Appendix B

Gas Bubble Trauma Monitoring and Data Reporting for 2024

Fish Passage Center
Portland, Oregon

FISH PASSAGE CENTER

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December 4, 2024

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

Dear Mr. Turner:

As per our agreement, we are providing a copy of our *Gas Bubble Trauma Monitoring and Data Reporting for 2024* to you, Trevor Conder (NOAA), and Kelsey Swieca (NOAA). This report summarizes Gas Bubble Trauma data collected during the 2024 spring and summer spill seasons.

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

Sincerely,

Michele DeHart
Fish Passage Center Manager

CC: Trevor Conder, NOAA Fisheries
Kelsey Swieca, NOAA Fisheries
Julie Ammann, USACE

Gas Bubble Trauma Monitoring and Data Reporting for 2024

Executive Summary

In 2024, 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. In 2024, the Washington Department of Environmental Quality (WDOE) introduced a new methodology (Stratified Mean Proportion) for estimating GBT incidence rates for non-salmonids. This new methodology was intended to better represent the species that make up small proportions of the GBT sample. However, the ODEQ did not adopt this new methodology. Therefore, the Stratified Mean Proportion methodology applied to non-salmonid GBT samples conducted in the Snake River while the more restrictive of the Stratified Mean and Traditional methodologies applied to non-salmonid GBT samples conducted in the Mid-Columbia River.

Total Dissolved Gas (TDG) levels in the Lower Snake and Middle Columbia rarely met the 125% tailrace TDG standard in the spring and were generally at or below the 115%/120% standard in the summer.

Among the salmonid and non-salmonid GBT samples conducted in 2024, the action criteria for reducing voluntary spill, due to GBT incidence rates, were never met. The highest salmonid GBT incidence rate observed by SMP personnel in 2024 was 4.6%, which occurred on July 24th at Little Goose Dam. However, it should be noted that only 22 total salmonids were examined in this GBT sample, well below the minimum sample size requirement of 50 fish examined. The highest non-salmonid GBT incidence rate observed by USGS was 9.9%, which was observed in the Ice Harbor tailrace on April 30th.

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

Analyses of salmonid GBT data over the last 29 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 2024, 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, 2024

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 2024 followed the same protocol that was issued in 2015. For more detailed information on the examination procedure, the 2024 GBT Monitoring Protocol is available on the FPC website (FPC 2024).

Non-Salmonid GBT Monitoring

In the spring of 2024, 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 backpack electrofishing and purse seining, 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 2024 GBT Monitoring Protocol (FPC 2024).

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 River 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.

Methods for Calculating GBT Incidence Rates

Prior to 2024, GBT incidence rates (*p*, expressed as a percentage) for both salmonids and non-salmonids were calculating using the Traditional method, as:

$$p = \frac{n}{N}, \qquad \text{[Eq. 1]}$$

where *n* is the total number of fish with signs of fin GBT and *N* is the total number of fish examined. In 2024, this Traditional method (Eq. 1) continued to be used for calculating GBT incidence rates for salmonids, but a new methodology for calculating non-salmonid GBT incidence rates was implemented by the Washington Department of Ecology (WDOE). This new methodology introduced the concept of a Stratified Mean Proportion for non-salmonid GBT incidence rates. The Stratified Mean Proportion was meant to better represent species that make up small proportions of the GBT sample and is calculated as:

$$p = \frac{\Sigma_{i=1}^{n_{species}} \left(\frac{n_i}{N_i}\right)}{n_{species}}, \qquad \text{[Eq. 2]}$$

where $\frac{n_i}{N_i}$ is the proportion of the species group *i* exhibiting GBT and $n_{species}$ is the number of species or groups. Based on criteria outlined by WDOE, N_i is no less than 10 for all species and species of low abundance (<10 individuals) may be grouped into an "other species" category but only when a minimum of three species groups occurs. The Oregon Department of Environmental Quality (ODEQ) did not adopt the Stratified Mean Proportion methodology and, instead, kept the Traditional methodology in place (Eq. 1). Both Snake River sites (LGR and IHR) are in the state of Washington and, therefore, only the Stratified Mean Methodology (Eq. 2) was used to evaluate whether non-salmonid GBT incidence rates at these sites exceeded the GBT action criteria. The Mid-Columbia sites (MCN and BON) are on the Washington and Oregon border and, therefore, both methodologies were used for evaluating non-salmonid GBT incidence rates against the action criteria. In this case, the greater value between the two methodologies was used when evaluating whether non-salmonid GBT incidence rates at MCN and BON exceeded GBT action criteria.

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 2024 GBT Sampling Protocol (FPC 2024).

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

Regardless of the methodology that is used for calculating the GBT incidence rate, 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 WDOE specifies that the GBT action criteria pertain to only native non-salmonid species. The 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 and methodology (Eq. 2) while summaries for the Middle Columbia sites are presented under both specifications and their respective methodology.

Therefore, for this report, we summarize salmonid GBT data using the Traditional methodology (Eq. 1) for all Snake and Mid-Columbia sites. For non-salmonid GBT samples at LGR and IHR, we summarize GBT data under the WDOE specification (i.e., native species only) using the Stratified Mean Proportion methodology (Eq. 2). For non-salmonid GBT samples at MCN and BON, we summarize GBT data under the WDOE specification (i.e., native species only) using the Stratified Mean Proportion methodology (Eq. 2) and under the ODEQ specification (i.e., all species) using the Traditional methodology (Eq. 1) and report both values. To reiterate, spill at MCN and BON is managed to the most restrictive of the two specifications and methodologies.

Given the added complication of different methodologies and specifications imposed by the water quality agencies (WDOE and ODEQ), we've provided a summary of which methodologies and specifications were used for estimating 2024 salmonid and non-salmonid GBT incidence rates for this report, by site (Table B-3).

Table B-3

Summary of methodologies and specifications used for evaluating salmonid and non-salmonid GBT incidence rates and managing spring spill in 2024, by site.

Site	Salmonids		Non-Salmonids	
	Methodology	**Specification**	**Methodology**	**Specification**
LGR	Traditional (Eq. 1)	Chinook & steelhead	Stratified Mean (Eq. 2)	Native species only
LGS	Traditional (Eq. 1)	Chinook & steelhead	---	---
LMN	Traditional (Eq. 1)	Chinook & steelhead	---	---
IHR	---	---	Stratified Mean (Eq. 2)	Native species only
MCN	Traditional (Eq. 1)	Chinook & steelhead	Stratified Mean (Eq. 2)	Native species only
			Traditional (Eq. 1)	All species
BON	Traditional (Eq. 1)	Chinook & steelhead	Stratified Mean (Eq. 2)	Native species only
			Traditional (Eq. 1)	All species

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

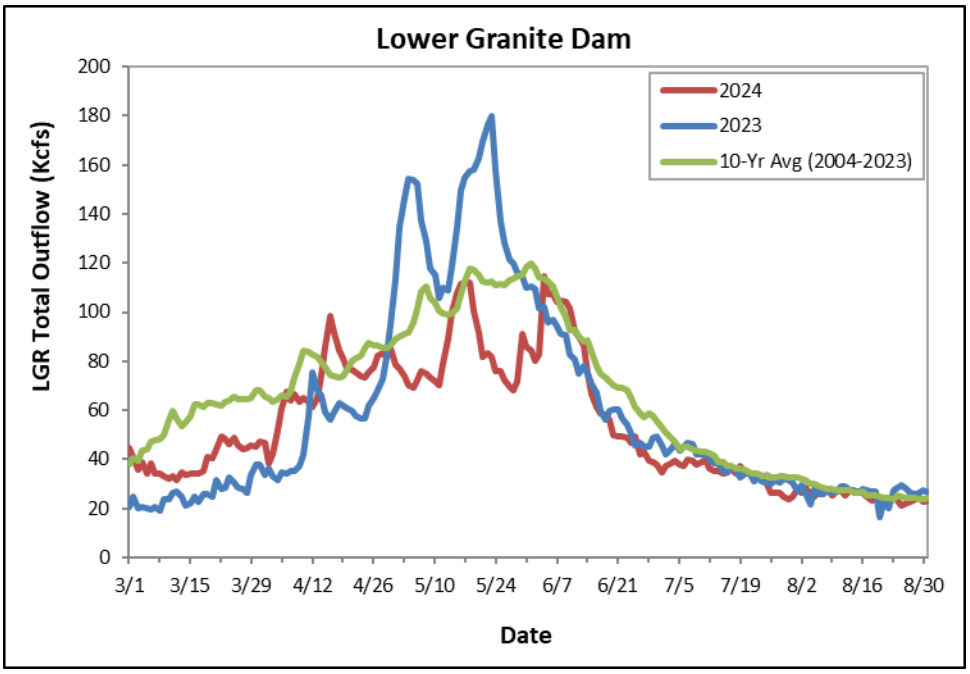
per sample. Second, samples sizes are evaluated as to whether they met a minimum target of 50 fish per sample. Finally, sample sizes are evaluated as to whether the minimum sample size requirement of 50 fish per week, per zone, was met. For this third method, we considered a week as Sunday-Saturday.

2024 Water Conditions and Spill Operations

The runoff volume (January–July) for the 2024 water year was below average in the Middle Columbia and Snake rivers. Runoff (January–July) was 76% of average (1991–2020) at The Dalles Dam (TDA) and 81% of average at LGR. To put the runoff volumes into perspective, the 2024 January–July runoff volumes at TDA and LGR were ranked 69th and 60th, respectively, over the last 76 years (1949–2024).

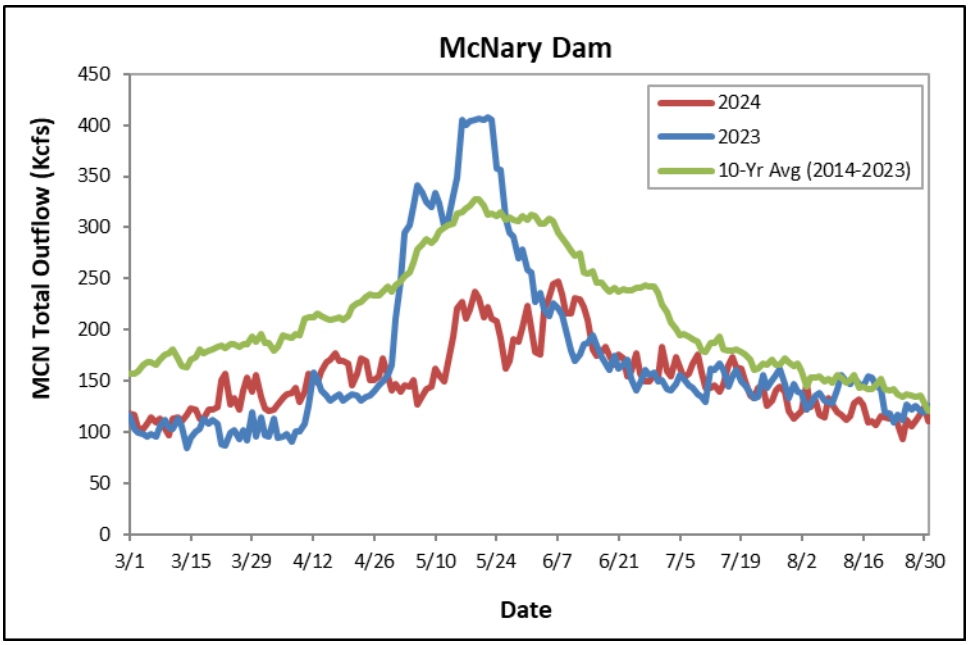
In 2024, there were three instances of peak flows in the Lower Snake River: one in mid-April, one in mid-May, and one in early June (Figure B-1). Overall, flows from March through August were generally below the current 10-year average. One exception to this was in mid-April when the first spike in flows occurred. During this time, flows were above the current 10-year average for approximately six days. During the second and third spikes in flows in mid- to late May and early June, flows were close to the current 10-year average for these periods. Daily average flows at LGR peaked on June 4th, at 114.4 Kcfs. Given the 125% tailrace TDG standard that was implemented during the spring spill season, flows were often not high enough to spill to the 125% TDG spill caps. Instead, spill during gas cap periods was mostly limited to all flows above powerhouse minimum requirements (i.e., minimum generation, spill the rest).

