The DOE and DEQ minimum sample size requirement of 50 non-salmonids per week was never met at LMN.

Table J-9

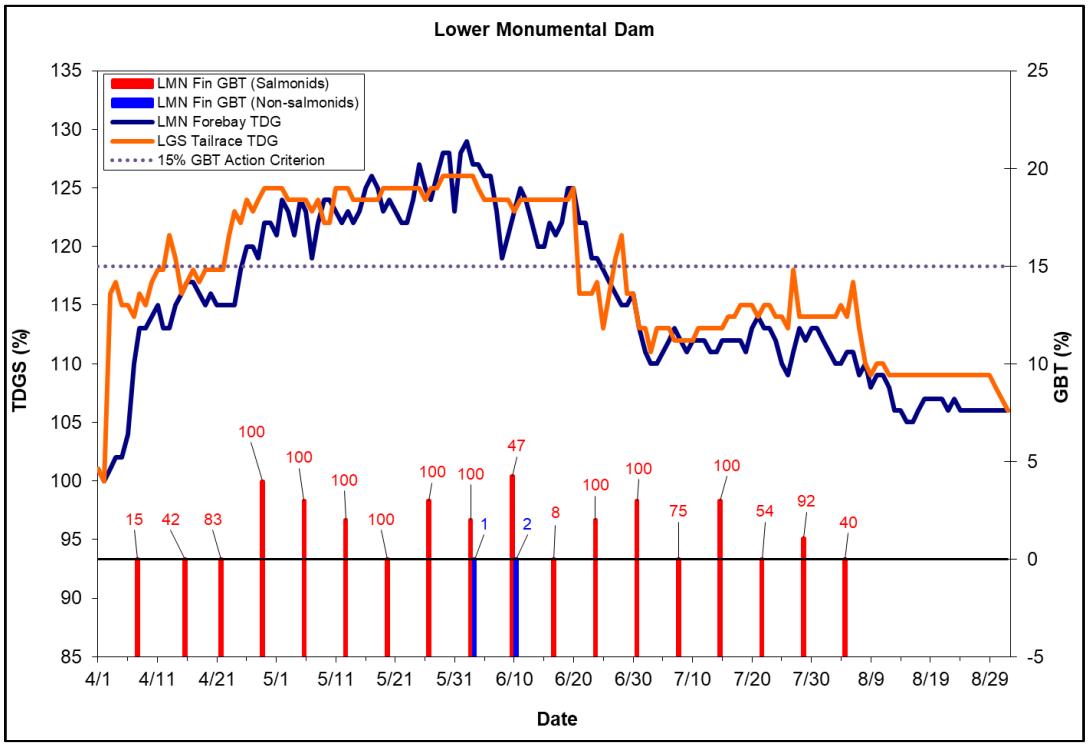
Detailed breakdown of GBT exams and signs of fin GBT at Lower Monumental Dam in 2020. Shaded columns indicate non-salmonid samples.

Sample Date	Salmonid Samples			Non-Salmonid Samples			
	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Species Sampled
4/8	15	0	0.0%	0	---	---	
4/16	42	0	0.0%	0	---	---	
4/22	83	0	0.0%	0	---	---	
4/29	100	4	4.0%	0	---	---	
5/6	100	3	3.0%	0	---	---	
5/13	100	2	2.0%	0	---	---	
5/20	100	0	0.0%	0	---	---	
5/27	100	3	3.0%	0	---	---	
6/3	100	2	2.0%	1	0	0.0%	Smallmouth Bass*
6/10	47	2	4.3%	2	0	0.0%	Bridgelip Sucker, Smallmouth Bass*
6/17	8	0	0.0%	0	---	---	
6/24	100	2	2.0%	---	---	---	
7/1	100	3	3.0%	---	---	---	
7/8	75	0	0.0%	---	---	---	
7/15	100	3	3.0%	---	---	---	
7/22	54	0	0.05	---	---	---	
7/29	92	1	1.1%	---	---	---	
8/5	40	0	0.0%	---	---	---	

* indicates non-native species

Figure J-5

Percent GBT observed in the salmonid (red bars) and non-salmonid (blue bars) samples at Lower Monumental Dam and 12-hour TDG at the Little Goose tailrace and Lower Monumental forebay in 2020.



Notes: 1) the y-axis for GBT incidence rate starts at -5% in order to display all GBT sample data, including days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) red and blue numbers over the bars indicate the total salmonids (red) and non-salmonids (blue) examined for GBT.

McNary Dam (MCN)

GBT sampling at MCN occurred from April 9th to August 5th. Similar to what has occurred in recent years, GBT sampling at MCN was reduced from twice per week to once per week due to elevated temperatures and increased mortality rates of recovering GBT-examined fish. The decision to reduce GBT sampling to once per week was made after the GBT sample on July 28th. At that time, TDG levels in the MCN forebay had been at or below 110% for four days and temperatures in the MCN forebay had been above 68°F for two days. This modification in the GBT sampling schedule was consistent with the COE's protocols to provide precautionary measures to avoid or minimize any direct or delayed mortality resulting from additional thermal stress when handling juvenile salmonid fishes at water temperatures above 68°F. MCN was to continue once-per-week sampling through the rest of the voluntary spill season. However, GBT sampling was terminated after the sample on August 5th due to decreasing fish numbers and forebay TDG levels that were at or below the EPA 110% standard.

As a reminder, the TDG standard for Upper Columbia PUD projects was 120% in the tailrace and 115% in the downstream forebay for the entire 2020 spill season. Total

dissolved gas in the Priest Rapids tailrace exceeded the 120% standard a total of 31 days in 2020 (Figure J-6). Of these 31 total days, 7 occurred in mid- to late May, 21 occurred in June, and 3 occurred in early July. The 125% tailrace TDG standard at IHR was exceeded on two occasions, May 29th and May 30th. Over the summer spill season (June 21-Aug. 31), TDG levels in the IHR tailrace never exceeded the 120% TDG standard and TDG in the MCN forebay exceeded the 115% TDG standard for four total days (June 23-24 and June 26-27).

