Appendix H

Gas Bubble Trauma Monitoring and Data Reporting for 2022

Fish Passage Center
Portland, Oregon

Gas Bubble Trauma Monitoring and Data Reporting for 2022

Executive Summary

In 2022, salmonid Gas Bubble Trauma (GBT) monitoring was conducted at three Snake and two Middle Columbia River sites during the spring and summer spill seasons, as part of the Smolt Monitoring Program (SMP). Non-salmonid GBT monitoring during the spring spill season was conducted by the U.S. Geological Survey (USGS) and included monitoring in the tailraces of two Snake River and two Middle Columbia River sites. Per the Oregon Department of Environmental Quality (ODEQ) order, SMP personnel also conducted non-salmonid GBT monitoring at the two Middle Columbia River sites in the summer.

Total Dissolved Gas (TDG) levels in the Lower Snake and Middle Columbia rivers were generally below the 125% tailrace TDG standard in April and most of May but above the 125% standard in for much of June. Exceedances of the 125% tailrace TDG standard in June were generally due to high flows that necessitated spill above the 125% TDG spill cap and/or lack of market conditions.

The action criteria for reducing voluntary spill, due to GBT incidence rates, were never met during the 2022 spring or summer spill seasons. The highest salmonid GBT incidence rate observed by SMP personnel in 2022 was 7.0%, which occurred on two occasions at Bonneville Dam. The highest non-salmonid GBT incidence rate observed by USGS personnel in the spring was 8.6%, which occurred in the McNary tailrace. The highest GBT incidence rate observed in the SMP non-salmonid monitoring program in the summer was 33.3%, which occurred at Bonneville Dam. However, it should be noted that this incidence rate is based on one fish exhibiting signs of fin GBT, out of only three total fish examined. Analyses of salmonid GBT data over the last 27 years 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%.

Overview

Salmonid GBT Monitoring

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. Data from GBT Monitoring samples are recorded using a data entry program (GBT.net) developed and maintained by the Fish Passage Center (FPC). Data are transmitted to the FPC, within 24-hours of collection, where they are processed into our servers and are made available to the fisheries management entities, water quality agencies of Washington and Oregon, and the public via web queries and reports (https://www.fpc.org/smolt/Q_smolt_smoltgbt_subsite.php). The fisheries management

agencies review the data in-season to determine if modifications to spill are necessary based on the GBT monitoring.

In 2022, the monitoring of juvenile salmonids for GBT was conducted at Middle Columbia and Snake River sites, as part of the Smolt Monitoring Program (SMP). Specifically, salmonids were collected and examined for signs of GBT 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. Unlike prior years, Rock Island Dam was not an SMP site in 2022 and, therefore, salmonid GBT monitoring did not occur. The goal of the salmonid GBT monitoring program was to sample 100 salmonids (Chinook and steelhead only) each day of sampling at each site. The proportion of each species sampled 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 GBT.

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 (at BON). Due to the configuration of the collection system at BON, sampling at the separator is not possible. 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 by sampling periodically throughout the day.

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 H-1 provides the frequency, duration, and method of collection for the salmonid GBT Monitoring Program, under the current protocol.

Table H-1
Summary of salmonid GBT Monitoring sampling schedule in spring and summer, 2022

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

At LGR, salmonid GBT monitoring only occurs in the spring. This is done to limit handling of listed subyearling Chinook when TDG levels above the project are generally very low. Sampling at each of the three Snake River sites occurs once per week. Every effort is made to limit overlap in sampling dates between sites. For example, the sampling days at LGR, LGS, and LMN are staggered throughout the week. Sites are encouraged to coordinate sampling schedules to accomplish this staggered schedule. Salmonid GBT sampling at each of the Mid-Columbia sites occurs twice per week. Sampling at BON may be temporarily reduced to once per week when Spring Creek NFH releases subyearling fall Chinook tules above the project. This is done to limit handling of these listed fish and is only necessary for 2-3 days post-release. In addition, sampling at MCN and BON may be reduced to once-per-week during periods of high temperatures.

To standardize handling and reporting practices among sites and to provide accounting for Endangered Species Act permitting purposes, the FPC modified the GBT handling protocol in 2015. Monitoring in 2022 followed the same protocol that was issued in 2015. For more detailed information on the examination procedure, the 2022 GBT Monitoring Protocol is available on the FPC website (FPC 2022).

Non-Salmonid GBT Monitoring

In the spring of 2022, the U.S. Geological Survey (USGS) conducted non-salmonid GBT monitoring on native non-salmonids in the tailraces of four FCRPS projects: Lower Granite, Ice Harbor, McNary, and Bonneville. Collections for the USGS non-salmonid GBT monitoring program were conducted weekly, using purse seining and backpack electrofishing, and were limited to areas in the tailrace of each of the above-mentioned projects. The Lower Granite tailrace was a new site for 2022. Detailed instructions for the non-salmonid monitoring personnel were included in the 2022 GBT Monitoring Protocol (FPC 2022).

The USGS non-salmonid GBT monitoring program was limited to the spring spill season. However, the Oregon Department of Environmental Quality (ODEQ) order approving modifications to the TDG standards requires non-salmonid monitoring in the Mid-Columbia during the summer. Therefore, SMP crews at McNary and Bonneville began collecting and examining any non-salmonids that were encountered during salmonid GBT monitoring efforts during the summer spill season. Up to 50 individuals of non-salmonid species (both native and non-native species) were examined for signs of GBT,

using the same procedures and protocols as the salmonid GBT Monitoring Program. Exams of non-salmonids by SMP crews only occurred when TDG levels were above 110% and when water temperatures were ≤68°F. Data gathered during these summer non-salmonid exams were for informational purposes only and were not used for management of summer spill.

Examination and Ranking Procedure

Prior to the start of the season, FPC staff conducted GBT training for both the salmonid and non-salmonid GBT monitoring crews. Non-salmonid monitoring crews were instructed to follow the same examination protocol and GBT ranking system as the salmonid GBT monitoring program and all data entry was accomplished with the GBT.net data entry program. Detailed instructions for non-salmonid GBT monitoring personnel were included in the 2022 GBT Sampling Protocol (FPC 2022).

Examinations for GBT were conducted using variable magnification (6x to 40x) dissecting microscopes. 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 H-2). Additional information was recorded for each fish during the examination, including species, age, fork length, fin clips, and tags present.

Table H-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

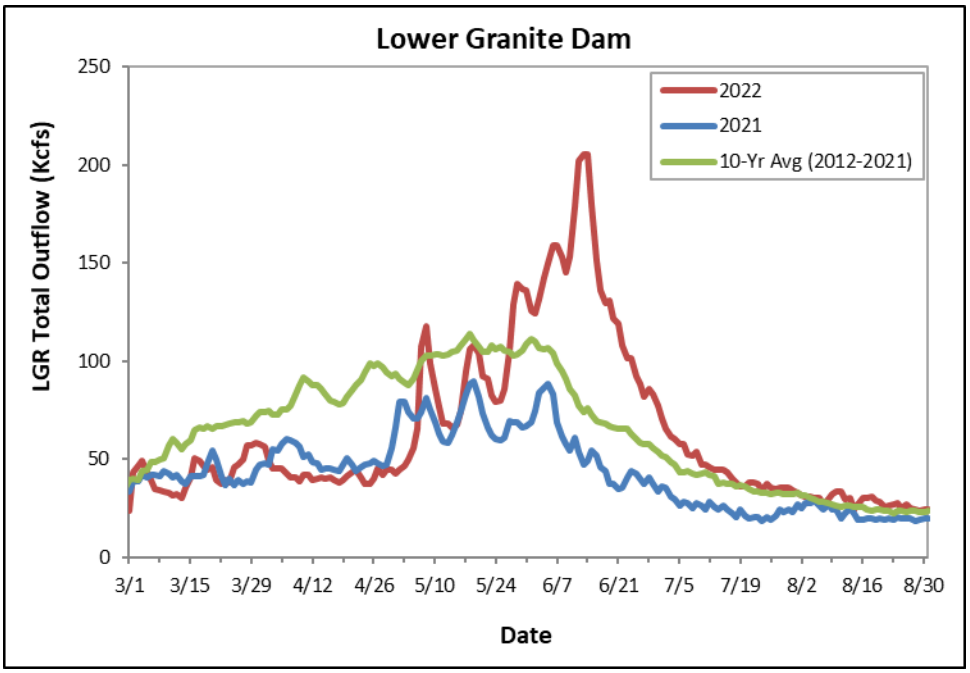
2022 Water Conditions and Spill Operations

The runoff volume (January–July) for the 2022 water year was average in the Middle Columbia River and near average in the Snake River. Runoff (January–July) was 102% of average (1991–2020) at The Dalles Dam and 91% of average at Lower Granite Dam. To put the runoff volumes into perspective, the 2022 January–July runoff volumes at The Dalles and Lower Granite were ranked 32nd and 49th, respectively, over the last 74 years (1949–2022).

In 2022, runoff in the Snake River followed a more typical shape, with peak flows in May and early June (Figure H-1). However, flows in March, April, and early May were well below average. From May 6th through May 28th, daily flows at Lower Granite fluctuated between below average, average, and above average. By May 29th, flows at Lower Granite were consistently above average, where they remained until mid-July.

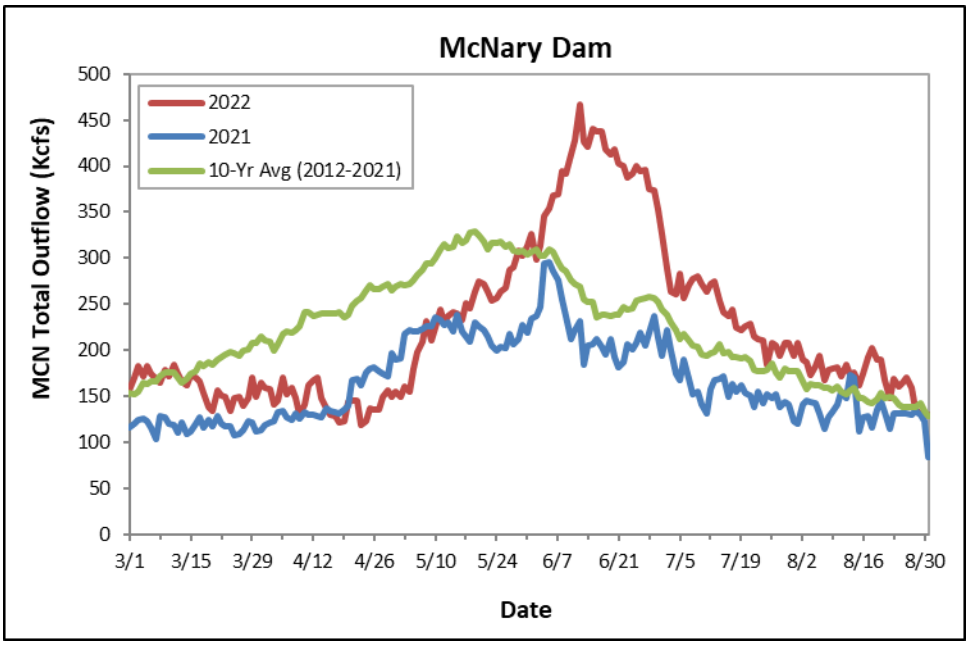
From mid-July through the end of August, flows were at or above the 10-year average (Figure H-1). Daily average flows at Lower Granite Dam peaked on June 14th, at approximately 205 Kcfs. Given the 125% tailrace TDG standard that was implemented during the spring spill season, flows in April and part of May were not high enough to spill to the 125% TDG spill caps. Instead, spill during gas cap periods was limited to all flows above powerhouse minimum requirements (i.e., "minimum generation, spill the rest"). By late May and June, flows were high enough to meet spill to the 125% TDG spill caps. In fact, there were some periods in June when spill exceeded the 125% TDG spill cap, due to limitations in hydraulic capacity.

