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November 14, 2013

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

Dear Mr. Proctor,

As per our agreement, we are providing both you and Mr. Paul Wagner of NOAA Fisheries with a copy of our "Gas Bubble Trauma Monitoring and Data Reporting for 2013." This report summarizes data collected during the 2013 juvenile salmonid migration.

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

Sincerely,

Michele DeHart
Fish Passage Center Manager

CC: Laura Hamilton, COE
Paul Wagner, NOAA Fisheries

Appendix L

Gas Bubble Trauma Monitoring And Data Reporting For 2013

**Fish Passage Center
Portland, Oregon**

Gas Bubble Trauma Monitoring and Data Reporting for 2013

Overview

The goal of the juvenile salmonid gas bubble trauma (GBT) monitoring program is to determine the relative extent that migrating juvenile salmonids have been exposed to harmful levels of total dissolved gas. The determination is based upon the prevalence and severity of GBT induced bubbles on the fish. The data are reported to the fisheries management entities, the water quality agencies of Washington and Oregon, and are available to other interested parties through Fish Passage Center weekly reports and daily postings to the FPC web site during the season (<http://www.fpc.org/smolt/gasbubbletrauma.html>).

The monitoring of juvenile salmonids in 2013 for GBT was conducted at Upper Columbia, Middle Columbia and Snake River sites. Fish were collected and examined for signs of GBT at Bonneville Dam and McNary Dam on the Middle Columbia River, and at Rock Island Dam on the Upper Columbia River. The Snake River monitoring sites were Lower Granite, Little Goose, and Lower Monumental dams. Sampling occurred two days per week at the Columbia River sites and one day a week at each of the Snake River sites throughout the spring and summer spill programs.

The goal of the sampling program was to sample 100 salmonids of the most prevalent species (limited to chinook and steelhead) during each day of sampling at each site, with the proportion of each species sampled dependent upon their prevalence at the time of sampling. Yearling Chinook and steelhead were sampled through the spring at all the sampling sites. Once subyearling Chinook predominated in the smolt collections, the program shifted from sampling yearling Chinook and steelhead to sampling subyearling Chinook, which continued through the end of August unless an adequate sample could not be collected. In this case, sampling for GBT may have ended prior to the end of August. Examinations of fish were done using variable magnification (6x to 40x) dissecting scopes. The eyes and unpaired 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 (Table L-1).

Table L-1
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

Additional information was recorded for each fish, including species, age, fork length, fin clips, and tags. The examination procedures were similar to those used in past years of the program (see the GBT Monitoring Protocol <ftp://ftp.fpc.org/GBT/> for details of exam procedures). All sampling sites were at dams, where fish could be collected from the juvenile fish bypass system. Fish to be examined for GBT were collected at the separator

at juvenile salmonid transportation collection sites, and by the standard collection methods at Rock Island and Bonneville dams.

The runoff (January–July) volume for the 2013 water year was near average in the Lower Columbia River but below average in the Lower Snake River. Runoff (January–July) was 96% of average (1981–2010) at the Dalles Dam and 69% of average at Lower Granite Dam. In the Snake River, this resulted in mostly lower than average flows throughout the spring and summer seasons, with peak flows in May (Figure L-1). In the Lower Columbia, the 2013 runoff resulted in near average flows in both the spring and summer periods (Figure L-2). The peak flow conditions in the Snake River and Lower Columbia rivers in mid-May resulted in uncontrolled spill for a few days at the Snake and Columbia River sites. At times TDG levels were slightly above the TDG waiver levels during this time period.

Figure L-1.
Average daily flows at Lower Granite Dam
2013, 2012, and the 10-year average