In all, 34 total GBT samples were conducted at MCN in 2020. Among these 34 total GBT samples at MCN, 3,383 total salmonids were examined for GBT and nine had at least one salmonid with signs of fin GBT (Figure J-6, Table J-10). The highest GBT incidence rate at MCN in 2020 was 2.0%, which occurred on April 9th and April 15th. Total dissolved gas in the PRD tailrace had been in the 102%-105% range and TDG in the IHR tailrace had been in the 101%-114% range over the week preceding the April 9th sample (Figure J-6). For the week prior to the sample on April 15th, TDG ranged from 120%-122% in the PRD tailrace and 118%-124% in the IHR tailrace (Figure J-6). For all seven other GBT samples where signs of fin GBT were present, GBT incidence rates were 1.0%. All salmonids that exhibited signs of fin GBT at MCN had rank 1 signs. The target sample size of 100 salmonids examined per GBT sample was met in all but one salmonid GBT samples. The single salmonid GBT sample that did not meet this sample size requirement was the last sample, which was conducted on August 5th. For this final sample, 83 total salmonids were examined for GBT, which met the DOE and DEQ minimum sample size requirement of 50 salmonids (Figure J-6, Table J-10).

Among the 21 GBT samples that were conducted during the spring spill season (Apr.-June 15) at MCN, non-salmonids were encountered at the separator on nine occasions (Figure J-6, Table-10). Among these nine occasions, total non-salmonid exams ranged from one fish per GBT sample to as many as four fish per GBT sample. Over the entire spring season, a total of 15 non-salmonids were examined for GBT at MCN. None of these 15 individuals exhibited signs of fin GBT (Figure J-6, Table J-10). The DOE and DEQ minimum sample size requirement of 50 non-salmonids per week was never met at MCN.

Table J-10

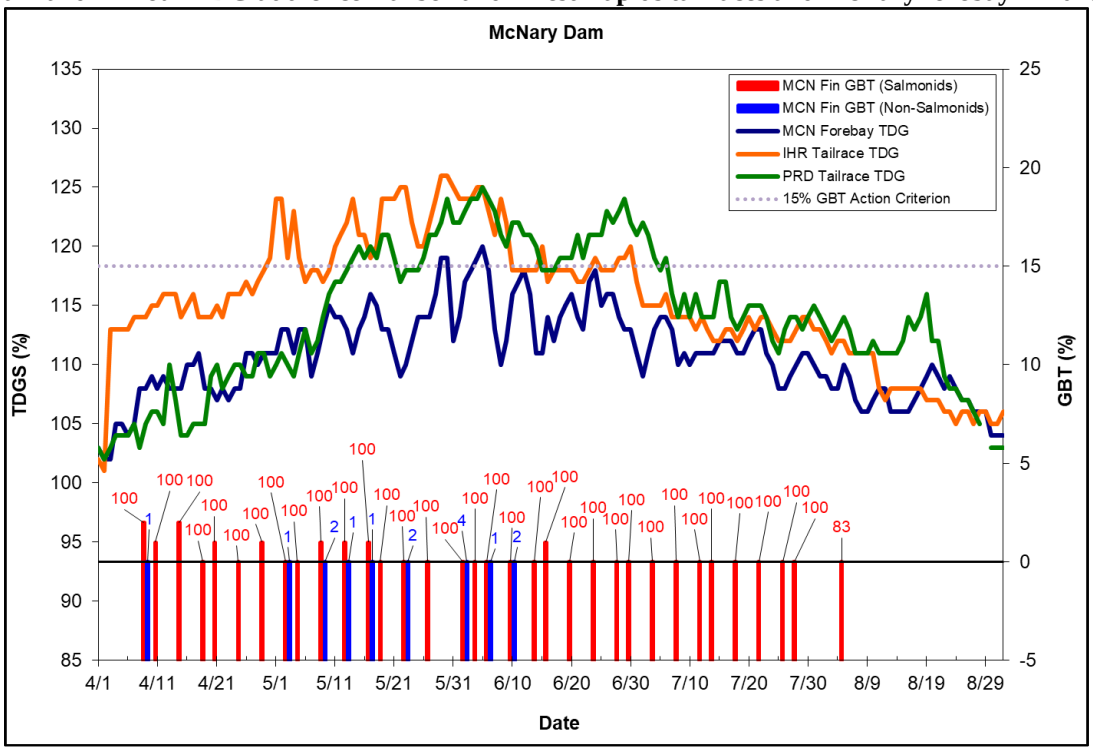
Detailed breakdown of GBT exams and signs of fin GBT at McNary Dam in 2020. Shaded columns indicate non-salmonid samples.

Sample Date	Salmonid Samples			Non-Salmonid Samples			
	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Species Sampled
4/9	100	2	2.0%	1	0	0.0%	Crappie*
4/11	100	1	1.0%	0	---	---	
4/15	100	2	2.0%	0	---	---	
4/19	100	0	0.0%	0	---	---	
4/21	100	1	1.0%	0	---	---	
4/25	100	0	0.0%	0	---	---	
4/29	100	1	1.0%	0	---	---	
5/3	100	0	0.0%	1	0	0.0%	Perch*
5/5	100	0	0.0%	0	---	---	
5/9	100	1	1.0%	2	0	0.0%	Perch*, Smallmouth Bass*
5/13	100	1	1.0%	1	0	0.0%	Perch*
5/17	100	1	1.0%	1	0	0.0%	Sculpin
5/19	100	0	0.0%	0	---	---	
5/23	100	0	0.0%	2	0	0.0%	Perch*, Smallmouth Bass*
5/27	100	0	0.0%	0	---	---	
6/2	100	0	0.0%	4	0	0.0%	Channel Catfish*, Carp*, Perch*, Sucker sp.
6/4	100	0	0.0%	0	---	---	
6/6	100	0	0.0%	1	0	0.0%	Perch*
6/10	100	0	0.0%	2	0	0.0%	Mountain Sucker, Smallmouth Bass*
6/14	100	0	0.0%	0	---	---	
6/16	100	1	1.0%	0	---	---	
6/20	100	0	0.0%	---	---	---	
6/24	100	0	0.0%	---	---	---	
6/28	100	0	0.0%	---	---	---	
6/30	100	0	0.0%	---	---	---	
7/4	100	0	0.0%	---	---	---	
7/8	100	0	0.0%	---	---	---	
7/12	100	0	0.0%	---	---	---	
7/14	100	0	0.0%	---	---	---	
7/18	100	0	0.0%	---	---	---	
7/22	100	0	0.0%	---	---	---	
7/26	100	0	0.0%	---	---	---	
7/28	100	0	0.0%	---	---	---	
8/5	83	0	0.0%	---	---	---	