Figure H-1.
Average daily flows at Lower Granite Dam in 2022, 2021, and the 10-year average



Peak runoff in the Middle Columbia was about a month later than the current 10-year average (Figure H-2). However, like the Snake River, flows in much of March, all of April, and much of May were below average and only reached average levels at the end of May (Figure H-2). Flows at McNary Dam peaked on June 12th, at approximately 467 Kcfs. Given the 125% tailrace TDG standard that was implemented during the spring, flows in 2022 were too low to spill to the site-specific 125% TDG spill caps for the month of April and much of May. Therefore, spill was limited to "minimum generation, spill the rest" operations. By late May and early June, flows in the Mid-Columbia were high enough that spill met 125% TDG spill caps (where applicable). In fact, by mid-June, flows were so high that spill often exceeded the 125% TDG spill cap, due to limitations in hydraulic capacity and/or lack of market conditions.

Figure H-2
Average daily flows at McNary Dam in 2022, 2021, and the 10-year average



On March 24, 2022, the 2022 Fish Operations Plan (FOP) was issued. The 2022 FOP described the U.S. Army Corps of Engineers' (COE) planned operations for juvenile fish passage at the four Lower Snake River and four Mid-Columbia River dams for the spring and summer fish migration seasons (Table H-3). The 2022 FOP followed negotiated spill operations that were specified in the Term Sheet for Stay of Preliminary Injunction Motion and Summary Judgement Schedule NWF et al. v. NMFS et al. (herein referred to as the Stay Agreement). This agreed upon operation differed from the original Flex Spill Agreement, 2019-2021. Unlike 2019-2021, flex spill operations occurred at only four projects in 2022 (Lower Granite, Little Goose, Lower Monumental, and John Day; Table H-3). Spill operations at the other four projects were 24-hour operations, with spill to the 125% tailrace TDG spill cap (Ice Harbor and McNary), an instantaneous spill proportion (The Dalles), or spill to a maximum FOP level (Bonneville) (Table H-3).

Table H-3

2022 spring and summer spill operations at Snake and Mid-Columbia FCRPS projects under the 2022 Fish Operations Plan.

Project	Spring Spill Period (Snake: Apr. 3-June 20) (Mid-Columbia: Apr. 10-June 15)		Summer Spill Period (Snake: June 21-Aug. 31) (Mid-Columbia: June 15-Aug. 31)	
	Pre-Adult Trigger[1]	Adult Trigger to End of Spring	Prior to Aug. 15	Aug. 15-Aug 31
LGR	125% Gas Cap (24 hours)	**Flex Spill:** 20 Kcfs (8 hours)[2,3] 125% Gas Cap (16 hours)	18 Kcfs	SW flow[7]
LGS	**Flex Spill:** 30% (8 hours)[2,3,4] 125% Gas Cap (16 hours)		30%[8]	SW flow or ~9 Kcfs[7]
LMN	125% Gas Cap (24 hours)	**Flex Spill:** 30 Kcfs (8 hours)[2,3] 125% Gas Cap (16 hours)	17 Kcfs	SW flow or ~8 Kcfs[7]
IHR	125% Gas Cap (24 hours)		30%	SW flow or ~9 Kcfs[7]
MCN	125% Gas Cap (24 hours)		57%	20 Kcfs
JDA	**Flex Spill:** 32% (8 hours)[5] 125% Gas Cap (16 hours)		35%	20 Kcfs
TDA	40% (24 hours)		40%	30%
BON	150 Kcfs (24 hours)[6]		95 Kcfs	50 Kcfs

[1] The adult salmonid abundance criteria at Lower Granite and Lower Monumental are satisfied when the earliest of the following conditions are met: (1) a cumulative total of 25 adult spring Chinook salmon (not including jacks) pass Lower Monumental Dam; or (2) a cumulative total of 50 adult spring Chinook salmon (not including jacks) pass Ice Harbor Dam; or (3) April 24, 2022.

[2] The COE will implement performance standard spill for 8 consecutive AM hours (0400-1200) to target times of peak adult passage. If lack of load conditions precludes the implementation of performance standard spill during these times, performance standard spill will begin as soon as practicable during AM hours and continue for up to 8 consecutive hours.

[3] During periods of high river flow that exceed powerhouse hydraulic capacity, implementing performance standard spill for 8-consecutive hours may result in storing additional inflow in the forebay above MOP. If it is necessary to pond water to achieve the 8-hour block of performance standard spill during high flows, water stored above MOP will be drafted over the remaining hours by increasing spill to pass inflow from 1200-1600 hours, then increasing spill as necessary from 1600-0400 to draft he pool back to MOP. If it is forecasted that the drafting spill will result in exceeding 130% TDG ion the tailrace, all 16 hours will be used to return the pool to MOP.

[4] Within one business day of a cumulative total of 25 adult Chinook (not including jacks) passing Lower Monumental, performance standard spill at Little Goose Dam will occur for 8 consecutive AM hours to target peak adult passage times. If lack of load conditions precludes the implementation of performance standard spill during these times, performance standard spill will begin as soon as practicable during AM hours and continue for up to 8 consecutive hours.

[5] Performance standard spill at John Day may occur with some flexibility, in either a single 8-hour block or two separate blocks per calendar day. Performance standard spill will not be implemented between 2200-0300.

[6] Due to erosion concerns, spill at BON is capped at 150 Kcfs, which is typically lower than the estimated 125% tailrace TDG spill cap.

[7] Surface passage weir (e.g., RSW, ASW, TSW), if open. If not open, spill will be an equivalent volume through the traditional spillbays. RSW spill (or equivalent) at LGR is a function of forebay elevations (see Chapter 9, Section 2.3.2.6.ii of the 2022 Fish Passage Plan for details).

[8] When flows fall below 32 Kcfs, the summer spill operation will transition to a constant spill volume of approximately 7 to 11 Kcfs to help stabilize project outflow, meet LMN target spill levels, and maintain MOP elevation at LGS. The constant spill level will be based on the previous day's average total outflow, as follows: 1) 11 Kcfs spill when total outflow was 28.0-32.0 Kcfs, 2) 9 Kcfs when total outflow was 24.0-27.9 Kcfs, and 3) 7 Kcfs when total outflow was ≤23.9 Kcfs. Actual spill may range ±1 Kcfs from the target spill level.

Other modifications that were made to spring spill operations under the Stay Agreement include: 1) 24-hour spill to the 125% TDG spill cap at Lower Granite and Lower Monumental until an adult trigger was met and 2) limiting performance standard spill at Lower Granite, Little Goose, and Lower Monumental to 8-consectuive hours, starting in the morning, for most of the spring spill season (Table H-3). At John Day Dam, the lower performance standard spill could occur with some flexibility, in either a single 8-hour block or two separate blocks per calendar day. However, this performance spill could not occur between 2200 and 0300 hours. Finally, gas cap spill at John Day was increased to the 125% tailrace TDG spill cap in 2022.

For the spring spill season, the COE estimated the 125% tailrace TDG spill caps for each FCRPS project each day. Where and when applicable, projects were operated to these estimated daily 125% tailrace TDG spill caps. The daily spill caps were published on the TMT website (http://pweb.crohms.org/tmt/documents/ops/spill/caps/).

Under the 2022 FOP, summer spill operations remained the same as what has occurred for the last two years (Table H-3). Summer spill operations were broken into two periods. The first period consisted of a single spill operation from the beginning of the summer spill season (June 16th in the Mid-Columbia River and June 21st in the Snake River) to August 14th. The second period consisted of a different spill operation from August 15th through August 31st.

In 2020, 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 maximum standard of 127% while Washington had a 2-hour maximum standard of 126% TDG. As part of their new 125% tailrace TDG standard, the Washington Department of Ecology (WDOE) and Oregon Department of Environmental Quality (ODEQ) specified 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

Below, we present the overall results from the salmonid and non-salmonid GBT monitoring conducted in the spring and summer of 2022. Following the summaries of overall results, we provide summaries of the GBT monitoring efforts for each site, along with a summary of TDG conditions at and upstream of the site.

In all, 10,553 juvenile salmonids were examined for GBT between April and August of 2022, as part of the salmonid GBT monitoring program under the SMP (Table H-4). Of these, 35% were yearling Chinook, 44% were subyearling Chinook, and 21% were steelhead.

Table H-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 2022 as part of the Smolt Monitoring Program.

Species	BON	MCN	LMN	LGS	LGR	Total
Chinook Subyearlings	1,288	2,080	338	896	0	4,602
Chinook Yearlings	1,445	919	396	396	574	3,730
Steelhead	124	588	548	462	499	2,221
Total	2,857	3,587	1,282	1,754	1,073	10,553

A total of 3,271 non-salmonids were examined by the USGS for the non-salmonid GBT monitoring program during the spring spill season (Table H-5). In all, thirteen different non-salmonid species were sampled by USGS. The most common non-salmonid species collected and examined were sculpin and northern pikeminnow. These two species represented approximately 47% and 36% of the total non-salmonids examined by USGS in 2022, respectively. The third and fourth most common non-salmonid species were the three-spined stickleback and peamouth, which represented approximately 8% and 5% of the non-salmonids examined by USGS in 2022. Collectively, these four species represented approximately 96% of the USGS non-salmonids examined.

Although the primary objective of the USGS non-salmonid GBT monitoring program was to collect and examine native non-salmonids for GBT, some salmonids were also collected and examined in a few of the samples. In all, 74 total salmonids were examined by the USGS crew across the four sites (Table H-5). Examined salmonids included primarily yearling and subyearling Chinook, but also included some chum fry.

Table H-5

Number of non-salmonids (unshaded) and salmonids (shaded) collected and examined for signs of GBT by USGS for the non-salmonid GBT monitoring program in the Lower Snake and Mid-Columbia rivers during the 2022 spring spill season.

Species	BON	MCN	IHR	LGR	Total
Sculpin	296	794	328	121	1,539
Northern Pikeminnow	45	2	368	771	1,186
Three-spined Stickleback	256	2	0	0	258
Peamouth	3	0	0	157	160
Sand Roller	0	0	0	44	44
Sucker, Other	6	1	0	17	24
Pac. Lamprey Ammocoete	0	1	21	0	22
Largescale Sucker	4	1	1	7	13
Mountain Whitefish	0	0	13	0	13
Longnose Dace	1	1	0	2	4
Chiselmouth	0	0	0	4	4
Speckled Dace	0	3	0	0	3
Pac. Lamprey Macropthalmia	0	0	1	0	1
Total Non-Salmonids	**611**	**805**	**732**	**1123**	**3,271**
Chinook, Subyearlings	1	17	0	18	36
Chinook, Yearlings	2	3	3	20	28
Chum	10	0	0	0	10
Total Salmonids	**13**	**20**	**3**	**38**	**74**
Grand Total	**624**	**825**	**735**	**1,161**	**3,345**

Under the summer non-salmonid monitoring program mandated by ODEQ, 55 total non-salmonids were examined by the SMP crews at Bonneville and McNary (Table H-6). Of these, 54 were collected at Bonneville and only one was collected at McNary. In all, eight different non-salmonid species were sampled by these SMP crews. The most common non-salmonid species collected and examined were larval and juvenile Pacific lamprey macropthalmia. Collectively, larval and juvenile Pacific lamprey represented approximately 73% of the non-salmonids examined by the SMP crews at Bonneville and McNary dams.

Table H-6
Number of non-salmonids collected and examined for signs of GBT by SMP crews at McNary and Bonneville dams, during the 2022 summer spill season.

Species	BON	MCN	Total
Pac. Lamprey Macropthalmia	32	0	32
Pac. Lamprey Ammocoetes	8	0	8
Northern Pikeminnow	4	0	4
Sculpin	3	0	3
Smallmouth Bass*	2	1	3
Peamouth	2	0	2
Three-spined Stickleback	2	0	2
Mountain Whitefish	1	0	1
Total Non-Salmonids	**54**	**1**	**55**

* indicates non-native species

Of the 10,553 salmonids that were examined by SMP crews at FCRPS projects in 2022, signs of fin GBT were observed in 84 individuals (0.8%) (Table H-7). Of the 84 salmonids that had signs of fin GBT in 2022, 79 (94%) had a maximum of Rank 1 signs. Four total salmonids (~5%) had a maximum of Rank 2 signs and only one fish (~1%) had a maximum of Rank 3 sings. Fish with Rank 3 or Rank 4 signs are considered to exhibit severe signs of GBT. Therefore, only one salmonid examined in 2022 exhibited severe signs of GBT. A more detailed breakdown of GBT exams and signs for 2022 can be found in Tables H-10 through H-19.