Figure B-1.
Average daily flows at Lower Granite Dam in 2024, 2023, and the 10-year average



Peak flows in the Middle Columbia River occurred in mid- to late May and early June (Figure B-2). Peak flows in 2024 were well below the current 10-year average for the entire spring and summer spill periods. Flows at MCN peaked on June 7th, at 247.6 Kcfs. Given the 125% tailrace TDG standard that was implemented during the spring, flows in 2024 were too low to spill to the site-specific 125% TDG spill caps for the entire spring spill season. Therefore, spring spill was limited to minimum generation, spill the rest operations.

Figure B-2
Average daily flows at McNary Dam in 2024, 2023, and the 10-year average



On March 22, 2024, the 2024 Fish Operations Plan (FOP) was issued. The 2024 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-4). The 2024 FOP followed the operations outlined in Appendix B of the December 2023 Joint Motion to Stay Litigation through 2028 (herein referred to as the 2023 Stay Agreement). The 2024 FOP specified variable spill levels (i.e., reduced spill during some portion of the day) at two projects: Little Goose (LGS) and John Day (JDA) dams (Table B-4). At Lower Granite (LGR) and Lower Monumental (LMN), planned spring spill was to the 125% tailrace TDG standard, 24-hours per day. However, the 2024 FOP included the possibility of reduced spill at these two projects if there were indications of adult delay from the Columbia Basin Research's Data Access in Real Time PIT-tag Adult Reach Distribution and Delay tool (DART Tool). If delay was detected at these projects for three consecutive days, and flows were below 160 Kcfs, then spill at LMN and/or LGR would be reduced for eight hours per day until the DART Tool no longer indicated delay. Spring spill operations at Ice Harbor (IHR), McNary (MCN), The Dalles (TDA), and Bonneville (BON) 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-4).

Under the 2024 FOP, summer spill volumes and/or proportions remained the same as what has occurred for the last four years (Table B-4). However, unlike the last four years, the reduction in summer spill levels occurred on August 1st in 2024. This reduction in summer spill levels occurred on August 15th in 2020-2023.

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/).

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.

Table B-4

2024 spring and summer spill operations at Snake and Mid-Columbia FCRPS projects under the 2024 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 July 31	Aug. 1-Aug 31
LGR	125% Gas Cap (24 hours)[2]		18 Kcfs	SW flow[7]
LGS	125% Gas Cap (24 hours)	30% (8 daytime hours)[3] 125% Gas Cap (16 night-time hours)	30%[8]	SW flow or ~7 Kcfs[7]
LMN	125% Gas Cap (24 hours)[2]		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	40% (16-18 daytime hours)[4] 125% Gas Cap (6-8 night-time hours)		35%	20 Kcfs
TDA	40% (24 hours)[5]		40%	30%
BON	150 Kcfs (24 hours)[6]		95 Kcfs	50 Kcfs

[1] The adult salmonid abundance criteria at Little Goose Dam is 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 24th.

[2] LGR and LMN spill levels will be decreased to 40% of project outflow for 8-hours per day during daytime hours (target start times: 0400-0800) when adult delay or passage issues are observed at both/ either project. The occurrence of an adult delay or passage issue will be determined by the DART Reach Distribution and Delay for PIT Tag Adult Returns tool. However, the determination of an adult delay or passage issue is dependent on a running 3-day minimum 7 PIT-tagged adult spring/summer Chinook detected at the downstream project and average outflows of <160 Kcfs each day of delay.

[3] The 8 hours of performance spill will occur between for 8 consecutive AM hours to target peak adult passage times. If lack of load conditions preclude 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 consecutive hours, and conclude no later than 2000 hours.

[4] Daytime hours change throughout the season and are defined in the 2024 Fish Passage Plan (Table JDA-5). Daytime hourly spill target of 40% river flows with ±5% flexibility in river flow for balancing reserves, consistent with current target spill calculations.

[5] TDG in The Dalles tailrace may fluctuate up to 125% prior to reducing spill at upstream projects or reducing spill at The Dalles below 40%. Maintain 40% spill for 24 hours at The Dalles and reduce John Day spill below the 125% TDG spill cap as needed for TDG management. Spill above 40%, up to 125% TDG, may occur for TDG management or for carrying reserves.

[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 2024 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.

Results

Below, we present the overall results from the salmonid and non-salmonid GBT monitoring conducted in the spring and summer of 2024. 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, 8,903 juvenile salmonids were examined for GBT between April and August of 2024, as part of the salmonid GBT monitoring program under the SMP (Table B-5). Of these, approximately 36% were yearling Chinook, 45% were subyearling Chinook, and 18% were steelhead.

Table B-5

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 2024 as part of the Smolt Monitoring Program.

Species	BON	MCN	LMN	LGS	LGR	Total
Chinook Subyearlings	1,300	1,401	458	881	0	4,040
Chinook Yearlings	1,321	1,076	142	429	249	3,217
Steelhead	78	333	524	293	418	1,646
Total	2,699	2,810	1,124	1,603	667	8,903

A total of 2,931 non-salmonids were examined by the USGS for the non-salmonid GBT monitoring program during the spring spill season (Table B-6). Of these, 2,679 (91%) 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 68% and 17% of the total non-salmonids examined in 2024, respectively. The third and fourth most common non-salmonid species were smallmouth bass and three-spined stickleback, which represented approximately 5% and 2% of the non-salmonids examined in 2024, respectively. Collectively, these four species of non-salmonids represented approximately 93% of the total non-salmonids examined. The non-salmonid GBT monitoring program did not examine any incidentally collected salmonids in 2024.

Among the 2,931 total non-salmonids that were examined by the USGS in spring 2024, 2,840 (97%) were collected through electrofishing while the remaining 91 (3%) were collected with purse seines. Examinations from seined fish occurred at only three sites, below BON, below IHR, and below LGR. The majority (79%) of examined fish that were collected via seine were examined below BON.

Finally, under the summer non-salmonid monitoring program mandated by ODEQ, 19 total non-salmonids were examined by the SMP crews at BON and MCN (Table B-7). Of these, seven were collected at BON and 12 were collected at MCN. In all, six different non-salmonid species were sampled by these SMP crews. The most common non-

salmonid species collected and examined in 2024 were juvenile shad, which represented approximately 58% 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 USGS for the non-salmonid GBT monitoring program in the Lower Snake and Mid-Columbia rivers during the 2024 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	448	752	425	376	**2,001**
Northen Pikeminnow	24	15	150	310	**499**
Smallmouth Bass	28	119	0	0	**147**
Three-spined Stickleback	71	0	0	0	**71**
Sucker, Species	3	8	0	42	**53**
Banded Killifish	36	10	0	0	**46**
Peamouth	0	1	0	16	**17**
Mountain Whitefish	14	0	1	0	**15**
Chiselmouth	0	0	0	13	**13**
Yellow Perch	3	10	0	0	**13**
Bluegill or Pumpkinseed	1	11	0	0	**12**
Largemouth Bass	0	11	0	0	**11**
Goby	9	0	0	0	**9**
Loach	9	0	0	0	**9**
Bullhead	0	4	0	0	**4**
Sucker, Largescale	2	0	1	0	**3**
Dace, Species	1	2	0	0	**3**
Pacific Lamprey ammocoete	0	0	1	0	**1**
Carp	0	1	0	0	**1**
Dace, Long-nosed	0	0	0	1	**1**
Pacific Lamprey adult	0	0	0	1	**1**
Dace, Speckled	1	0	0	0	**1**
Grand Total	**650**	**578**	**759**	**944**	**2,931**

Table B-7

Number of non-salmonids collected and examined for signs of GBT by SMP crews at McNary and Bonneville dams, during the 2024 summer spill season. Data are sorted by total sampled, in descending order. Shaded rows indicate non-native species.

Species	BON	MCN	Total
Shad, juvenile	0	11	11
Smallmouth Bass	1	1	2
Peamouth	2	0	2
Sculpin	2	0	2
Pacific Lamprey Ammocoete	1	0	1
Banded Killifish	1	0	1
Total Non-Salmonids	**7**	**12**	**19**

Of the 8,903 total salmonids that were examined by SMP crews at FCRPS projects in 2024, signs of fin GBT were observed in 31 individuals (1.07%, Table B-8). All 31 salmonids with signs of fin GBT in 2024 had a maximum of Rank 1 signs. Therefore, no salmonids exhibited signs of severe fin GBT in 2024.

Table B-8

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 2024 as part of the Smolt Monitoring Program.

	Fin GBT by Site					Grand
Species	BON	MCN	LMN	LGS	LGR	Total
Chinook Subyearlings	7	0	5	4	0	16
Chinook Yearlings	9	0	1	0	1	11
Steelhead	0	1	2	1	0	4
Total	**16**	**1**	**8**	**5**	**1**	**31**

Of the 2,931 total non-salmonids that were examined by USGS in 2024, 97 (3.31%) had signs of fin GBT (Table B-9). Of these, 72 had a maximum Rank 1 signs, 15 had a maximum Rank 2 signs, 7 had a maximum Rank 3 signs, and 3 had a maximum Rank 4 signs. As mentioned above, 2,679 of the non-salmonids that were examined for GBT in 2024 were native species. Of these, 93 (3.47%) had signs of fin GBT (Table B-9). Of these, 68 had a maximum Rank 1 signs, 15 had a maximum Rank 2 signs, 7 had a maximum Rank 3 signs, and 3 had a maximum Rank 4 signs.

The most common non-salmonid species exhibiting signs of fin GBT were sculpin. In fact, sculpin made up nearly 90% of all signs of fin GBT in 2024, even though they comprised only 68% of the total non-salmonids examined. The second most common non-salmonid species exhibiting signs of fin GBT were northern pikeminnow, which represented approximately 5% of all signs of fin GBT.

In addition to the signs of fin GBT that were observed, several non-salmonids 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.

Table B-9

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 2024 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	7	40	16	24	**87**
Northen Pikeminnow	0	0	1	4	**5**
Smallmouth Bass	2	2	0	0	**4**
Sucker, Species	0	0	0	1	**1**
Three-spined Stickleback	0	0	0	0	**0**
Banded Killifish	0	0	0	0	**0**
Peamouth	0	0	0	0	**0**
Mountain Whitefish	0	0	0	0	**0**
Chiselmouth	0	0	0	0	**0**
Yellow Perch	0	0	0	0	**0**
Bluegill or Pumpkinseed	0	0	0	0	**0**
Largemouth Bass	0	0	0	0	**0**
Goby	0	0	0	0	**0**
Loach	0	0	0	0	**0**
Bullhead	0	0	0	0	**0**
Sucker, Largescale	0	0	0	0	**0**
Dace, Species	0	0	0	0	**0**
Pacific Lamprey ammocoete	0	0	0	0	**0**
Carp	0	0	0	0	**0**
Dace, Long-nosed	0	0	0	0	**0**
Pacific Lamprey adult	0	0	0	0	**0**
Dace, Speckled	0	0	0	0	**0**
Grand Total	**9**	**42**	**17**	**29**	**97**

Finally, no signs of fin GBT were observed among the 19 total non-salmonids that were collected and examined for GBT by the SMP crews at Bonneville and McNary dams in the summer of 2024.