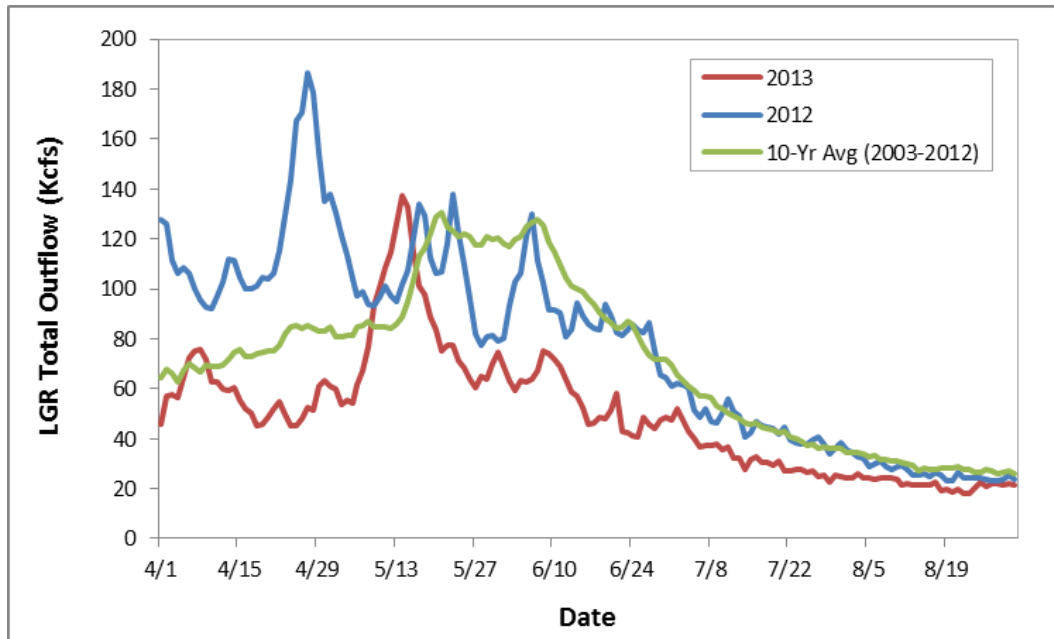


Figure L-2
Average daily flows at McNary Dam
2013, 2012 and the 10-year average



Results

In all, 13,558 juvenile salmonids were examined for GBT between April and August of 2013 (Table L-2). The fish were collected as part of the Smolt Monitoring Program.

Table L-2.
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 2013 as part of the GBT Monitoring Program.

Species	BON	MCN	LMN	LGS	LGR	RIS	Total
Chinook Subyearlings	1,575	2,124	654	736	0	1,023	6,112
Chinook Yearlings	1,036	1,391	516	614	421	935	4,913
Steelhead	257	299	673	527	323	454	2,533
Total	2,868	3,814	1,843	1,877	744	2,412	13,558

Fin signs were found in 42 or 0.31% of the total fish sampled at all sites (Table L-3). The fish examined and determined to have signs of GBT exhibited the fin signs that were most often rank 1, where less than 5% of a fin area was covered with bubbles. No signs of rank 2 or 3 were seen in 2013, but one fish with rank 4 was encountered at Rock Island Dam in early July. A more detailed breakdown of GBT exams and signs for 2013 can be found at the end of this appendix (Tables L-5 through L-10).

Table L-3

Number of juvenile salmonids found with fin GBT at dams on the Lower Snake River and on the Columbia River from April to August 2013 as part of the GBT Monitoring Program.

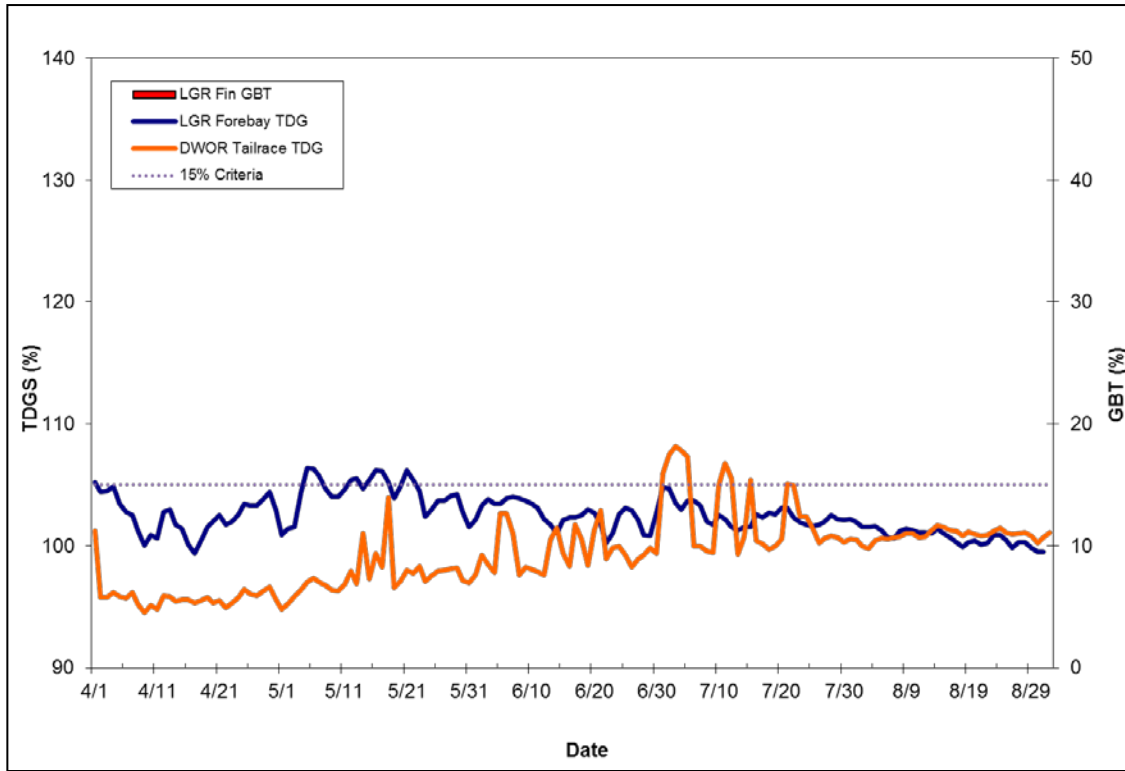
Sum of Fin GBT	Site						Grand Total
Species	BON	MCN	LMN	LGS	LGR	RIS	
CH0	4	11	0	3	0	1	19
CH1	2	8	0	1	0	8	19
ST	0	2	0	0	0	2	4
Grand Total	6	21	0	4	0	11	42