Table H-7
Number of juvenile salmonids observed with fin GBT at dams on the Lower Snake River and in the Mid-Columbia River from April to August 2022 as part of the Smolt Monitoring Program.

	Fin GBT by Site					Grand
Species	BON	MCN	LMN	LGS	LGR	Total
Chinook Subyearlings	17	2	10	8	0	37
Chinook Yearlings	17	8	9	3	0	37
Steelhead	2	3	4	1	0	10
Total	**36**	**13**	**23**	**12**	**0**	**84**

Of the 3,271 total non-salmonids that were examined by USGS in spring of 2022, 51 (1.6%) had signs of fin GBT (Table H-8). Of these, 37 had a maximum of Rank 1 signs of fin GBT, 11 had a maximum of Rank 2 signs, one had a maximum of Rank 3 signs, and two had a maximum of Rank 4 signs. Therefore, three total non-salmonids had severe signs of fin GBT in 2022. In addition to the signs of fin GBT that were observed, several fish were observed with signs of GBT in non-protocol areas (i.e., somewhere other than the unpaired fins). Details of these non-protocol signs are covered in the site-specific summaries below. Of the 74 total salmonids that were examined for GBT by the USGS non-salmonid monitoring crew, zero were observed with signs of fin GBT (Table H-8).

Table H-8

Number of non-salmonids (unshaded) and salmonids (shaded) observed with fin GBT from exams conducted by the USGS non-salmonid GBT monitoring crew in the spring of 2022.

Species	BON	MCN	IHR	LGR	Total
Sculpin	4	32	8	1	45
Northern Pikeminnow	0	0	0	4	4
Three-spined Stickleback	1	0	0	0	1
Peamouth	0	0	0	1	1
Sand Roller	0	0	0	0	0
Sucker, Other	0	0	0	0	0
Pac. Lamprey Ammocoete	0	0	0	0	0
Largescale Sucker	0	0	0	0	0
Mountain Whitefish	0	0	0	0	0
Longnose Dace	0	0	0	0	0
Chiselmouth	0	0	0	0	0
Speckled Dace	0	0	0	0	0
Pac. Lamprey Macropthalmia	0	0	0	0	0
Total Non-Salmonids	**5**	**32**	**8**	**6**	**51**
Chinook, Subyearlings	0	0	0	0	0
Chinook, Yearlings	0	0	0	0	0
Chum	0	0	0	0	0
Total Salmonids	**0**	**0**	**0**	**0**	**0**
Grand Total	**5**	**32**	**8**	**6**	**51**

Finally, of the 55 total non-salmonids that were collected and examined for GBT by the SMP crews at Bonneville and McNary dams in the summer, two had signs of fin GBT (Table H-9). One was a Pacific lamprey macropthalmia and one was a peamouth. Both fish had Rank 1 signs of fin GBT.

Table H-9
Number of non-salmonids observed with fin GBT from exams conducted by the SMP crews at Bonneville and McNary in the summer of 2022.

Species	BON	MCN	Total
Pac. Lamprey Macropthalmia	1	0	1
Pac. Lamprey Ammocoetes	0	0	0
Northern Pikeminnow	0	0	0
Sculpin	0	0	0
Smallmouth Bass*	0	0	0
Peamouth	1	0	1
Three-spined Stickleback	0	0	0
Mountain Whitefish	0	0	0
Total Non-Salmonids	**2**	**0**	**2**

* indicates non-native species

There are two action criteria for reducing voluntary spill based on GBT incidence rates. These action criteria are: 1) 15% of fish showing any signs of fin GBT, or 2) 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., Ranks 3 or 4). It should be noted that the action criteria specifically mention fin GBT. Therefore, signs of GBT that were observed in non-protocol areas by the USGS non-salmonid monitoring crew are not part of the assessment of whether GBT incident rates meet or exceed these criteria.

Voluntary spill may be reduced, if possible, when one or both criteria are met. These action criteria were developed based on salmonid 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). To our knowledge, similar lab studies have not been conducted on non-salmonid species. However, the same action criteria apply to the non-salmonid species examined during the spring spill season. The 15% criterion was never met in 2022. There was one day in the summer when 33% of the non-salmonids examined at BON had signs of fin GBT, but this was based on a sample of three total fish and, as mentioned above, the action criteria did not apply to the summer non-salmonid monitoring. The criterion of 5% severe GBT was also never met in 2022.

As mentioned above, the salmonid GBT monitoring program has a target sample size of 100 salmonids per GBT sample. The USGS non-salmonid GBT monitoring program adopted this target sample size. The WDOE and ODEQ 125% tailrace TDG standards have a minimum sample size requirement of 50 fish per week, per zone (i.e., Snake River vs. Mid-Columbia). For this report, we summarize sample sizes in three ways. First, we evaluated whether the sample target of 100 fish per sample was met. Second, we evaluate whether a target of 50 fish per sample was met. Finally, we evaluate whether the

minimum sample size requirement of 50 fish per week, per zone, was met. For this third method, we considered a week as Sunday-Saturday.

Lower Granite Dam (LGR)

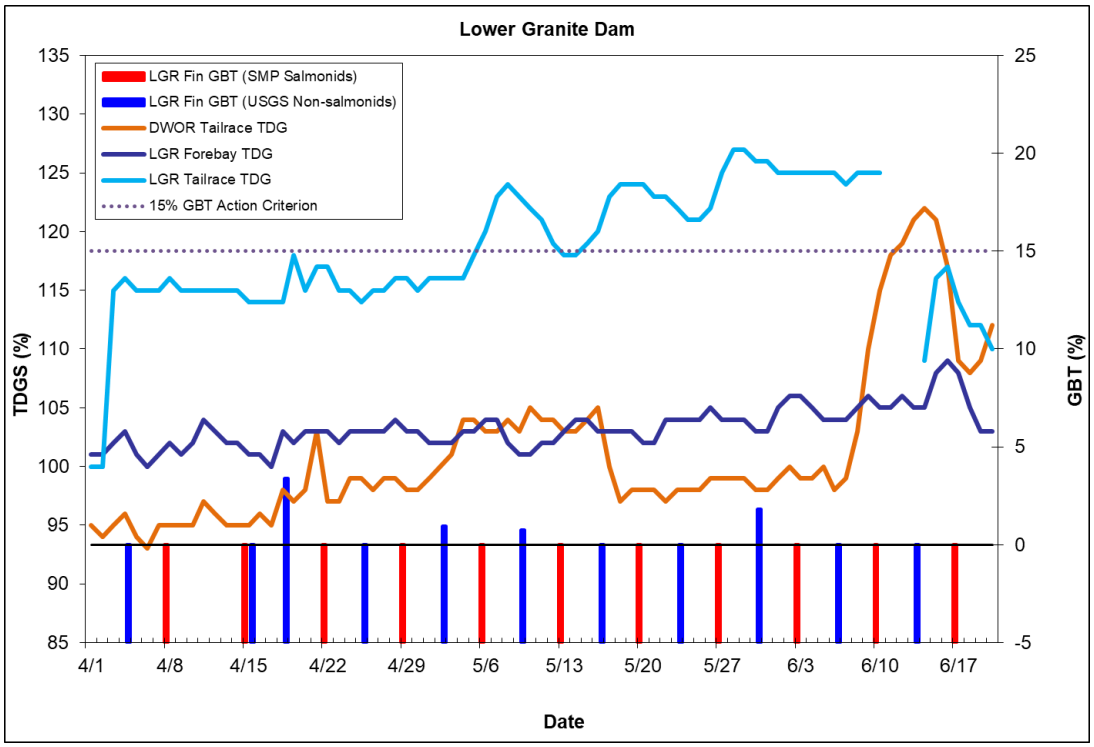
The 12-hour average TDG in the Dworshak Dam (DWR) tailrace exceeded the 110% Environmental Protection Agency (EPA) standard for eight total days in the spring of 2022 (Figure H-3). All eight of these exceedances occurred in June (June 10-16 and June 20th) and were the result of increased outflows due to high inflows and reservoir elevations for refill. Despite the exceedances in the DWOR tailrace, the 12-hour average TDG in the LGR forebay never exceeded 110% during the spring spill season. Finally, the 12-hour average TDG in the LGR tailrace exceeded the 125% standard for a total of four days during the spring spill season (May 28-May 31). These exceedances were due to high flows and the need to spill above the 125% TDG spill cap during periods when hydraulic capacity had been reached. The maximum 12-hour average TDG over this four-day period was 127%. However, it should be noted that the TDG monitor in the Lower Granite tailrace went out of service on June 10th. A temporary monitor was installed in a different location on June 14th but data from this temporary monitor were noticeably different from the original location and should be interpreted with caution (Figure H-3).

Salmonid GBT monitoring at LGR is typically used to provide a background level of GBT for migrating juvenile salmonids that are first entering the hydrosystem. Salmonid GBT sampling at LGR began on April 8th and ran through June 17th. In all, eleven salmonid GBT samples were conducted at LGR in 2022. Among these eleven GBT samples, 1,073 target salmonids were examined, and no signs of fin GBT were observed (Figure H-3, Table H-10).

The target sample size of 100 salmonids examined per GBT sample was met in all but two salmonid GBT samples (Table H-10). The minimum sample target of 50 fish per salmonid GBT sample was met in all samples. Finally, when considered collectively with LGS and LMN, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met in the Snake River Zone all spring spill season and most of the summer spill season. There were two weeks in the summer (August 14-20 and August 21-27) when the minimum sample size of 50 salmonids per week was not met in the Snake River Zone. These were the last two weeks of the summer spill season, when salmonid GBT sampling in the Snake River Zone was only occurring at LGS.

Figure H-3

Percent GBT observed in the SMP salmonid (red bars) and USGS non-salmonid (blue bars) samples at Lower Granite Dam and 12-hour average TDG at the Dworshak tailrace (orange line), Lower Granite forebay (dark blue line), and Lower Granite Tailrace (light blue line) in spring of 2022.



Note, the y-axis for GBT incidence rate starts at -5% to better illustrate days where GBT incidence rates were 0% (i.e., solid black horizontal line).

Table H-10

Detailed breakdown of salmonid GBT exams and signs of fin GBT at Lower Granite Dam in 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/8/2022	100	0	0.0%
4/15/2022	100	0	0.0%
4/22/2022	85	0	0.0%
4/29/2022	104	0	0.0%
5/6/2022	100	0	0.0%
5/13/2022	100	0	0.0%
5/20/2022	101	0	0.0%
5/27/2022	100	0	0.0%
6/3/2022	100	0	0.0%
6/10/2022	83	0	0.0%
6/17/2022	100	0	0.0%

The LGR tailrace was used as one of the non-salmonid GBT monitoring sites by USGS during the spring spill season. Non-salmonid GBT sampling below LGR occurred once per week, from April 4th through June 13th. Eleven total non-salmonid GBT samples

were conducted in the LGR tailrace. Of the 11 non-salmonid GBT samples conducted, four had at least one fish with signs of fin GBT (Figure H-3, Table H-11). The GBT incidence rates for these four non-salmonid samples ranged from 0.8% to 3.4%. The highest GBT incidence rate of 3.4% occurred on April 18th, when tailrace TDG levels had been in the 114-115% range (Figure H-3). Finally, no instances of severe GBT were observed in the non-salmonid samples below LGR.

Among the 11 non-salmonid GBT samples, 1,123 total non-salmonids were examined, and six total fish had signs of fin GBT (Table H-11). In all, eight total species of non-salmonids were sampled below LGR and examined for GBT. The most common species sampled below LGR was the northern pikeminnow, which represented approximately 69% of the total non-salmonids examined at this site. Of the six fish that exhibited signs of fin GBT from sampling below LGR, one was a peamouth, one was a sculpin, and four were northern pikeminnow. Of the six fish exhibiting signs of fin GBT, five had Rank 1 signs and one had Rank 2 signs.