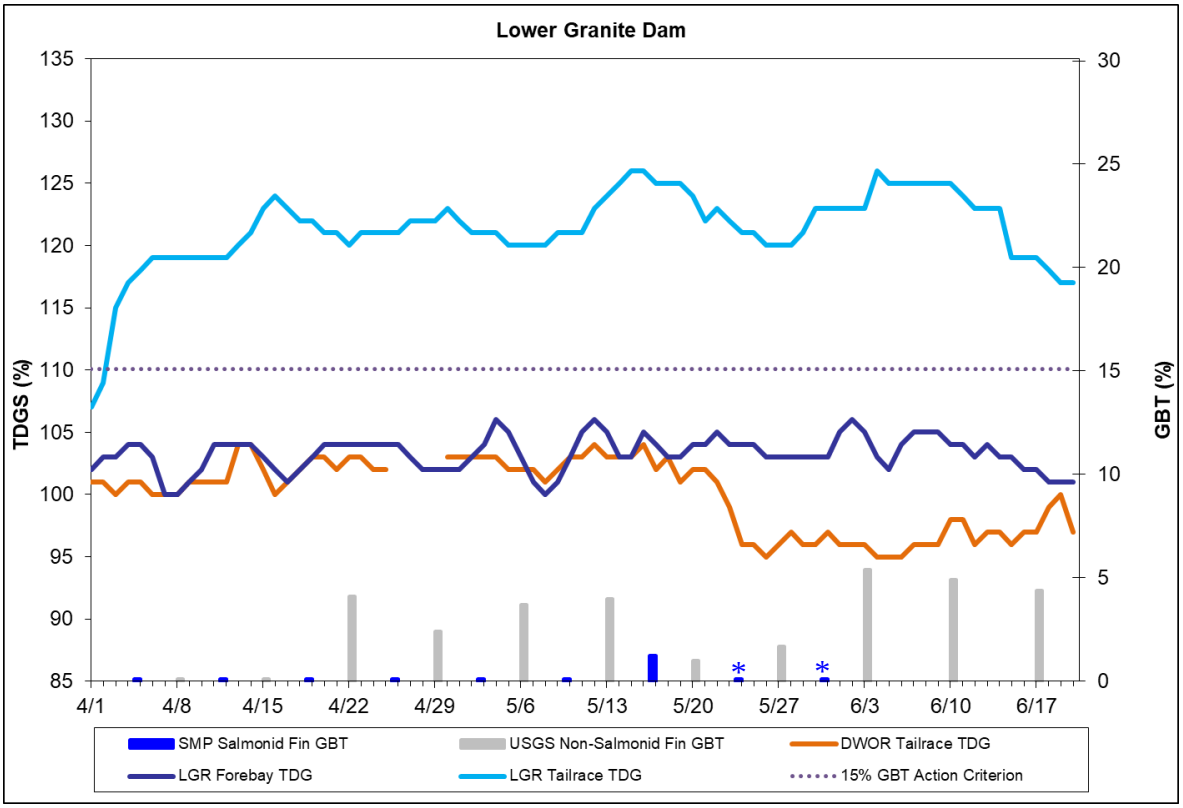
A more detailed breakdown of salmonid and non-salmonid GBT exams and signs for 2024 can be found in Tables B-10 through B-20.

Lower Granite Dam (LGR)

The 12-hour average TDG in the Dworshak Dam (DWR) tailrace never exceeded the 110% Environmental Protection Agency (EPA) standard in the spring of 2024 (Figure B-3). The 12-hour average TDG in the LGR forebay never exceeded 110% but the 12-hour average TDG in the LGR tailrace exceeded the 125% standard for a total of three days during the spring spill season (May 16-16 and June 4; Figure B-3). All three days had a 12-hour average TDG of 126%.

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 2024.



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-10 and B-11 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 5th and ran through May 31st. However, the SMP crew at LGR was unable to collect any yearling Chinook or steelhead in the time allotted for the May 31 sample, due to rapidly declining passage of spring migrants. Therefore, GBT sampling at LGR was suspended after the May 31 sample. In all, nine total salmonid

GBT samples were conducted at LGR in 2024. Across these nine GBT samples, 667 target salmonids were examined and only one fish exhibited signs of fin GBT. This single fish with signs of fin GBT was observed in the sample from May 17th (Figure B-3, Table B-10). The GBT incidence rate for this single sample was 1.1% and the single fish had Rank 1 signs.

The target sample size of 100 salmonids examined per GBT sample was met in four of the nine salmonid GBT samples at LGR (Table B-10). 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 DOE and DEQ minimum sample size requirement of 50 salmonids per week, per zone, was met in the Snake River Zone all spring spill season.

Table B-10
Detailed breakdown of salmonid GBT exams and signs of fin GBT at Lower Granite Dam in 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]
4/5/2024	100	0	0.0%
4/12/2024	100	0	0.0%
4/19/2024	100	0	0.0%
4/26/2024	100	0	0.0%
5/3/2024	97	0	0.0%
5/10/2024	78	0	0.0%
5/17/2024	87	1	1.1%
5/24/2024	5	0	0.0%
5/31/2024	0	0	---

[A] The reported GBT incidence rate for salmonids at LGR is based on the Traditional methodology (Eq. 1)

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 8th through June 17th. Eleven 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, using the Stratified Mean Proportion methodology (Eq. 2). Therefore, the non-salmonid data presented in this report for LGR follow these criteria.

Native Non-Salmonids

Across the 11 non-salmonid GBT samples conducted below LGR in spring 2024, 759 total native non-salmonids were examined and 29 exhibited signs of fin GBT (Table B-11). In all, seven 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 50% of the total native non-salmonids examined at this site. Of the 29 native non-salmonids that exhibited signs of fin GBT, 24 were sculpin, four were northern pikeminnow, and one was a sucker.

Of the 11 total GBT samples, nine had at least one native non-salmonid with signs of fin GBT (Figure B-3, Table B-11). The GBT incidence rates among native species for these nine samples ranged from 0.9% to 5.3%. The highest GBT incidence rate of 5.3% occurred on June 3rd. In the week prior to this sample, the 12-hour average TDG in the LGR tailrace was in the 120-123% range. Signs of severe fin GBT (i.e., Rank 3 or 4) were observed on five occasions at LGR (May 13th, May 20th, June 3rd, June 10th, and June 17th). The incidence rates for severe fin GBT were below the 5% action criterion on all five occasions (Range: 0.7-1.1%). All instances of severe fin GBT were observed in sculpin.

Table B-11
Detailed breakdown of native non-salmonid GBT exams conducted by USGS below Lower Granite Dam in spring of 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]	Species Examined[B]	Number with Non-Protocol GBT
4/8/2024	67	0	0.0%	LP, NP, PM, SC, SU	0
4/15/2024	62	0	0.0%	NP, PM, SC, SU	0
4/22/2024	87	2	4.0%	CM, NP, PM, SC, SU	1
4/29/2024	82	2	2.3%	CM, NP, PM, SC, SU	0
5/6/2024	73	3	3.6%	CM, NP, SC, SU	6
5/13/2024	88	4	3.9%	CM, NP, SC, SU	2
5/20/2024	57	1	0.9%	LD, NP, PM, SC, SU	2
5/27/2024	70	2	1.6%	CM, NP, SC, SU	4
6/3/2024	58	4	5.3%	NP, SC, SU	9
6/10/2024	51	3	4.8%	NP, PM, SC, SU	8
6/17/2024	64	8	4.3%	CM, SC, SU	6

[A] The reported GBT incidence rate for native non-salmonids at LGR is based on the Stratified Mean Proportion methodology (Eq. 2)

[B] Native non-salmonid Species Codes: CM = Chiselmouth, LP = Pacific Lamprey Adult, 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 never met in the 11 total samples from below LGR (Table B-11). However, the minimum target sample size of 50 native non-salmonids examined per GBT sample was met in all 11 samples. Finally, when considered collectively with IHR, the DOE and DEQ 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 38 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations (Table B-11). All but two were sculpin, with the

remaining two being northern pikeminnow. The observations of bubbles in non-protocol locations were spread out over eight of the 11 samples conducted below LGR.

Finally, of the 759 total native non-salmonids collected and examined from below LGR, 757 (99.7%) were collected through backpack electrofishing. The remaining two (0.03%) were collected through purse seines. All 29 of the native non-salmonids that exhibited signs of fin GBT were collected with backpack electrofishing. In addition, all 38 non-salmonids that were observed with bubbles in non-protocol locations, and no signs of fin GBT, were collected with electrofishing.

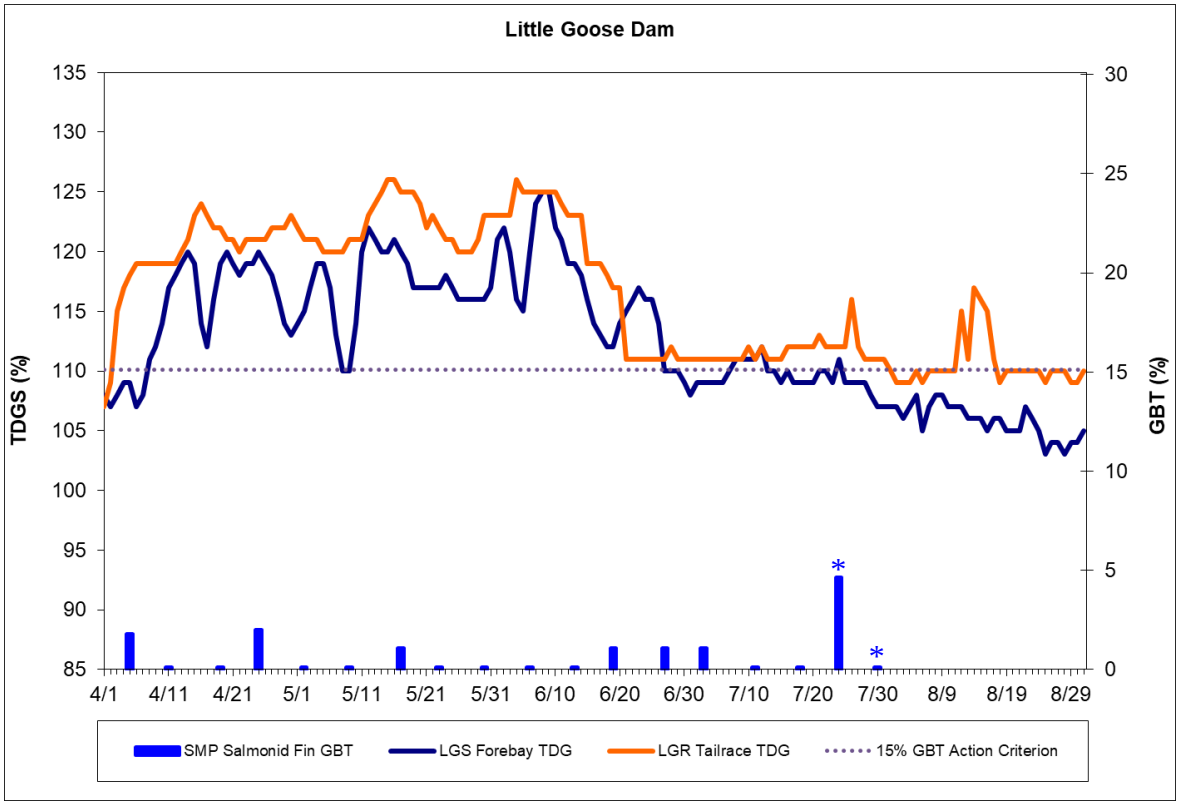
Little Goose Dam (LGS)

Over the spring spill period, 12-hour average TDG levels in the LGR tailrace exceeded the 125% tailrace TDG standard on three occasions (May 15-16 and June 4; Figure B-4). All three days had a 12-hour average TDG of 126%, which was the maximum 12-hour average for the LGR tailrace over the entire spring spill season.

