FISH PASSAGE CENTER

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Davis G. Moriuchi
Acting Director, Programs
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PO Box 2870
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Dear Mr. Moriuchi,

As per your request we are providing both you and Dr. Mark Schneider of NOAA Fisheries with a copy of our "Gas Bubble Trauma Monitoring and Data Reporting for 2007". This report summarizes data collected during the 2007 juvenile salmonid migration.

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

Sincerely,

Michele DeHart
Fish Passage Center Manager

CC: David Ponganis, COE
Jim Adams, COE
Dr. Mark Schneider, NOAA-Fisheries

Gas Bubble Trauma Monitoring and Data Reporting for 2007

Overview

The monitoring of juvenile salmonids in 2007 for gas bubble trauma (GBT) was conducted at Mid Columbia, Lower Columbia and Snake river sites. Fish were collected and examined for signs of GBT at Bonneville Dam and McNary Dam on the Lower-Columbia River, and at Rock Island Dam on the Mid-Columbia River. The Snake River monitoring sites were Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam. Prior to 2005, monitoring was conducted at all sites during the spring spill season and at Mid Columbia and lower Columbia river sites during the summer spill program. However, beginning in 2005 summer monitoring at the Snake River sites started as a result of the Court ordered summer spill program. This year summer spill in the Snake River occurred from June 20, 2007 until August 31, 2007.

Yearling Chinook and steelhead were sampled through the spring at all the sites. Once subyearling Chinook predominated smolt collections, the sampling of subyearling Chinook occurred until the end of August.

Sampling occurred two days per week at the Columbia River sites and one day a week at each of the Snake River sites during the time period that spill was implemented. The goal was to sample 100 salmonids of the most prevalent species (limited to chinook and steelhead) during each day of sampling at each site, the proportion of each species dependent upon their prevalence at the time of sampling. 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 in the fins were quantified using a ranking system based on the percent area of the fins covered with bubbles (Table 1).

Table 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 covered with bubbles
2	6% to 25% of a fin area covered with bubbles
3	26% to 50% of a fin area covered with bubbles
4	> than 50% of a fin area covered with bubbles

The eyes of the fish were also examined and the eye with the highest amount of bubbles was ranked using the same criteria as was used for the fins. Additional information was recorded for each fish including, species, age, race, rearing disposition, 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 for details of exam procedures).

Sampling techniques varied somewhat based on the location. This year all sampling sites were at dams, where fish could be collected from the juvenile fish bypass system. At those dams where fish crossed separators the fish were collected as they entered the separator. Rock Island Dam is the only site where fish were held in a tank (up to 24 hours) prior to examination.

The runoff for the 2007 water year was 63% of average (1971-2000) at Lower Granite and 89% of average at The Dalles Dam. This below average water year resulted in markedly low flows during most of the 2007 spill season at Lower Granite Dam (Figure 1).

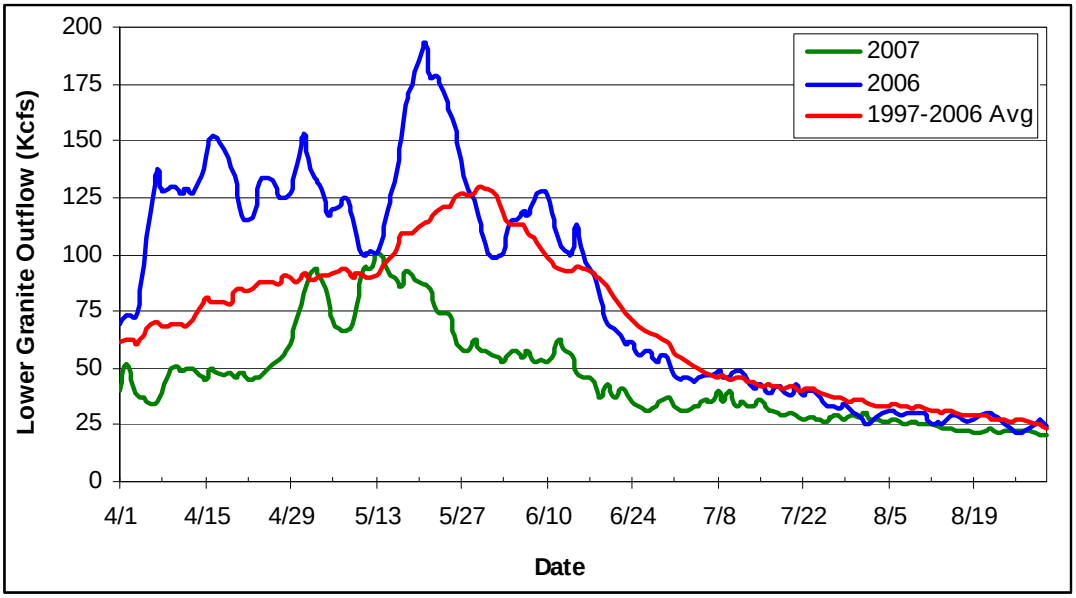

Figure 1. Average daily flows at Lower Granite Dam (2007, 2006, and the 10 year average)

Results

In all, 13,054 juvenile salmonids were examined for GBT between April and August of 2007 (Table 2).

