Appendix B

Gas Bubble Trauma Monitoring and Data Reporting for 2023

Fish Passage Center
Portland, Oregon

Gas Bubble Trauma Monitoring and Data Reporting for 2023

Executive Summary

In 2023, 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 SMP 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 but by early May, flows had increased in the Snake River so spill to the 125% tailrace TDG standard was possible, and sometimes exceeded. Occasional exceedances of the 125% tailrace TDG standard at some sites in May were generally due to involuntary spill that mostly resulted from high flows, lack of market conditions, and/or temporary reductions in powerhouse capacity due to unit outages (e.g., Little Goose Dam).

Among the salmonid GBT samples, the action criteria for reducing voluntary spill, due to GBT incidence rates, were never met during the 2023 spring or summer spill seasons. The highest salmonid GBT incidence rate observed by SMP personnel in 2023 was 13.0%, which occurred on May 17th at Bonneville Dam.

However, among the USGS non-salmonid GBT samples, the action criteria were exceeded on three separate occasions during the spring spill season. The first occasion occurred on May 9th in the sample conducted below Ice Harbor Dam. The GBT incidence rate on that occasion was 26.4% among native non-salmonids. The second occasion occurred on May 30th, again in the sample below Ice Harbor Dam. The GBT incidence rate for the sample on May 30th was 15.4% among native non-salmonids. Each of these occasions resulted in a one-week reduction in gas cap spill (to the 115%/120% TDG standard) at Little Goose, Lower Monumental, and Ice Harbor dams. The first occasion also led to a reduction in spill at Lower Granite Dam, but this reduction only lasted for one day. The third occasion occurred on May 18th in the sample below Bonneville Dam. On this occasion, it was the 5% severe GBT criterion that was exceeded, with an incidence rate of 5.3% for severe GBT. However, spill in the Middle Columbia River could not be reduced as a result of this exceedance, as Bonneville Dam was in involuntary spill operations at the time.

In the summer, the SMP non-salmonid monitoring program at McNary and Bonneville dams conducted five total non-salmonid samples and no signs of GBT were observed in these samples.

Analyses of salmonid GBT data over the last 28 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). These data are reviewed in-season to determine if modifications to spill are necessary based on the GBT monitoring.

In 2023, 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. 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 was terminated prior to the end of August because of high temperatures, generally low TDG, 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. Examined fish at LGR, LGS, LMN, and MCN were netted at the separator. Due to the configuration of the collection system at BON, sampling at the separator is not possible. Therefore, examined fish at BON are taken from the sample tank. 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 Middle Columbia River sites and one day a week at each of the Snake River sites throughout the spring and summer spill seasons. Table B-1 provides the frequency, duration, and method of collection for the salmonid GBT Monitoring Program, under the current protocol.

Table B-1
Summary of salmonid GBT Monitoring sampling schedule in spring and summer, 2023

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 2023 followed the same protocol that was issued in 2015. For more detailed information on the examination procedure, the 2023 GBT Monitoring Protocol is available on the FPC website (FPC 2023).

Non-Salmonid GBT Monitoring

In the spring of 2023, the U.S. Geological Survey (USGS) conducted GBT monitoring on non-salmonids in the tailraces of four FCRPS projects: LGR, Ice Harbor (IHR), MCN, and BON. 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. Detailed instructions for the non-salmonid monitoring personnel were included in the 2023 GBT Monitoring Protocol (FPC 2023).

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 Middle Columbia during the summer. Therefore, SMP crews at MCN and BON 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 2023 GBT Sampling Protocol (FPC 2023).

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 B-2). Additional information was recorded for each fish during the examination, including species, age, fork length, fin clips, and tags present.

Table B-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

GBT Action Criteria and Sample Size Targets

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, Table B-2). It should be noted that the action criteria specifically mention fin GBT. Therefore, signs of GBT

that were observed in eyes or non-protocol areas (e.g., head, paired fins, body, etc.) 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 2007). Similar lab studies have not been conducted on non-salmonid species. The impacts of GBT on non-salmonids are assumed to be the same as salmonids. In the absence of comparable lab studies for non-salmonids, the salmonid GBT action criteria also apply to the non-salmonid samples.

The state water quality agencies have different specifications for which non-salmonid species should be included when assessing the above-mentioned action criteria. The Washington Department of Ecology (WDOE) specifies that the GBT action criteria pertain to only native non-salmonid species. The Oregon Department of Environmental Quality (ODEQ) specifies that the GBT action criteria apply to all non-salmonid species. The Snake River sites (below LGR and IHR) are in the state of Washington so only the WDOE specification applies to these sites. The Mid-Columbia sites (below MCN and BON) are on the border and, therefore, the most restrictive of the WDOE and ODEQ specifications apply to these sites. Therefore, summaries of non-salmonid GBT data for Snake River sites are presented under the WDOE specification while summaries for the Middle Columbia sites are presented under both specifications.

As mentioned above, both the salmonid and non-salmonid GBT monitoring programs have a target sample size of 100 examined fish per GBT sample. The 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, sample sizes are summarized in three ways. First, sample sizes are evaluated as to whether they met the target of 100 fish per sample. Second, samples sizes are evaluated as to whether they met a minimum target of 50 fish per sample. Finally, sample sizes are evaluated as to 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.

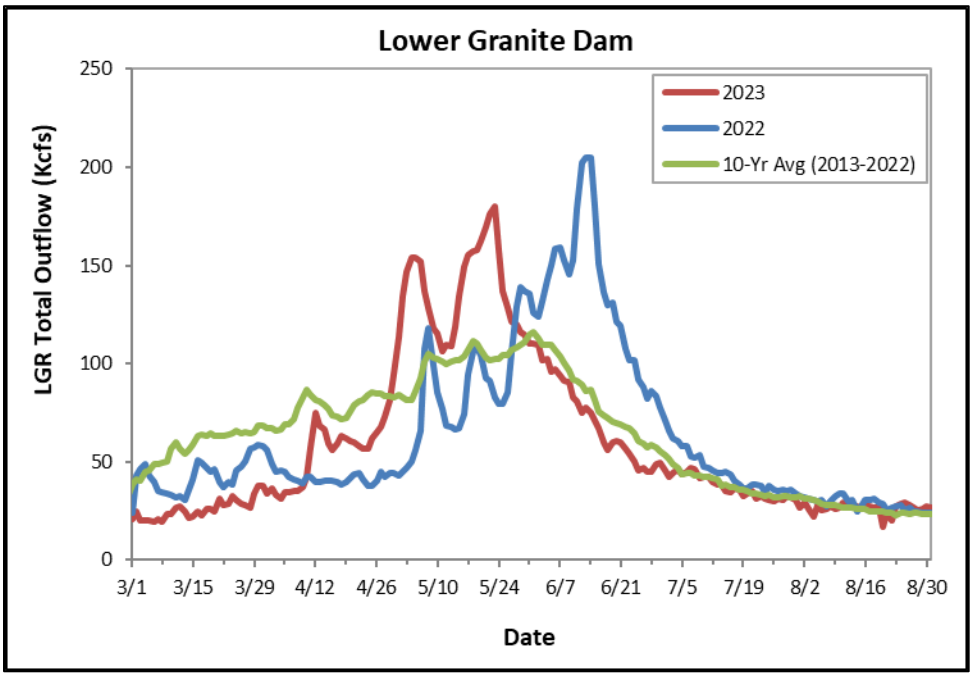
2023 Water Conditions and Spill Operations

The runoff volume (January–July) for the 2023 water year was below average in the Middle Columbia and Snake rivers. Runoff (January–July) was 77% of average (1991–2020) at The Dalles Dam (TDA) and 85% of average at LGR. To put the runoff volumes into perspective, the 2023 January–July runoff volumes at TDA and LGR were ranked 68th and 57th, respectively, over the last 75 years (1949–2023).

In 2023, runoff in the Snake River followed a more typical shape, with peak flows in May (Figure B-1). However, flows in March, April, and June were below the current

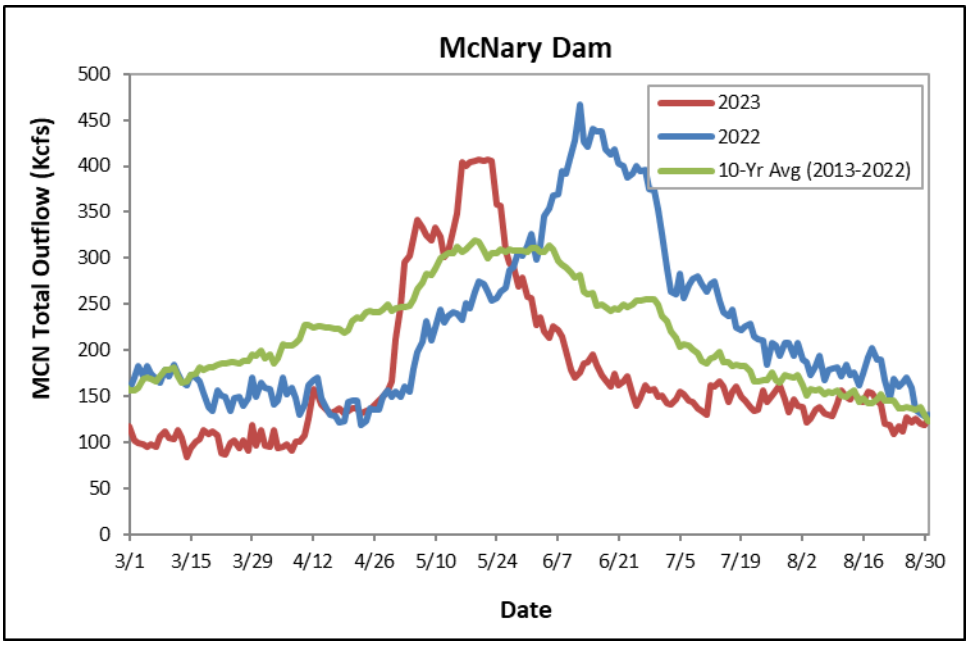
10-year average. From April 30th through May 30th daily average flows at LGR were above the current 10-year average (Figure B-1). Daily average flows at LGR peaked on May 23rd, at 180 Kcfs. Given the 125% tailrace TDG standard that was implemented during the spring spill season, flows in April and much of June 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). From April 30th through June 7th, flows were generally high enough to meet spill to the spill caps. In fact, there were some periods in mid-May when spill exceeded the 125% TDG spill cap, due to periods of involuntary spill.

Figure B-1.
Average daily flows at Lower Granite Dam in 2023, 2022, and the 10-year average



Peak runoff in the Middle Columbia River also occurred in May, similar to the current 10-year average (Figure B-2). Like the Snake River, March, April, and June flows were below the current 10-year average while flows were above the 10-year average for most of May (Figure B-2). Flows at MCN peaked on May 22nd, at approximately 407 Kcfs. Given the 125% tailrace TDG standard that was implemented during the spring, flows in 2023 were too low to spill to the site-specific 125% TDG spill caps for the month of April and much of June. Therefore, spill was limited to minimum generation, spill the rest operations. By early May, flows in the Mid-Columbia were high enough that spill met 125% TDG spill caps (where applicable). In fact, by mid-May, flows were so high that spill often exceeded the 125% TDG spill cap, due to periods of involuntary spill.

Figure B-2
Average daily flows at McNary Dam in 2023, 2022, and the 10-year average



On March 27, 2023, the 2023 Fish Operations Plan (FOP) was issued. The 2023 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 B-3). The 2023 FOP followed an extension of 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 of 2019-2021. Like in 2022, flex spill operations in 2023 occurred at only four projects (LGR, LGS, LMN, and John Day (JDA); Table B-3). Spill operations at the other four projects were 24-hour operations, with spill to the 125% tailrace TDG spill cap (IHR and MCN), an instantaneous spill proportion (TDA), or spill to a maximum FOP level (BON; Table B-3).

When compared to 2022, the 2023 FOP had one modification, which was at LMN. Unlike previous years, the performance standard spill operation at LMN was to spill to 40% of instantaneous flows. Performance standard spill in previous years was to spill to a set volume of 30 Kcfs.