Table H-11
Detailed breakdown of USGS non-salmonid (unshaded) and salmonid (shaded) GBT exams and signs of fin GBT from the Lower Granite Dam tailrace in spring of 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A,B]	Number with Non-Protocol GBT
4/4/2022	112	0	0.0%	NP, SC, SU	0
4/15/2022	108	0	0.0%	LU, NP, SC	2
4/18/2022	59	2	3.4%	CM, LU, NP, PM, SC	0
4/18/2022	23	0	0.0%	CH0, CH1	0
4/25/2022	105	0	0.0%	LD, NP, PM, SC	0
4/25/2022	2	0	0.0%	CH0	0
5/2/2022	103	1	1.0%	NP, SC	0
5/2/2022	10	0	0.0%	CH1	0
5/9/2022	129	1	0.8%	CM, NP, PM, SU	0
5/9/2022	3	0	0.0%	CH1	0
5/16/2022	107	0	0.0%	NP, PM, SC	1
5/23/2022	103	0	0.0%	NP, SC	2
5/30/2022	109	2	1.8%	NP, PM, SC, SU	4
6/6/2022	68	0	0.0%	LD, NP, PM, SC	0
6/13/2022	120	0	0.0%	CM, LU, NP, PM, SR, SU	1

[A] Non-salmonid Species Codes: CM = Chiselmouth, LD = Longnose Dace, LU = Largescale Sucker, NP = Northern Pikeminnow, PM = Peamouth, SC = Sculpin, SR = Sand Roller, and SU = Sucker Sp.
[B] Salmonid Species Codes: CH0 = Subyearling Chinook, CH1 = Yearling Chinook.

The target sample size of 100 non-salmonids examined per GBT sample was met in all but two samples (Table H-11). The minimum target sample size of 50 non-salmonids examined per GBT sample was met in all 11 samples. Finally, when considered collectively with IHR, the WDOE and ODEQ minimum sample size requirement of 50

non-salmonids per week, per zone, was met every week that non-salmonid sampling occurred in the Snake River Zone.

The USGS crew observed signs of bubbles in non-protocol locations (i.e., locations other than the unpaired fins) in some of the non-salmonid GBT samples below LGR. Bubbles in non-protocol locations do not count towards the GBT monitoring action criteria. A total of 10 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations (Table H-11). Of these, seven were sculpin, two were northern pikeminnow, and one was a peamouth. The observations of bubbles in non-protocol locations were spread out over five of the 11 samples conducted below LGR.

In addition to examining non-salmonids collected below LGR, USGS also examined 38 total incidentally collected salmonids (Table H-11). Of these, 18 were subyearling Chinook and 20 were yearling Chinook. No signs of fin GBT were observed in the salmonids that were collected and examined by USGS. In addition, no bubbles were observed in non-protocol locations.

Finally, of the 1,123 total non-salmonids collected and examined from below LGR, 656 (58.4%) were collected through backpack electrofishing and 467 (41.6%) were collected through purse seines. All 38 salmonids that were examined from below LGR were collected through purse seines. Of the six non-salmonids that exhibited signs of fin GBT, four were collected with backpack electrofishing and two were collected with purse seines. Of the 10 non-salmonids that were observed with bubbles in non-protocol locations, and no signs of fin GBT, nine were collected with electrofishing and one was collected with a purse seine.

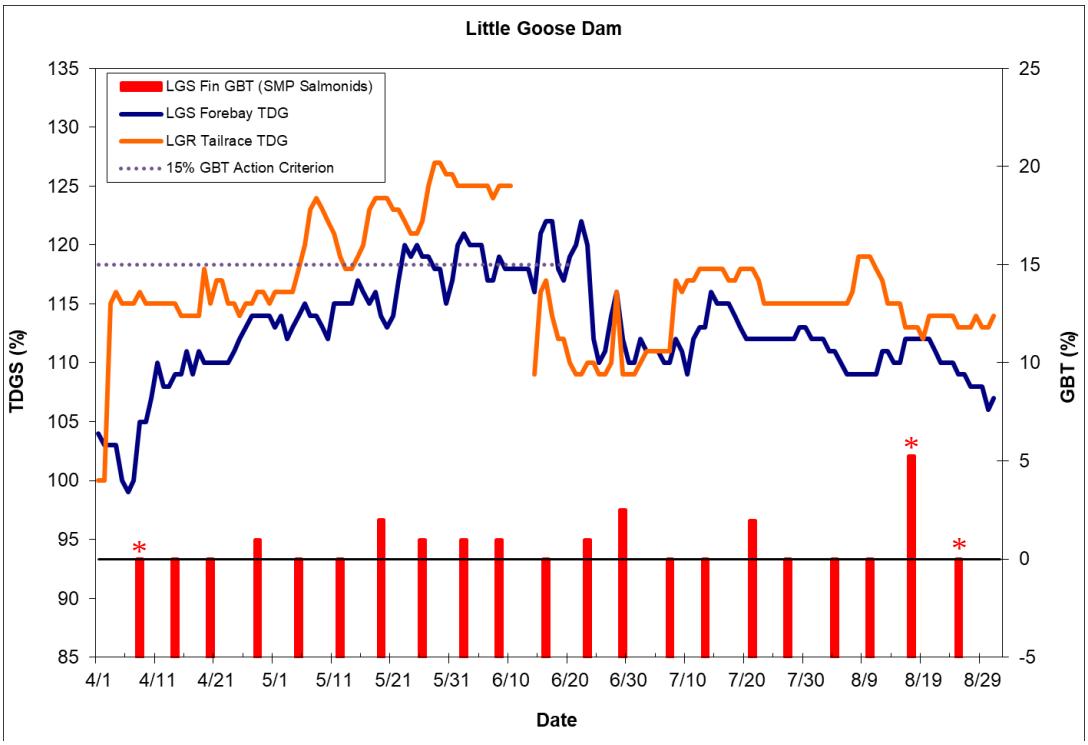
Little Goose Dam (LGS)

During the spring spill season (Apr. 3-June 20), 12-hour average TDG levels in the LGR tailrace exceeded the 125% tailrace standard for four total days (May 28-May 31; Figure H-4). The maximum 12-hour average TDG over this four-day period was 127%. It should be noted that the TDG monitor in the Lower Granite tailrace went out of service on June 10th. A temporary monitor was installed in a different location on June 14th but data from this temporary monitor were noticeably different from the original location and should be interpreted with caution (Figure H-4).

During the summer spill period (June 21-August 31), TDG levels in the LGR tailrace never exceeded the 120% tailrace TDG standard (Figure H-4). The forebay monitor was not a point of compliance until June 21st, when the summer spill season started. The 115% forebay standard was exceeded in the LGS forebay for five total days of the summer spill season. The exceedances of the forebay standard all occurred in the beginning of the summer spill season and were likely due to TDG from the last few days of the spring spill operation at LGR. By June 29th, the 12-hour average TDG in the LGS forebay was at or below 115%, where it remained for the rest of the summer spill season.

Figure H-4

Percent GBT observed in the SMP salmonid (red bars) samples at Little Goose Dam and 12-hour average TDG at the Lower Granite tailrace (orange line) and Little Goose forebay (dark blue line) in 2022.



Notes: 1) the y-axis for GBT incidence rate starts at -5% to better illustrate days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met for the SMP salmonid samples (see Table H-12 for details).

Gas Bubble Trauma monitoring for salmonids at LGS occurred from April 8th to August 25th. Salmonid sampling at LGS was terminated after the sample on August 25th, due to low sample sizes over the previous two samples, elevated temperatures, and generally low TDG levels.

Twenty-one total salmonid GBT samples were conducted at LGS in 2022. Among the 21 GBT samples at LGS, 1,754 total salmonids were examined for GBT and nine GBT samples had at least one salmonid exhibiting signs of fin GBT (Figure H-4, Table H-12). All signs of fin GBT observed at LGS in 2022 were Rank 1 signs. The highest GBT incidence rate at LGS occurred on August 17th, where 5.3% of the examined salmonids exhibited signs of fin GBT. However, it should be noted that this GBT sample did not meet the sample size criteria of 50 fish examined and the 5.3% incidence rate was based on 19 total fish examined, with one fish exhibiting signs of fin GBT. Among the remaining eight GBT samples where signs of fin GBT were present, GBT incidence rates ranged from 1.0% to 2.5% (Figure H-4, Table H-12).

Table H-12
Detailed breakdown of salmonid GBT exams and signs of fin GBT at Little Goose Dam in 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/8/2022	31	0	0.0%
4/14/2022	100	0	0.0%
4/20/2022	52	0	0.0%
4/28/2022	100	1	1.0%
5/5/2022	100	0	0.0%
5/12/2022	100	0	0.0%
5/19/2022	100	2	2.0%
5/26/2022	100	1	1.0%
6/2/2022	100	1	1.0%
6/8/2022	100	1	1.0%
6/16/2022	99	0	0.0%
6/23/2022	101	1	1.0%
6/29/2022	79	2	2.5%
7/7/2022	100	0	0.0%
7/13/2022	102	0	0.0%
7/21/2022	102	2	2.0%
7/27/2022	82	0	0.0%
8/4/2022	79	0	0.0%
8/10/2022	101	0	0.0%
8/17/2022	19	1	5.3%
8/25/2022	7	0	0.0%

The target sample size of 100 salmonids examined per GBT sample was met in 13 of the 21 total samples at LGS (Table H-12). The minimum sample size target of 50 salmonids per week was met in all but three samples (Table H-12 and Figure H-4). Finally, when considered collectively with LGR and LMN, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met in the Snake River Zone all spring spill season and most of the summer spill season. There were two weeks in the summer (August 14-20 and August 21-27) when the minimum sample size of 50 salmonids per week was not met in the Snake River Zone. These were the last two weeks of the summer spill season, when salmonid GBT sampling in the Snake River Zone was only occurring at LGS.

Lower Monumental Dam (LMN)

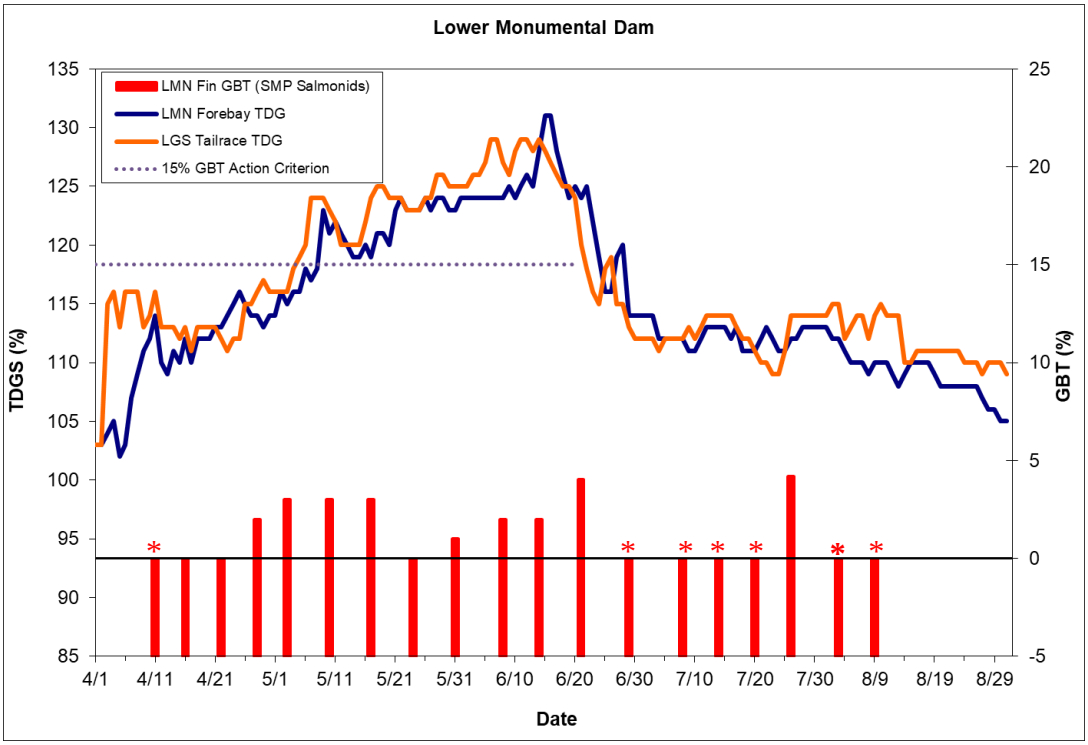
Over the spring spill season, 12-hour average TDG levels in the LGS tailrace exceeded the 125% tailrace standard for 17 total days (Figure H-5). These 17 exceedances occurred over the last few weeks of the spring spill season and were due to high flows that necessitated spill at LGS to be above the 125% TDG spill cap during periods when hydraulic capacity had been reached. The maximum 12-hour average TDG in the LGS tailrace was 129%, which occurred on five occasions in June (Figure H-5).