The action criteria for GBT is established as 15% of fish showing any signs of fin GBT, or 5% of the fish sampled showing signs of fin GBT greater than or equal to rank 3. Neither of these two action criteria was met in 2013.

Lower Granite Dam (LGR)

GBT sampling at LGR occurred from April 9th to May 28th. LGR does not sample for GBT when subyearling Chinook predominate the sample. Total dissolved gas (TDG) in the Dworshak Dam tailrace never exceeded 120% in 2013 and TDG in the LGR forebay never exceeded 115%. No signs of GBT were observed at LGR in 2013 (Table L-3).

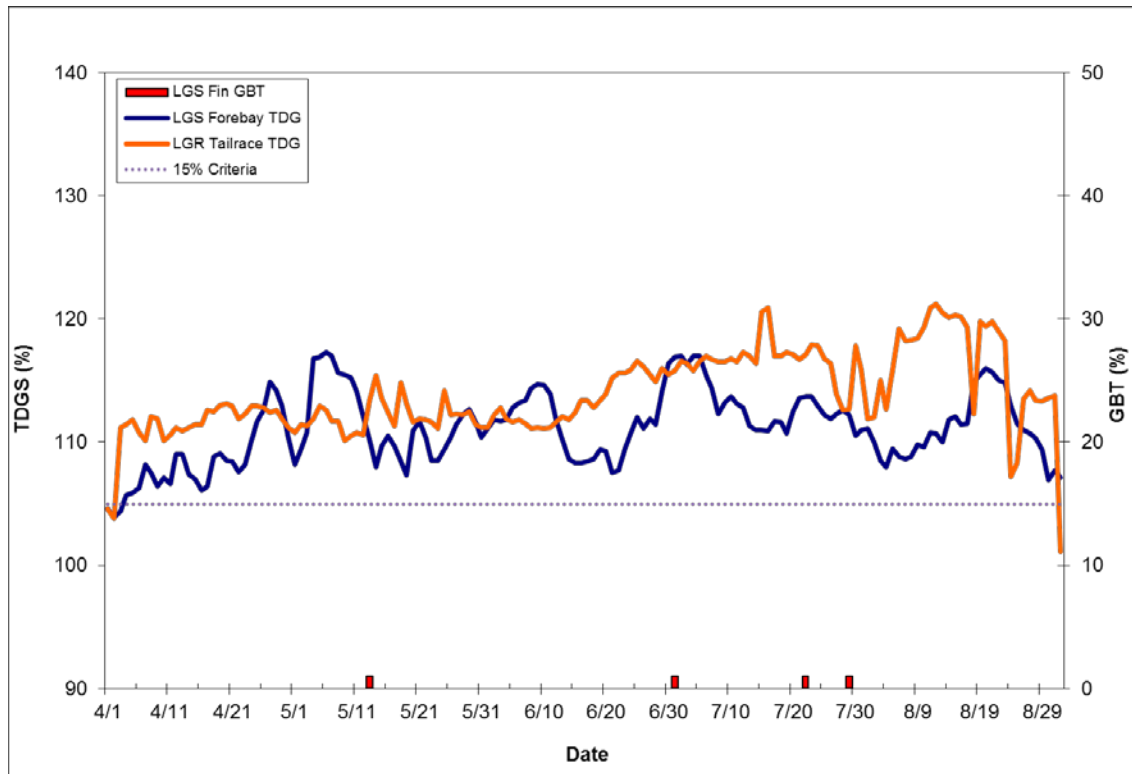
Figure L-3
Percent GBT observed in the sample at Lower Granite Dam



Little Goose Dam (LGS)

GBT sampling at LGS occurred from April 7th to August 5th. Sampling was terminated after August 5th at LGS because of the inability to collect the sample necessary to conduct GBT exams. Both the prevalence and severity of GBT signs at LGS were low in 2013. Signs of GBT were detected only on four occasions in 2013, with a maximum GBT rate of 1% on each of these four occasions (Figure L-4, Table L-6). All incidences of GBT at LGS in 2013 were at the rank 1 level. TDG levels in the LGR tailrace exceeded the 120% criteria for a short period in mid-July and mid-August (Figure L-4). In addition, TDG in the LGS forebay exceeded the 115% criteria for brief periods in early May, early July, and mid-August (Figure L-4).