Table B-3

2023 spring and summer spill operations at Snake and Mid-Columbia FCRPS projects under the 2023 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 16-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 ~7 Kcfs[7]
LMN	125% Gas Cap (24 hours)	**Flex Spill:** 40% 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, 2023.

[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. If a second block is needed, it will start as soon as load conditions allow, continue for at least two hours, and conclude no later than 2000 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 should be drafted over the remaining hours by increasing spill to pass inflow from 1200-1600, then increasing spill as necessary from 1600-0400 to draft the pool back to MOP. If it is forecasted that the drafting spill will result in exceeding 130% TDG in the tailrace, all 16 hours will be used to return the pool to MOP. In lack of load conditions, performance standard spill blocks will be prioritized at Little Goose, Lower Monumental, and Lower Granite dams, in that order.

[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 2023 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.

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 Technical Management Team (TMT) website (http://pweb.crohms.org/tmt/documents/ops/spill/caps/).

Under the 2023 FOP, summer spill operations remained the same as what has occurred for the last three years (Table B-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 2023. 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, 8,914 juvenile salmonids were examined for GBT between April and August of 2023, as part of the salmonid GBT monitoring program under the SMP (Table B-4). Of these, approximately 48% were yearling Chinook, 16% were subyearling Chinook, and 37% were steelhead.

Table B-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 2023 as part of the Smolt Monitoring Program.

Species	BON	MCN	LMN	LGS	LGR	Total
Chinook Subyearlings	1,331	1,531	539	845	0	**4,246**
Chinook Yearlings	1,026	1,044	408	371	434	**3,283**
Steelhead	83	262	339	306	395	**1,385**
Total	**2,440**	**2,837**	**1,286**	**1,522**	**829**	**8,914**

Table B-5

Number of non-salmonids 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 2023 spring spill season. Data are sorted by total sampled, in descending order. Shaded rows indicate non-native species.

Species	BON	MCN	IHR	LGR	Total
Sculpin	777	799	547	610	**2,733**
Northen Pikeminnow	31	121	547	89	**788**
Smallmouth Bass	35	203	103	86	**427**
Peamouth	0	0	0	274	**274**
Banded Killifish	52	6	55	0	**113**
Three-spined Stickleback	92	12	0	0	**104**
Largemouth Bass	2	3	37	32	**74**
Yellow Perch	5	28	22	0	**55**
Loach	41	0	0	0	**41**
Bullhead	0	16	17	3	**36**
Sucker, Other	5	4	4	16	**29**
Dace, Unidentified Species	1	23	0	0	**24**
Goby	21	0	0	0	**21**
Mountain Whitefish	0	0	12	0	**12**
Dace, Speckled	1	4	0	0	**5**
Chiselmouth	0	0	0	4	**4**
Dace, Long-nosed	1	2	0	0	**3**
Crappie, Species	0	0	2	0	**2**
Madtom	0	0	2	0	**2**
Redside Shiner	0	2	0	0	**2**
Pacific Lamprey ammocoete	0	0	1	0	**1**
Brook Lamprey adult	1	0	0	0	**1**
Grand Total	**1,065**	**1,223**	**1,349**	**1,114**	**4,751**

A total of 4,751 non-salmonids were examined by the USGS for the non-salmonid GBT monitoring program during the spring spill season (Table B-5). Of these, 3,980 (84%) were native species. Over the entire spring spill season, 22 different non-salmonid species were sampled, of which 13 were native species. The most common non-salmonid species collected and examined were sculpin and northern pikeminnow. These two species

represented approximately 58% and 17% of the total non-salmonids examined in 2023, respectively. The third and fourth most common non-salmonid species were smallmouth bass and peamouth, which represented approximately 9% and 6% of the non-salmonids examined in 2023, respectively. Collectively, these four species of non-salmonids represented approximately 89% of the total non-salmonids examined. Unlike past years, the non-salmonid GBT monitoring program did not examine any incidentally collected salmonids in 2023.

Among the 4,751 total non-salmonids that were examined by the USGS in spring 2023, 4,485 (94%) were collected through electrofishing while the remaining 266 (6%) were collected with purse seines. Examinations from seined fish only occurred at three sites (below BON, below IHR, and below LGR) and the vast majority (83%) of examined fish that were collected via seine were examined below LGR.

Finally, under the summer non-salmonid monitoring program mandated by ODEQ, 15 total non-salmonids, across five different species, were examined by the SMP crews at BON and MCN (Table B-6). Of these, seven were collected at BON and eight were collected at MCN. In all, five different non-salmonid species were sampled by these SMP crews. The most common non-salmonid species collected and examined juvenile Pacific lamprey (i.e., macropthalmia), which represented approximately 53% of the non-salmonids examined by the SMP crews at BON and MCN.

Table B-6

Number of non-salmonids collected and examined for signs of GBT by SMP crews at McNary and Bonneville dams, during the 2023 summer spill season. Data are sorted by total sampled, in descending order. Shaded rows indicate non-native species.

Species	BON	MCN	Total
Pacific Lamprey Macropthalmia	4	4	8
Smallmouth Bass	1	2	3
Shad, Juvenile	0	2	2
Northern Pikeminnow	1	0	1
Yellow Perch	1	0	1
Total Non-Salmonids	**7**	**8**	**15**

Of the 8,914 total salmonids that were examined by SMP crews at FCRPS projects in 2023, signs of fin GBT were observed in 95 individuals (1.07%, Table B-7). Of these, 74 (78%) had a maximum of Rank 1 signs. Sixteen total salmonids (17%) had a maximum of Rank 2 signs and five fish (5%) had a maximum of Rank 3 signs. Fish with Rank 3 or Rank 4 signs are considered to exhibit severe signs of GBT. Therefore, five total salmonids examined in 2023 exhibited signs of severe GBT.

Table B-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 2023 as part of the Smolt Monitoring Program.

Species	Fin GBT by Site					Grand Total
	BON	MCN	LMN	LGS	LGR	
Chinook Subyearlings	4	13	3	11	0	**31**
Chinook Yearlings	31	2	9	9	1	**52**
Steelhead	2	0	6	2	2	**12**
Total	**37**	**15**	**18**	**22**	**3**	**95**

Table B-8

Number of non-salmonids observed with fin GBT from exams conducted by the USGS non-salmonid GBT monitoring crew in the Lower Snake and Mid-Columbia rivers during the 2023 spring spill season. Data are sorted by total observations of fin GBT, in descending order. Shaded rows indicate non-native species.

Species	BON	MCN	IHR	LGR	Total
Sculpin	17	44	54	19	**134**
Peamouth	0	0	0	10	**10**
Smallmouth Bass	1	2	4	2	**9**
Northern Pikeminnow	0	0	6	1	**7**
Largemouth Bass	0	0	0	2	**2**
Loach	2	0	0	0	**2**
Bullhead	0	0	1	0	**1**
Crappie, Species	0	0	1	0	**1**
Sucker, Species	0	0	0	1	**1**
Pacific lamprey ammocoete	0	0	0	0	**0**
Banded Killifish	0	0	0	0	**0**
Chiselmouth	0	0	0	0	**0**
Goby	0	0	0	0	**0**
Dace, Long-nosed	0	0	0	0	**0**
Brook lamprey adult	0	0	0	0	**0**
Madtom	0	0	0	0	**0**
Mountain Whitefish	0	0	0	0	**0**
Yellow Perch	0	0	0	0	**0**
Shiner, Redside	0	0	0	0	**0**
Dace, Speckled	0	0	0	0	**0**
Three-spined Stickleback	0	0	0	0	**0**
Dace, Unidentified Species	0	0	0	0	**0**
Grand Total	**20**	**46**	**66**	**35**	**167**

Of the 4,751 total non-salmonids that were examined by USGS in 2023, 167 (3.52%) had signs of fin GBT (Table B-8). Of these, 108 (65%) had a maximum of Rank 1 signs of fin GBT, 34 (20%) had maximum Rank 2 signs, 11 (7%) had maximum Rank 3

signs, and 14 (8%) had maximum Rank 4 signs. As mentioned above, 3,980 of the non-salmonids that were examined for GBT in 2023 were native species. Of these, 152 (3.82%) had signs of fin GBT (Table B-8); 95 (63%) of which had a maximum of Rank 1 signs of fin GBT, 34 (22%) had a maximum Rank 2 signs, 10 (7%) had a maximum Rank 3 signs, and 13 (9%) had a maximum Rank 4 signs.

The most common non-salmonid species exhibiting signs of fin GBT were sculpin. In fact, sculpin made up approximately 80% of all signs of fin GBT in 2023, even though they comprised only 58% of the total non-salmonids examined. The second most common non-salmonid species exhibiting signs of fin GBT were peamouth, which represented approximately 6% of all signs of fin GBT.

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.

Finally, no signs of fin GBT were observed among the 15 total non-salmonids that were collected and examined for GBT by the SMP crews at Bonneville and McNary dams in the summer of 2023.

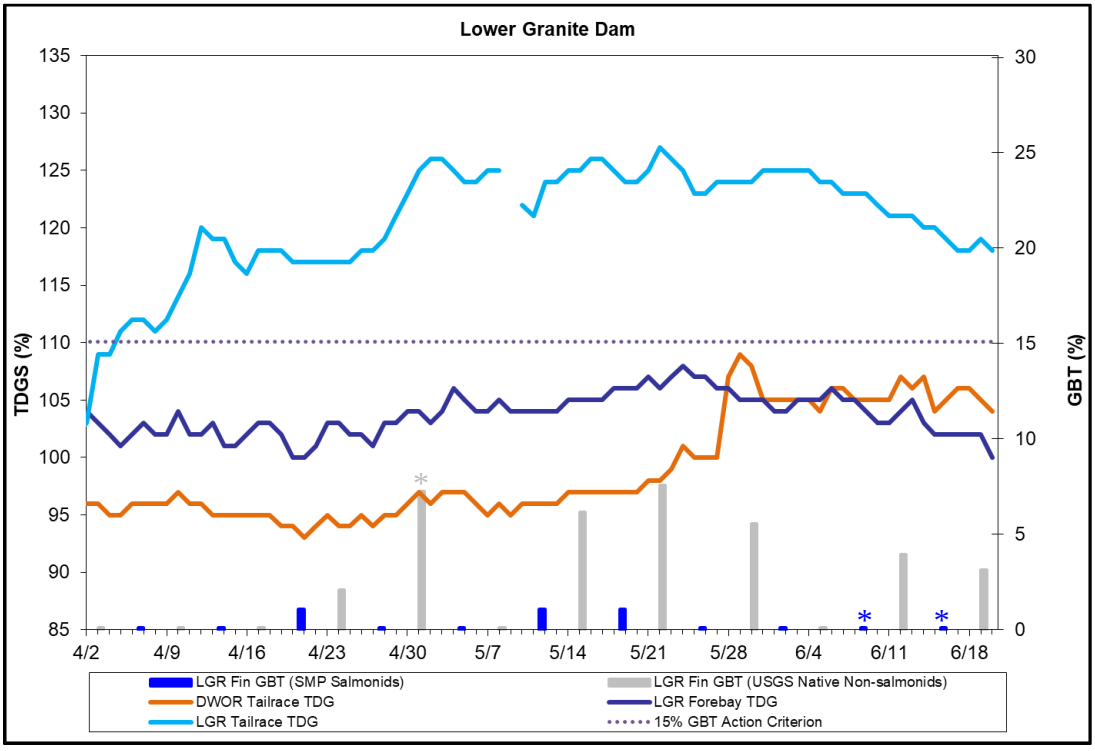
A more detailed breakdown of salmonid and non-salmonid GBT exams and signs for 2023 can be found in Tables B-10 through B-19.

Lower Granite Dam (LGR)

The 12-hour average TDG in the Dworshak Dam (DWR) tailrace never exceeded 110% in the spring of 2023 (Figure B-3). The 12-hour average TDG in the LGR forebay also never exceeded 110% during the spring spill season. The 12-hour average TDG in the LGR tailrace exceeded the 125% tailrace TDG standard for a total of six days during the spring spill season (May 2-3, May 16-17, and May 22-23; Figure B-3). The last of these instances (May 22-23) was due to high flows and the need to spill above the 125% TDG spill cap (i.e., involuntary spill) during periods of high flows and hydraulic capacity and/or lack of market conditions. The maximum 12-hour average TDG over these six days was 127%, which occurred on May 22nd (Figure B-3).