During the summer spill period, 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 exceeded in the LGS forebay for four total days during the summer spill season (June 22-25), with 12-hour average TDG levels of 116-117% (Figure B-4). These exceedances were likely due to the higher spill levels that were implemented at the end of the spring spill season through June 20th. The 12-hour average TDG in the LGS forebay never exceeded 115% after June 25th.

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 2024.



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).

Salmonids

Gas Bubble Trauma monitoring for salmonids at LGS occurred from April 5th to July 30th. Salmonid GBT sampling at LGS was terminated after the sample on July 30th, due to decreased sample sizes, elevated temperatures, and generally low TDG levels at that time.

Eighteen total salmonid GBT samples were conducted at LGS in 2024. Among the 18 GBT samples at LGS, 1,603 total salmonids were examined for GBT and eight total fish had signs of fin GBT (Table B-12). All of the salmonids that were observed with signs of fin GBT at LGS had Rank 1 signs. Among the 18 total salmonid samples at LGS, seven had at least one fish with signs of fin GBT (Figure B-4 and Table B-12). The GBT incidence rates for these seven salmonid samples ranged from 1.0% to 4.5% with the highest rate occurring on July 24th. However, it should be noted that only 22 total salmonids were examined in the July 24th sample, which is below the minimum sample size requirement.

Table B-12
Detailed breakdown of salmonid GBT exams and signs of fin GBT at Little Goose Dam in 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]
4/5/2024	59	1	1.7%
4/11/2024	100	0	0.0%
4/19/2024	103	0	0.0%
4/25/2024	106	2	1.9%
5/2/2024	100	0	0.0%
5/9/2024	100	0	0.0%
5/17/2024	101	1	1.0%
5/23/2024	101	0	0.0%
5/30/2024	100	0	0.0%
6/6/2024	101	0	0.0%
6/13/2024	100	0	0.0%
6/19/2024	100	1	1.0%
6/27/2024	102	1	1.0%
7/3/2024	103	1	1.0%
7/11/2024	101	0	0.0%
7/18/2024	101	0	0.0%
7/24/2024	22	1	4.5%
7/30/2024	3	0	0.0%

[A] The reported GBT incidence rate for salmonids at LGS is based on the Traditional methodology (Eq. 1).

The target sample size of 100 salmonids examined per GBT sample was met in all but three of the 18 total salmonid samples at LGS (Table B-12). The minimum sample size target of 50 salmonids per week was met in all but two samples (Table B-12). 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 were two weeks in the summer (July 21-27 and July 28-August 3) when the minimum sample size of 50 salmonids per week was not met in the Snake River Zone. These were the last two weeks 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)

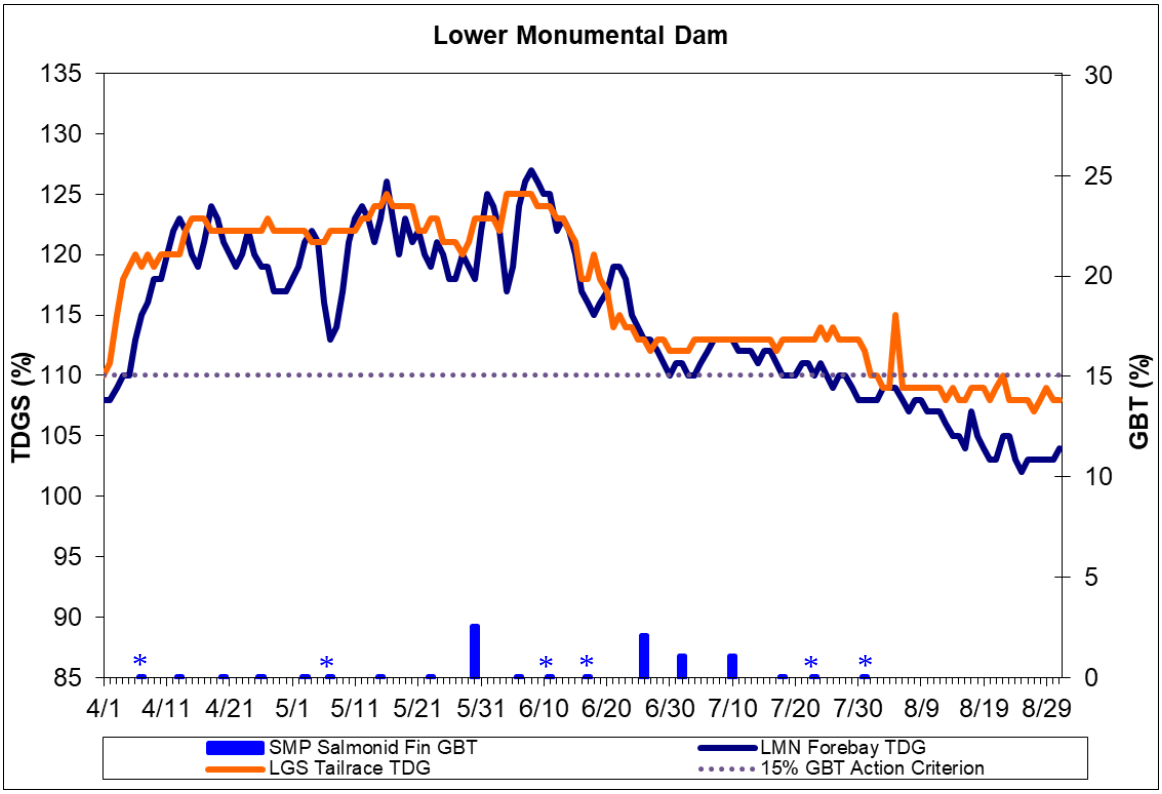
Over the spring spill season, 12-hour average TDG levels in the LGS tailrace never exceeded the 125% tailrace standard (Figure B-5). The maximum 12-hour average TDG in the LGS tailrace was 125%, which occurred on only six occasions (May 16th and June 4-8; Figure B-5).

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 the first three days of

summer spill (June 21-23). These exceedances 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.

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 2024.



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-13 for details).

Salmonids

The only GBT monitoring that occurred at LMN in 2024 was of salmonids, conducted once-per-week by the SMP crew from LGS. In 2024, salmonid GBT sampling at LMN occurred from April 7th to July 31st. Sampling was terminated after the sample on July 31st 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 2024. Of these 18 GBT samples at LMN, 1,124 total salmonids were examined for GBT and five total fish had signs of fin GBT (Table B-13). All five fish that had signs of fin GBT at LMN had Rank 1 signs.

Among the 18 total salmonid GBT samples conducted, four had at least one salmonid exhibiting signs of fin GBT (Figure B-5, Table B-13). GBT incidence rates among these four samples ranged from 1.0% to 2.5%, with the highest GBT incidence occurring on May 30th. Total dissolved gas in the LGS tailrace had been in the 120-123% range over the week prior to this sample.

Table B-13

Detailed breakdown of salmonid GBT exams and signs of fin GBT at Lower Monumental Dam in 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]
4/7/2024	32	0	0.0%
4/13/2024	51	0	0.0%
4/20/2024	99	0	0.0%
4/26/2024	100	0	0.0%
5/3/2024	102	0	0.0%
5/7/2024	16	0	0.0%
5/15/2024	101	0	0.0%
5/23/2024	93	0	0.0%
5/30/2024	81	2	2.5%
6/6/2024	100	0	0.0%
6/11/2024	32	0	0.0%
6/17/2024	8	0	0.0%
6/26/2024	50	1	2.0%
7/2/2024	100	1	1.0%
7/10/2024	101	1	1.0%
7/18/2024	51	0	0.0%
7/23/2024	3	0	0.0%
7/31/2024	4	0	0.0%

[A] The reported GBT incidence rate for salmonids at LGS is based on the Traditional methodology (Eq. 1).

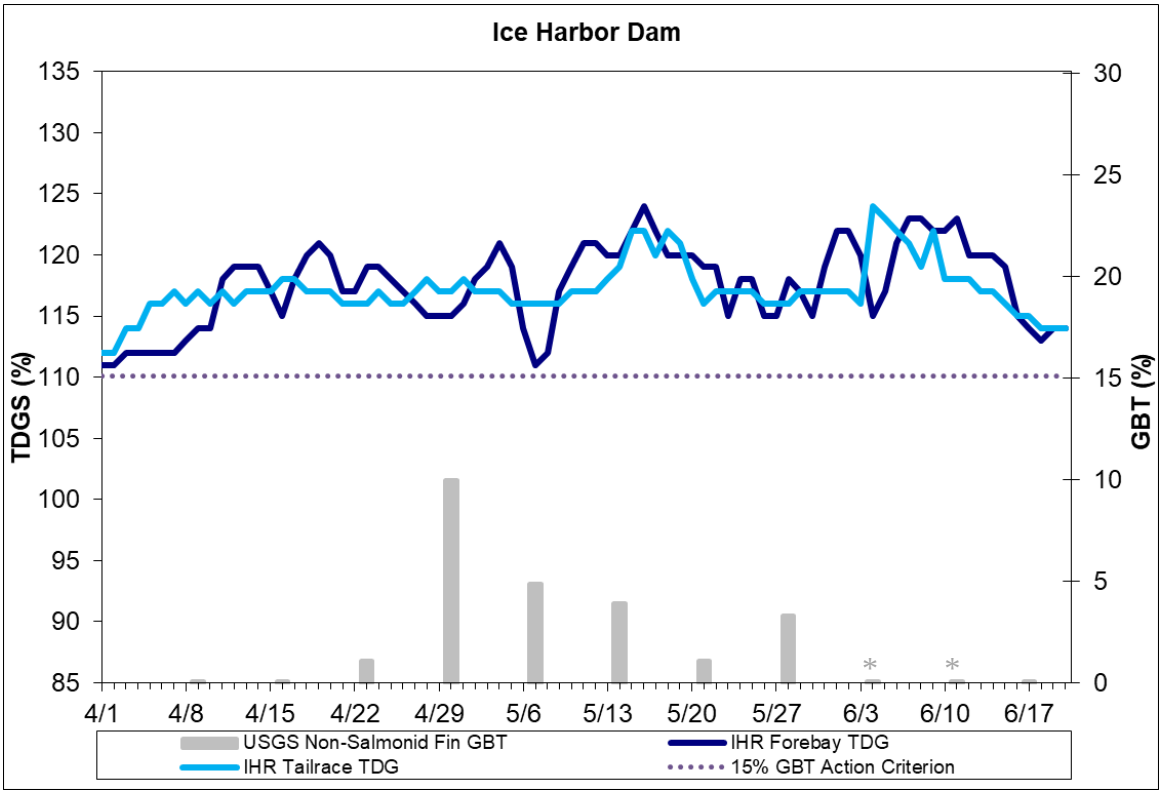
The target sample size of 100 salmonids examined per GBT sample was met in six of the 18 total GBT samples at LMN (Table B-13). The minimum sample size target of 50 salmonids per week was met in all but six samples in 2024 (Figure B-5; Table B-13). Finally, when considered collectively with LGR and LGS, 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 were two weeks in the summer (July 21-27 and July 28-August 3) when the minimum sample size of 50 salmonids per week was not met in the Snake River Zone. These were the last two weeks 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 never exceeded the 125% tailrace standard in the spring of 2024 (Figure B-6). In fact, the maximum 12-hour average TDG in the IHR tailrace was 124%, which occurred only once over the entire spring spill period (June 4th; Figure B-6).

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 2024.



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).