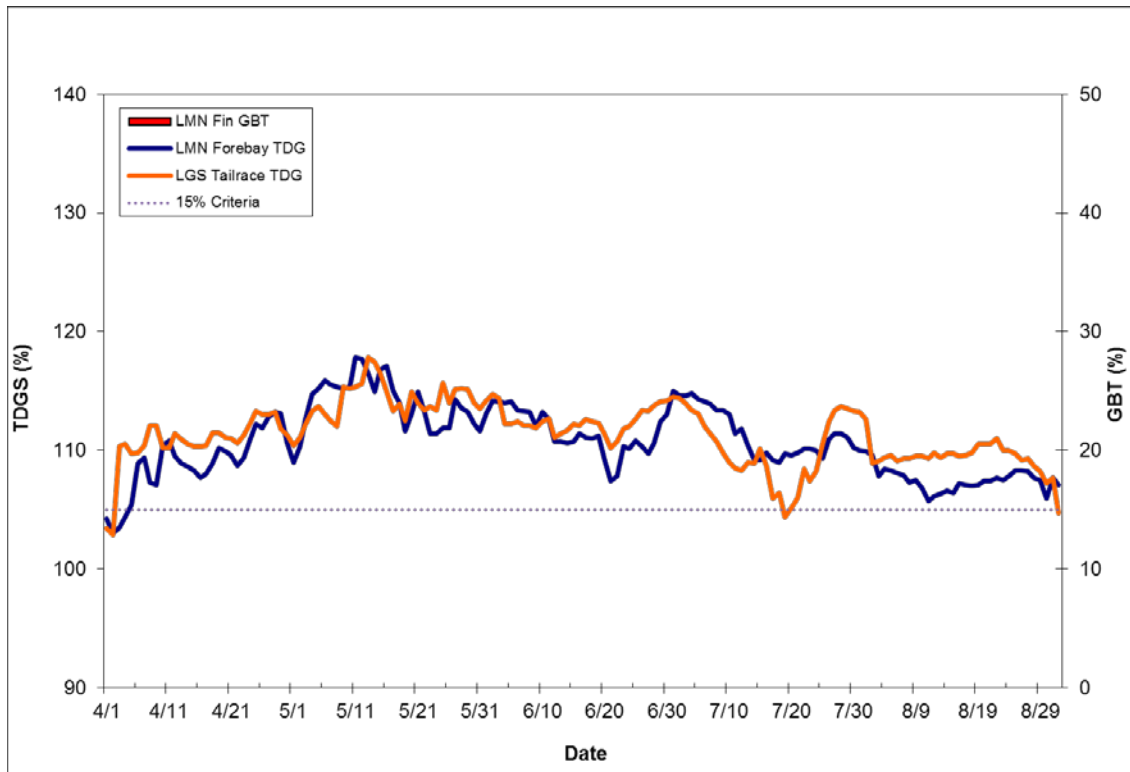
Figure L-4
Percent GBT observed in the sample at Little Goose Dam



Lower Monumental Dam (LMN)

GBT sampling at LMN occurred from April 4th to July 31st. Sampling was terminated after July 31st because of the inability to collect the sample necessary to conduct GBT exams. There were no signs of GBT at Lower Monumental Dam in 2013 (Table L-7). Total dissolved gas in the LGS tailrace never exceeded 120% in 2013 (Figure L-5). TDG in the Lower Monumental forebay exceeded 115% for a period in early to mid-May (Figure L-5).