Figure B-3

Percent GBT observed in the SMP salmonid (blue bars) and USGS native non-salmonid (grey bars) GBT 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 2023.



Notes: 1) GBT incidence bars that appear to be slightly above zero are zeros, to illustrate that samples were conducted on those days and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met (See Tables B-9 and B-10 for details).

Salmonids

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 7th and ran through June 16th. In all, 11 total salmonid GBT samples were conducted at LGR in 2023. Among these 11 GBT samples, 829 target salmonids were examined and three total fish exhibited signs of fin GBT. Signs of fin GBT were observed in three of the 11 total samples at LGR: April 21st, May 12th, and May 19th (Figure B-3, Table B-9). In all three instances, GBT incidence rates were 1% and all signs of fin GBT observed were Rank 1.

The target sample size of 100 salmonids examined per GBT sample was met in all but five salmonid GBT samples (Table B-9). The minimum sample target of 50 fish per salmonid GBT sample was met in all but the last two 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.

Table B-9
Detailed breakdown of salmonid GBT exams and signs of fin GBT at Lower Granite Dam in 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/7/2023	84	0	0.0%
4/14/2023	79	0	0.0%
4/21/2023	100	1	1.0%
4/28/2023	100	0	0.0%
5/5/2023	100	0	0.0%
5/12/2023	101	1	1.0%
5/19/2023	100	1	1.0%
5/26/2023	100	0	0.0%
6/2/2023	56	0	0.0%
6/9/2023	7	0	0.0%
6/16/2023	2	0	0.0%

Non-Salmonids

The LGR tailrace was used as one of the non-salmonid GBT monitoring sites for the USGS program. Non-salmonid GBT sampling below LGR occurred once per week, from April 3rd through June 19th. Twelve total non-salmonid GBT samples were conducted in the LGR tailrace. Since LGR is in the state of Washington, the non-salmonid GBT action criteria pertain to native non-salmonids and, therefore, data presented here are for native non-salmonids only.

Native Non-Salmonids

Among the 12 non-salmonid GBT samples conducted below LGR in spring 2023, 993 total native non-salmonids were examined and 31 individuals exhibited signs of fin GBT (Table B-10). In all, five total species of native non-salmonids were sampled and examined below LGR. The most common species sampled below LGR was the sculpin, which represented approximately 61% of the total native non-salmonids examined at this site. Of the 31 native non-salmonids that exhibited signs of fin GBT, 19 were sculpin, 10 were peamouth, one was a northern pikeminnow, and one was a sucker.

Of the 12 total GBT samples, seven had at least one native non-salmonid with signs of fin GBT (Figure B-3, Table B-10). The GBT incidence rates among native species for these seven samples ranged from 2.0% to 7.5%. The highest GBT incidence rate of 7.5% occurred on May 22nd, which coincided with the highest tailrace TDG levels of the season and were the result of involuntary spill due to high flows. Signs of severe fin GBT (i.e., Rank 3 or 4) were observed on three occasions at LGR (May 1st, May 15th, and May 30th). The incidence rates for severe fin GBT were below the 5% action criterion on all three occasions (Range: 0.9%-2.4%). All instances of severe GBT observed at LGR were observed in sculpin.

Table B-10
Detailed breakdown of native non-salmonid GBT exams conducted by USGS below Lower Granite Dam in spring of 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A]	Number with Non-Protocol GBT
4/3/2023	65	0	0.0%	NP, PM, SC	0
4/10/2023	56	0	0.0%	NP, PM, SC	0
4/17/2023	65	0	0.0%	NP, PM, SC, SU	0
4/24/2023	101	2	2.0%	CM, NP, PM, SC, SU	0
5/1/2023	42	3	7.1%	NP, PM, SC	2
5/8/2023	71	0	0.0%	NP, PM, SC, SU	0
5/15/2023	99	6	6.1%	NP, PM, SC, SU	4
5/22/2023	107	8	7.5%	NP, PM, SC	1
5/30/2023	110	6	5.5%	NP, PM, SC, SU	4
6/5/2023	107	0	0.0%	NP, PM, SC	0
6/12/2023	104	4	3.8%	NP, PM, SC, SU	1
6/19/2023	66	2	3.0%	NP, PM, SC, SU	0

[A] Native non-salmonid Species Codes: CM = Chiselmouth, NP = Northern Pikeminnow, PM = Peamouth, SC = Sculpin, and SU = Sucker Sp.

The target sample size of 100 native non-salmonids examined per GBT sample was met in only five of the 12 total samples from below LGR (Table B-10). The minimum target sample size of 50 native non-salmonids examined per GBT sample was met in all but one sample (May 1st). 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 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 native non-salmonid GBT samples below LGR. Bubbles in non-protocol locations do not count towards the GBT monitoring action criteria. A total of 12 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations (Table B-10). Of these, 10 were sculpin and the remaining two were peamouth. The observations of bubbles in non-protocol locations were spread out over five of the 12 samples conducted below LGR.

Finally, of the 993 total native non-salmonids collected and examined from below LGR, 777 (78%) were collected through backpack electrofishing and 216 (22%) were collected through purse seines. Of the 31 native non-salmonids that exhibited signs of fin GBT, 19 were collected with backpack electrofishing and 12 were collected with purse seines. Of the 12 non-salmonids that were observed with bubbles in non-protocol locations, and no signs of fin GBT, nine were collected with electrofishing and three were collected with a purse seine.

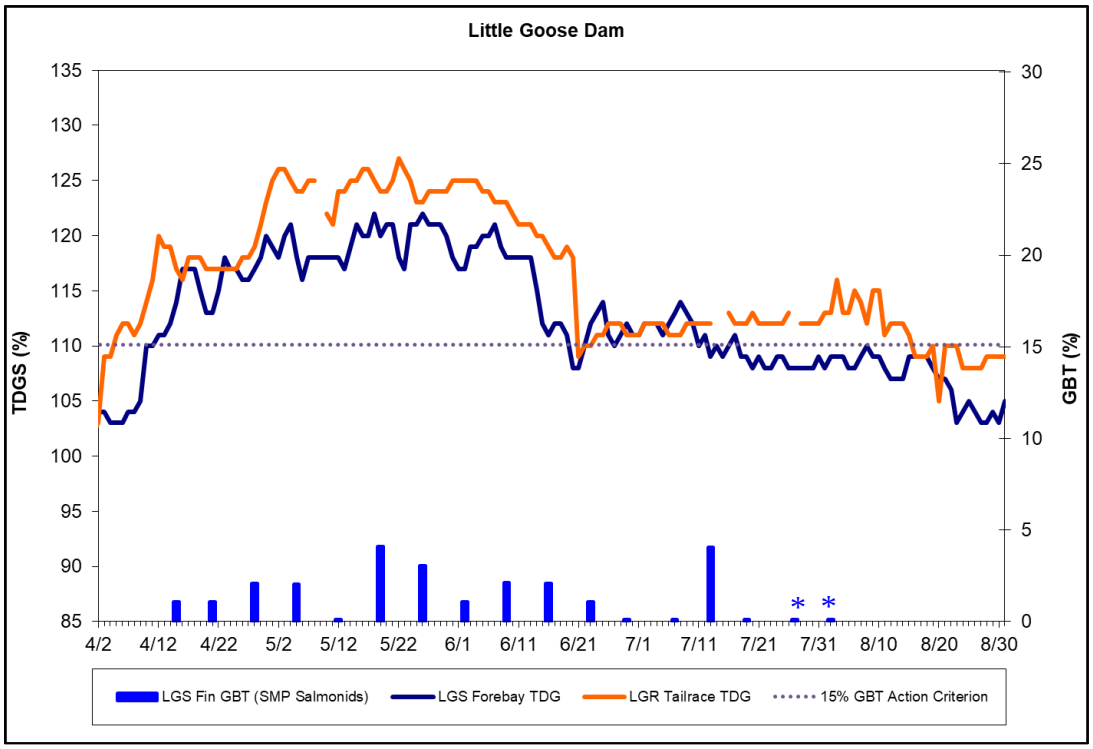
Little Goose Dam (LGS)

Over the spring spill period, 12-hour average TDG levels in the LGR tailrace exceeded the 125% tailrace TDG standard for a total of six days (May 2-3, May 16-17, and May 22-23; Figure B-4). The last of these instances (May 22-23) was due to the need to spill above the 125% TDG spill cap (i.e., involuntary spill) due to high flows and hydraulic capacity and/or lack of market conditions. The maximum 12-hour average TDG over these six days was 127%, which occurred on May 22nd (Figure B-4).

During the summer spill period (June 21-August 31), TDG levels in the LGR tailrace never exceeded the 120% tailrace TDG standard (Figure B-4). The forebay monitor was not a point of compliance until June 21st, when the summer spill season started. The 115% forebay standard was also never exceeded in the LGS forebay during the summer spill season.

Figure B-4

Percent GBT observed in the SMP salmonid samples (bars) at Little Goose Dam and 12-hour average TDG at the Lower Granite tailrace (orange line) and Little Goose forebay (dark blue line) in 2023.



Notes: 1) GBT incidence bars that appear to be slightly above zero are zeros, to illustrate that samples were conducted on those days and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met (see Table B-11 for details).

Salmonids

Gas Bubble Trauma monitoring for salmonids at LGS occurred from April 15th to August 2nd. Salmonid GBT sampling at LGS was terminated after the sample on August

2nd, due to decreased sample sizes, elevated temperatures, and generally low TDG levels at that time.

Seventeen total salmonid GBT samples were conducted at LGS in 2023. Among the 17 GBT samples at LGS, 1,522 total salmonids were examined for GBT and 22 total fish had signs of fin GBT (Table B-11). Among the fish with signs of fin GBT, 20 (91%) had Rank 1 signs, one (4.5%) had Rank 2 signs, and one (4.5%) had Rank 3 signs. Among the 17 total salmonid samples at LGS, 11 had at least one fish with signs of fin GBT (Figure B-4 and Table B-11). The GBT incidence rates for these 11 salmonid samples ranged from 1.0% to 4.0% with the highest rate occurring on May 19th. Total dissolved gas in the Lower Granite tailrace had been in the 124%-126% range over the week prior to this sample on May 19th (Figure B-4). Severe GBT was observed on one occasion (May 26th). In this case, the incidence rate for severe GBT was 1.0%.