During the summer spill period (June 21-August 31), TDG levels in the LGS tailrace never exceeded the 120% tailrace TDG standard (Figure H-5). The forebay

monitor was not a point of compliance until June 21st, when summer spill began. The 115% forebay standard was exceeded in the LMN forebay for eight total days of the summer spill season. These exceedances of the forebay standard all occurred in the beginning of the summer spill season (June 21-28) and were likely due to TDG from the last few days of the spring spill operations at LGS. By June 29th, the 12-hour average TDG in the LMN forebay was below 115%, where it remained for the rest of the summer spill season.

Figure H-5

Percent GBT observed in the SMP salmonid (bars) samples at Lower Monumental Dam and 12-hour average TDG at the Little Goose tailrace (orange line) and Lower Monumental forebay (blue line) in 2022.



Notes: 1) the y-axis for GBT incidence rate starts at -5% to better illustrate days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met for the SMP salmonid samples (see Table H-13 for details).

Only salmonid GBT monitoring occurred at LMN in 2022, under the SMP. GBT sampling at LMN occurred from April 11th to August 9th. Sampling was terminated after the sample on August 9th due to increased temperatures, decreased TDG levels in the Snake River, and decreasing numbers of fish in the sample that precluded the ability to meet sample size requirements. In all, 19 total GBT samples were conducted at LMN in 2022. Of these 19 GBT samples at LMN, 1,282 total salmonids were examined for GBT and nine GBT samples had at least one salmonid exhibiting signs of fin GBT (Figure H-5, Table H-13). The highest GBT incidence rates in 2022 at LMN were 4.3% on July 26th and 4.0% on

June 21st. Total dissolved gas in the LGS tailrace had been in the 109-112% range over the week preceding the July 26 sample and TDG in the LMN forebay was in the 111-113% range (Figure H-5). Prior to the June 21 sample, TDG in the LGS tailrace had been in the 124-129% range while that in the LMN forebay had been in the 124-131% range. Among the seven remaining GBT samples where signs of fin GBT were present, GBT incidence rates ranged from 1.0% to 3.0%. No signs of severe GBT were observed at LMN in 2022. In fact, all 23 salmonids that exhibited signs of fin GBT at LMN in 2022 had Rank 1 signs.

Table H-13

Detailed breakdown of salmonid GBT exams and signs of fin GBT at Lower Monumental Dam in 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/11/2022	36	0	0.0%
4/16/2022	64	0	0.0%
4/22/2022	98	0	0.0%
4/28/2022	100	2	2.0%
5/3/2022	100	3	3.0%
5/10/2022	100	3	3.0%
5/17/2022	100	3	3.0%
5/24/2022	105	0	0.0%
5/31/2022	100	1	1.0%
6/8/2022	100	2	2.0%
6/14/2022	101	2	2.0%
6/21/2022	99	4	4.0%
6/29/2022	47	0	0.0%
7/8/2022	11	0	0.0%
7/14/2022	11	0	0.0%
7/20/2022	20	0	0.0%
7/26/2022	72	3	4.2%
8/3/2022	4	0	0.0%
8/9/2022	14	0	0.0%

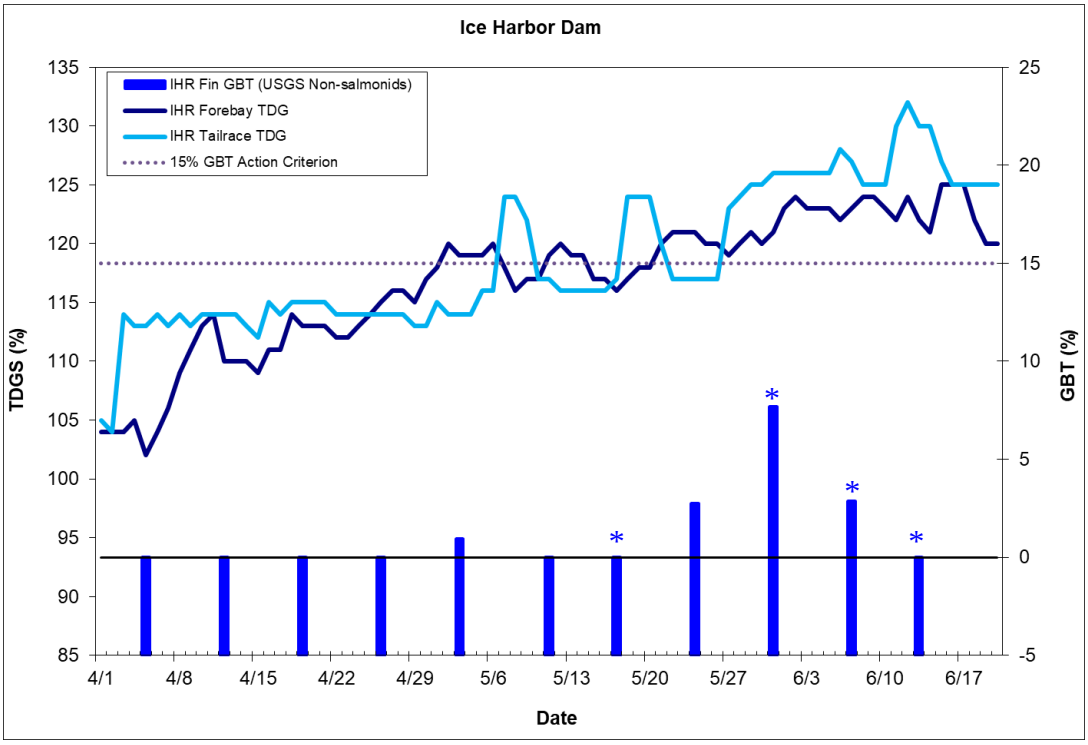
The target sample size of 100 salmonids examined per GBT sample was met in only eight of the 19 total GBT samples at LMN (Table H-13). The minimum sample size target of 50 salmonids per week was met in all but seven samples in 2022 (Table H-13, Figure H-5). Finally, when considered collectively with LGR and LGS, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met in the Snake River Zone all spring spill season and most of the summer spill season. There were two weeks in the summer (August 14-20 and August 21-27) when the minimum sample size of 50 salmonids per week was not met in the Snake River Zone. These were the last two weeks of the summer spill season, when salmonid GBT sampling in the Snake River Zone was only occurring at LGS.

Ice Harbor Dam (IHR)

IHR is not an SMP site and, therefore, salmonid GBT monitoring does not occur there. However, the IHR tailrace was one of the USGS non-salmonid GBT monitoring sites. Non-salmonid GBT sampling below IHR occurred weekly, from April 5th through June 13th. Total dissolved gas levels in the IHR tailrace exceeded the 125% tailrace TDG standard for 13 total days in the spring of 2022 (Figure H-6). All 13 exceedances occurred over the last three weeks of the spring spill season and were due to high flows that necessitated spill at IHR to be above the 125% TDG spill cap during periods when hydraulic capacity had been reached. The maximum hourly TDG level in the IHR tailrace was 132%, which occurred on June 12th.

Figure H-6

Percent GBT observed in the USGS non-salmonid (blue bars) samples in the Ice Harbor tailrace and 12-hour average TDG at the Ice Harbor forebay (dark blue line) and Ice Harbor tailrace (light blue line) in 2022.



Notes: 1) the y-axis for GBT incidence rate starts at -5% to better illustrate days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met for the USGS non-salmonid samples (see Table H-14 for details).

Eleven total non-salmonid GBT samples were conducted in the IHR tailrace in the spring of 2022. Of these, four had at least one fish with signs of fin GBT (Figure H-6, Table H-14). The GBT incidence rates for these four non-salmonid samples raged from 0.9% to 7.7%. The highest GBT incidence rate of 7.7% occurred on May 31st. It should be noted that only 39 total non-salmonids were examined in the May 31 sample and the 7.7%

incidence rate is based on three fish with signs of fin GBT (Table H-14). Finally, no instances of severe GBT were observed in the non-salmonid samples below IHR.

Table H-14
Detailed breakdown of USGS non-salmonid (unshaded) and salmonid (shaded) GBT exams and signs of fin GBT from the Ice Harbor Dam tailrace in spring of 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A,B]	Number with Non-Protocol GBT
4/5/2022	51	0	0.0%	AP, NP, SC	0
4/12/2022	90	0	0.0%	AP, NP, SC	2
4/19/2022	77	0	0.0%	AP, NP, SC	2
4/26/2022	102	0	0.0%	MP, NP, SC	0
4/26/2022	3	0	0.0%	CH1	0
5/3/2022	107	1	1.0%	AP, MW, NP, SC	1
5/11/2022	82	0	0.0%	AP, NP, SC	0
5/17/2022	36	0	0.0%	AP, MW, NP, SC	0
5/24/2022	109	3	2.8%	AP, NP, SC	6
5/31/2022	39	3	7.7%	NP, SC	1
6/7/2022	35	1	2.9%	MW, NP, SC	0
6/13/2022	4	0	0.0%	LU, MW, NP	0

[A] Non-salmonid Species Codes: AP = Pacific Lamprey Ammocoete, MP = Pacific Lamprey Macropthalmia, LU = Largescale Sucker, MW = Mountain Whitefish, NP = Northern Pikeminnow, SC = Sculpin.
[B] Salmonid Species Codes: CH1 = Yearling Chinook.

Among the 11 non-salmonid GBT samples conducted in the IHR tailrace, 732 total non-salmonids were examined, and eight total fish had signs of fin GBT (Table H-14). In all, six total species of non-salmonids were sampled and examined below IHR. The most common species sampled below IHR were northern pikeminnow and sculpin, which represented approximately 50% and 45% of the total non-salmonids examined at this site, respectively. All eight of the non-salmonids that exhibited signs of fin GBT from sampling below IHR were sculpin. Six of these eight sculpin had Rank 1 signs of fin GBT and the other two had Rank 2 signs.

The target sample size of 100 non-salmonids examined per GBT sample was met in only three samples (Table H-14). The minimum target sample of 50 non-salmonids examined per GBT sample was met in all but four samples. Finally, when considered collectively with LGR, the WDOE and ODEQ minimum sample size requirement of 50 non-salmonids per week, per zone, was met every week that sampling occurred in the Snake River Zone.

The USGS crew observed signs of bubbles in non-protocol locations in some of the non-salmonid GBT samples below IHR. In all, 12 total fish that did not otherwise have signs of fin GBT were observed with bubbles in non-protocol locations (Table H-14). All 12 non-salmonids with bubbles in non-protocol locations were sculpin and the observations of non-protocol bubbles were spread out over five of the 11 samples.

In addition to examining non-salmonids collected below IHR, USGS also examined three incidentally collected salmonids (Table H-14). All three salmonids were yearling Chinook and no signs of fin GBT were observed. In addition, no bubbles were observed in non-protocol locations.