Non-Salmonids

Salmonid GBT monitoring does not occur at IHR. However, the IHR tailrace was one of the USGS non-salmonid GBT monitoring sites. Non-salmonid GBT sampling below IHR occurred weekly, from April 9th through June 17th. Eleven 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, using the Stratified Mean Proportions methodology (Eq. 2). Therefore, the data presented here follow those criteria.

Native Non-Salmonids

Among the 11 non-salmonid GBT samples conducted below IHR in spring 2024, 578 total native non-salmonids were examined and 17 exhibited signs of fin GBT (Table B-14). 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. Sculpin accounted for approximately 74% of the non-salmonids examined below IHR while Northern Pikeminnow accounted for nearly 26% of examined non-salmonids. Only one individual of each of the remaining three species (Pacific lamprey ammocoete, largescale sucker, and mountain whitefish) was examined in 2024. Of the 17 native non-salmonids that exhibited signs of fin GBT, 16 were sculpin and one was a northern pikeminnow.

Of the 11 total GBT samples, six had at least one native non-salmonid with signs of fin GBT (Figure B-6, Table B-14). The GBT incidence rates among native species for these six non-salmonid samples ranged from 1.0% to 9.9%. The highest GBT incidence rate of 9.9% occurred on April 30th. In the week prior to this April 30 GBT sample, the 12-hour average TDG in the IHR tailrace had been in the 116-118% range (Figure B-6).

Signs of severe fin GBT (i.e., Rank 3 or 4) were observed on one occasion at IHR in 2024 (May 14th). The incidence rate for severe fin GBT was 1.3%. which was below the 5% action criterion. This single instance of severe GBT at IHR was observed in a sculpin.

Table B-14

Detailed breakdown of native non-salmonid GBT exams conducted by USGS below Ice Harbor Dam in spring of 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Indicence Rate[A]	Species Examined[B]	Number with Non-Protocol GBT
4/9/2024	50	0	0.0%	NP, SC	0
4/16/2024	56	0	0.0%	AP, NP, SC	0
4/23/2024	67	1	1.0%	NP, SC	3
4/30/2024	67	6	9.9%	NP, SC	4
5/7/2024	50	3	4.8%	NP, SC	4
5/14/2024	53	3	3.8%	NP, SC	6
5/21/2024	52	1	1.0%	NP, SC	3
5/28/2024	50	3	3.2%	NP, SC	7
6/4/2024	39	0	0.0%	NP, SC	3
6/11/2024	39	0	0.0%	LU, MW, NP, SC	0
6/17/2024	55	0	0.0%	SC	2

[A] The reported GBT incidence rate for native non-salmonids at IHR is based on the stratified mean proportion methodology (Equation 2)

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

The target sample size of 100 native non-salmonids examined per GBT sample was never met in 2024 (Table B-14). The minimum target sample size of 50 native non-salmonids examined per GBT sample was met in all but two IHR samples (June 4 and June

11). 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 non-salmonid sampling occurred in the Snake River Zone.

The USGS crew observed signs of bubbles in non-protocol locations (i.e., locations other than the unpaired fins) in some of the native non-salmonid GBT samples below IHR. Bubbles in non-protocol locations do not count towards the GBT monitoring action criteria. A total of 32 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations (Table B-14). All 32 individuals were sculpin. The observations of bubbles in non-protocol locations were spread out over eight of the 11 samples conducted below IHR.

Finally, of the 578 total native non-salmonids collected and examined from below IHR, 554 (96%) were collected through backpack electrofishing and 24 (4%) were collected through purse seines. All 17 of the native non-salmonids that exhibited signs of fin GBT below IHR were collected with backpack electrofishing. All 32 of the native non-salmonids that were observed with bubbles in non-protocol locations, and no signs of fin GBT, were collected with electrofishing.

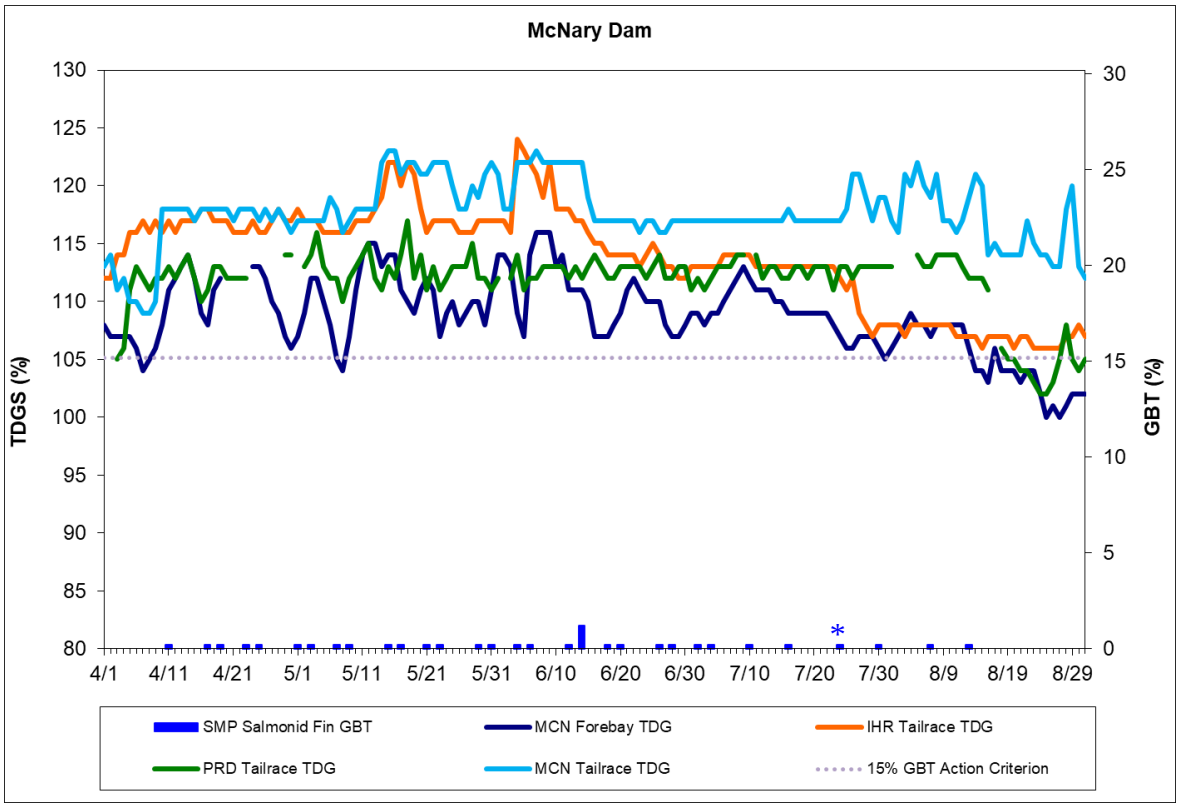
McNary Dam (MCN)

Over the 2024 spring spill period, 12-hour average TDG levels in the IHR tailrace never exceeded the 125% tailrace standard (Figure B-7). In fact, the maximum 12-hour average TDG in the IHR tailrace was 125%, which occurred only once (June 4th). Spill in the Upper Columbia is managed to the 115%/120% TDG standard. The 12-hour average TDG in the Priest Rapids (PRD) tailrace never exceeded 120% in the spring (Figure B-7). The maximum 12-hour TDG in the PRD tailrace was 117%, which occurred only once (May 18th). Finally, the 12-hour average TDG in the MCN tailrace never exceeded 125% in the spring of 2024. The maximum 12-hour average TDG was 123%, which occurred on three occasions (May 15-16 and June 7; Figure B-7)

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 MCN forebay never exceeded the 115% forebay TDG standard that was in place over the summer spill season. Over the summer spill season, the maximum 12-hour average TDG in the MCN forebay was 113%, which occurred on July 9th (Figure B-7).

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 2024.



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-15 for details)

Salmonids

Salmonid GBT sampling at MCN occurred from April 11th to August 13th (Table B-15). Like recent years, salmonid GBT sampling at MCN was reduced from twice-per-week to once-per-week due to elevated temperatures and increased mortalities in the recovery raceway. This reduction in sampling frequency occurred after the sample on July 10th. At that time, TDG levels in the MCN forebay were 112% (Figure B-7) and temperatures in the MCN forebay were 67.2°F and increasing rapidly. 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 13th. 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 2024, with 2,810 total salmonids examined (Table B-15). Among the 31 total salmonid GBT samples, only one (June 14th) had at least one salmonid with signs of fin GBT. This single sample with signs of fin GBT had a GBT incidence rate of 1.0% (Figure B-7; Table B-15). Total dissolved gas in the IHR and PRD tailraces had been in the 117-121% and 112-113% ranges, respectively, over the week prior to this Jue 14 sample. The single fish with signs of fin GBT had Rank 1 signs. Therefore, no signs of severe GBT were observed among salmonids examined at MCN in 2024.

Table B-15

Detailed breakdown of SMP salmonid GBT exams and signs of fin GBT at McNary Dam in 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]
4/11/2024	100	0	0.0%
4/17/2024	99	0	0.0%
4/19/2024	100	0	0.0%
4/23/2024	100	0	0.0%
4/25/2024	100	0	0.0%
5/1/2024	100	0	0.0%
5/3/2024	100	0	0.0%
5/7/2024	100	0	0.0%
5/9/2024	100	0	0.0%
5/15/2024	100	0	0.0%
5/17/2024	100	0	0.0%
5/21/2024	100	0	0.0%
5/23/2024	100	0	0.0%
5/29/2024	100	0	0.0%
5/31/2024	88	0	0.0%
6/4/2024	65	0	0.0%
6/6/2024	100	0	0.0%
6/12/2024	100	0	0.0%
6/14/2024	100	1	1.0%
6/18/2024	100	0	0.0%
6/20/2024	100	0	0.0%
6/26/2024	100	0	0.0%
6/28/2024	100	0	0.0%
7/2/2024	100	0	0.0%
7/4/2024	81	0	0.0%
7/10/2024	100	0	0.0%
7/16/2024	60	0	0.0%
7/24/2024	6	0	0.0%
7/30/2024	60	0	0.0%
8/7/2024	100	0	0.0%
8/13/2024	51	0	0.0%

[A] The reported GBT incidence rate for salmonids at MCN is based on the Traditional methodology (Eq. 1).