Table B-11
Detailed breakdown of salmonid GBT exams and signs of fin GBT at Little Goose Dam in 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/15/2023	100	1	1.0%
4/21/2023	100	1	1.0%
4/28/2023	101	2	1.98%
5/5/2023	102	2	2.0%
5/12/2023	100	0	0.0%
5/19/2023	100	4	4.0%
5/26/2023	101	3	3.0%
6/2/2023	101	1	1.0%
6/9/2023	99	2	2.0%
6/16/2023	50	1	2.0%
6/23/2023	102	1	1.0%
6/29/2023	100	0	0.0%
7/7/2023	101	0	0.0%
7/13/2023	101	4	4.0%
7/19/2023	95	0	0.0%
7/27/2023	46	0	0.0%
8/2/2023	23	0	0.0%

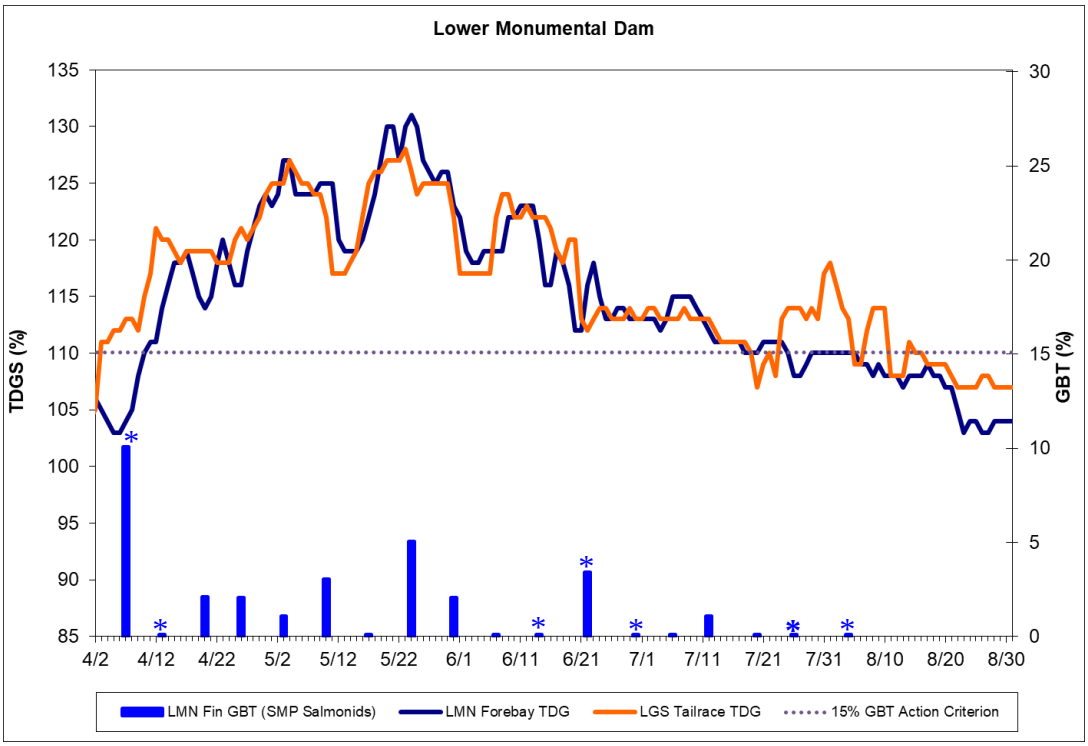
The target sample size of 100 salmonids examined per GBT sample was met in 12 of the 17 total samples at LGS (Table B-11). The minimum sample size target of 50 salmonids per week was met in all but two samples (Table B-11). Finally, when considered collectively with LGR and LMN, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met in the Snake River Zone all spring spill season. There was one week in the summer (July 30-August 5) when the minimum sample size of 50 salmonids per week was not met in the Snake River Zone. This was the last week that salmonid GBT monitoring occurred in the Snake River Zone, as sampling was terminated due a combination of low sample sizes, elevated temperatures, and generally low TDG levels.

Lower Monumental Dam (LMN)

Over the spring spill season, 12-hour average TDG levels in the LGS tailrace exceeded the 125% tailrace standard for nine total days (May 3-4 and May 18-24; Figure B-5). The exceedances that occurred from May 18th through May 24th were due to high flows and unit outages that lead to decreased hydraulic capacity and, therefore, a need for involuntary spill. The maximum 12-hour average TDG in the LGS tailrace was 128%, which occurred on May 23rd (Figure B-5).

Figure B-5

Percent GBT observed in the SMP salmonid samples (bars) at Lower Monumental Dam and 12-hour average TDG at the Little Goose tailrace (orange line) and Lower Monumental forebay (blue line) in 2023.



Notes: 1) GBT incidence bars that appear to be slightly above zero are zeros, to illustrate that samples were conducted on those days and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met (see Table B-12 for details).

During the summer spill period (June 21-August 31), TDG levels in the LGS tailrace never exceeded the 120% tailrace TDG standard (Figure B-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 two total days of the summer spill season. These exceedances of the forebay standard were both in the beginning of the summer spill season (June 22-23) and were likely due to TDG from the last few days of the spring spill operations at LGS. By June 24th, the 12-hour average TDG in the LMN forebay was at or below 115%, where it remained for the rest of the summer spill season.

Salmonids

Only salmonid GBT monitoring occurred at LMN in 2023, under the SMP. Salmonid GBT sampling at LMN occurred from April 7th to August 4th. Sampling was terminated after the sample on August 4th 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, 18 total GBT samples were conducted at LMN in 2023. Of these 18 GBT samples at LMN, 1,286 total salmonids were examined for GBT and 18 total fish had signs of fin GBT (Table B-12). Among the fish with signs of fin GBT, 17 (94%) had Rank 1 signs and one (6%) had Rank 2 signs.

Among the 18 total salmonid GBT samples conducted, nine had at least one salmonid exhibiting signs of fin GBT (Figure B-5, Table B-12). GBT incidence rates among these nine samples ranged from 1.0% to 10.0%, with the highest GBT incidence occurring in the first sample (April 10th). However, it should be noted that the sample on April 10th did not meet minimum sample size requirements, as only 10 fish were examined. Among the samples that met minimum sample size requirements, the highest GBT incidence rate was 5.0%, which occurred on May 24th. Total dissolved gas in the LGS tailrace had been in the 125%-128% range over the week prior to this sample.

Table B-12

Detailed breakdown of salmonid GBT exams and signs of fin GBT at Lower Monumental Dam in 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/7/2023	10	1	10.0%
4/13/2023	19	0	0.0%
4/20/2023	100	2	2.0%
4/26/2023	102	2	2.0%
5/3/2023	100	1	1.0%
5/10/2023	102	3	2.9%
5/17/2023	100	0	0.0%
5/24/2023	101	5	5.0%
5/31/2023	101	2	2.0%
6/7/2023	101	0	0.0%
6/14/2023	27	0	0.0%
6/22/2023	30	1	3.3%
6/30/2023	44	0	0.0%
7/6/2023	102	0	0.0%
7/12/2023	101	1	1.0%
7/20/2023	104	0	0.0%
7/26/2023	41	0	0.0%
8/4/2023	1	0	0.0%

The target sample size of 100 salmonids examined per GBT sample was met in 11 of the 18 total GBT samples at LMN (Table B-12). The minimum sample size target of 50 salmonids per week was met in all but seven samples in 2023 (Table B-12, Figure B-5).

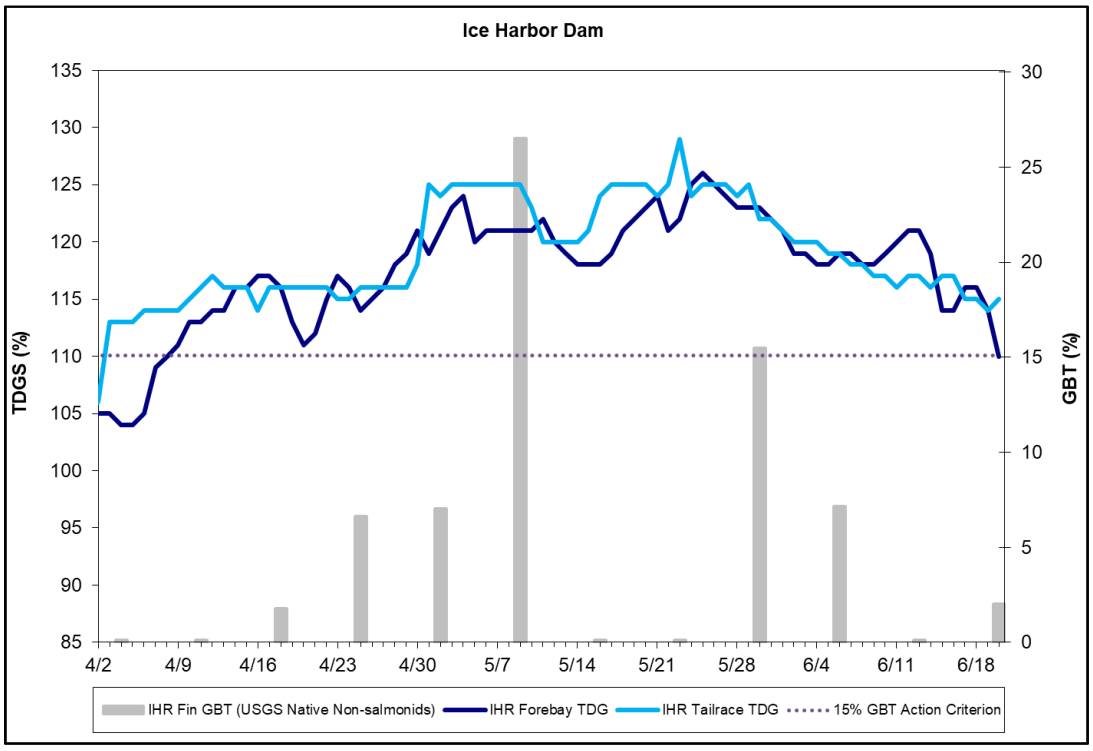
Finally, when considered collectively with LGR and LGS, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met in the Snake River Zone all spring spill season. There was one week in the summer (July 30-August 5) when the minimum sample size of 50 salmonids per week was not met in the Snake River Zone. This was the last week that salmonid GBT monitoring occurred in the Snake River Zone, as sampling was terminated due a combination of low sample sizes, elevated temperatures, and generally low TDG levels.

Ice Harbor Dam (IHR)

Total dissolved gas levels in the IHR tailrace exceeded the 125% tailrace standard for one day in the spring of 2023 (May 23rd; Figure B-6). This exceedance was due to high flows and the need to provide involuntary spill due to hydraulic capacity conditions. The 12-hour average TDG on this single day was 129%.

Figure B-6

Percent GBT observed in the USGS native non-salmonid (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 2023.



Note: 1) GBT incidence bars that appear to be slightly above zero are zeros, to illustrate that samples were conducted on those days (see Table B-13 for details).

Non-Salmonids

Salmonid GBT monitoring does not occur at IHR, as this site is not part of the SMP. However, the IHR tailrace was one of the USGS non-salmonid GBT monitoring sites. Non-salmonid GBT sampling below IHR occurred weekly, from April 4th through June 20th. Twelve total non-salmonid GBT samples were conducted in the IHR tailrace. Since IHR is in the state of Washington, the non-salmonid GBT action criteria pertain to native non-salmonids and, therefore, data presented here are for native non-salmonids only.

Native Non-Salmonids

Among the 12 non-salmonid GBT samples conducted below IHR in spring 2023, 1,111 total native non-salmonids were examined and 60 exhibited signs of fin GBT (Table B-13). In all, five total species of native non-salmonids were sampled and examined below IHR. The most common species sampled below IHR were sculpin and northern pikeminnow, each of which represented approximately 49% of the total native non-salmonids examined at this site. Of the 60 native non-salmonids that exhibited signs of fin GBT, 54 were sculpin and six were northern pikeminnow.

Of the 12 total GBT samples, seven had at least one native non-salmonid with signs of fin GBT (Figure B-6, Table B-13). The GBT incidence rates among native species for these seven non-salmonid samples ranged from 1.7% to 26.4%. The highest GBT incidence rate of 26.4% occurred on May 9th and was above the GBT action criteria of 15% GBT incidence. This triggered a one-week reduction in spill at LGS, LMN, and IHR and a 24-hour reduction at LGR. In the week prior to the sample on May 9th, the 12-hour average TDG in the IHR tailrace had been in the 124%-125% range (Figure B-6). The sample on May 30th also had a GBT incidence rate that exceeded the 15% GBT action criterion which also triggered a one-week reduction in spill at LGS, LMN, and IHR. In this case, the GBT incidence rate among native non-salmonids was 15.4%. On both of these occasions, the vast majority of signs of fin GBT were among sculpin. In the sample from May 9th, 106 total native non-salmonids were examined for GBT and 99 (93%) were sculpin. A total of 28 of these native non-salmonids had signs of fin GBT and all 28 were sculpin. In the sample from May 30th, 52 total native non-salmonids were examined for GBT and 42 (81%) were sculpin. A total of eight native non-salmonids had signs of fin GBT and all but one were sculpin.

Signs of severe fin GBT (i.e., Rank 3 or 4) were observed on four occasions at IHR in 2023 (April 25th, May 2nd, May 9th, and May 30th). The incidence rates for severe fin GBT were below the 5% action criterion on all four occasions (Range: 0.9%-4.7%). All instances of severe GBT observed at IHR were observed in sculpin.