* indicates non-native species

Figure J-6

Percent GBT observed in the salmonid (red bars) and non-salmonid (blue bars) samples at McNary Dam and 12-hour TDG at the Ice Harbor and Priest Rapids tailraces and McNary forebay in 2020.



Notes: 1) the y-axis for GBT incidence rate starts at -5% in order to display all GBT sample data, including days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) red and blue numbers over the bars indicate the total salmonids (red) and non-salmonids (blue) examined for GBT.

Bonneville Dam (BON)

GBT sampling at BON occurred from April 20th to August 5th. The late start this year was due to low fish numbers in early April and releases of listed subyearling fall Chinook tules from Spring Creek NFH, which occurred on April 10th and April 13th. GBT sampling is typically suspended when Spring Creek NFH releases occur, in order to minimize handling of these listed fish. This year, due to COVID-19, Spring Creek NFH released a total of 10.5 million subyearling Chinook tules in April, instead of splitting the total over an April and a May release. Due to increased temperatures in late July, GBT sampling at BON was reduced from twice-per-week to once per week. However, only one additional GBT sample was conducted after the sample on July 29th. This single sample occurred on August 5th. After the GBT sample on August 5th, subyearling Chinook passage continued to decline and GBT sampling for 2020 was terminated, due to the inability to reach sample size requirements. With exception to two days (August 16-17), the 12-hour average TDG in the BON forebay was at or below the EPA 110% standard over the month of August.

During the spring spill season, the 12-hour average TDG in the John Day (JDA) and The Dalles Dam (TDA) tailraces never exceeded 125% (Figure J-7). The maximum 12-hour average TDG in each of these two tailraces was 125%, which occurred on two occasions at JDA (June 1st and 2nd) and two occasions at TDA (May 29th and June 7th). Over the summer spill season (June 16-Aug. 31), TDG levels in the JDA tailrace exceeded the 120% TDG standard on one occasion (June 30th at 121% TDG) and TDG in the tailrace at TDA exceeded the 120% standard on two occasions (June 23rd and 24th at 122% and 121% TDG, respectively). Total dissolved gas in the BON forebay exceeded the 115% TDG standard for five total days over the summer spill period. These five days were June 16th, June 19-20, and June 23-24. The 12-hour average TDG for these five days ranged from 117% to 119%.

In all, 31 total GBT samples were conducted at BON in 2020. Among these 31 total GBT samples at BON, 3,012 total salmonids were examined for GBT and nine had at least one salmonid with signs of fin GBT (Figure J-7, Table J-11). The highest GBT incidence rate at BON in 2020 was 5.0%, which occurred on May 17th. Total dissolved gas in the JDA tailrace had been in the 119%-121% range and TDG in the tailrace at TDA had been in the 121%-124% range over the week preceding the May 17th sample (Figure J-7). For all eight other GBT samples where signs of fin GBT were present at BON, GBT incidence rates ranged from 1.0% to 2.0% Of the 17 total salmonids that exhibited signs of fin GBT at BON in 2020, 14 exhibited rank 1 signs and three exhibited rank 2 signs. The target sample size of 100 salmonids examined per GBT sample was met in all but four salmonid GBT samples. The four salmonid GBT samples that did not meet the 100 fish sample size requirement occurred on April 29th, May 6th, May 27th, and August 5th. All salmonid GBT samples at BON met the DOE and DEQ minimum sample size requirement of 50 salmonids (Figure J-7, Table J-11).

Among the 17 GBT samples that were conducted during the spring spill season (Apr.-June 15) at BON, non-salmonids were available for GBT exams on ten separate occasions (Figure J-7, Table-11). Among these ten occasions, total non-salmonid exams ranged from one fish examined to as many as three fish examined for GBT. Over the entire spring season, a total of 14 total non-salmonids were examined for GBT at BON. None of these 14 individuals exhibited signs of fin GBT (Figure J-7, Table J-11). The DOE and DEQ minimum sample size requirement of 50 non-salmonids per week was never met at BON.