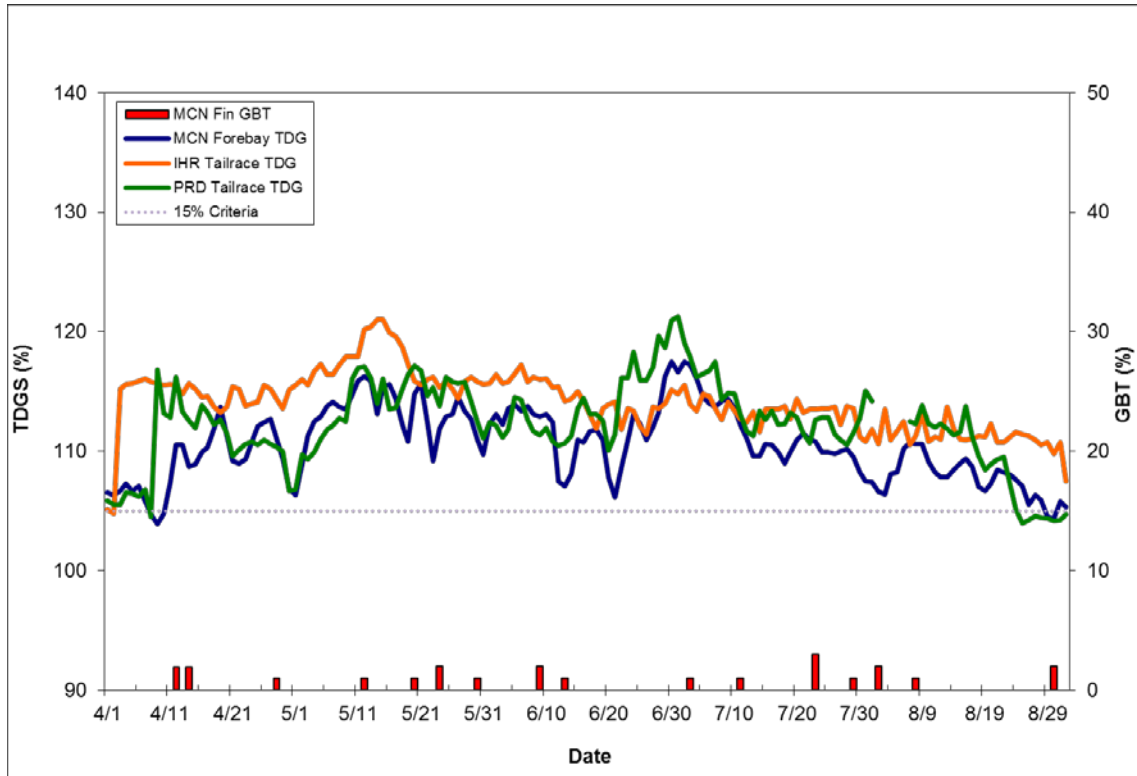
Figure L-5
Percent GBT observed in the sample at Lower Monumental Dam.



McNary Dam (MCN)

GBT sampling at MCN occurred from April 8th to August 30th. The TDG levels in the tailraces at Priest Rapids (PRD) and Ice Harbor (IHR) dams exceeded 120% for a very short period in 2013. At the IHR tailrace, TDG exceeded 120% for four days in mid-May while at the PRD tailrace; TDG exceeded 120% for two days in late June/early July (Figure L-6). Total dissolved gas at the MCN forebay exceeded 115% for short periods in mid-May and early July (Figure L-6). The number of incidences of GBT at McNary Dam in 2013 was higher than what was observed in the Snake River at Little Goose and Lower Monumental dams. In all, there were 16 days where signs of GBT were observed at MCN in 2013 (Figure L-6, Table L-8). Of these, the maximum rate of GBT was 3.0%, which occurred on July 23rd (Figure L-6, Table L-8). All of the fish that showed signs of GBT at MCN in 2013 had rank 1 signs.

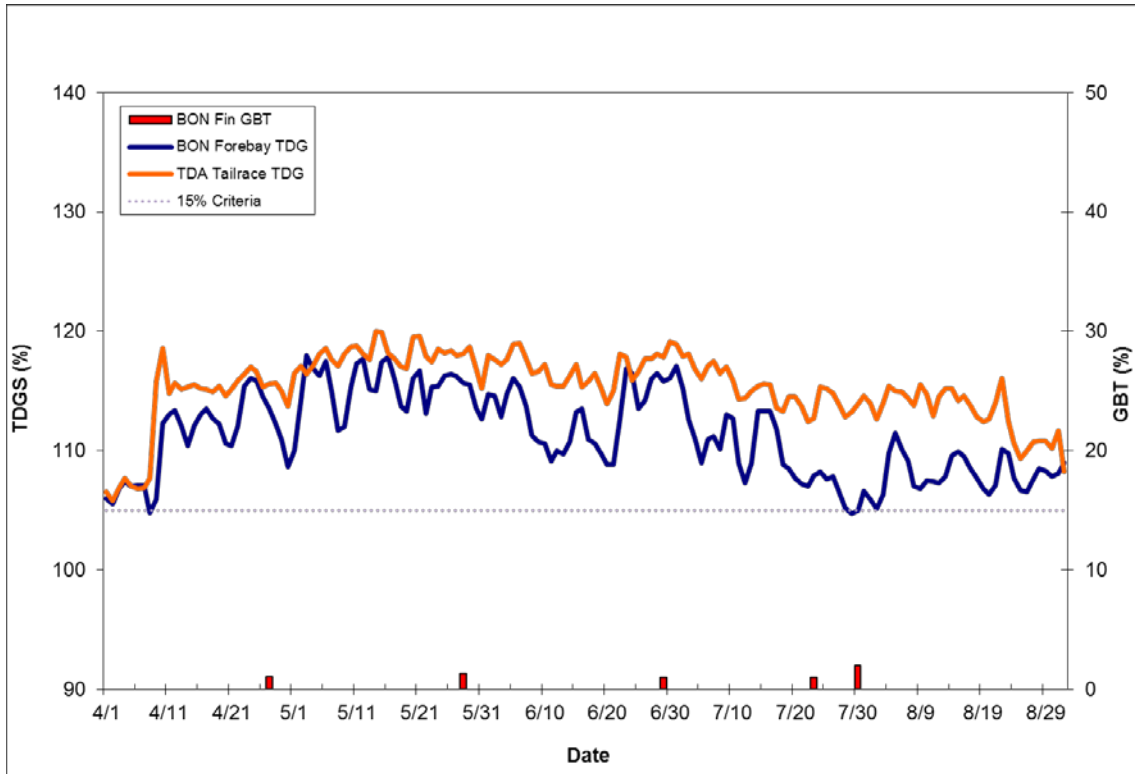
Figure L-6
Percent GBT observed in the sample at McNary Dam.