Table 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 2007 as part of the GBT Monitoring Program.

	Site						
Species	**BON**	**MCN**	**LMN**	**LGS**	**LGR**	**RIS**	**Total**
Chinook Subyearlings	1,785	1,957	43	609	1	1,145	5,540
Chinook Yearlings	1,609	1,157	344	311	259	992	4,672
Steelhead	252	186	605	972	318	509	2,842
Total	**3,646**	**3,300**	**992**	**1,892**	**578**	**2,646**	**13,054**

Fin signs were found in 319 or 2.4% of the fish sampled at all sites (Table 3). Four fish were found with severe fin signs (rank 3 or higher) while, 47 and 268 fish had less severe fin signs of rank 2 and 1, respectively. Table 4 compares the 2007 estimates of the overall percentage of fish with signs of GBT to past years' estimates.

Table 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 2007 as part of the GBT Monitoring Program.

	Site						
Species	**BON**	**MCN**	**LMN**	**LGS**	**LGR**	**RIS**	**Total**
Chinook Subyearlings	2	0	0	19	0	6	27
Chinook Yearlings	38	0	1	2	0	7	48
Steelhead	10	0	51	180	0	3	244
Total	**50**	**0**	**52**	**201**	**0**	**16**	**319**

Table 4. Percent of sampled fish with signs of fin GBT estimated for the total fish observed.

Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Total % Signs	3.3	3.2	1.0	0.3	0.2	0.001	0.7	1.5	0.18	0.46	1.6	2.4
% signs excluding RIS	4.2	4.3	1.6	1.4	0.2	0.1	0.7	0.5	0.18	0.11	1.4	2.9

The Biological Opinion Spill Program was managed using the data collected for total dissolved gas (TDG) levels. However, signs of GBT in fins of juvenile fish, examined as part of the biological monitoring, were used to complement the physical monitoring program. NOAA Fisheries originally established the action criteria for the biological monitoring program at 15% prevalence of total fish having fin signs **or** 5% with severe signs (rank 3 or greater) in fins. At times these criteria were exceeded in 2007. The criteria were exceeded in the Snake River at Little Goose Dam during early and mid-June and again in late July. The criteria were also exceeded at Lower Monumental Dam sporadically throughout June and July.

The Fish Passage Center Staff provided information on the incidence of gas bubble trauma (GBT) in juvenile Snake River steelhead on June 8, 2007 (**http://www.fpc.org/documents/memos/90-07.pdf**) and again on June 11, 2007 (**http://www.fpc.org/documents/memos/92-07.pdf**) and technical discussions took place among the Salmon Managers at the Fish Passage Advisory Committee. In past years' the Snake River GBT sampling program typically ended on June 20th (or earlier) since, until 2005, there was no summer spill program at the fish transportation sites in the Snake River. In the few years of monitoring at the Snake River projects since 2005 it has been observed that typically the incidence of GBT in steelhead tends to increase slightly towards the end of the season, although not to the degree that occurred in 2007. The question then arose as to why the higher incidence was being observed in 2007.

Steelhead Sampling at Little Goose and Lower Monumental Dams:

In an effort to understand the implications of the increase in incidence of Rank 1 signs of GBT, the frequency of monitoring was increased at Little Goose and Lower Monumental dams. During this time the projects were requested to initiate the collection of subyearling Chinook for GBT monitoring, as their passage numbers had begun to increase.

Table 5 shows the percent GBT for steelhead at Little Goose Dam and Table 6 shows that data for Lower Monumental Dam. Three things can be noted regarding the observations:

1. An increased proportion of steelhead smolts were observed with mostly Rank 1 signs of GBT, but at the same time very few subyearling migrants exhibited signs of GBT.
2. The goal of obtaining 100 individuals of the predominate species was often not achieved.
3. With the exception of the first June observation at either site, the TDG levels observed in the forebays were below the state and federal standards of 110% and not within the range of the waiver standards.

Table 5. Observation of GBT in yearling Chinook, steelhead, and sub-yearling Chinook at Little Goose Dam in 2007.

	Yearling Chinook		Steelhead		Subyearling Chinook		All Species	Percent TDG	
Date	# Exam.	% GBT	# Exam.	%GBT	# Exam.	% GBT	% GBT	LGS–FB	LGR-TW
5-Jun	6	0%	94	14.9%	0	N/A	14.0%	112.8	112.9
8-Jun	2	50.0%	92	39.1%	6	0.0%	37.0%	108.2	112.2
10-Jun	0	N/A	50	26.0%	100	3.0%	10.7%	110.9	113.6
12-Jun	2	0.0%	50	22.0%	98	5.1%	10.7%	109.3	111.8
19-Jun	2	0.0%	61	55.7%	14	7.1%	45.5%	109.6	115.7
26-Jun	1	0.0%	2	50.0%	99	3.0%	3.9%	109.3	114.8
3-Jul	3	0.0%	4	25.0%	97	2.1%	2.9%	110.3	113.6
10-Jul	0	N/A	12	66.7%	90	5.6%	12.7%	109.2	113.6
24-Jul	0	N/A	82	28.0%	16	0.0%	23.5%	107.5	111.0

Table 6. Observation of GBT in yearling Chinook, steelhead, and sub-yearling Chinook at Lower Monumental Dam in 2007.