Table J-11

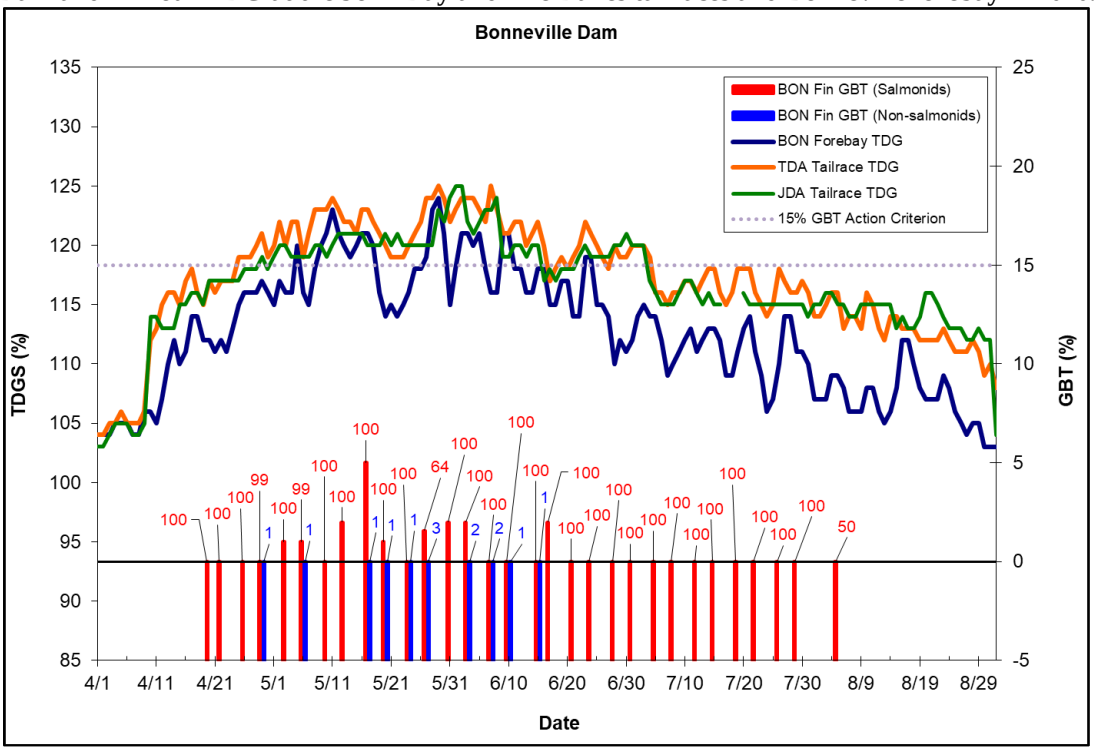
Detailed breakdown of GBT exams and signs of fin GBT at Bonneville Dam in 2020. Shaded columns indicate non-salmonid samples.

Sample Date	Salmonid Samples			Non-Salmonid Samples			
	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Num. Exam.	Num. with Fin GBT	Percent with Fin GBT	Species Sampled
4/20	100	0	0.0%	0	---	---	
4/22	100	0	0.0%	0	---	---	
4/26	100	0	0.0%	0	---	---	
4/29	99	0	0.0%	1	0	0.0%	Peamouth
5/3	100	1	1.0%	0	---	---	
5/6	99	1	1.0%	1	0	0.0%	Peamouth
5/10	100	0	0.0%	0	---	---	
5/13	100	2	2.0%	0	---	---	
5/17	100	5	5.0%	1	0	0.0%	Peamouth
5/20	100	1	1.0%	1	0	0.0%	Peamouth
5/24	100	0	0.0%	1	0	0.0%	Three-spine stickleback
5/27	64	1	1.6%	3	0	0.0%	Peamouth, Smallmouth Bass*, Three-spine stickleback
5/31	100	2	2.0%	0	---	---	
6/3	100	2	2.0%	2	0	0.0%	Peamouth, Sucker sp.
6/7	100	0	0.0%	2	0	0.0%	Mountain whitefish, Sucker sp.
6/10	100	0	0.0%	1	0	0.0%	Three-spine stickleback
6/15	100	0	0.0%	1	0	0.0%	Perch*
6/17	100	2	2.0%	---	---	---	
6/21	100	0	0.0%	---	---	---	
6/24	100	0	0.0%	---	---	---	
6/28	100	0	0.0%	---	---	---	
7/1	100	0	0.0%	---	---	---	
7/5	100	0	0.0%	---	---	---	
7/8	100	0	0.0%	---	---	---	
7/12	100	0	0.0%	---	---	---	
7/15	100	0	0.0%	---	---	---	
7/19	100	0	0.0%	---	---	---	
7/22	100	0	0.0%	---	---	---	
7/26	100	0	0.0%	---	---	---	
7/29	100	0	0.0%	---	---	---	
8/5	50	0	0.0%	---	---	---	

* indicates non-native species

Figure J-7

Percent GBT observed in the salmonid (red bars) and non-salmonid (blue bars) samples at Bonneville Dam and 12-hour TDG at the John Day and The Dalles tailraces and Bonneville forebay in 2020.



Notes: 1) the y-axis for GBT incidence rate starts at -5% in order to display all GBT sample data, including days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) red and blue numbers over the bars indicate the total salmonids (red) and non-salmonids (blue) examined for GBT.

Rock Island Dam (RIS)

GBT sampling at RIS occurred from April 21st to August 6th. Due to low subyearling Chinook passage numbers, GBT sampling was suspended in mid-June (June 16th and June 18th) and again in late June/early July (June 30th and July 2nd). Due to rapidly decreasing subyearling Chinook collections, GBT sampling at RIS was terminated after the sample on August 6th.

Total dissolved gas levels in the Rocky Reach tailrace exceeded the 120% standard for a total of 75 days in 2020 (Figure J-8). In general, these exceedances occurred for the period of May 9th through the end of July. The maximum 12-hour average TDG in the RRH tailrace was 136%, which occurred on one occasion, June 28th. Total dissolved gas levels in the Rock Island (RIS) forebay exceeded the 115% standard for a total of 46 days in 2020. In general, these exceedances occurred for the period of May 29th through mid-July and the maximum 12-hour TDG in the RIS forebay was 125%, which occurred on June 28th and 29th.

As mentioned earlier, staff at the FPC and SMP staff at RIS continued modified GBT sampling protocol in 2020. This modified sampling protocol was the same as what was implemented in 2018 and 2019 and similar to the pilot protocol that had been implemented in 2016 and 2017. Results from 2016-2019 indicated that past GBT incidence rates at RIS are likely biased high and should be considered in the context of the sampling protocol used in those years (i.e., 100% traditionally sampled fish that were held for up to 24-hours). In 2020, efforts to sample "fresh" fish were maximized, under current budget and scheduling constraints. Results from GBT sampling presented here are for all fish sampled at RIS, regardless of whether they were "fresh" or sampled under traditional means. A more detailed discussion of the modified protocol and evaluation of the data are provided in a separate discussion below (Evaluation of Modified Sampling Protocol at Rock Island).