Bonneville Dam (BON)

GBT sampling at BON occurred from April 20th to August 24th. At Bonneville Dam, there were five days in 2013 when signs of GBT in fish were recorded (Figure L-7, Table L-9). Of these five days, the maximum GBT rate was 2.0%, which occurred on July 30th (Figure L-7, Table L-9). All of the fish that exhibited signs of GBT at BON in 2013 had signs that were rank 1. TDG in the tailrace at The Dalles Dam never exceeded 120% in 2013 (Figure L-7). However, TDG in the BON forebay exceeded 115% for brief periods throughout the spill season. The longest continuous period where the BON forebay exceeded 115% was seven days at the end of May (Figure L-7).

Figure L-7
Percent GBT observed in the sample at Bonneville Dam.



Rock Island Dam (RIS)

GBT sampling at RIS occurred from April 15th to August 18th. Sampling was terminated after August 18th at RIS because of the inability to collect the sample necessary to conduct GBT exams. There were eight total days where signs of GBT were detected at RIS in 2013 (Figure L-8, Table L-10). The maximum GBT rate at RIS in 2013 was 3.0%, which occurred on June 5th (Figure L-8, Table L-10). Overall, TDG in the Upper Columbia was relatively low in 2013. TDG levels in the tailraces of Grand Coulee (GCL), Chief Joseph (CHJ), and Wells (WEL) dams never exceeded 120% in 2013 (Figure L-8). However, TDG in the tailrace at Rocky Reach Dam (RRH) exceeded 120% for short periods throughout the spill season (Figure L-8). The longest continuous period where the TDG in the RRH tailrace exceeded 120% was eight days, from June 28th to July 5th (Figure L-8). Among the various forebay monitors above RIS, only those in the RRH forebay and RIS forebay had TDG levels that exceeded 115% (Figure L-8). Of the 11 fish that showed signs of GBT at RIS in 2013, all but one were rank 1. (A single fish was recorded with rank 4 signs in its anal fin, however, based on past experience we would not have expected to observe these signs at the prevailing TDG levels. It is possible that this was an incorrect data entry, but it could not be verified that this was the case. Consequently, the observation was retained in the database.)

Figure L-8
Percent GBT observed in the sample at Rock Island Dam.