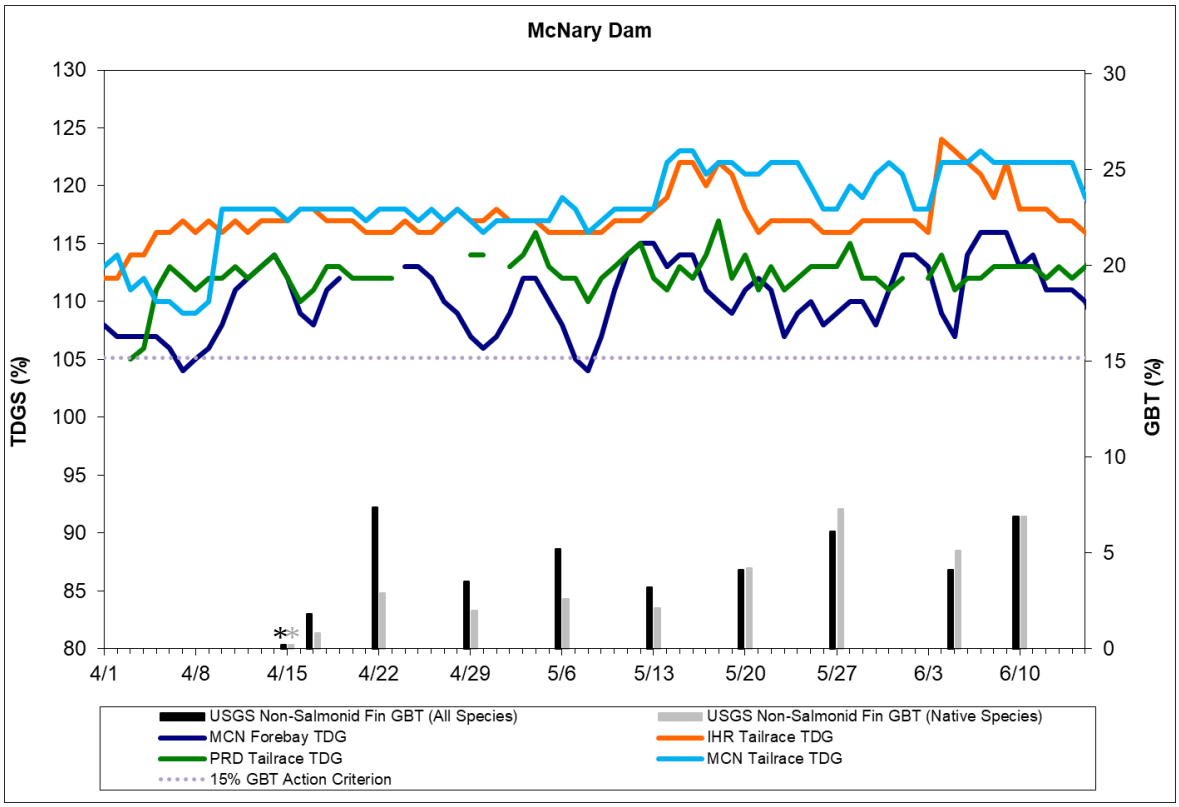
The target sample size of 100 salmonids examined per GBT sample was met in all but eight of the salmonid GBT samples at MCN (Table B-15). The minimum sample size target of 50 salmonids per GBT sample was met in all but one salmonid samples (July 24th; Table B-15). Finally, when considered collectively with BON, the WDOE and ODEQ minimum sample size requirement of 50 salmonids per week, per zone, was met in every week that salmonid GBT monitoring occurred 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 15th through June 10th (Figure B-8). Ten total non-salmonid GBT samples were conducted in the MCN tailrace in 2024. Since MCN is located at the border of Washington and Oregon, methodologies and specifications for the non-salmonid GBT action criteria apply (i.e., WA - native species using the Stratified Mean methodology (Eq. 2) and OR - all species with the Traditional methodology (Eq. 1)) and spill was managed to the more restrictive. Therefore, we present data for both combinations of specifications/methodologies 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 2024.



Notes: 1) Black bars are for the ODEQ specification of all species combined using Traditional methodology (Eq. 1) and grey bars are for the WDOE specification of native species only using the Stratified Mean methodology (Eq. 2), 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-16 and B-17 for details.

All Non-Salmonid Species

Across the 10 non-salmonid GBT samples conducted below MCN in spring 2024, 944 total non-salmonids were examined and 42 exhibited signs of fin GBT (Figure B-8; Table B-16). In all, 12 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 80% and 13% of the total non-salmonids examined at this site, respectively. Of the 42 total non-salmonids that exhibited signs of fin GBT, 40 were sculpin and two were smallmouth bass.

Table B-16

Detailed breakdown of USGS non-salmonid (all species combined) GBT exams and signs of fin GBT from the McNary Dam tailrace in spring of 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]	Species Examined[B]	Number with Non-Protocol GBT
4/15/2024[C]	27	0	0.0%	SC	0
4/17/2024[C]	61	1	1.6%	SC, SU, UD	4
4/22/2024	111	8	7.2%	BH, BK, BM, BS, SC, SU, UD	5
4/29/2024	90	3	3.3%	BH, BK, BL, BM, BS, CP, NP, SC, SU	11
5/6/2024	100	5	5.0%	BK, BL, BM, BS, NP, PE, PM, SC, SU	8
5/13/2024	132	4	3.0%	BK, BL, BM, BS, NP, SC	8
5/20/2024	103	4	3.9%	BK, BL, BM, BS, PE, SC	9
5/27/2024	102	6	5.9%	BS, SC	6
6/5/2024	129	5	3.9%	BK, BS, PE, SC	11
6/10/2024	89	6	6.7%	BS, SC	14

[A] The reported GBT incidence rate for all non-salmonids at MCN is based on the traditional methodology (Eq. 1)

[B] Native non-salmonid Species Codes: BH = Bullhead, BK = Banded Killifish, BL = Bluegill or Pumpkinseed, BM = Largemouth Bass, BS = Smallmouth Bass, CP = Carp, NP = Northern Pikeminnow, PE = Yellow Perch, PM = Peamouth, SC = Sculpin, SU = Sucker, species, and UD = Dace, species.

[C] The April 15 and 17 samples occurred in the same week and are combined when assessing sample size targets.

Of the 10 total GBT samples conducted below MCN, nine had at least one non-salmonid with signs of fin GBT (Figure B-8, Table B-16). The GBT incidence rates among non-salmonids for these nine samples ranged from 1.6% to 7.2%. The highest GBT incidence rate of 7.2% occurred on April 22nd. In the week prior to this April 22 sample, the 12-hour average TDG in the MCN tailrace had been in the 117%-118% range (Figure B-8). A total of 111 non-salmonids were examined in the April 22 sample, 98 of which were sculpin, six were smallmouth bass, three were suckers, and one each of bullhead, banded killifish, largemouth bass, and dace (unidentified). A total of 8 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 three occasions at MCN in 2024 (April 22nd, May 6th, and June 10th). The incidence rates for severe fin GBT were below the 5% action criterion on all three occasions (Range: 0.9%-1.1%). All three instances of severe GBT observed at MCN were observed in sculpin.

The target sample size of 100 non-salmonids examined per GBT sample was met in all but three samples below MCN (Table B-16). The minimum target sample size of 50 non-salmonids examined per GBT sample was 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 76 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations and all 76 were sculpin (Table B-16). The observations of bubbles in non-protocol locations were spread out over nine of the 10 samples conducted below MCN.

All 944 non-salmonids collected and examined from below MCN in 2024 were collected through backpack electrofishing. Therefore, all 42 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 12 total non-salmonids over two different sample dates (June 18th and August 13th). Of the 12 fish examined, 11 were juvenile shad and one was a smallmouth bass. No signs of fin GBT were observed during this summer sampling.

Native Non-Salmonids

A total of 778 native non-salmonids were examined below MCN in spring 2024, 40 of which exhibited signs of fin GBT (Table B-17). All 40 native non-salmonid exhibiting signs of fin GBT below MCN were sculpin. In all, five different species of native non-salmonids were examined below MCN in spring 2024. The most common native species were sculpin, which made up approximately 97% of all native species examined. Northern pikeminnow were the second most common native species from below MCN, comprising approximately 2% of the total native species examined.

Table B-17
Detailed breakdown of USGS non-salmonid (native species only) GBT exams and signs of fin GBT from the McNary Dam tailrace in spring of 2027.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]	Species Examined[B]	Number with Non-Protocol GBT
4/15/2024	27	0	0.0%	SC	0
4/17/2024	61	1	0.6%	SC, SU, UD	4
4/22/2024	102	8	2.7%	SC, SU, UD	5
4/29/2024	65	3	1.8%	NP, SC, SU	11
5/6/2024	76	5	2.4%	NP, PM, SC, SU	8
5/13/2024	109	4	1.9%	NP, SC	8
5/20/2024	75	3	4.0%	SC	9
5/27/2024	85	6	7.1%	SC	6
6/5/2024	103	5	4.9%	SC	11
6/10/2024	75	5	6.7%	SC	14

[A] The reported GBT incidence rate for native non-salmonids at MCN is based on the stratified mean proportion methodology (Eq. 2).

[B] Native non-salmonid Species Codes: NP = Northern Pikeminnow, PM = Peamouth, SC = Sculpin, SU = Sucker, species, and UD = Dace, species.

[C] The April 15 and 17 samples occurred in the same week and are combined when assessing sample size targets.

Of the 10 total GBT samples conducted below MCN, nine had at least one native non-salmonid with signs of fin GBT (Figure B-8, Table B-17). The GBT incidence rates (using the Stratified Mean methodology) among native non-salmonids for these nine samples ranged from 0.6% to 7.1%. The highest native non-salmonid GBT incidence rate of 7.1% occurred on May 27th. A total of 85 non-salmonids were examined in the sample from May 27th, all of which were sculpin. Of these, 6 had signs of fin GBT.

Signs of severe fin GBT (i.e., Rank 3 or 4) among native non-salmonids were observed on three occasions at MCN in 2024 (April 22nd, May 6th, and June 10th). The incidence rates for severe fin GBT were below the 5% action criterion on all three occasions (Range: 0.3%-1.3%). All instances of severe GBT observed at MCN were Rank 3 and observed in sculpin.

The target sample size of 100 native non-salmonids examined per GBT sample was met in only three samples below MCN (Table B-17). 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 76 native non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations, and all 76 were sculpin (Table B-

17). The observations of bubbles in non-protocol locations were spread out over nine of the 10 samples conducted below MCN.

All 778 native non-salmonids collected and examined from below MCN in 2024 were collected through backpack electrofishing. Therefore, all 40 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). There were no native non-salmonids examined among the two non-salmonid GBT samples that were conducted at MCN in the summer of 2024. All non-salmonid species collected and examined during these two samples were non-native species (juvenile shad and smallmouth bass).

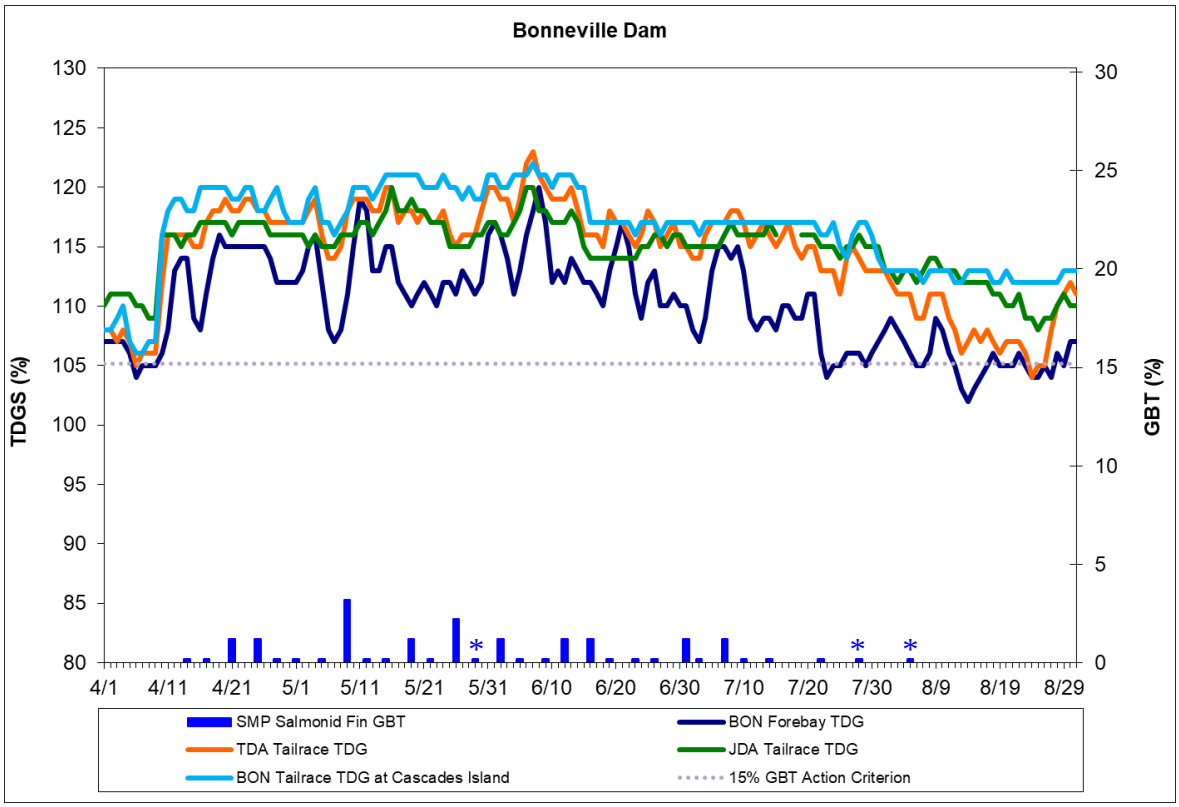
Bonneville Dam (BON)

During the spring spill season, the 12-hour average TDG in the tailraces at John Day (JDA) or The Dalles (TDA) never exceeded 125% (Figure B-9). In fact, the maximum 12-hour average TDG in these two tailraces was 120% at JDA and 123% at TDA. The 12-hour average TDG in the BON tailrace (at Cascades Island) also never exceeded the 125% tailrace TDG standard (Figure B-9). The maximum 12-hour average TDG in the BON tailrace was 122%, which occurred on June 7th.