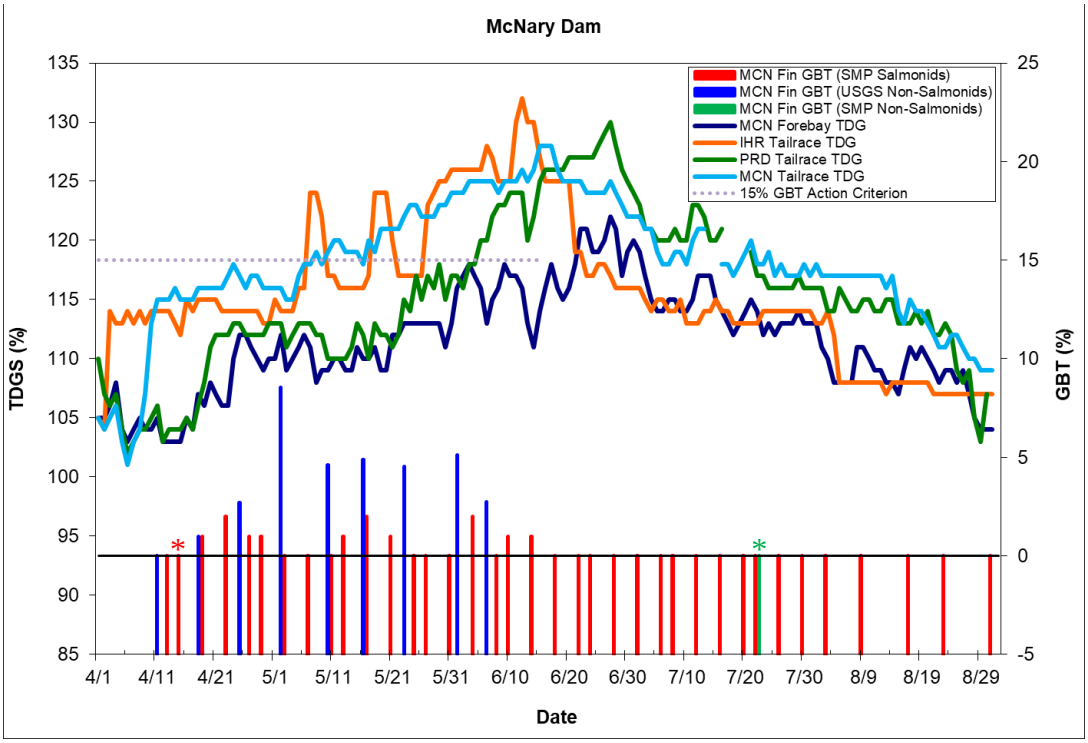
Finally, of the 732 total non-salmonids collected and examined from below IHR, 680 (92.9%) were collected through backpack electrofishing and 52 (7.1%) were collected through purse seines. All three yearling Chinook that were examined from below IHR were collected through purse seines. Of the eight non-salmonids that exhibited signs of fin GBT, seven were collected with backpack electrofishing and one was collected with a purse seine. All 12 of the non-salmonids with bubbles in non-protocol locations, and otherwise no signs of fin GBT, were collected with electrofishing.

McNary Dam (MCN)

Over the spring spill period, 12-hour average TDG levels in the IHR tailrace exceeded the 125% tailrace standard for 13 total days (May 31-June 7 and June 11-15; Figure H-7). These exceedances were due to high flows and the need for IHR to spill above the 125% TDG spill cap during periods when hydraulic capacity had been reached. The maximum 12-hour average TDG in the IHR tailrace over this thirteen-day period was 132%, which occurred on June 12th. The 12-hour average TDG in the Priest Rapids (PRD) tailrace exceeded the 120% tailrace standard that applies to the Upper Columbia River for a total of 13 days (June 7-12 and June 14-20) of spring (Figure H-7). The maximum 12-hour average TDG in the PRD tailrace over this 13-day period was 127%, which occurred on June 20th. Finally, the 12-hour average TDG in the MCN tailrace exceeded the 125% tailrace TDG standard for three total days of the spring spill season (June 12th and June 14-15). In fact, 12-hour average TDG in the McNary tailrace continued to exceed 125% into the summer spill period (June 16-18), with a maximum 12-hour average TDG of 128% on June 16th and 17th.

Over the summer spill season for IHR (June 21-Aug. 31), TDG levels in the IHR tailrace never exceeded the 120% tailrace TDG standard (Figure H-7). However, the 12-hour average TDG in the McNary forebay exceeded the 115% forebay TDG standard for a total of 17 days of the IHR summer spill season (June 21-July 3 and July 12-15). Most of these exceedances were likely due to high spill and TDG from Priest Rapids Dam, as the 12-hour average TDG levels in the PRD tailrace were above 125% over much of this same time (Figure H-7). In fact, the 12-hour average TDG in the Priest Rapids tailrace peaked at 130% on June 27th.

Figure H-7
Percent GBT observed in the SMP salmonid (red bars), USGS non-salmonid (blue bars), and SMP non-salmonid (green bars) samples at McNary Dam and 12-hour average TDG at the Ice Harbor tailrace (orange line), Priest Rapids tailrace (green line), McNary tailrace (light blue line), and McNary forebay (dark blue line) in 2022.



Notes: 1) the y-axis for GBT incidence rate starts at -5% to better illustrate days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met for the SMP salmonid (red) and SMP non-salmonid (green) samples (see Table H-15 for details of the salmonid samples; the single SMP non-salmonid sample (green bar) had only one fish examined).

Salmonid GBT sampling at MCN occurred from April 13th to August 31st (Table H-15). Like recent years, GBT sampling at MCN was reduced from twice-per-week to once-per-week due to elevated temperatures. This reduction in sampling frequency occurred after the sample on August 3rd. At that time, TDG levels in the MCN forebay were still slightly above 110% (Figure H-7) but temperatures in the MCN forebay were nearly 70°F. 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 salmonids at water temperatures above 68°F. MCN continued once-per-week sampling through the rest of the summer spill season.

In all, 37 total salmonid GBT samples were conducted at MCN in 2022, with 3,587 total salmonids examined (Figure H-7 and Table H-15). Among the 37 total salmonid GBT samples, 10 had at least one salmonid with signs of fin GBT. The highest GBT incidence rate was 2.0%, which occurred on three occasions (Figure H-7, Table H-15).

Among the 3,587 total salmonids examined by the SMP crew for GBT, 13 total fish had signs of fin GBT, and all were Rank 1 signs.

Table H-15
Detailed breakdown of SMP salmonid GBT exams and signs of fin GBT at McNary Dam in 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/13/2022	100	0	0.0%
4/15/2022	42	0	0.0%
4/19/2022	100	1	1.0%
4/23/2022	100	2	2.0%
4/27/2022	100	1	1.0%
4/29/2022	100	1	1.0%
5/3/2022	100	0	0.0%
5/7/2022	100	0	0.0%
5/11/2022	100	0	0.0%
5/13/2022	100	1	1.0%
5/17/2022	100	2	2.0%
5/21/2022	100	1	1.0%
5/25/2022	100	0	0.0%
5/27/2022	100	0	0.0%
5/31/2022	75	0	0.0%
6/4/2022	100	2	2.0%
6/8/2022	100	0	0.0%
6/10/2022	100	1	1.0%
6/14/2022	100	1	1.0%
6/18/2022	100	0	0.0%
6/22/2022	100	0	0.0%
6/24/2022	100	0	0.0%
6/28/2022	101	0	0.0%
7/2/2022	102	0	0.0%
7/6/2022	100	0	0.0%
7/8/2022	100	0	0.0%
7/12/2022	100	0	0.0%
7/16/2022	100	0	0.0%
7/20/2022	100	0	0.0%
7/22/2022	100	0	0.0%
7/26/2022	100	0	0.0%
7/30/2022	100	0	0.0%
8/3/2022	100	0	0.0%
8/9/2022	96	0	0.0%
8/17/2022	100	0	0.0%
8/23/2022	100	0	0.0%
8/31/2022	71	0	0.0%

The target sample size of 100 salmonids examined per GBT sample was met in all but four of the salmonid GBT samples at MCN (Table H-15). The minimum sample size

target of 50 salmonids per GBT sample was met in all but one salmonid sample (April 15th). Finally, when considered collectively with BON, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met every week that salmonid GBT sampling occurred in the Mid-Columbia Zone.

The MCN tailrace was used as one of the non-salmonid GBT monitoring sites for the USGS non-salmonid GBT monitoring program. Non-salmonid GBT sampling below MCN occurred once per week, from April 11th through June 6th. Nine total non-salmonid GBT samples were conducted in the MCN tailrace. Of these, eight had at least one fish with signs of fin GBT (Figure H-7, Table H-16). The GBT incidence rates for these eight non-salmonid samples ranged from 1.0% to 8.6%. The highest GBT incidence rate of 8.6% occurred on May 2nd. The 12-hour average TDG in the MCN tailrace had been in the 116%-117% range in the week prior to this May 2nd sample. Finally, three total non-salmonids exhibited signs of severe GBT (i.e., Rank 3 or 4) over the spring spill season. Each of these three fish were observed in three separate samples (May 16th, May 23rd, and June 1st) and, therefore, the incident rates for severe GBT on these dates ranged from 0.9% to 1.3%.

Table H-16
Detailed breakdown of USGS non-salmonid (unshaded) and salmonid (shaded) GBT exams and signs of fin GBT from the McNary Dam tailrace in spring of 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A,B]	Number with Non-Protocol GBT
4/11/2022	59	0	0.0%	SC, SK	0
4/18/2022	102	1	1.0%	AP, SC, SD, SU	0
4/25/2022	111	3	2.7%	SC	5
4/25/2022	20	0	0.0%	CH1, CH0	0
5/2/2022	105	9	8.6%	SC	2
5/10/2022	65	3	4.6%	SC	0
5/16/2022	102	5	4.9%	SC, SD	2
5/23/2022	110	5	4.5%	SC, SK	10
6/1/2022	78	4	5.1%	SC	4
6/6/2022	73	2	2.7%	LD, LU, NP, SC	2

[A] Non-salmonid Species Codes: AP = Pacific Lamprey Ammocoete, LD = Longnose Dace, LU = Largescale Sucker, NP = Northern Pikeminnow, SC = Sculpin, SD = Speckled Dace, SK = Three-spined Stickleback, and SU = Sucker Sp.
[B] Salmonid Species Codes: CH0 = Subyearling Chinook, CH1 = Yearling Chinook.

Among the nine non-salmonid GBT samples in the MCN tailrace, 805 total non-salmonids were examined, and 32 total non-salmonids had signs of fin GBT (Table H-16). In all, eight total species of non-salmonids were sampled and examined below MCN. The most common species sampled below MCN were sculpin, which represented nearly 99% of the total non-salmonids examined at this site. All 32 of the non-salmonids that exhibited signs of fin GBT from sampling below MCN were sculpin. Of the 32 sculpin that exhibited signs of fin GBT in 2022, 21 had a maximum rank of Rank 1, eight had a

maximum rank of Rank 2, one had a maximum rank of Rank 3, and two had a maximum rank of Rank 4.

The target sample size of 100 non-salmonids examined per GBT sample was met in all but four of the USGS samples (Table H-16). The minimum target sample size of 50 non-salmonids examined per GBT sample was met in all nine samples. Finally, when considered collectively with BON, the WDOE and ODEQ minimum sample size requirement of 50 non-salmonids per week, per zone, was met every week that sampling occurred in the Mid-Columbia River Zone.

The USGS crew observed signs of bubbles in non-protocol locations (i.e., locations other than the unpaired fins) in some of the non-salmonid GBT samples below MCN. A total of 25 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations and all 25 were sculpin (Table H-16). The observations of bubbles in non-protocol locations were spread out over six of the nine samples conducted below MCN.

In addition to examining non-salmonids collected below MCN, USGS also examined 20 total incidentally collected salmonids (Table H-16). Of these, 17 were subyearling Chinook and three were yearling Chinook. No signs of fin GBT were observed in the salmonids that were collected and examined by USGS. In addition, no bubbles were observed in non-protocol locations.