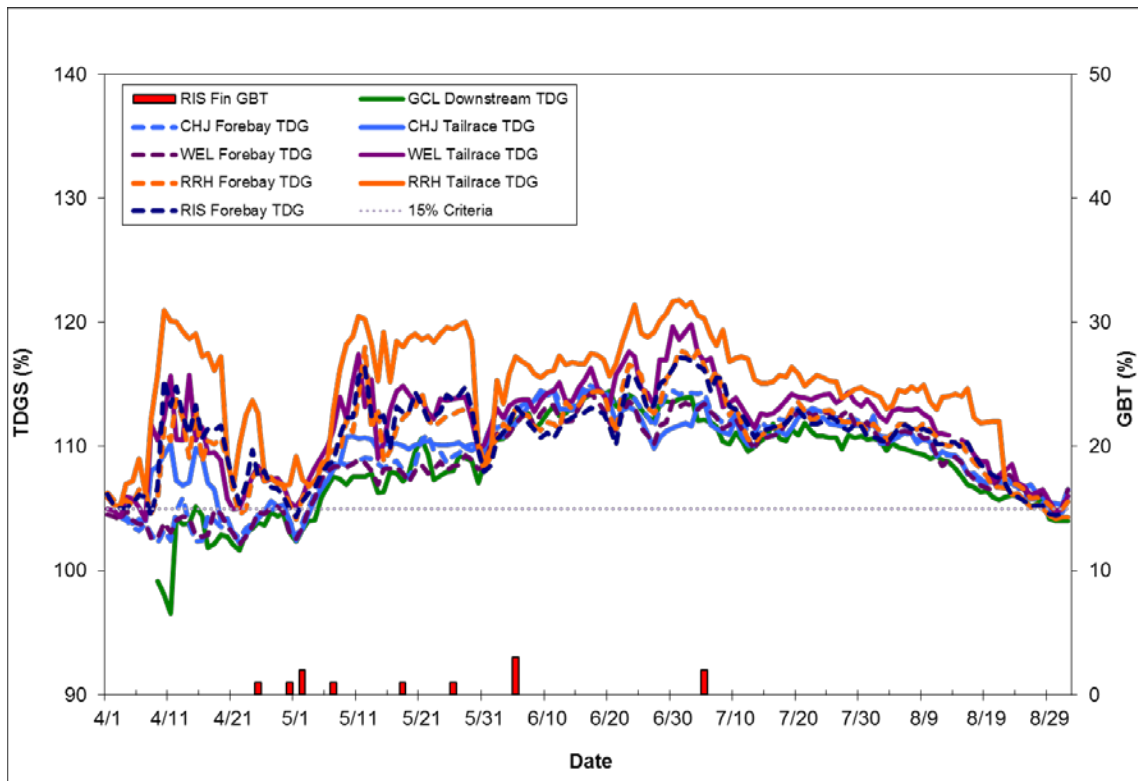


Table L-4 compares the 2013 estimates of the overall percentage of fish with signs of GBT to past years' estimates. This is not meant as a measurement of overall GBT, but is used to easily display the annual relative magnitude of GBT in 2013 compared to past years. As can be seen in the table the overall annual incidence of GBT in 2013 was in the lower range among the past 17 years.

Table L-4
Percent of sampled fish with signs of fin GBT estimated for
the total fish observed in each year 1996 to 2013.

Year	Total % Signs	% Signs excluding RIS
1996	3.3	4.2
1997	3.2	4.3
1998	1.0	1.6
1999	0.3	1.4
2000	0.2	0.2
2001	0.001	0.1
2002	0.7	0.7
2003	1.5	0.5
2004	0.18	0.18
2005	0.46	0.11
2006	1.6	1.4
2007	2.4	2.9
2008	0.5	0.7
2009	0.29	0.23
2010	0.36	0.43
2011	2.5	0.95
2012	0.68	0.44
2013	0.31	0.28

Discussion

The Biological Opinion Spill Program is managed; whenever possible, using the data collected for TDG levels. The GBT biological monitoring is meant to complement the physical monitoring program. GBT sampling was successfully accomplished for the 2013 migration season.

The GBT monitoring program has consistently shown over the years of implementation that signs of GBT are minimal when TDG is managed to the criteria levels of 115/120% TDG. Historically signs of GBT do not approach the action criteria until TDG levels are near 130% supersaturation levels in the tailraces, or forebays, of dams.

The 2013 TDG was managed close to the 115/120% criteria, and the low incidence of signs of GBT observed this year reflects that management.

Table L-5

Detailed breakdown of GBT exams and signs of fin GBT at Lower Granite Dam in 2013.

Exam Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/9/2013	100	0	0.0%
4/16/2013	100	0	0.0%
4/24/2013	100	0	0.0%
4/30/2013	100	0	0.0%
5/7/2013	100	0	0.0%
5/14/2013	100	0	0.0%
5/21/2013	100	0	0.0%
5/28/2013	44	0	0.0%

Table L-6

Detailed breakdown of GBT exams and signs of fin GBT at Little Goose Dam in 2013.

Exam Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/7/2013	100	0	0.0%
4/12/2013	100	0	0.0%
4/17/2013	100	0	0.0%
4/22/2013	100	0	0.0%
4/27/2013	100	0	0.0%
5/2/2013	100	0	0.0%
5/6/2013	100	0	0.0%
5/13/2013	100	1	1.0%
5/20/2013	100	0	0.0%
5/27/2013	77	0	0.0%
6/4/2013	101	0	0.0%
6/10/2013	100	0	0.0%
6/17/2013	88	0	0.0%
6/24/2013	60	0	0.0%
7/1/2013	100	1	1.0%
7/8/2013	100	0	0.0%
7/15/2013	100	0	0.0%
7/22/2013	100	1	1.0%
7/29/2013	100	1	1.0%
8/5/2013	51	0	0.0%

Table L-7

Detailed breakdown of GBT exams and signs of fin GBT at Lower Monumental Dam in 2013.

Exam Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/4/2013	4	0	0.0%
4/13/2013	56	0	0.0%
4/16/2013	100	0	0.0%
4/19/2013	100	0	0.0%
4/22/2013	100	0	0.0%
4/25/2013	100	0	0.0%
4/28/2013	100	0	0.0%
5/1/2013	75	0	0.0%
5/4/2013	93	0	0.0%
5/8/2013	100	0	0.0%
5/15/2013	100	0	0.0%
5/22/2013	100	0	0.0%
5/29/2013	50	0	0.0%
6/5/2013	100	0	0.0%
6/12/2013	102	0	0.0%
6/19/2013	53	0	0.0%
6/26/2013	51	0	0.0%
7/3/2013	100	0	0.0%
7/10/2013	100	0	0.0%
7/17/2013	100	0	0.0%
7/24/2013	100	0	0.0%
7/31/2013	59	0	0.0%

Table L-8
Detailed breakdown of GBT exams and signs of fin GBT at McNary Dam in 2013.