In all, 28 total GBT samples were conducted at RIS in 2020. All 28 GBT samples had at least some salmonids with signs of fin GBT (Figure J-8, Table J-12). GBT incidence rates at RIS ranged from as low as 1% of examined salmonids exhibiting signs of fin GBT to as high as 11.0% of examined salmonids exhibiting signs of fin GBT (Figure J-8, Table J-12). The highest incidence of 11.0% GBT occurred on June 2nd. Total dissolved gas levels in the RIS forebay had been in the 114-119% range over the week prior to this exam and TDG levels in the RRH tailrace has been in the 123-130% range over the preceding week. In addition, there were two samples at RIS with GBT incidence rates of 10% (May 21st and May 26th). Prior to these exams, TDG in the RIS forebay had been in the 113-116% range while TDG in the RRH tailrace had been in the 120-123% range. Of the 119 total fish that exhibited signs of fin GBT at RIS in 2020, 114 had Rank 1 signs and the remaining 5 had Rank 2 signs.

It should be noted that GBT monitoring of non-salmonids is only necessary if/when projects operate their spill programs to the new 125% tailrace TDG standard. Spill operations at the Upper Columbia PUD projects follow the 120% tailrace and 115% forebay standard. Therefore, GBT monitoring for non-salmonids is not necessary at these sites and the SMP did not attempt to monitor non-salmonids for GBT at RIS as part of the 2020 pilot program.

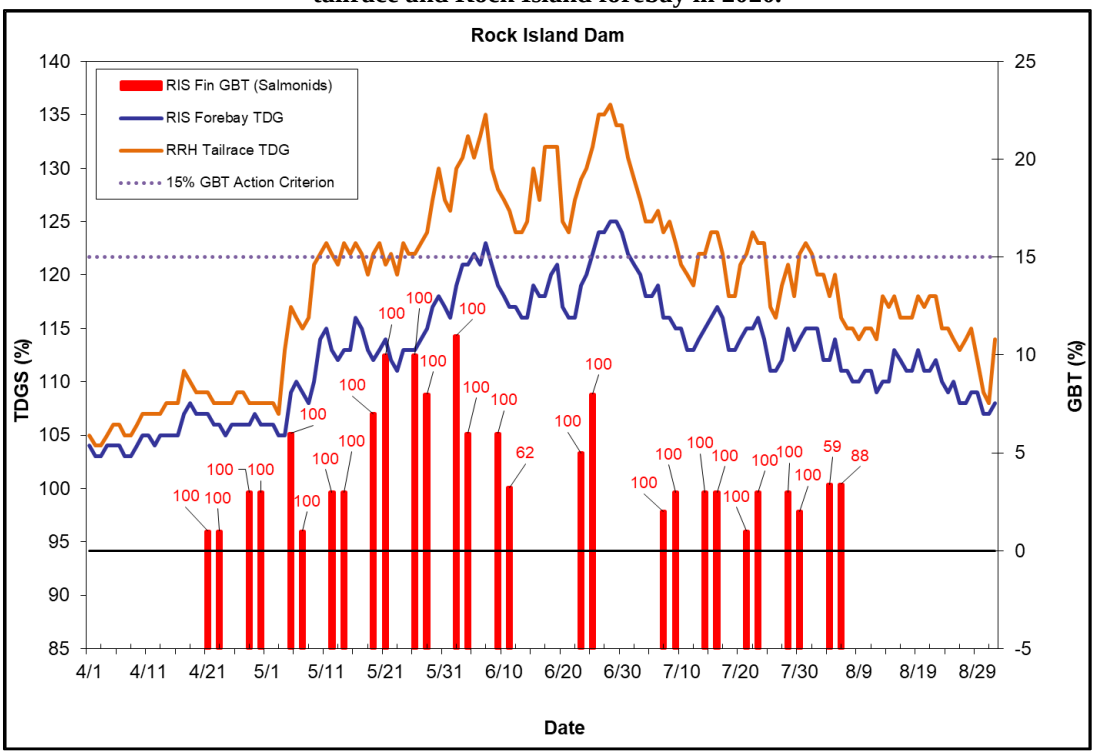
Table J-12

Detailed breakdown of GBT exams (total, "traditional", and "fresh" examined) and signs of fin GBT at Rock Island Dam in 2020.

Sample Date	Total Number Examined	Total Percent with Fin GBT	Number Examined "Traditional"	Percent with Fin GBT "Traditional"	Number Examined "Fresh"	Percent with Fin GBT "Fresh"
4/21	100	1.0%	99	1.0%	1	0.0%
4/23	100	1.0%	91	1.1%	9	0.0%
4/28	100	3.0%	87	3.4%	13	0.0%
4/30	100	3.0%	85	3.5%	15	0.0%
5/5	100	6.0%	85	5.9%	15	6.7%
5/7	100	1.0%	---	---	100	1.0%
5/12	100	3.0%	13	15.4%	87	1.1%
5/14	100	3.0%	---	---	100	3.0%
5/19	100	7.0%	79	8.9%	21	0.0%
5/21	100	10.0%	85	11.8%	15	0.0%
5/26	100	10.0%	71	12.7%	29	3.4%
5/28	100	8.0%	66	12.1%	34	0.0%
6/2	100	11.0%	54	18.5%	46	2.2%
6/4	100	6.0%	44	11.4%	56	1.8%
6/9	100	6.0%	10	10.0%	90	5.6%
6/11	62	3.2%	32	3.1%	30	3.3%
6/23	100	5.0%	38	7.9%	62	3.2%
6/25	100	8.0%	75	9.3%	25	4.0%
7/7	100	2.0%	100	2.0%	---	---
7/9	100	3.0%	70	4.3%	30	0.0%
7/14	100	3.0%	100	3.0%	---	---
7/16	100	3.0%	72	4.2%	28	0.0%
7/21	100	1.0%	82	1.2%	18	0.0%
7/23	100	3.0%	100	3.0%	---	---
7/28	100	3.0%	84	3.6%	16	0.0%
7/30	100	2.0%	96	2.1%	4	0.0%
8/4	59	3.4%	52	1.9%	7	14.3%
8/6	88	3.4%	86	2.3%	2	50.0%

Figure J-8

Percent GBT observed in the samples at Rock Island Dam and 12-hour TDG at the Rocky Reach tailrace and Rock Island forebay in 2020.