Of the 805 total non-salmonids collected and examined from below MCN, 798 (99.1%) were collected through backpack electrofishing and seven (0.9%) were collected through purse seines. All 20 salmonids that were examined from below MCN were collected through purse seines. All 32 non-salmonids that exhibited signs of fin GBT were collected with backpack electrofishing. In addition, all 25 non-salmonids that were observed with bubbles in non-protocol locations, and no signs of fin GBT, were collected with electrofishing.

Finally, per ODEQ requirements, the SMP crew at MCN attempted to collect non-salmonid for GBT monitoring during the summer spill season. However, only one non-salmonid was collected over this period. The single fish collected and examined at MCN was a smallmouth bass from the GBT sample on July 22nd. No signs of GBT were observed in this single fish.

Bonneville Dam (BON)

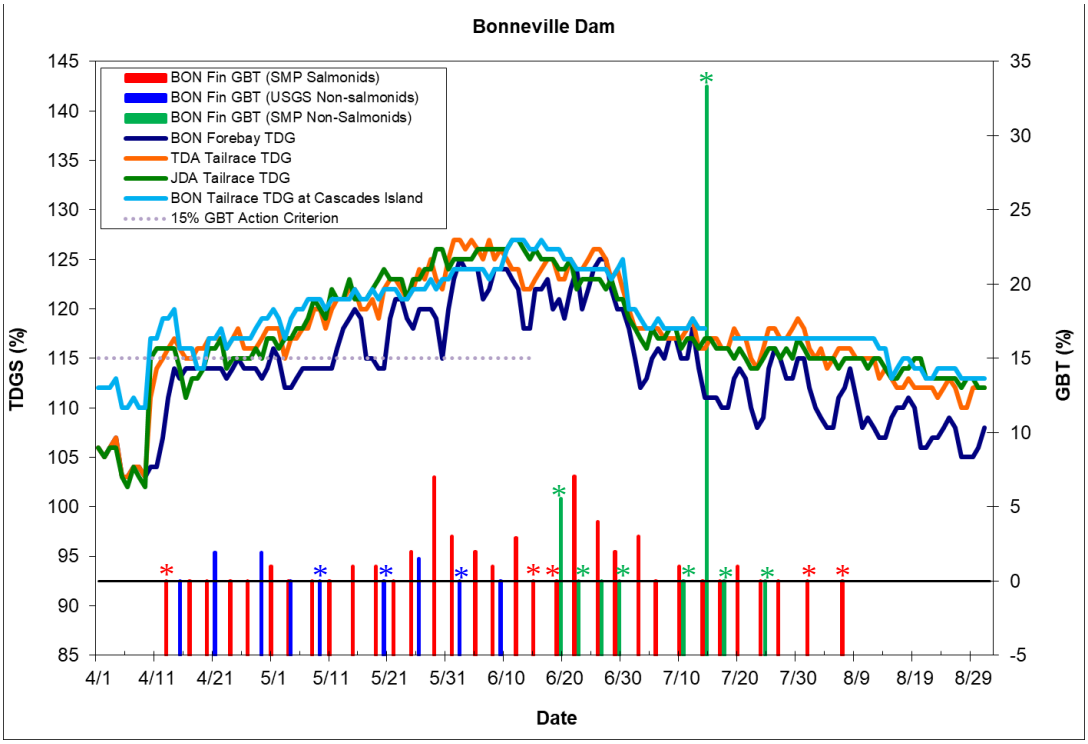
During the spring spill season, the 12-hour average TDG in the John Day (JDA) tailrace exceeded 125% for 12 total days (May 29-30, June 6-13, and June 15; Figure H-8). Many of these exceedances occurred during periods when JDA spilled above the 125% spill cap, due to high flows. The maximum 12-hour average TDG in the JDA tailrace was 127%, which occurred twice (June 11-12). The 12-hour average TDG in the tailrace at The Dalles (TDA) exceeded 125% for seven total days (June 1-5, June 7, and June 9). The maximum 12-hour average TDG in the tailrace at TDA was 127%, which occurred on four

occasions. Finally, the 12-hour average TDG in the BON tailrace (at Cascades Island) exceeded the 125% tailrace TDG standard for two total days (June 9th and June 11th), with a 12-hour average TDG of 126%. Both exceedances occurred during a period when spill at BON was above the prescribed 150 Kcfs spill level, due to high flows.

Over the summer spill season for the Mid-Columbia River (June 16-August 31), TDG levels in the tailraces of JDA and TDA exceeded the 120% tailrace TDG standard for 15 total days (June 16-30; Figure H-8). In addition, the 12-hour average TDG in the BON forebay exceeded the 115% forebay TDG standard for a total of 16 days (June 16-July 1). Most of these exceedances were due to high spill over the first three weeks of the summer spill season due to high flows and lack of market conditions.

Figure H-8

Percent GBT observed in the salmonid (red bars), USGS non-salmonid (blue bars), and SMP non-salmonid (green bars) GBT samples at Bonneville Dam and 12-hour average TDG at the John Day tailrace (green line), The Dalles tailrace (orange line), Bonneville tailrace (light blue line), and the Bonneville forebay (dark blue line) in 2022.



Notes: 1) the y-axis for GBT incidence rate starts at -5% to better illustrate days where GBT incidence rates were 0% (i.e., solid black horizontal line) and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met for SMP salmonid (red), USGS non-salmonid (blue), and SMP non-salmonid (green) samples (see Tables H-17, H-18, and H-19 for details).

Salmonid GBT sampling at BON occurred from April 13th to August 7th (Table H-17, Figure H-8). Salmonid GBT sampling at BON typically occurs twice-per-week.

However, sampling can be suspended when Spring Creek NFH releases occur, to minimize handling of these listed fish. Spring Creek NFH made a single emergency release of all fish in March of 2022, prior to the initiation of salmonid GBT sampling. Due to high temperatures and generally low TDG levels, the frequency of GBT sampling at BON was reduced to once-per-week after the sample on August 1st. Due to decreasing fish numbers, continued high temperatures, and generally low TDG levels, salmonid GBT sampling at BON ended after the sample on August 7th.

Table H-17

Detailed breakdown of SMP salmonid GBT exams and signs of fin GBT at Bonneville Dam in 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/13/2022	29	0	0.0%
4/17/2022	89	0	0.0%
4/20/2022	100	0	0.0%
4/24/2022	100	0	0.0%
4/27/2022	100	0	0.0%
5/1/2022	100	1	1.0%
5/4/2022	100	0	0.0%
5/8/2022	100	0	0.0%
5/11/2022	100	0	0.0%
5/15/2022	100	1	1.0%
5/19/2022	100	1	1.0%
5/22/2022	100	0	0.0%
5/25/2022	100	2	2.0%
5/29/2022	100	7	7.0%
6/1/2022	100	3	3.0%
6/5/2022	100	2	2.0%
6/8/2022	100	1	1.0%
6/12/2022	69	2	2.9%
6/15/2022	33	0	0.0%
6/19/2022	22	0	0.0%
6/22/2022	71	5	7.0%
6/26/2022	100	4	4.0%
6/29/2022	100	2	2.0%
7/3/2022	100	3	3.0%
7/6/2022	100	0	0.0%
7/10/2022	100	1	1.0%
7/14/2022	100	0	0.0%
7/17/2022	100	0	0.0%
7/20/2022	100	1	1.0%
7/24/2022	100	0	0.0%
7/27/2022	100	0	0.0%
8/1/2022	15	0	0.0%
8/7/2022	29	0	0.0%

In all, 33 total salmonid GBT samples were conducted at BON in 2022, with 2,857 total salmonids examined. Of the 33 total salmonid GBT samples, 15 had at least one salmonid with signs of fin GBT (Figure H-8, Table H-17). The highest GBT incidence rate for salmonids at BON was 7.0%, which occurred on two occasions. The first of these occasions was May 29th. The 12-hour average TDG in the JDA and TDA tailraces had been in the 121-124% and 121-125% ranges, respectively, over the week prior to the sample on May 29th. The second instance of a salmonid GBT instance rate of 7.0% was June 22nd. Over the week prior to this sample, the 12-hour average TDG in the JDA and TDA tailraces had been in the 124-126% and 123-125% ranges, respectively. Among the other 13 salmonid GBT samples where signs of fin GBT were observed at BON, GBT incidence rates ranged from 1.0% to 4.0% (Table H-17).

Among the 2,857 total salmonids that were examined by SMP crews at BON in 2022, 36 total had signs of fin GBT (Table H-17). Of these, 31 had Rank 1 signs, four had Rank 2 signs, and one had Rank 3 signs. Rank 3 signs are considered severe GBT. This individual with severe GBT was observed in the sample from June 5th. The overall GBT incidence rate for the June 5 sample was 2.0% and the severe GBT incidence rate was 1.0% (Table H-17).

The target sample size of 100 salmonids examined per GBT sample was met in all but eight salmonid GBT samples (Table H-17). All but five of the salmonid GBT samples at BON met the minimum sample size target of 50 salmonids. Finally, when considered collectively with MCN, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met every week that salmonid GBT sampling occurred in the Mid-Columbia River Zone.

The BON tailrace was used as one of the non-salmonid GBT monitoring sites for the USGS program. Non-salmonid GBT sampling below BON occurred once per week, from April 15th through June 9th. Nine total non-salmonid GBT samples were conducted in the BON tailrace. Of these, three had at least one fish with signs of fin GBT (Figure H-8, Table H-18). The GBT incidence rates for these three non-salmonid samples raged from 1.5% to 1.9%. The highest GBT incidence rate of 1.9% occurred on two occasions (April 21st and April 29th). The 12-hour average TDG in the BON tailrace (at Cascades Island) had been in the 114%-120% and 116%-118% ranges in the week prior to each of these samples, respectively. No signs of severe fin GBT were observed among the non-salmonids examined by USGS below BON in 2022.

Among the nine samples conducted by USGS in the BON tailrace, 611 total non-salmonids were examined, and five total non-salmonids had signs of fin GBT (Table H-18). In all, seven total species of non-salmonids were sampled below BON and examined for GBT. The most common species sampled below BON were sculpin and three-spined stickleback, which represented approximately 48% and 42% of the total non-salmonids examined at this site, respectively. Of the five non-salmonids that exhibited signs of fin GBT from sampling below BON, four were sculpin and one was a three-spined stickleback. Finally, all five non-salmonids exhibiting signs of fin GBT had Rank 1 signs.

Table H-18
Detailed breakdown of USGS non-salmonid (unshaded) and salmonid (shaded) GBT exams and signs of fin GBT from the Bonneville Dam tailrace in spring of 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A,B]	Number with Non-Protocol GBT
4/15/2022	103	0	0.0%	NP, SC, SK	0
4/15/2022	13	0	0.0%	CH1, CH0, UM	0
4/21/2022	103	2	1.9%	NP, SC, SK, SU	1
4/29/2022	103	2	1.9%	NP, SC, SK	2
5/4/2022	102	0	0.0%	NP, SC, SK, SU	5
5/9/2022	21	0	0.0%	NP, PM, SC, SK	0
5/20/2022	22	0	0.0%	LD, LU, SC, SK	1
5/26/2022	65	1	1.5%	LU, SC, SK, SU	1
6/2/2022	39	0	0.0%	NP, PM, SC, SK, SU	0
6/9/2022	53	0	0.0%	NP, SC, SK, SU	0

[A] Non-salmonid Species Codes: LD = Longnose Dace, LU = Largescale Sucker, NP = Northern Pikeminnow, PM = Peamouth, SC = Sculpin, SK = Three-spined Stickleback, and SU = Sucker Sp.
[B] Salmonid Species Codes: CH0 = Subyearling Chinook, CH1 = Yearling Chinook, UM = Chum.

The target sample size of 100 non-salmonids examined per GBT sample was met in only four samples (Table H-18). The minimum target sample size of 50 non-salmonids examined per GBT sample was met in all but three samples. Finally, when considered collectively with MCN, the WDOE and ODEQ minimum sample size requirement of 50 non-salmonids per week, per zone, was met in every week that sampling occurred.