Exam Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/8/2013	18	0	0.0%
4/12/2013	52	1	1.9%
4/14/2013	52	1	1.9%
4/18/2013	99	0	0.0%
4/22/2013	100	0	0.0%
4/26/2013	100	0	0.0%
4/28/2013	100	1	1.0%
5/2/2013	100	0	0.0%
5/6/2013	100	0	0.0%
5/10/2013	100	0	0.0%
5/12/2013	100	1	1.0%
5/16/2013	100	0	0.0%
5/20/2013	100	1	1.0%
5/24/2013	100	2	2.0%
5/26/2013	100	0	0.0%
5/30/2013	100	1	1.0%
6/3/2013	100	0	0.0%
6/7/2013	100	0	0.0%
6/9/2013	100	2	2.0%
6/13/2013	100	1	1.0%
6/17/2013	17	0	0.0%
6/17/2013	83	0	0.0%
6/21/2013	100	0	0.0%
6/23/2013	100	0	0.0%
6/27/2013	100	0	0.0%
7/1/2013	100	0	0.0%
7/3/2013	100	1	1.0%
7/7/2013	100	0	0.0%
7/11/2013	100	1	1.0%
7/15/2013	100	0	0.0%
7/23/2013	100	3	3.0%
7/25/2013	100	0	0.0%
7/29/2013	100	1	1.0%
8/2/2013	100	2	2.0%
8/4/2013	100	0	0.0%
8/8/2013	100	1	1.0%
8/12/2013	100	0	0.0%
8/14/2013	100	0	0.0%
8/18/2013	87	0	0.0%
8/22/2013	100	0	0.0%
8/28/2013	55	0	0.0%
8/30/2013	51	1	2.0%

Table L-9

Detailed breakdown of GBT exams and signs of fin GBT at Bonneville Dam in 2013.

Exam Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/20/2013	57	0	0.0%
4/23/2013	84	0	0.0%
4/27/2013	94	1	1.1%
4/30/2013	100	0	0.0%
5/8/2013	94	0	0.0%
5/11/2013	100	0	0.0%
5/14/2013	100	0	0.0%
5/18/2013	100	0	0.0%
5/21/2013	100	0	0.0%
5/25/2013	88	0	0.0%
5/28/2013	75	1	1.3%
6/1/2013	70	0	0.0%
6/4/2013	54	0	0.0%
6/8/2013	85	0	0.0%
6/11/2013	66	0	0.0%
6/16/2013	26	0	0.0%
6/18/2013	26	0	0.0%
6/22/2013	100	0	0.0%
6/26/2013	100	0	0.0%
6/29/2013	100	1	1.0%
7/2/2013	100	0	0.0%
7/6/2013	100	0	0.0%
7/9/2013	100	0	0.0%
7/13/2013	100	0	0.0%
7/20/2013	100	0	0.0%
7/23/2013	100	1	1.0%
7/28/2013	100	0	0.0%
7/30/2013	100	2	2.0%
8/4/2013	100	0	0.0%
8/6/2013	100	0	0.0%
8/10/2013	41	0	0.0%
8/14/2013	71	0	0.0%
8/18/2013	97	0	0.0%
8/20/2013	31	0	0.0%
8/24/2013	9	0	0.0%

Table L-10

Detailed breakdown of GBT exams and signs of fin GBT at Rock Island Dam in 2013.

Exam Date	Number Examined	Number with Fin GBT	Percent with Fin GBT
4/15/2013	78	0	0.0%
4/23/2013	42	0	0.0%
4/25/2013	100	1	1.0%
4/30/2013	100	1	1.0%
5/2/2013	100	2	2.0%
5/7/2013	100	1	1.0%
5/11/2013	100	0	0.0%
5/17/2013	100	0	0.0%
5/18/2013	100	1	1.0%
5/21/2013	100	0	0.0%
5/23/2013	100	0	0.0%
5/26/2013	100	1	1.0%
5/27/2013	100	0	0.0%
6/5/2013	100	3	3.0%
6/8/2013	46	0	0.0%
6/23/2013	44	0	0.0%
6/27/2013	100	0	0.0%
6/28/2013	50	0	0.0%
7/2/2013	100	0	0.0%
7/5/2013	50	1	2.0%
7/9/2013	50	0	0.0%
7/11/2013	100	0	0.0%
7/16/2013	50	0	0.0%
7/18/2013	100	0	0.0%
7/23/2013	100	0	0.0%
7/24/2013	100	0	0.0%
8/6/2013	100	0	0.0%
8/8/2013	58	0	0.0%
8/18/2013	44	0	0.0%