Table B-13
Detailed breakdown of native non-salmonid GBT exams conducted by USGS below Ice Harbor Dam in spring of 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A]	Number with Non-Protocol GBT
4/4/2023	108	0	0.0%	NP, SC	0
4/11/2023	111	0	0.0%	NP, SC	0
4/18/2023	118	2	1.7%	NP, SC	0
4/25/2023	107	7	6.5%	NP, SC	1
5/2/2023	101	7	6.9%	NP, SC, SU	6
5/9/2023	106	28	26.4%	NP, SC	15
5/16/2023	64	0	0.0%	MW, NP, SC, SU	0
5/23/2023	52	0	0.0%	NP, SC	3
5/30/2023	52	8	15.4%	NP, SC	5
6/6/2023	85	6	7.1%	NP, SC, SU	4
6/13/2023	103	0	0.0%	NP, SC	4
6/20/2023	104	2	1.9%	AP, NP, SC	1

[A] Native non-salmonid Species Codes: AP = Pacific Lamprey Ammocoete, MW = Mountain Whitefish, NP = Northern Pikeminnow, SC = Sculpin, and SU = Sucker Sp.

The target sample size of 100 native non-salmonids examined per GBT sample was met in all but four samples from below IHR (Table B-13). The minimum target sample size of 50 native non-salmonids examined per GBT sample was met in all IHR 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 (i.e., locations other than the unpaired fins) in some of the native non-salmonid GBT samples below IHR. Bubbles in non-protocol locations do not count towards the GBT monitoring action criteria. A total of 39 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations (Table B-13). Of these, 38 were sculpin and one was a northern pikeminnow. The observations of bubbles in non-protocol locations were spread out over eight of the 12 samples conducted below IHR.

Finally, of the 1,111 total native non-salmonids collected and examined from below IHR, 1,078 (97%) were collected through backpack electrofishing and 33 (3%) were collected through purse seines. All 60 of the native non-salmonids that exhibited signs of fin GBT below IHR were collected with backpack electrofishing. All 39 of the native non-salmonids that were observed with bubbles in non-protocol locations, and no signs of fin GBT, were collected with electrofishing.

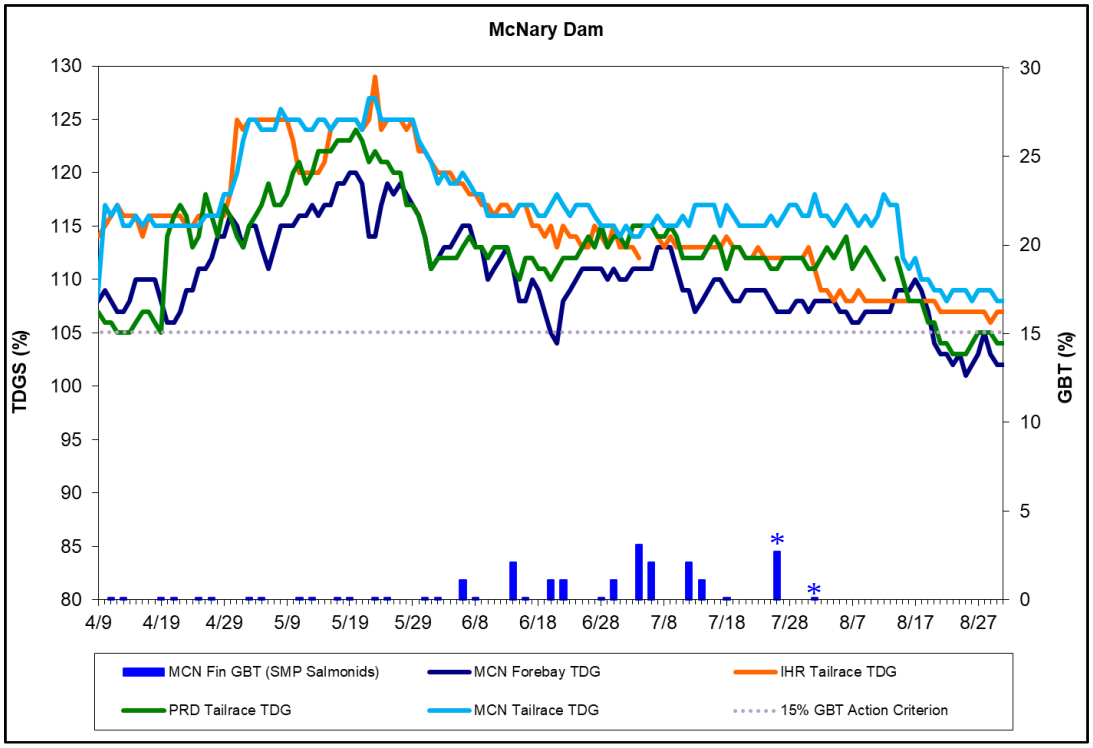
McNary Dam (MCN)

Over the 2023 spring spill period, 12-hour average TDG levels in the IHR tailrace exceeded the 125% tailrace standard on only one occasion (May 23rd; Figure B-7). This

single exceedance was 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 12-hour average TDG in the IHR tailrace on this single occasion was 129%. Spill in the Upper Columbia is managed to the 115%/120% TDG standard. The 12-hour average TDG in the Priest Rapids (PRD) tailrace exceeded 120% for a total of 13 days (May 11th and May 13-25) of spring. The maximum 12-hour average TDG in the PRD tailrace over this 13-day period was 124% (May 20th). Finally, the 12-hour average TDG in the MCN tailrace exceeded 125% for three total days (May 8th and May 22-23; Figure B-7), with a maximum 12-hour average TDG of 127% (May 22-23). The TDG exceedances on May 22nd and May 23rd were due to involuntary spill (i.e., spill above the 125% tailrace TDG standard) due to lack of load conditions.

Figure B-7

Percent GBT observed in the SMP salmonid (bars) GBT 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 2023.



Notes: 1) GBT incidence bars that appear to be slightly above zero are zeros, to illustrate that samples were conducted on those days and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met (see Table B-14 for details)

Over the summer spill season for IHR (June 21-August. 31), TDG levels in the IHR tailrace never exceeded the 120% tailrace TDG standard (Figure B-7). In addition, the 12-hour average TDG in the McNary forebay never exceeded the 115% forebay TDG standard that was in place for the summer spill season.

Salmonids

Salmonid GBT sampling at MCN occurred from April 11th to August 1st (Table B-14). 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 July 13th. At that time, TDG levels in the MCN forebay were below 110% (Figure B-7) and 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 until salmonid GBT monitoring was terminated after the sample on August 1st. Salmonid GBT monitoring was terminated prior to the end of the summer spill season because of a combination of factors, including low TDG levels, decreasing subyearling Chinook passage, and elevated temperatures.

In all, 31 total salmonid GBT samples were conducted at MCN in 2023, with 2,837 total salmonids examined (Table B-14). Among the 37 total salmonid GBT samples, 10 samples had at least one salmonid with signs of fin GBT. When signs of GBT were observed, GBT incidence rates ranged from 1.0% to 3.0%, with the highest incidence rate occurring on July 4th (Figure B-7; Table B-14). The 12-hour average TDG in the IHR and PRD tailraces had been in the 113%-115% range over the week prior to this sample (Figure B-7). Among the 2,837 total salmonids examined by the SMP crew for GBT, 15 total fish had signs of fin GBT and all were Rank 1 signs.

Table B-14
Detailed breakdown of SMP salmonid GBT exams and signs of fin GBT at McNary Dam in 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/11/2023	100	0	0.0%
4/13/2023	81	0	0.0%
4/19/2023	67	0	0.0%
4/21/2023	61	0	0.0%
4/25/2023	100	0	0.0%
4/27/2023	100	0	0.0%
5/3/2023	100	0	0.0%
5/5/2023	100	0	0.0%
5/11/2023	100	0	0.0%
5/13/2023	100	0	0.0%
5/17/2023	100	0	0.0%
5/19/2023	100	0	0.0%
5/23/2023	100	0	0.0%
5/25/2023	100	0	0.0%
5/31/2023	100	0	0.0%
6/2/2023	80	0	0.0%
6/6/2023	100	1	1.0%
6/8/2023	100	0	0.0%
6/14/2023	100	2	2.0%
6/16/2023	100	0	0.0%
6/20/2023	100	1	1.0%
6/22/2023	100	1	1.0%
6/28/2023	100	0	0.0%
6/30/2023	100	1	1.0%
7/4/2023	100	3	3.0%
7/6/2023	100	2	2.0%
7/12/2023	100	2	2.0%
7/14/2023	100	1	1.0%
7/18/2023	100	0	0.0%
7/26/2023	38	1	2.6%
8/1/2023	10	0	0.0%

The target sample size of 100 salmonids examined per GBT sample was met in all but six of the salmonid GBT samples at MCN (Table B-14). The minimum sample size target of 50 salmonids per GBT sample was met in all but two salmonid samples. Finally, when considered collectively with BON, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met in all but the last week of salmonid GBT monitoring in the Mid-Columbia River zone.

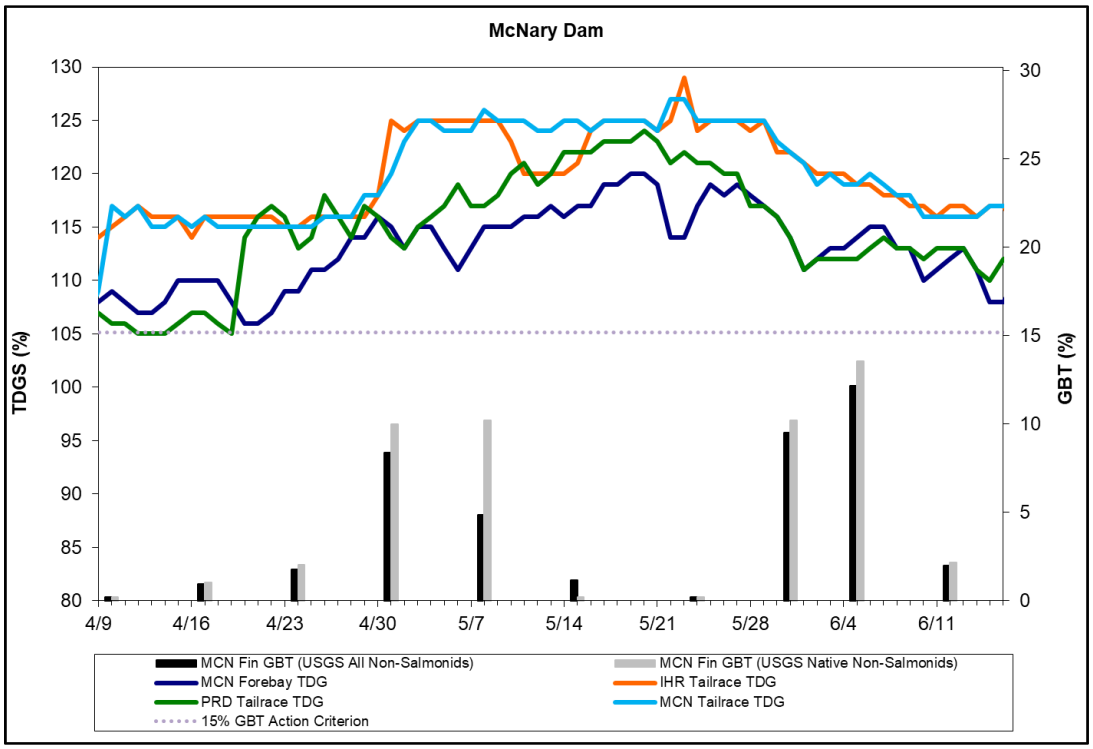
Non-Salmonids

The MCN tailrace was used as one of the non-salmonid GBT monitoring sites for the USGS program. Non-salmonid GBT sampling below MCN occurred once per week, from April 10th through June 12th. Ten total non-salmonid GBT samples were conducted in

the MCN tailrace in 2023. Since MCN is located at the border of Washington and Oregon, both specifications for the non-salmonid GBT action criteria apply (i.e., WA - native species only or OR - all species) and spill was managed to the more restrictive specification. Therefore, data for both specifications are presented in the summaries below.