Notes: 1) the y-axis for GBT incidence rate starts at -5% in order to display all GBT sample data, including days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) red numbers over the bars indicate the total salmonids examined for GBT.

Finally, Table J-13 compares the 2020 estimates of the overall percentage of salmonids with signs of fin GBT to past years' estimates. This is not meant as a measurement of overall GBT but is used to easily display the annual relative magnitude of GBT in 2020 compared to past years. We include overall percentages both with and without Rock Island Dam included, given that this site caused the estimate to be biased high, particularly in high flow years. As can be seen in the table, with Rock Island included, the overall annual incidence of GBT in 2020 was the 9th highest among the last 25 years. Without Rock Island, the 2020 overall annual incidence of GBT was the 10th highest of the last 25 years.

Table J-13
Percent of sampled salmonids with signs of fin GBT estimated for the total fish observed in each year 1996 to 2020.

Year	Total % Signs	% Signs excluding RIS
1996	3.30	4.20
1997	3.20	4.30
1998	1.00	1.60
1999	0.30	1.40
2000	0.20	0.20
2001	0.001	0.10
2002	0.70	0.70
2003	1.50	0.50
2004	0.18	0.18
2005	0.46	0.11
2006	1.60	1.40
2007	2.40	2.90
2008	0.50	0.70
2009	0.29	0.23
2010	0.36	0.43
2011	2.50	0.95
2012	0.68	0.44
2013	0.31	0.28
2014	0.25	0.17
2015	0.19	0.13
2016	0.18	0.07
2017	4.55	1.38
2018	3.04	1.17
2019	1.98	0.76
2020	**1.57**	**0.77**

Evaluation of Modified Sampling Protocol at Rock Island

In 2016 and 2017, FPC staff and SMP personnel at RIS implemented a pilot sampling protocol to reduce the amount of time GBT sample fish were held in the trap prior to examination. Under the pilot protocol, SMP personnel at RIS attempted to collect fish for the GBT sample directly from the dewatering screens, as they entered the trap. Under this pilot protocol, the direct sampling was limited to 1-2 hours in the morning, before the full sample was enumerated. If the total number of "freshly sampled" fish fell short of the target sample size of 100 fish, SMP personnel would then examine fish from the daily collection, until the target sample size was met. Each "fresh" fish from the GBT sample was flagged with a code in the database for later identification. In 2018 and 2019, SMP staff at RIS implemented a modified sampling protocol to maximize the number of "fresh" fish in the GBT samples, under current budget and scheduling constraints. This modified sampling protocol included two periods for collecting "fresh" fish: one in the late morning or afternoon and a second in the early morning, just before the sampling period ended. The duration of the "fresh" sampling periods varied and were dependent on several

factors, including staffing schedules, staff availability, and fish numbers. As with the pilot from 2016 and 2017, if the total number of "fresh" fish fell short of the target sample size of 100, SMP personnel would then examine fish in the "traditional" method until the target sample size was met. This modified sampling protocol to maximize the number of "fresh" fish in the GBT sample was continued in 2020.

The FPC staff has provided three separate analyses of GBT incidence rates of "traditional" versus "fresh" sampled fish at RIS over the years (FPC 2017, FPC 2018, and FPC 2019). Results from these analyses have all demonstrated that, on average, "traditional" fish had a higher GBT incidence rates than "fresh" fish. Given this, it appears that historic GBT rates at RIS are likely biased high, as these were collected using only "traditional" fish. Therefore, the FPC concluded that GBT rates at RIS should be considered in the context of the sampling protocol that was implemented at the time of their collection. From the modified sampling protocols that were implemented in 2016-2019, it appears that using "fresh" fish in the GBT sample may reduce this bias and potentially make results from RIS GBT sampling more representative of what is occurring to the run-at-large. However, the degree to which "fresh" fish are used in the GBT sample will influence the degree to which the bias is reduced. It is worth noting that increasing the number of "fresh" fish to meet the sample size target of 100 fish may not completely eliminate the bias because it is still unknown how long fish spend in the powerhouse and bypass channel before being routed to the sample tank at RIS. Based on the results from these analyses, the FPC recommended that SMP staff at RIS continue to implement the modified sampling protocol to maximize the number of "fresh" fish in the GBT samples in future years.

Historical Summary (1996–2020)

The Gas Bubble Trauma monitoring program has been implemented on salmonids annually since 1996. There are 25 years of data available and, because of involuntary spill events, data for salmonid GBT are available over a wide range of total dissolved gas concentrations. In fact, over this historic record, observations have occurred at tailwater TDG levels as high as 140%. This has allowed the assessment of the impacts of TDG on the salmonid population over a wide range of tailwater TDG conditions. Given the fact that GBT results at RIS are bias high (see previous section), this assessment was limited to FCRPS monitoring sites (LGR, LGS, LMN, MCN, and BON).

The daily sample size criteria based on the GBT monitoring protocol is 100 salmonids. In this analysis, some flexibility was considered and all daily samples with greater than 75 salmonids were included. For each GBT sample in this dataset, we estimated the average TDG from the upstream tailrace. This average tailrace TDG was adjusted for water transit time, which was based on the daily average flow from the day of the GBT sample. There were two exceptions to this. First, for the samples conducted at Bonneville Dam, the tailrace TDG that was used was from the John Day tailrace monitor. This was done because the variability in TDG from the John Day tailrace better represented the variability in the GBT samples taken at BON. Second, for the samples conducted at Lower Granite Dam, the corresponding TDG that was used was from the Lower Granite