The USGS crew observed signs of bubbles in non-protocol locations (i.e., locations other than the unpaired fins) in some of the non-salmonid GBT samples below BON. A total of 10 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations (Table H-18). Of these, nine were sculpin and one was a three-spined stickleback. The observations of bubbles in non-protocol locations were spread out over five of the nine samples conducted below BON.

In addition to examining non-salmonids collected below BON, USGS also examined 13 total incidentally collected salmonids (Table H-18). Of these, 10 were chum fry, two were yearling Chinook, and one was a subyearling Chinook. No signs of fin GBT were observed in the salmonids that were collected and examined by USGS. In addition, no bubbles were observed in non-protocol locations.

Of the 611 total non-salmonids collected and examined from below BON, 455 (74.5%) were collected through backpack electrofishing and 156 (25.5%) were collected through purse seines. All 13 salmonids that were examined from below BON were collected through purse seines. Of the five non-salmonids that exhibited signs of fin GBT, four were collected with backpack electrofishing and one was collected with a purse seine. In addition, of the 10 non-salmonids that were observed with bubbles in non-protocol

locations, and no signs of fin GBT, nine were collected with electrofishing and one was collected with a purse seine.

Finally, per ODEQ requirements, the SMP crew at BON also examined non-salmonids for GBT monitoring during the summer spill season. Over the summer spill season, non-salmonids were examined in eight total samples at BON (Table H-19). Sample sizes for all eight of these samples were small (Range: 1-18 examined). Signs of fin GBT were observed in two of these samples and GBT incidence rates were 5.6% (June 19th) and 33.3% (July 14th). Although the ODEQ order requires summer GBT monitoring for non-salmonids, the action criteria for reducing spill do not apply to these samples and, even if they did, the minimum sample size requirement of 50 fish examined per week was never met.

In all, 54 total non-salmonids were examined by the SMP crew at BON in the summer of 2022 (Table H-19). Of these, only two had signs of fin GBT. One was a peamouth in the sample from June 19th and the other was a Pacific lamprey macropthalmia in the sample from July 14th. Both fish had Rank 1 signs of fin GBT.

Table H-19
Detailed breakdown of SMP non-salmonid GBT exams and signs of fin GBT at Bonneville Dam in summer of 2022.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A]
6/19/2022	18	1	5.6%	BS, MP, NP, PE
6/22/2022	15	0	0.0%	AP, MP, MW, NP, SC, SK
6/26/2022	12	0	0.0%	AP, MP, PE
6/29/2022	2	0	0.0%	AP, MP
7/10/2022	1	0	0.0%	AP
7/14/2022	3	1	33.3%	MP, NP, SC
7/17/2022	1	0	0.0%	BS
7/24/2022	2	0	0.0%	SC, SK

[A] Non-salmonid Species Codes: AP = Pacific Lamprey Ammocoete, BS = Smallmouth Bass (Non-native), MP = Pacific Lamprey Macropthalmia, MW = Mountain Whitefish, NP = Northern Pikeminnow, PE = Peamouth, SC = Sculpin, and SK = Three-spined Stickleback.

Finally, Table H-20 compares the 2022 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 2022 compared to past years. Given that salmonid GBT monitoring did not occur at Rock Island in 2022, the overall percentages presented in Table H-20 are only for the salmonid samples conducted at FCRPS projects (i.e., Rock Island excluded). At 0.8%, the overall annual GBT incidence rate for 2022 was the 11th highest over the last 27 years.

Table H-20
Overall percent of examined salmonids with signs of fin GBT in each year (1996 to 2022). Data from 1996-2021 are for salmonid samples conducted at FCRPS projects only (i.e., Rock Island excluded).

Year	Overall Percent GBT (%)
1996	4.20
1997	4.30
1998	1.60
1999	1.40
2000	0.20
2001	0.10
2002	0.70
2003	0.50
2004	0.18
2005	0.11
2006	1.40
2007	2.90
2008	0.70
2009	0.23
2010	0.43
2011	0.95
2012	0.44
2013	0.28
2014	0.17
2015	0.13
2016	0.07
2017	1.38
2018	1.17
2019	0.76
2020	0.77
2021	1.01
2022	**0.80**

Historical Summary (1996–2022)

The GBT monitoring program has been implemented on salmonids annually since 1996. There are 27 years of data available and, because of involuntary spill events and recent changes to TDG standards, data for salmonid GBT are available over a wide range of TDG levels. 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 were likely bias high (USACE 2022, Appendix H), this assessment was limited to FCRPS monitoring sites (LGR, LGS, LMN, MCN, and BON).

The daily sample size target, based on the GBT monitoring protocol, is 100 salmonids. In this analysis, some flexibility was considered and all daily samples with ≥75 salmonids examined 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 and forebay elevation 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, Grande Ronde, Imnaha, Salmon, 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. It should be noted that 2021 samples conducted at LGR could not be used in this analysis. This is because the forebay monitor in the LGR forebay was not installed until June 18th and, therefore, we had no way of matching the data from GBT samples to TDG levels in the LGR forebay.

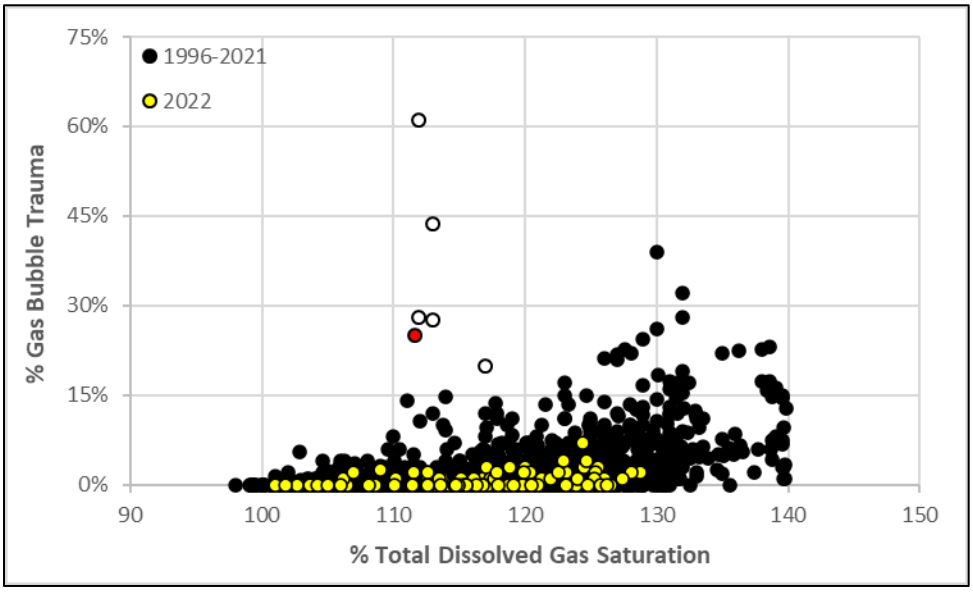
Excluding Rock Island Dam samples, a total of 3,216 daily exams fit into our criteria of ≥75 fish examined over the 27 years of available data, where GBT data could be matched to upstream TDG data. This equated to a total of 360,006 fish examined. The GBT monitoring program has consistently shown over 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 FCRPS Biological Opinion Spill program.

With these data, we evaluated how often the 15% fin GBT incidence criterion has been met over the last 27 years, and under what tailrace TDG levels this occurred. In all the years when TDG and GBT data have been collected (3,126 samples meeting our sample size criterion), there have been only 37 instances when the 15% GBT criterion was exceeded (Figure H-9). Of those 37 instances, five (open circles in Figure H-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 H-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 not met in 2022 (yellow circles in Figure H-9), despite the 125% tailrace TDG standard that was utilized for the spring spill season.

Of the 3,216 GBT samples that met the sample size criteria for this historic review, 337 had TDG levels of ≥125%. Of these 337 samples with corresponding TDG levels of ≥125%, only 28 (or 8.3%) had GBT incidence rates that met or exceeded the 15% fin GBT criterion. This means that the remaining 309 GBT samples (or 91.7%) had fin GBT incidence rates below the 15% action criterion (Figure H-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%.

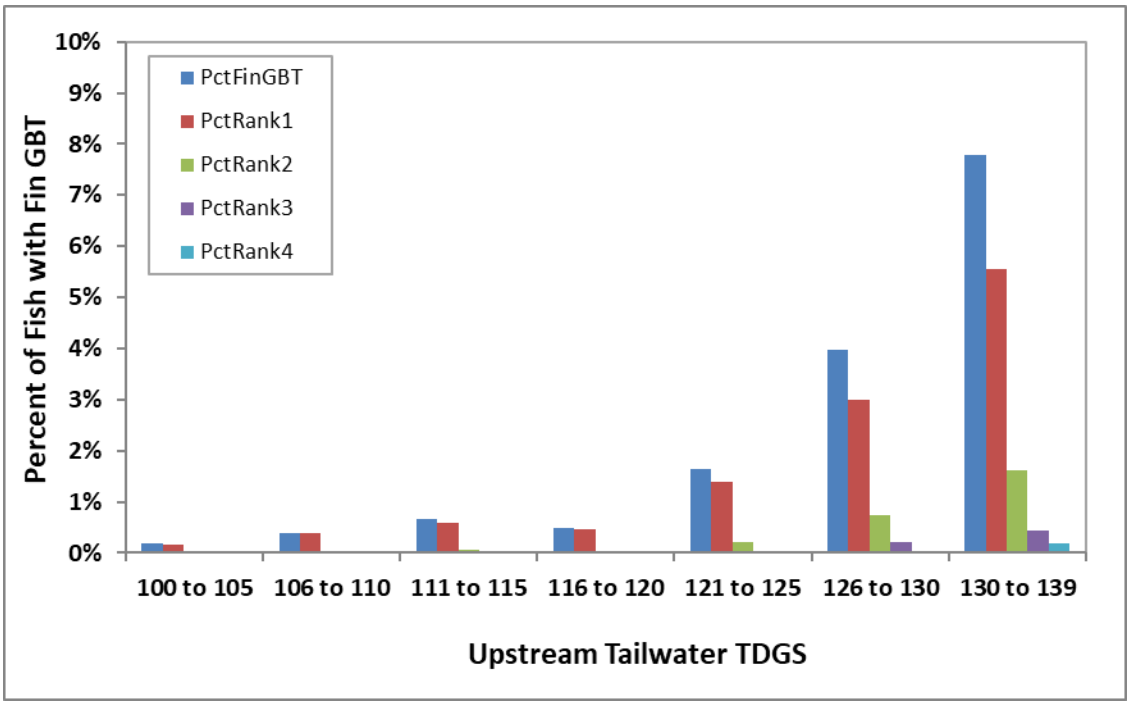
Figure H-9
Percent GBT observed as a function of TDG observed in upstream tailrace in 1996-2021 (black circles) and 2022 (yellow circles).



* 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 at LGS.

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 H-10). From Figure H-10 two things are apparent. First, the incidence of fish observed with signs of fin 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 fin 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 H-10
Percent of all fish collected from 1996–2022 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 2022 migration season. In accordance with operations outlined by the 2022 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. Flows in the Lower Snake and Mid-Columbia rivers were low for all of April through the first half of May and spill levels did not reach the 125% TDG spill caps until the second half of May and June. Due to high flows and/or lack of market conditions in June, TDG exceeded the 125% tailrace standard at times.

For both the salmonid and non-salmonid GBT samples, the action criterion of 15% fin GBT was never met in 2022. In addition, the action criterion of 5% severe fin GBT was also never met in 2022. The highest GBT incidence rate observed in salmonids in 2022 was 7.0%, which occurred on two occasions at Bonneville Dam (May 29th and June 22nd). The highest GBT incidence rate observed in the USGS non-salmonid monitoring program in the spring was 8.6%, which occurred on May 2nd in the McNary tailrace. The highest GBT incidence rate observed in the SMP non-salmonid monitoring program was 33.3%, which occurred on July 14th at Bonneville Dam. However, it should be noted that this

incidence rate is based on one fish exhibiting signs of fin GBT, out of only three total fish examined.

Data collected over the past 27 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%.

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