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). The 12-hour average TDG in the BON forebay exceeded the 115% forebay TDG standard on one occasion during the summer spill period (June 21st; Figure B-9).

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 2024.



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-18 for details).

Salmonids

Salmonid GBT sampling at BON occurred from April 14th to August 5th (Figure B-9; Table B-18). Salmonid GBT sampling at BON typically occurs twice-per-week. However, GBT sampling can be suspended when Spring Creek NFH releases occur, to minimize handling of these listed fish. In 2024, Spring Creek NFH conducted a single release on April 3rd and 4th, before spring spill began. Therefore, salmonid GBT sampling was not affected by the release in 2024. 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 14th. Due to decreasing fish numbers, continued high temperatures, and generally low TDG levels, salmonid GBT sampling at BON ended after the sample on August 5th.

Table B-18

Detailed breakdown of SMP salmonid GBT exams and signs of fin GBT at Bonneville Dam in 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]
4/14/2024	100	0	0.0%
4/17/2024	100	0	0.0%
4/21/2024	100	1	1.0%
4/25/2024	100	1	1.0%
4/28/2024	100	0	0.0%
5/1/2024	100	0	0.0%
5/5/2024	100	0	0.0%
5/9/2024	100	3	3.0%
5/12/2024	100	0	0.0%
5/15/2024	100	0	0.0%
5/19/2024	100	1	1.0%
5/22/2024	100	0	0.0%
5/26/2024	100	2	2.0%
5/29/2024	34	0	0.0%
6/2/2024	100	1	1.0%
6/5/2024	100	0	0.0%
6/9/2024	100	3	0.0%
6/12/2024	100	1	1.0%
6/16/2024	100	1	1.0%
6/19/2024	100	0	0.0%
6/23/2024	100	0	0.0%
6/26/2024	100	0	0.0%
7/1/2024	100	1	1.0%
7/3/2024	100	0	0.0%
7/7/2024	100	1	1.0%
7/10/2024	100	0	0.0%
7/14/2024	100	0	0.0%
7/22/2024	56	0	0.0%
7/28/2024	6	0	0.0%
8/5/2024	3	0	0.0%

[A] The reported GBT incidence rate for salmonids at BON is based on the Traditional methodology (Eq. 1).

In all, 30 total salmonid GBT samples were conducted at BON in 2024, with 2,699 total salmonids examined. Of the 30 total salmonid GBT samples, 10 had at least one salmonid with signs of fin GBT (Figure B-9; Table B-18). Among these 10 samples, GBT incidence rates ranged from 1.0% to 3.0%, with the highest GBT incidence rate occurring on May 9th. In the week prior to the sample on May 9th, TDG in the JDA and TDA tailraces had been in the 115-116% and 114-119% ranges, respectively. No signs of severe fin GBT were observed among salmonids examined at BON in 2024.

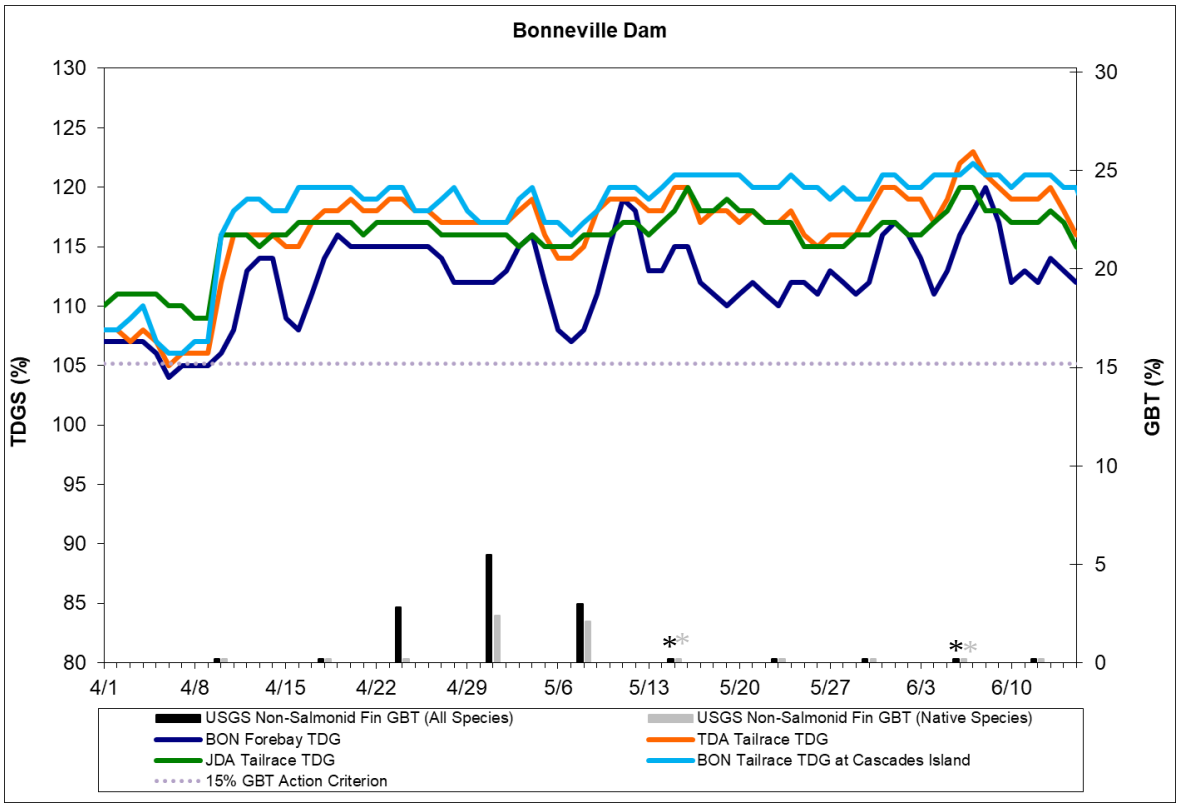
The target sample size of 100 salmonids examined per GBT sample was met in all but four salmonid GBT samples (May 29th, July 22nd, July 28th, and August 5th; Table B-18). All but three salmonid GBT samples at BON met the minimum sample size target of

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 that salmonid GBT sampling occurred in the Mid-Columbia River Zone.

Non-Salmonids

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 2024.



Notes: 1) Black bars are for the ODEQ specification of all species combined using Traditional methodology (Eq. 1) and grey bars are for the WDOE specification of native species only using the Stratified Mean methodology (Eq. 2), 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-19 and B-20 for details.

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 10th through June 12th (Figure B-10). 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 and methodologies for the non-salmonid GBT action criteria apply (i.e., WA - native species only using the Stratified Mean Proportion methodology or OR - all species using the Traditional methodology).

Therefore, spring spill at BON was managed to the more restrictive specification/methodology combination. For this reason, we present data for both combinations of specification/methodologies in the summaries below.

All Non-Salmonid Species

Across the 10 non-salmonid GBT samples conducted below BON in spring 2024, 650 total non-salmonids were examined and nine exhibited signs of fin GBT (Table B-19). 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 69% and 11% of the total non-salmonids examined at this site, respectively. Of the nine total non-salmonids that exhibited signs of fin GBT, seven were sculpin and two were smallmouth bass.

Table B-19

Detailed breakdown of non-salmonid GBT exams (all species combined) conducted by USGS below Bonneville Dam in spring of 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]	Species Examined[B]	Number with Non-Protocol GBT
4/10/2024	75	0	0.0%	NP, SC, SK	0
4/18/2024	67	0	0.0%	NP, SC, SK, SU	0
4/24/2024	78	2	2.6%	BK, BS, LO, NP, SC, SK	12
5/1/2024	95	5	5.3%	BK, BS, GO, LO, NP, PE, SC, SK	2
5/8/2024	72	2	2.8%	BK, BS, GO, LO, SC, SK	5
5/15/2024	16	0	0.0%	BK, BS, GO, LO, NP, SC	1
5/23/2024	64	0	0.0%	BK, BL, BS, GO, LO, LU, PE, SC, SD, SK	1
5/30/2024	93	0	0.0%	BK, BS, GO, LO, MW, NP, SC, SK	4
6/6/2024	31	0	0.0%	BK, MW, NP, SK	0
6/12/2024	59	0	0.0%	BK, BS, LO, PE, SC, SK, SU, UD	0

[A] The reported GBT incidence rate for all non-salmonids at BON is based on the Traditional methodology (Eq. 1).

[B] Native non-salmonid Species Codes: BK = Banded Killifish, BL = Bluegill or Pumpkinseed, BS = Smallmouth Bass, GO = Goby, LO = Loach, LU = Largescale Sucker, MW = Mountain Whitefish, NP = Northern Pikeminnow, PE = Yellow Perch, SC = Sculpin, SD = Speckled Dace, SK = Three-spined Stickleback, SU = Sucker, species, and UD = Dace, species.

Of the 10 total GBT samples conducted below BON, three had at least one non-salmonid with signs of fin GBT (Figure B-10; Table B-19). The GBT incidence rates (using the Traditional methodology) among non-salmonids for these three samples ranged from 2.6% to 5.3%. The highest GBT incidence rate of 5.3% occurred on May 1st. In the week prior to this GBT sample, the 12-hour average TDG in the BON tailrace had been in

the 117-120% range (Figure B-10). A total of 95 non-salmonids were examined in the sample from May 1st. Of these, 75 were sculpin, six were smallmouth bass, six were three-spined stickleback, four were northern pikeminnow, and one each were banded killifish, goby, loach, and yellow perch. A total of five fish had signs of fin GBT in this sample, all of which were sculpin. No signs of severe fin GBT were observed among non-salmonids sampled below BON in 2024.

The target sample size of 100 non-salmonids examined per GBT sample was never met in 2024 (Table B-19). The minimum target sample size of 50 non-salmonids examined per GBT sample was met in all but two samples below BON (May 15 and June 6; Table B-19). 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 25 non-salmonids, that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations and all but one were sculpin (Table B-19). The one other fish that had non-protocol signs of GBT was a smallmouth bass. The observations of bubbles in non-protocol locations were spread out over six of the 10 samples conducted below BON.