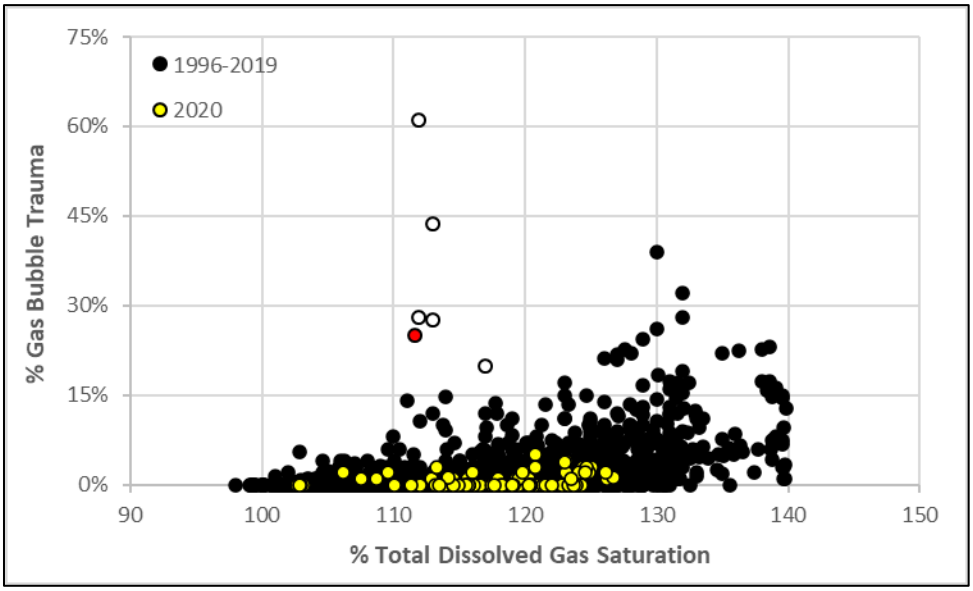
forebay, on the day that the sample was conducted. This was done because fish entering Lower Granite Dam would have originated from any number of tributaries, including the Clearwater River, Grande Ronde River, Imnaha River, Salmon River, or mainstem Snake River. Total dissolved gas levels for any one of these tributaries may not represent what the run-at-large was exposed to prior to entering the LGR pool. Total dissolved gas in the Lower Granite forebay is at least a measure of the TDG that all fish entering Lower Granite were exposed to upon entry into the FCRPS system. With these data, we evaluated how often the 15% fin GBT incidence criterion has been met over the last 25 years, and at what tailrace TDG levels this occurred

Excluding Rock Island Dam samples, a total of 3,047 daily exams fit into our criteria of ≥75 fish examined over the 25 years of available data. This equated to a total of 343,352 fish examined. The GBT monitoring program has consistently shown over the years that signs of GBT are minimal when TDG is managed to the total dissolved gas standards that have been used over the years for implementation of the Federal Columbia River Power System (FCRPS) Biological Opinion Spill program.

In all the years when TDG and GBT data have been collected (3,047 samples meeting our sample size criterion), there have been only 37 instances when the 15% GBT criterion was exceeded (Figure J-9). Of those 37 instances, five (open circles in Figure J-9) can be attributed to late migrating steelhead smolts in 2002 and 2007. At the time these steelhead smolts were collected at Little Goose or Lower Monumental dams, approximately 98% of the juvenile steelhead migrating that year had already passed this project. These late migrating fish were observed in the forebay of the dam on the surface, had prolonged migration times, and were likely residualizing (FPC 2007a, FPC 2007c). These fish may be considered anomalous and were likely present due to the very low flow conditions that occurred those years. Another anomalous GBT incidence rate was recorded at Little Goose Dam in April of 2008, when 25% of the GBT sample was recorded as having signs of GBT in the fins (red circle in Figure J-9). The estimated TDG in the LGR tailrace was 112%. However, it was later determined that the person conducting the exam may have misidentified deformed fin rays as bubbles, particularly in steelhead dorsal fins (USACE 2008, Appendix M). A total of 23 of the 25 fish with signs of GBT were steelhead. Only six of these steelhead had signs of GBT in other fins when the dorsal fin information was excluded. Two of the yearling Chinook from this sample were identified with GBT. With dorsal GBT excluded, the GBT rate for this date was likely closer to 8%. The other 31 instances when the 15% GBT criterion was exceeded occurred when TDG was greater than 120%. Of these 31 instances, 28 (90.3%) were observed at TDG concentrations greater than 125%. As noted earlier, the 15% GBT action criterion was met only once in 2020 but that one instance was based on only five salmonids examined for GBT. Among the GBT samples that met the criteria of ≥75 examined for this historical review, the 15% fin GBT action criteria was not met in 2020 (yellow circles in Figure J-9), despite the new 125% tailrace TDG standard that was utilized for the spring spill season.

Figure J-9

Percent GBT observed as a function of TDG observed in upstream tailrace in 1996-2019 (black circles) and 2020 (yellow circles).