Figure B-8

Percent GBT observed in the USGS non-salmonid GBT samples at McNary Dam (bars) 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 spring 2023.



Notes: 1) Black bars are for all species combined (OR specification) and grey bars are for native species only (WA specification) and 2) GBT incidence bars that appear to be slightly above zero are zeros, to illustrate that samples were conducted on those days (see Tables B-15 and B-16 for details).

All Non-Salmonid Species

Among the 10 non-salmonid GBT samples conducted below MCN in spring 2023, 1,223 total non-salmonids were examined and 46 exhibited signs of fin GBT (Table B-15). In all, 13 total species of non-salmonids were sampled and examined below MCN. The most common species sampled below MCN were sculpin and smallmouth bass. These two species represented approximately 65% and 17% of the total non-salmonids examined at this site, respectively. Of the 46 total non-salmonids that exhibited signs of fin GBT, 44 were sculpin and two were smallmouth bass.

Of the 10 total GBT samples conducted below MCN, eight had at least one non-salmonid with signs of fin GBT (Figure B-8, Table B-15). The GBT incidence rates among non-salmonids for these eight samples ranged from 0.75% to 11.97%. The highest GBT incidence rate of 11.97% occurred on June 5th. In the week prior to this sample, the 12-hour average TDG in the MCN tailrace had been in the 119%-125% range (Figure B-8). A total of 117 non-salmonids were examined in sample on June 5th, 105 of which were sculpin, eight were smallmouth bass, and four were bullhead. A total of 14 fish had signs of fin GBT in this sample, all of which were sculpin.

Signs of severe fin GBT (i.e., Rank 3 or 4) were observed on four occasions at MCN in 2023 (May 1st, May 8th, June 5th, and June 12th). The incidence rates for severe fin GBT were below the 5% action criterion on all four occasions (Range: 0.9%-3.4%). All instances of severe GBT observed at MCN were observed in sculpin.

Table B-15
Detailed breakdown of USGS non-salmonid (all species combined) GBT exams and signs of fin GBT from the McNary Dam tailrace in spring of 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A]	Number with Non-Protocol GBT
4/10/2023	134	0	0.0%	BH, BK, BS, NP, SC, SU, UD	0
4/17/2023	133	1	0.75%	BH, BS, NP, PE, SC, SK	0
4/24/2023	128	2	1.56%	BS, NP, PE, RS, SC, UD	2
5/1/2023	122	10	8.2%	BH, BS, LD, NP, RS, SC, SD, SK	13
5/8/2023	107	5	4.67%	BL, BS, PE, SC, SK, SU, UD	2
5/15/2023	103	1	0.97%	BK, BS, PE, SC, UD	2
5/24/2023	149	0	0.0%	BH, BK, BS, NP, PE, SC, SK, UD	1
5/31/2023	118	11	9.32%	BS, PE, SC, SK, SU	12
6/5/2023	117	14	11.97%	BH, BS, SC	10
6/12/2023	112	2	1.79%	BH, BL, BS, SC, SU	12

[A] Non-salmonid Species Codes: BH = Bullhead, BK = Banded Killifish, BL = Bluegill or Pumpkinseed, BS = Smallmouth Bass, LD = Dace, Long-nosed, NP = Northern Pikeminnow, PE = Yellow Perch, RS = Redside Shiner, SC = Sculpin, SD = Dace, Speckled, SK = Three-spined Stickleback, SU = Sucker, and UD = Dace, Unidentified.

The target sample size of 100 non-salmonids examined per GBT sample was met in all 10 samples below MCN (Table B-15). Therefore, the minimum target sample size of 50 non-salmonids examined per GBT sample was also met all spring season. 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 54 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations and 53 were sculpin (Table B-15). The single non-sculpin that exhibited signs of non-protocol GBT was a smallmouth bass which was examined in the sample from May 15th. The observations of bubbles in non-protocol locations were spread out over eight of the 10 samples conducted below MCN.

All 1,223 non-salmonids collected and examined from below MCN in 2023 were collected through backpack electrofishing. Therefore, all 46 non-salmonids that exhibited signs of fin GBT were collected with backpack electrofishing.

Finally, per ODEQ requirements, the SMP crew at MCN attempted to collect non-salmonids for GBT monitoring during the summer spill season. However, very few sample dates fit the criteria for summer non-salmonid GBT sampling (i.e., TDG levels >110% and water temperatures ≤68°F). In all, SMP personnel at MCN collected eight total non-salmonids over three different sample dates (June 22nd, July 26th, and August 1st). Of the eight fish examined, four were Pacific lamprey macropthalmia, two were smallmouth bass, and two were juvenile shad. No signs of fin GBT were observed during this summer sampling.

Native Non-Salmonids

A total of 967 native non-salmonids were examined below MCN in spring 2023, 44 of which exhibited signs of fin GBT (Table B-16). All 44 native non-salmonid exhibiting signs of fin GBT below MCN were sculpin. In all, eight different species of native non-salmonids were examined below MCN in spring 2023. The most common native species were sculpin, which made up approximately 83% of all native species examined. Northern pikeminnow were the second most common native species from below MCN, comprising approximately 13% of the total native species examined.

Of the 10 total GBT samples conducted below MCN, seven had at least one native non-salmonid with signs of fin GBT (Figure B-8, Table B-16). The GBT incidence rates among native non-salmonids for these seven samples ranged from 0.85% to 13.33%. The highest native non-salmonid GBT incidence rate of 13.33% occurred on June 5th. A total of 105 non-salmonids were examined in the June 5 sample, all of which were sculpin. Of these, 14 had signs of fin GBT.

Signs of severe fin GBT (i.e., Rank 3 or 4) among native non-salmonids were observed on four occasions at MCN in 2023 (May 1st, May 8th, June 5th, and June 12th). The incidence rates for severe fin GBT were below the 5% action criterion on all four occasions (Range: 1.0%-3.8%). All instances of severe GBT observed at MCN were observed in sculpin.

Table B-16
Detailed breakdown of USGS non-salmonid (native species only) GBT exams and signs of fin GBT from the McNary Dam tailrace in spring of 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A]	Number with Non-Protocol GBT
4/10/2023	115	0	0.0%	NP, SC, SU, UD	0
4/17/2023	118	1	0.85%	NP, SC, SK	0
4/24/2023	108	2	1.85%	NP, RS, SC, UD	2
5/1/2023	102	10	9.8%	LD, NP, RS, SC, SD, SK	13
5/8/2023	50	5	10.0%	SC, SK, SU, UD	2
5/15/2023	51	0	0.0%	SC, UD	1
5/24/2023	115	0	0.0%	NP, SC, SK, UD	1
5/31/2023	100	10	10.0%	SC, SK, SU	12
6/5/2023	105	14	13.33%	SC	10
6/12/2023	103	2	1.94%	SC, SU	12

[A] Non-salmonid Species Codes: LD = Dace, Long-nosed, NP = Northern Pikeminnow, RS = Redside Shiner, SC = Sculpin, SD = Dace, Speckled, SK = Three-spined Stickleback, SU = Sucker, and UD = Dace, Unidentified.

The target sample size of 100 native non-salmonids examined per GBT sample was met in all but two samples below MCN (Table B-16). The minimum target sample size of 50 native non-salmonids examined per GBT sample was met in all 10 samples from below MCN. Finally, when considered collectively with BON, the WDOE and ODEQ minimum sample size requirement of 50 native 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 native non-salmonid GBT samples below MCN. A total of 53 native non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations, all of which were sculpin (Table B-16). The observations of bubbles in non-protocol locations were spread out over eight of the 10 samples conducted below MCN.

All 967 native non-salmonids collected and examined from below MCN in 2023 were collected through backpack electrofishing. Therefore, all 44 native non-salmonids that exhibited signs of fin GBT were collected with backpack electrofishing.

Finally, per ODEQ requirements, the SMP crew at MCN attempted to collect non-salmonids for GBT monitoring during the summer spill season. However, very few sample dates fit the criteria for summer non-salmonid GBT sampling (i.e., TDG levels >110% and water temperatures ≤68°F). Native non-salmonids were collected in only one of the three samples conducted (June 22nd) and only one native species was collected (Pacific lamprey macropthalmia) in that sample. No signs of fin GBT were observed among the four total lamprey juveniles examined that day.

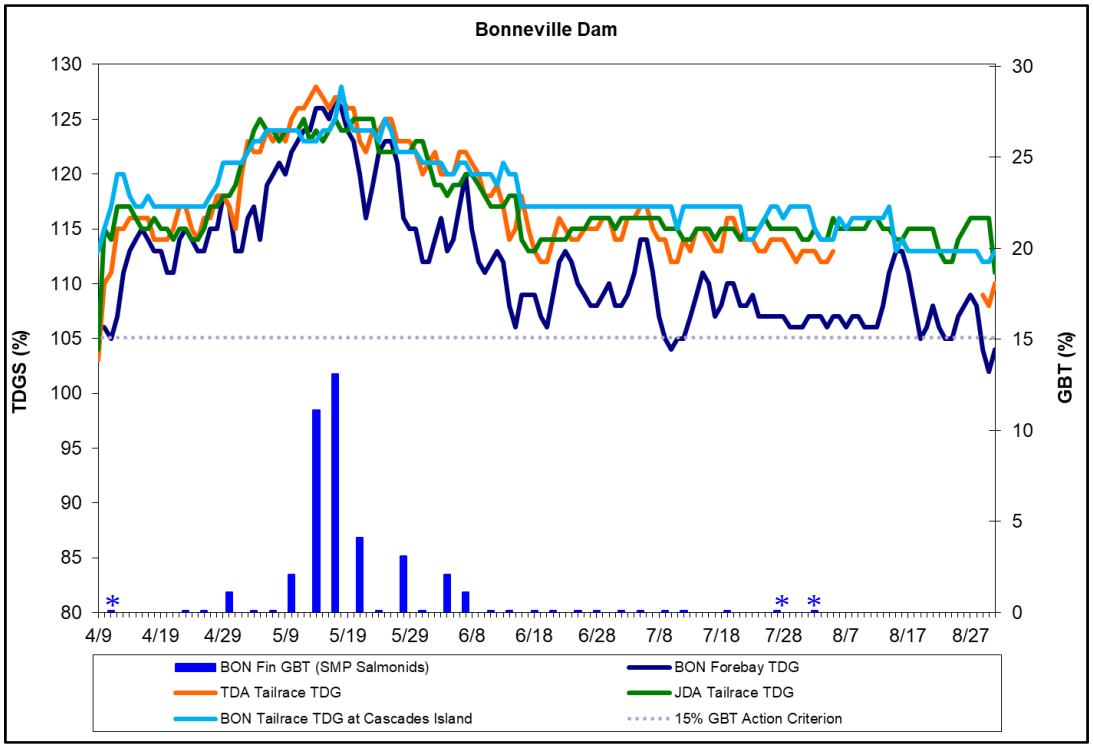
Bonneville Dam (BON)

During the spring spill season, the 12-hour average TDG in the John Day (JDA) tailrace never exceeded 125% (Figure B-9). The 12-hour average TDG in the tailrace at The Dalles Dam (TDA) exceeded 125% for 10 total days (May 11-20). During a portion of this period, involuntary spill (i.e., spill above the 125% spill cap) was provided due to high flows and hydraulic capacity and/or lack of load conditions. The maximum 12-hour average TDG in the tailrace at TDA was 128%, which occurred on May 14th. Finally, the 12-hour average TDG in the BON tailrace (at Cascades Island) exceeded the 125% tailrace TDG standard on one occasion (May 18th; Figure B-9), with a 12-hour average TDG of 128%. This exceedance was the result of involuntary spill due to high flows.

Over the summer spill season (June 16-August 31), TDG levels in the tailraces of JDA and TDA never exceeded the 120% tailrace TDG standard (Figure B-9). In addition, the 12-hour average TDG in the BON forebay never exceeded the 115% forebay TDG standard.

Figure B-9

Percent GBT observed in the salmonid (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 at Cascades Island (light blue line), and the Bonneville forebay (dark blue line) in 2023.