Of the 650 total non-salmonids collected and examined from below BON in 2024, 585 (90%) were collected through backpack electrofishing. The remaining 65 fish (10%) were collected with a purse seine. All non-salmonids that exhibited signs of fin GBT were collected with backpack electrofishing and all 25 non-salmonids that exhibited signs of 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, only a few summer sample dates fit the criteria for non-salmonid GBT sampling (i.e., TDG levels >110% and water temperatures ≤68°F). In all, SMP personnel at BON collected non-salmonids on five different occasions (June 19th, June 23rd, July 1st, July 7th, and July 10th). In all, seven total non-salmonids were examined for GBT over the summer of 2024. Of these seven fish, two were sculpin, two were peamouth, and one each were Pacific lamprey ammocoetes, banded killifish, and smallmouth bass. No signs of fin GBT were observed during this summer sampling.

Native Non-Salmonids

A total of 564 native non-salmonids were examined below BON in spring 2024, seven of which exhibited signs of fin GBT (Table B-20). All seven 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 2024. The most common native species were sculpin, which made up approximately 76% of all native species

examined. Three-spined stickleback were the second most common native species from below BON, comprising approximately 12.5% of the total native species examined.

Of the 10 total GBT samples conducted below BON, only two had at least one native non-salmonid with signs of fin GBT (Figure B-10; Table B-20). The GBT incidence rates (using the Stratified Mean Proportion methodology) among native non-salmonids for these two samples ranged from 1.9% to 2.2%. The highest native non-salmonid GBT incidence rate of 2.2% occurred on May 1st. A total of 85 native non-salmonids were examined in the May 1 sample and five fish had signs of fin GBT. All five fish with signs of fin GBT on May 1st were sculpin. No signs of severe fin GBT were observed among the native non-salmonids examined below BON.

Table B-20

Detailed breakdown of non-salmonid GBT exams (native species only) conducted by USGS below Bonneville Dam in spring of 2024.

Sample Date	Number Examined	Number with Fin GBT	GBT Incidence Rate[A]	Species Examined[B]	Number with Non-Protocol GBT
4/10/2024	75	0	0.0%	NP, SC, SK	0
4/18/2024	67	0	0.0%	NP, SC, SK, SU	0
4/24/2024	69	0	0.0%	NP, SC, SK	12
5/1/2024	85	5	2.2%	NP, SC, SK	2
5/8/2024	54	2	1.9%	SC, SK	4
5/15/2024	9	0	0.0%	NP, SC	1
5/23/2024	53	0	0.0%	LU, SC, SD, SK	1
5/30/2024	82	0	0.0%	MW, NP, SC, SK	4
6/6/2024	20	0	0.0%	MW, NP, SK	0
6/12/2024	50	0	0.0%	SC, SK, SU, UD	0

[A] The reported GBT incidence rate for native non-salmonids at BON is based on the Stratified Mean Proportion methodology (Eq. 2)

[B] Native non-salmonid Species Codes: LU = Largescale Sucker, MW = Mountain Whitefish, NP = Northern Pikeminnow, SC = Sculpin, SD = Speckled Dace, SK = Three-spined Stickleback, SU = Sucker, species, and UD = Dace, species.

The target sample size of 100 native non-salmonids examined per GBT sample was never met below BON in 2024 (Table B-20). The minimum target sample size of 50 native non-salmonids examined per GBT sample was met in all but two samples (May 15th and June 6th; Table B-20). However, 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 24 native non-salmonids (all sculpin), that did not otherwise have signs of fin GBT, were observed with bubbles in non-protocol locations (Table B-20). The observations of bubbles in non-protocol locations were spread out over six of the 10 samples conducted below BON.

Of the 564 native non-salmonids that were collected and examined from below BON in 2024, 516 (91.5%) were collected through backpack electrofishing and the remaining 48 (9.5%) were collected with a purse seine. All seven native non-salmonids that exhibited signs of fin GBT were collected with backpack electrofishing and all 24 native non-salmonids that were observed with signs of GBT in non-protocol locations (with no 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, 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 four total sample dates (June 19th, June 23rd, July 1st, and July 7th). Of the five native non-salmonids examined, two were sculpin, two were peamouth, and one was a Pacific lamprey ammocoete. No signs of fin GBT were observed among the native non-salmonids examined during this summer sampling.

Historical Summary (1996–2024)

Table B-21 compares the 2024 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 2024 compared to past years. The overall percentages presented in Table B-21 are only for the salmonid samples conducted at FCRPS projects (i.e., Rock Island is excluded from applicable years). At 0.35%, the overall annual GBT incidence rate for 2024 was ranked 20th over the last 29 years.

Table B-21
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
2024	**0.35**

As mentioned above, the GBT monitoring program has been implemented on salmonids annually since 1996. Therefore, there are 29 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 (Appendix H of USACE 2022), 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

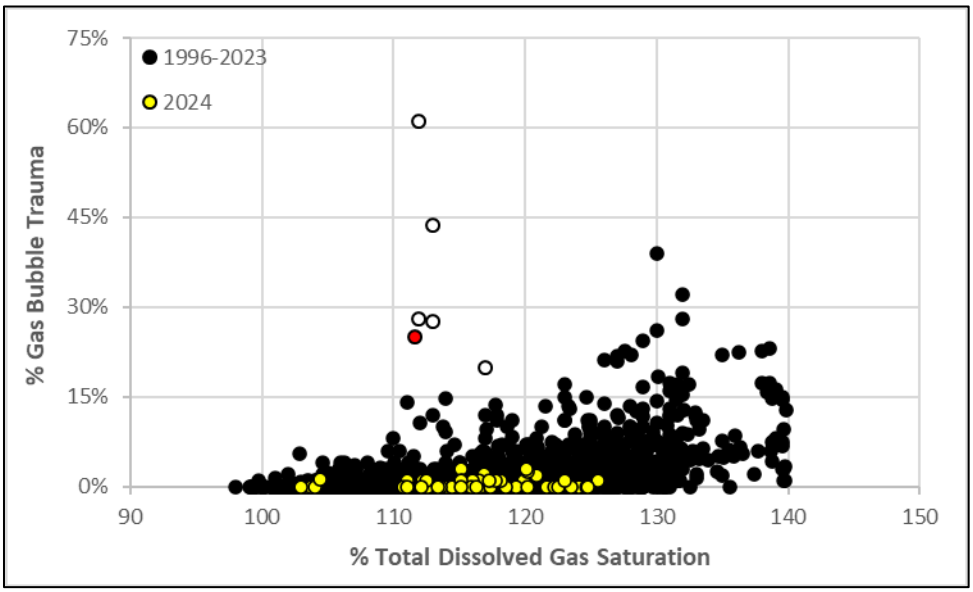
salmonids examined were included. For each GBT sample in this dataset, we estimated the average TDG from the upstream tailrace. This average tailrace TDG was adjusted for water transit time, which was based on the daily average flow and forebay elevation from the day of the GBT sample. There were two 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 TDG 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 3,382 daily exams fit into our criteria of ≥75 fish examined over the 29 years of available data, where GBT data could be matched to upstream TDG data. This equated to a total of 376,534 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 29 years, and under what tailrace TDG levels this occurred. In all the years when TDG and GBT data have been collected (3,382 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 2024 (yellow circles in Figure B-11), despite the 125% tailrace TDG standard that was utilized for the spring spill season. Due to generally low flows, tailrace TDG levels rarely reached 125% in 2024 (see site-specific summarizes for details).

Figure B-11
Percent GBT observed as a function of TDG observed in upstream tailrace in 1996-2023 (black circles) and 2024 (yellow circles).



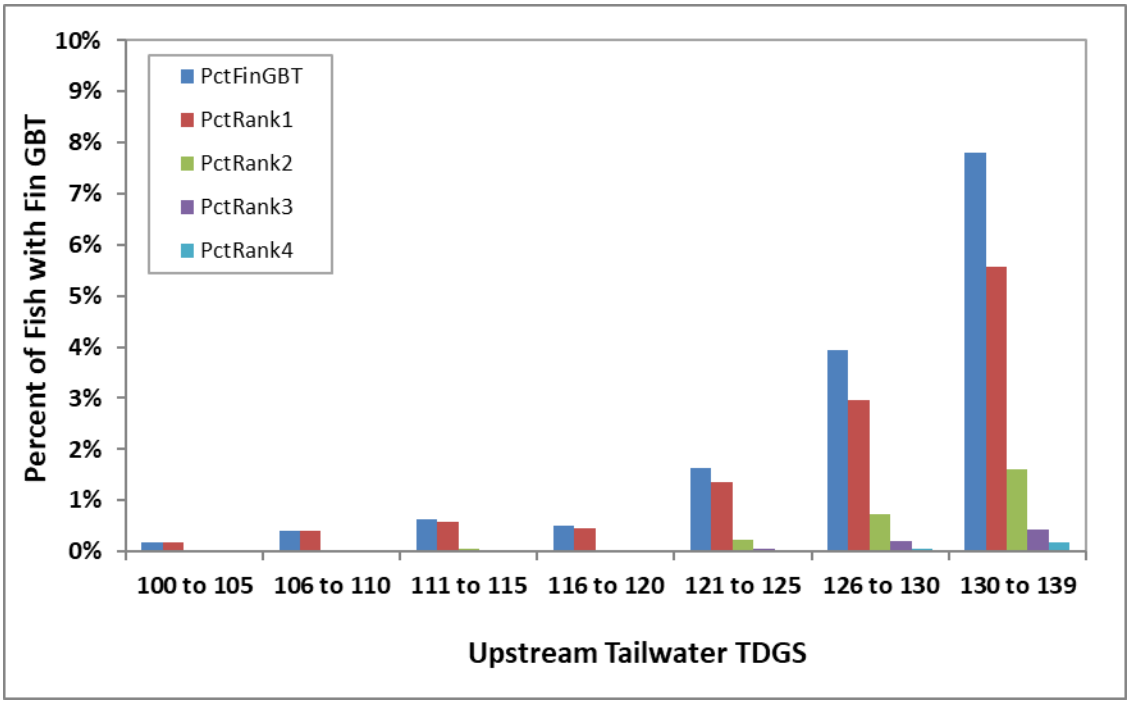
* Open circles indicate observations for late migrating steelhead in 2002 and 2007.
** Red circle indicates observation in 2008 when deformed fin rays may have been misidentified as GBT at LGS.

Of the 3,382 GBT samples that met the sample size criteria for this historic review, 344 had corresponding TDG levels of ≥125%. Of these, only 28 (or 8.1%) had GBT incidence rates that met or exceeded the 15% fin GBT criterion. This means that the remaining 316 GBT samples (or 91.9%) 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 1996–2024 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 2024 migration season. In accordance with operations outlined by the 2024 FOP, the water quality standards for TDG were 125% in the tailrace for the spring and 115%/120% (Washington) or 120% tailrace (Oregon) in the summer. Flows in the Lower Snake and Mid-Columbia rivers were generally low in 2024, such that spill to the 125% spill caps was generally not possible in the spring and TDG was mostly below the 115%/120% standard in the summer.

For the salmonid GBT samples, the action criterion of 15% fin GBT was never met or exceeded in 2024. In addition, the action criterion of 5% severe fin GBT was also never met or exceeded in 2024 among the salmonid samples. The highest GBT incidence rate observed in salmonids in 2024 was 4.5% (using the Traditional methodology), which occurred in the sample at Little Goose Dam on July 24th. However, it should be noted that this GBT incidence rate was based on only 22 examined salmonids.

For the USGS non-salmonid GBT samples, the 15% fin GBT action criterion was also never met or exceeded, regardless of which specification or methodology was used for estimating GBT incidence rates. In addition, the action criterion of 5% severe fin GBT was never met or exceeded in 2024 among the USGS non-salmonid GBT samples. The maximum GBT incidence rate observed in 2024 was 9.9% (native species only and using the Stratified Mean Proportion methodology), which occurred on April 30th in the Ice Harbor tailrace. 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 29 years strongly suggest 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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