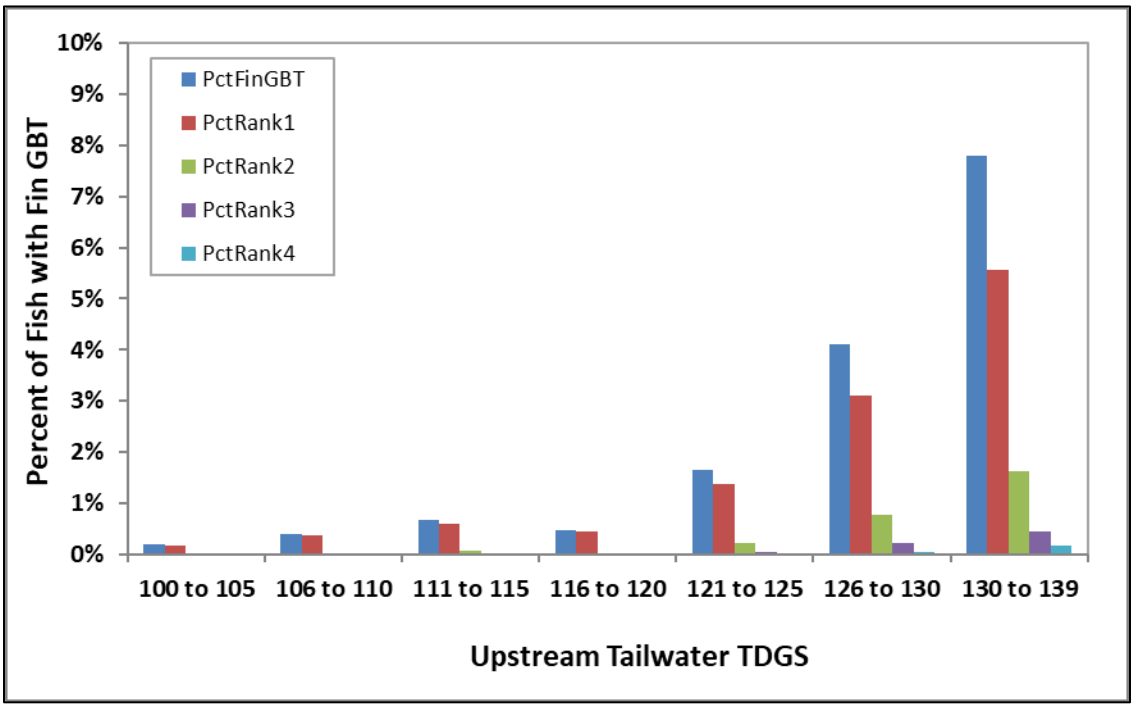


* Open circles indicate observations for late migrating steelhead in 2002 and 2007.
** Red circle indicates observation in 2008 when deformed fin rays may have been misidentified as GBT.

Of the 3,047 GBT samples that met the sample size criteria for this historic review, 324 had TDG levels of ≥125%. Of these 324 samples with corresponding TDG levels of ≥125%, only 28 (or 8.6%) had GBT incidence rates that met or exceeded the 15% fin GBT criterion. This means that the remaining 296 GBT samples (or 91.5%) had fin GBT incidence rates below the 15% action criterion (Figure J-9). These analyses indicate that the 15% fin GBT action criterion is generally not triggered at TDG levels less than 120% in the tailrace and even rarely triggered at tailrace TDG levels above 125%.

Over the historic record there have been several instances when GBT data were collected during periods of uncontrolled spill that led to higher levels of TDG. This allows fish collected over the years to be sorted into groups that migrated under similar TDG levels (Figure J-10). From Figure J-10 two things are apparent. First, the incidence of fish observed with signs of GBT and the severity of those signs increases with increasing levels of TDG supersaturation. This is consistent with the research on which the monitoring program was developed. Second, signs of GBT are almost non-existent below 120% TDG, begin increasing slightly between 121% and 125% TDG, and then increase in both incidence and severity above 125% TDG.

Figure J-10
Percent of all fish collected from 1996–2020 showing signs of GBT at given TDG levels.



Discussion

The Biological Opinion Spill Program is managed using the physical monitoring data collected by TDG monitors in the forebay and tailrace of each FCRPS project. The GBT biological monitoring is meant to complement the physical monitoring program. GBT sampling was successfully accomplished for the 2020 migration season. In accordance with operations outlined by the 2020 Flex Spill Agreement and 2020 FOP, the water quality standards were modified to 125% tailrace TDG in the spring and 115%/120% (Washington) or 120% tailrace (Oregon) in the summer. Given the new TDG standard in the spring, flows in the Lower Snake and Mid-Columbia rivers were generally manageable and there was no spill in excess of the estimated 125% TDG spill caps due to high flows.

The 15% action criterion was met only once in 2020. However, this sample was based on only five salmonids examined and, therefore, did not meet the minimum sample size requirement that was established by the state water quality agencies for the curtailment of spill. Among the GBT samples that met the minimum sample size requirement of 50 salmonids, the highest level of GBT observed in 2020 was 11.0%, which was observed at Rock Island Dam. The highest level observed in the FCRPS, among GBT samples that met the minimum sample size requirement, was 6.3%, which occurred on June 8th at Little Goose Dam.

Data collected over the past 25 years strongly suggest that the Biological Monitoring serves as an effective management tool providing "early warning" of potentially harmful levels of TDG. What we have learned from the historic data is that the

"early warning" signs are not triggered at TDG levels less than 120% at the tailrace monitors. Most observations indicating potential harm occurred when TDG levels in the tailrace exceeded 125%.

Finally, in response to requests from the Washington Department of Fish and Wildlife (WDFW), the FPC conducted two analyses of data collected during the 2020 Pilot Study to monitor GBT in non-salmonids (FPC 2020b, FPC 2020c). Much of the data used for these analyses are also presented in this report. Based on these analyses, we offer the following conclusions/recommendations that may be useful as the COE, water quality agencies, fisheries agencies, and tribes discuss future GBT Monitoring for non-salmonids.

- ***It does not appear that the DOE and DEQ minimum sample size requirements for non-salmonid species can be met using the current GBT Monitoring Program under the SMP.***
- ***Even if current GBT sampling under the SMP were expanded to a longer duration (i.e., more hours per day), it is unlikely that DOE and DEQ minimum sample size requirements for non-salmonids could be met.***
- ***The FPC has consistently recommended against using fish from the sample tank for GBT monitoring because fish held in shallow water do not provided accurate data in terms of GBT incidence rates.***
    - Even if this were done, the number of weeks that meet the DOE and DEQ minimum sample size requirement of 50 non-salmonids per week, per zone, would be low and would be completely dependent on the use of larval and juvenile lamprey from the sample tank.
    - Very little is known about GBT in larval and juvenile lamprey and examination of larval and juvenile lamprey would increase handling, which should be avoided.
    - Given that results from non-salmonid GBT monitoring will be heavily weighted on lamprey, we have significant concerns that management decisions may be made based on a species that we have very little data for.
- ***The SMP has been flat funded since 2017. Adding GBT exams for non-salmonids from the sample tank would require additional staff, equipment, and/or staff time than what is currently occurring. There is no funding for non-salmonid GBT sampling in the present SMP funding.***

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