Notes: 1) GBT incidence bars that appear to be slightly above zero are zeros, to illustrate that samples were conducted on those days and 2) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met (see Table B-17 for details).

Salmonids

Salmonid GBT sampling at BON occurred from April 11th to August 2nd (Table B-17, Figure B-9). 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. In 2023, Spring Creek NFH conducted releases on April 11th and April 20th. To allow fish from these releases to pass, salmonid GBT monitoring was suspended from April 11th through April 23rd. 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 July 9th. Due to decreasing fish numbers, continued high temperatures, and generally low TDG levels, salmonid GBT sampling at BON ended after the sample on August 2nd.

Table B-17

Detailed breakdown of SMP salmonid GBT exams and signs of fin GBT at Bonneville Dam in 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/11/2023	7	0	0.0%
4/23/2023	100	0	0.0%
4/26/2023	100	0	0.0%
4/30/2023	100	1	1.0%
5/4/2023	100	0	0.0%
5/7/2023	100	0	0.0%
5/10/2023	100	2	2.0%
5/14/2023	100	11	11.0%
5/17/2023	100	13	13.0%
5/21/2023	100	4	4.0%
5/24/2023	100	0	0.0%
5/28/2023	100	3	3.0%
5/31/2023	100	0	0.0%
6/4/2023	100	2	2.0%
6/7/2023	100	1	1.0%
6/11/2023	64	0	0.0%
6/14/2023	100	0	0.0%
6/18/2023	100	0	0.0%
6/21/2023	100	0	0.0%
6/25/2023	100	0	0.0%
6/28/2023	100	0	0.0%
7/2/2023	100	0	0.0%
7/5/2023	53	0	0.0%
7/9/2023	100	0	0.0%
7/12/2023	100	0	0.0%
7/19/2023	100	0	0.0%
7/27/2023	12	0	0.0%
8/2/2023	4	0	0.0%

In all, 28 total salmonid GBT samples were conducted at BON in 2023, with 2,440 total salmonids examined. Of the 28 total salmonid GBT samples, eight had at least one salmonid with signs of fin GBT (Figure B-9, Table B-17). Among these eight samples, GBT incidence rates ranged from 1.0% to 13.0%, with the highest GBT incidence rate occurring on May 17th. In the week prior to the sample on May 17th, the 12-hour average TDG in the JDA and TDA tailraces had been in the 123%-124% and 125%-128% ranges, respectively. The second highest GBT incidence rate of 11% occurred in the May 14th sample. In the week prior to this sample, the 12-hour average TDG in the JDA and TDA tailraces had been in the 123%-125% and 123%-127% ranges, respectively.

Among the 2,440 total salmonids that were examined by SMP crews at BON in 2023, 37 total fish had signs of fin GBT (Table B-17). Of these, 19 had Rank 1 signs, 14 had Rank 2 signs, and four had Rank 3 signs. Rank 3 signs are considered severe GBT. The individuals exhibiting severe GBT were observed in the samples on May 14th (one fish) and May 17th (three fish) samples. The GBT incidence rates for severe GBT were 1.0% and 3.0% for these two sample dates, respectively.

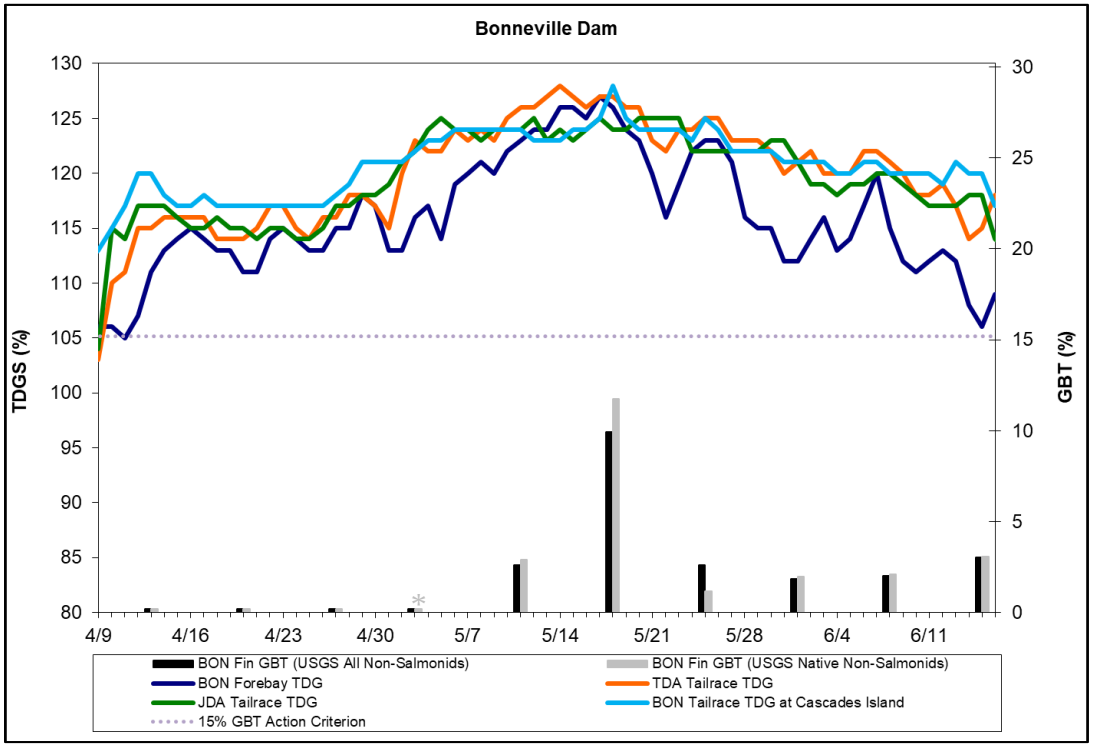
The target sample size of 100 salmonids examined per GBT sample was met in all but five salmonid GBT samples (Table B-17). All but three salmonid GBT samples at BON met the minimum sample size target of 50 salmonids. Finally, when considered collectively with MCN, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met every week except the last week (July 30-August 5) of salmonid GBT sampling in the Mid-Columbia River Zone.

Non-Salmonids

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 13th through June 15th. Ten total non-salmonid GBT samples were conducted in the BON tailrace. Like MCN, BON is located at the border of Washington and Oregon and, therefore, both specifications for the non-salmonid GBT action criteria apply (i.e., WA - native species only or OR - all species) and spill was managed to the more restrictive specification. Therefore, data for both specifications are presented in the summaries below.

Figure B-10

Percent GBT observed in the USGS non-salmonid GBT samples below Bonneville Dam (bars) and 12-hour average TDG at the John Day tailrace (green line), The Dalles tailrace (orange line), Bonneville tailrace at Cascades Island (light blue line), and the Bonneville forebay (dark blue line) in spring 2023.



Notes: 1) Black bars are for all species combined (OR specification) and grey bars are for native species only (WA specification) and 2) GBT incidence bars that appear to be slightly above zero are zeros, to illustrate that samples were conducted on those days, and 3) asterisks over the bars indicate days where the minimum sample size target of 50 fish examined was not met (see Tables B-18 and B-19 for details).

All Non-Salmonid Species

Among the 10 non-salmonid GBT samples conducted below BON in spring 2023, 1,065 total non-salmonids were examined and 20 exhibited signs of fin GBT (Table B-18). In all, 14 total species of non-salmonids were sampled and examined below BON. The most common species sampled below BON were sculpin and three-spined stickleback. These two species represented approximately 73% and 9% of the total non-salmonids examined at this site, respectively. Of the 20 total non-salmonids that exhibited signs of fin GBT, 17 were sculpin, two were loach, and one was a smallmouth bass.

Of the 10 total GBT samples conducted below BON, six had at least one non-salmonid with signs of fin GBT (Figure B-10, Table B-18). The GBT incidence rates among non-salmonids for these six samples ranged from 1.7% to 9.7%. The highest GBT incidence rate of 9.7% occurred on May 18th. In the week prior to this GBT sample, the 12-hour average TDG in the BON tailrace had been in the 123%-125% range and the 12-hour TDG for May 18th was 128% (Figure B-10). A total of 72 non-salmonids were examined in the sample from May 18th. Of these, 44 were sculpin, 10 were loach, six each

were banded killifish and three-spined stickleback, four were smallmouth bass, and one each were northern pikeminnow and unidentified dace. A total of seven fish had signs of fin GBT in this sample, of which six were sculpin and one was a loach.

Signs of severe fin GBT (i.e., Rank 3 or 4) were observed on one occasion at BON in 2023 (May 18th). The incidence rate for severe fin GBT was 4.2%, which was below the 5% action criterion. All instances of severe GBT observed at BON were observed in sculpin.

Table B-18
Detailed breakdown of non-salmonid GBT exams (all species combined) conducted by USGS below Bonneville Dam in spring of 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A]	Number with Non-Protocol GBT
4/13/2023	90	0	0.0%	BK, BL, BS, GO, LO, NP, PE, SC, SK, SU	0
4/20/2023	130	0	0.0%	BK, BS, LO, NP, PE, SC, SK, SU	1
4/27/2023	129	0	0.0%	BK, BL, BS, GO, LO, NP, SC, SK, SU	1
5/3/2023	53	0	0.0%	BK, BS, GO, LD, LO, NP, SC, SK	0
5/11/2023	126	3	2.4%	BK, BS, GO, LO, SC, SK	0
5/18/2023	72	7	9.7%	BK, BS, LO, NP, SC, SK, UD	5
5/25/2023	126	3	2.4%	BK, BS, LK, LO, SC, SK	3
6/1/2023	121	2	1.7%	BK, GO, LO, PE, SC, SD, SK	6
6/8/2023	111	2	1.8%	GO, LO, SC, SK	8
6/15/2023	107	3	2.8%	GO, LO, SC, SK	4

[A] Non-salmonid Species Codes: BK = Banded Killifish, BL = Bluegill or Pumpkinseed, BS = Smallmouth Bass, GO = Goby, LD = Dace, Long-nosed, LK = Brook Lamprey adult, LO = Loach, NP = Northern Pikeminnow, PE = Yellow Perch, SC = Sculpin, SD = Dace, Speckled, SK = Three-spined Stickleback, SU = Sucker, and UD = Dace, Unidentified.

The target sample size of 100 non-salmonids examined per GBT sample was met in all but three samples below BON (Table B-18). The minimum target sample size of 50 non-salmonids examined per GBT sample was met in all 10 samples below BON. Finally, when considered collectively with MCN, 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 BON. A total of 28 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations and all but two were sculpin (Table B-18). The two

other fish that had non-protocol signs of GBT were a banded killifish and a three-spined stickleback. The observations of bubbles in non-protocol locations were spread out over seven of the 10 samples conducted below BON.

Of the 1,065 total non-salmonids collected and examined from below BON in 2023, 1,063 (99.8%) were collected through backpack electrofishing. The remaining two fish (one sculpin and one three-spined stickleback) were collected with a purse seine on May 11th. All 20 non-salmonids that exhibited signs of fin GBT were collected with backpack electrofishing and all 28 non-salmonids that exhibited signs of fin GBT in non-protocol locations (with no signs of fin GBT) were also collected with backpack electrofishing.

Finally, per ODEQ requirements, the SMP crew at BON attempted to collect non-salmonids for GBT monitoring during the summer spill season. However, very few sample dates fit the criteria for summer non-salmonid GBT sampling (i.e., TDG levels >110% and water temperatures ≤68°F). In all, SMP personnel at BON collected seven total non-salmonids over two different sample dates (June 25th and July 2nd). Of the seven fish examined, four were Pacific lamprey macropthalmia and one each were smallmouth bass, northern pikeminnow, and yellow perch. No signs of fin GBT were observed during this summer sampling.

Native Non-Salmonids

A total of 909 native non-salmonids were examined below BON in spring 2023, 17 of which exhibited signs of fin GBT (Table B-19). All 17 native non-salmonids exhibiting signs of fin GBT below BON were sculpin. In all, eight different species of native non-salmonids were examined below BON in spring 2023. The most common native species were sculpin, which made up approximately 86% of all native species examined. Three-spined stickleback were the second most common native species from below BON, comprising approximately 10% of the total native species examined.

Of the 10 total GBT samples conducted below BON, six had at least one native non-salmonid with signs of fin GBT (Figure B-10, Table B-19). The GBT incidence rates among native non-salmonids for these six samples ranged from 0.9% to 11.5%. The highest native non-salmonid GBT incidence rate of 11.5% also occurred on May 18th. A total of 52 native non-salmonids were examined in sample from May 18th and six had signs of fin GBT. All six fish with signs of fin GBT on May 18th were sculpin.

Signs of severe fin GBT (i.e., Rank 3 or 4) among native non-salmonids were observed on only one occasion at BON in 2023 (May 18th). All fish exhibiting signs of severe GBT in this single sample were sculpin and the incidence rate for severe fin GBT was 5.8%, which is above the action criteria. However, spill operations were not changed as a result of this high level of severe GBT because involuntary spill was occurring at the time, due to high flows, and spill could not be reduced.

Table B-19
Detailed breakdown of non-salmonid GBT exams (native species only) conducted by USGS below Bonneville Dam in spring of 2023.

Sample Date	Number Examined	Number with Fin GBT	Percent with Fin GBT	Species Examined[A]	Number with Non-Protocol GBT
4/13/2023	71	0	0.0%	NP, SC, SK, SU	0
4/20/2023	107	0	0.0%	NP, SC, SK, SU	1
4/27/2023	108	0	0.0%	NP, SC, SK, SU	1
5/3/2023	32	0	0.0%	LD, NP, SC, SK	0
5/11/2023	111	3	2.7%	SC, SK	0
5/18/2023	52	6	11.5%	NP, SC, SK, UD	4
5/25/2023	106	1	0.9%	LK, SC, SK	3
6/1/2023	113	2	1.8%	SC, SD, SK	6
6/8/2023	105	2	1.9%	SC, SK	8
6/15/2023	104	3	2.9%	SC, SK	4

[A] Non-salmonid Species Codes: LD = Dace, Long-nosed, LK = Brook Lamprey adult, NP = Northern Pikeminnow, SC = Sculpin, SD = Dace, Speckled, SK = Three-spined Stickleback, SU = Sucker, and UD = Dace, Unidentified.

The target sample size of 100 native non-salmonids examined per GBT sample was met in all but three samples below BON (Table B-19). The minimum target sample size of 50 native non-salmonids examined per GBT sample was met in all but one (May 3) sample. Finally, when considered collectively with MCN, the WDOE and ODEQ minimum sample size requirement of 50 native 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 native non-salmonid GBT samples below BON. A total of 27 native non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations (Table B-19). Of these, 26 were sculpin and one was a three-spined stickleback. The observations of bubbles in non-protocol locations were spread out over seven of the 10 samples conducted below BON.

Of the 909 native non-salmonids that were collected and examined from below BON in 2023, 907 (99.8%) were collected through backpack electrofishing and only two were collected with a purse seine. All 17 native non-salmonids that exhibited signs of fin GBT were collected with backpack electrofishing.

Per ODEQ requirements, the SMP crew at BON attempted to collect non-salmonids for GBT monitoring during the summer spill season. However, very few sample dates fit the criteria for summer non-salmonid GBT sampling (i.e., TDG levels >110% and water temperatures ≤68°F). In all, SMP personnel at BON collected five total native non-salmonids over these two sample dates (June 25th and July 2nd). Of the five native non-salmonids examined, four were Pacific lamprey macropthalmia and one was a northern pikeminnow. No signs of fin GBT were observed among the native non-salmonids examined during this summer sampling.

Historical Summary (1996–2023)

Table B-20 compares the 2023 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 2023 compared to past years. The overall percentages presented in Table B-20 are only for the salmonid samples conducted at FCRPS projects (i.e., Rock Island is excluded from applicable years). At 1.07%, the overall annual GBT incidence rate for 2023 was the 9th highest over the last 28 years.

Table B-20
Overall percent of examined salmonids with signs of fin GBT in each year at FCRPS projects.

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
2023	**1.07**

As mentioned above, the GBT monitoring program has been implemented on salmonids annually since 1996. Therefore, there are 28 years of available data and,

because of involuntary spill events and recent changes to TDG standards and the fish spill program, 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 allows for 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).

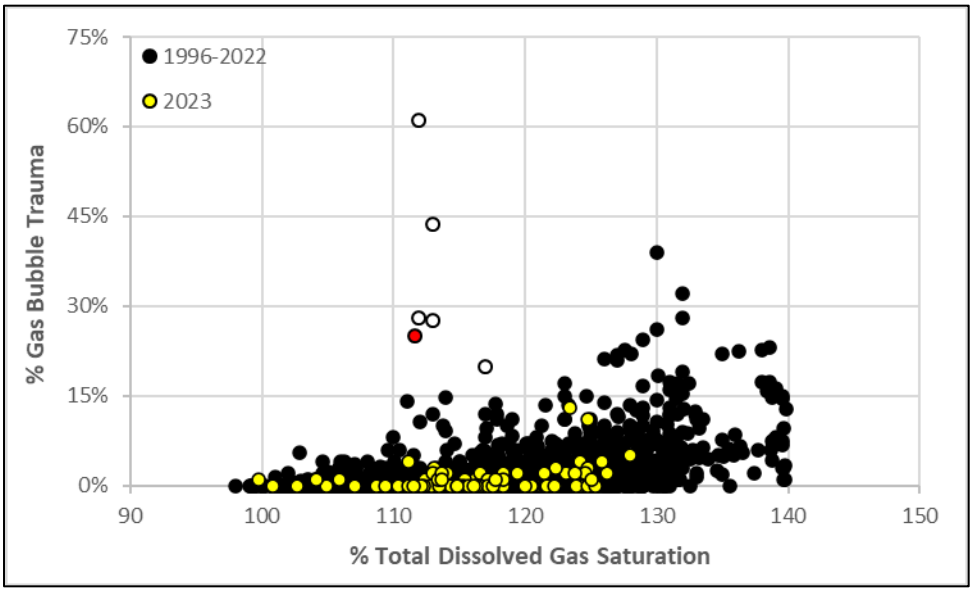
The daily sample size target, based on the GBT monitoring protocol, is 100 salmonids. In this analysis, some flexibility was considered and all daily samples with ≥75 salmonids examined were included. For each GBT sample in this dataset, we estimated the average TDG from the upstream tailrace. This average 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 pool 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 3,299 daily exams fit into our criteria of ≥75 fish examined over the 28 years of available data, where GBT data could be matched to upstream TDG data. This equated to a total of 368,308 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 28 years, and under what tailrace TDG levels this occurred. In all the years when TDG and GBT data have been collected (3,299 samples meeting our sample size criterion), there have been only 37 instances when the 15% GBT criterion was exceeded (Figure B-11). Of those 37 instances, five (open circles in Figure B-11) 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 B-11). 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 levels of >125%. As noted earlier, the 15% GBT action criterion was not met among the salmonid GBT samples in 2023 (yellow circles in Figure B-11), despite the 125% tailrace TDG standard that was utilized for the spring spill season.

Figure B-11
Percent GBT observed as a function of TDG observed in upstream tailrace in 1996-2022 (black circles) and 2023 (yellow circles).



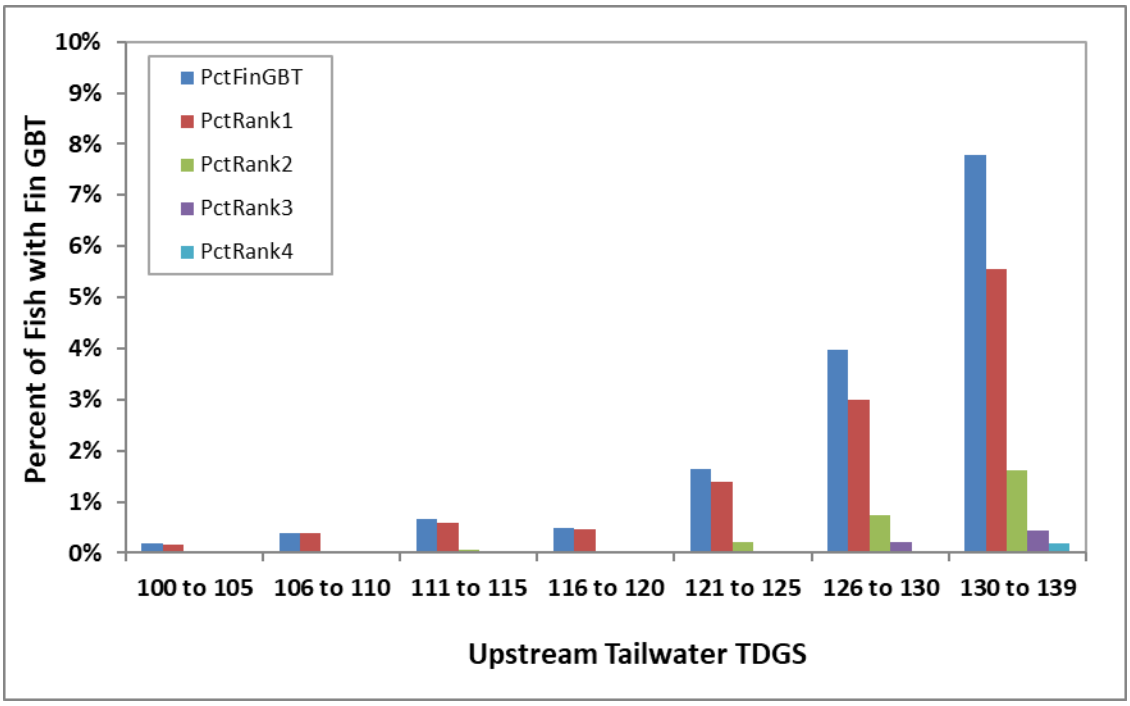
* Open circles indicate observations for late migrating steelhead in 2002 and 2007.
** Red circle indicates observation in 2008 when deformed fin rays may have been misidentified as GBT at LGS.

Of the 3,299 GBT samples that met the sample size criteria for this historic review, 343 had corresponding TDG levels of ≥125%. Of these, only 28 (or 8.2%) had GBT incidence rates that met or exceeded the 15% fin GBT criterion. This means that the remaining 315 GBT samples (or 91.8%) had fin GBT incidence rates below the 15% action criterion (Figure B-11). 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 at or 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 B-12). From Figure B-12 two things are apparent. First, the incidence of salmonids 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 B-12
Percent of all salmonids collected from 1996–2023 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 2023 migration season. In accordance with operations outlined by the 2023 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 and much of June such that spill to the 125% spill caps was not

possible. In general, flows in May were high enough that spill to the 125% spill caps was met (where applicable). In fact, during peak flows in mid-May, involuntary spill was provided and, spill at several projects exceeded the 125% TDG spill caps.

For the salmonid GBT samples, the action criterion of 15% fin GBT was never met or exceeded in 2023. In addition, the action criterion of 5% severe fin GBT was also never met or exceeded in 2023 among the salmonid samples. The highest GBT incidence rate observed in salmonids in 2023 was 13.0%, which occurred in the sample at Bonneville Dam on May 17th.

For the USGS non-salmonid GBT samples, the 15% fin GBT action criterion was exceeded on two occasions (May 9th and May 30th), both from non-salmonids examined below Ice Harbor Dam. The GBT incidence rates among native non-salmonids were 26.4% (May 9th) and 15.4% (May 30th) and each occasion led to a one-week period of reduced spill at Little Goose, Lower Monumental, and Ice Harbor dams. During this time, gas cap spill was reduced to the 115%/120% TDG standard, instead of the 125% tailrace TDG standard. In addition, the action criterion of 5% severe GBT was exceeded in the sample below Bonneville Dam on May 18th. However, this was during a period of involuntary spill so a reduction in spill was not possible. Finally, no signs of fin GBT were observed in the summer non-salmonid GBT samples that were conducted by SMP personnel at Bonneville and McNary dams.

Data collected over the past 28 years strongly suggests that 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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