	Yearling Chinook		Steelhead		Subyearling Chinook		All Species	Percent TDG	
Date	Exam.	% GBT	# Exam.	% GBT	# Exam.	% GBT	% GBT	LMN-FB	LGS-TW
4-Jun	2	0%	64	18.8%	0	N/A	18.2%	114.3	113.8
7-Jun	4	0%	18	27.8%	0	N/A	22.7%	109	112.2
11-Jun	3	33%	33	48.5%	5	0%	41.5%	110.2	109.4
25-Jun	0	N/A	1	0.0%	0	N/A	0.0%	106.9	108.3
1-Jul	0	N/A	2	50.0%	23	0%	4.0%	107	107.8
8-Jul	0	N/A	1	100.0%	3	0%	25.0%	107.6	109.3
22-Jul	0	N/A	3	0.0%	3	0%	0.0%	105	107.6
29-Jul	0	N/A	5	40.0%	3	0%	25.0%	106.3	107.9

From the data it was apparent that the late migrating juvenile steelhead were disproportionately displaying the signs of GBT. The Salmon Managers were addressing a situation that affected the tail end of the steelhead migration, where water quality standards were not being exceeded, and where there was a desire to maintain protection for the increasing subyearling population. Given the low TDG levels at the projects the Salmon Managers investigated the potential causes of this occurrence from a project operations and migration conditions perspective.

Passage Timing and Travel Time

Historically steelhead smolt passage at Lower Granite Dam peaks in early May (50% passage date) with over 90% of steelhead migrants passing by late May, which was the migration pattern exhibited in 2007 (Figure 2).

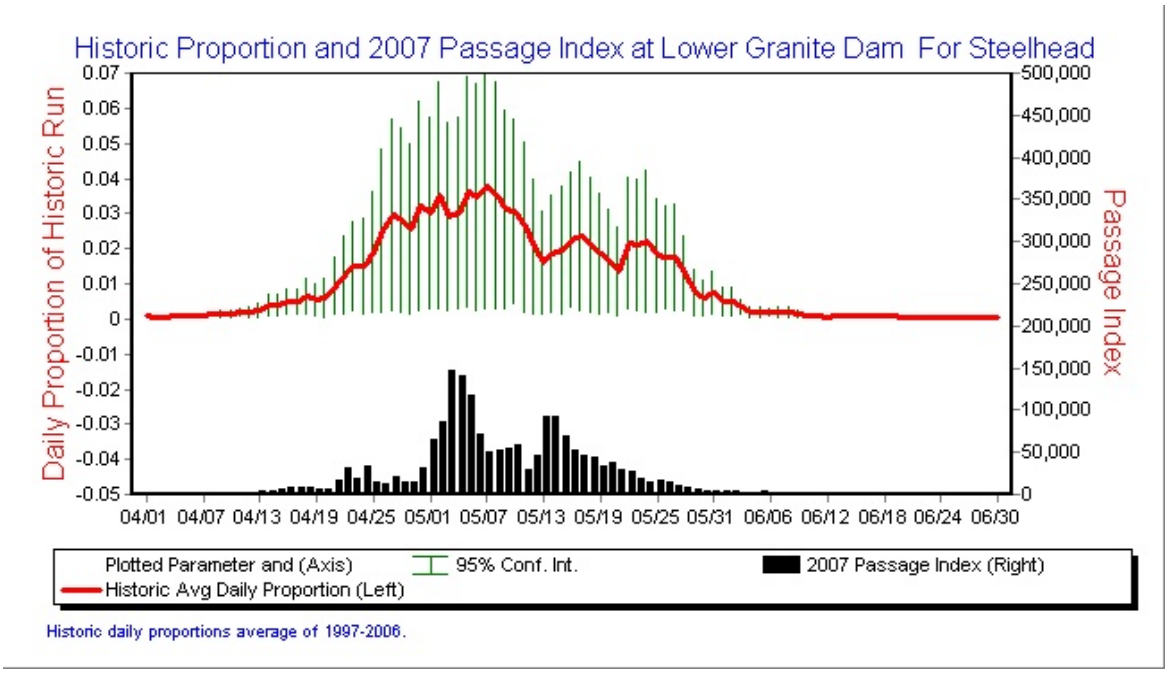

Figure 2. The 2007 steelhead passage index compared to historic data at Lower Granite Dam.

Observations of steelhead smolts displaying an increase in Rank 1 signs of GBT were first detected at Little Goose Dam on June 5, 2007. Based on migration timing data, approximately 95.1% of the steelhead population had passed Little Goose Dam by this date (Figure 3). However, while most of the steelhead had passed the project, the subyearling migration was beginning to increase significantly with 5.3% of the subyearling Chinook past Little Goose Dam on that date and with the magnitude of the subyearling population ten times that of the steelhead migrants. There was a desire to provide good in-river migration conditions for subyearling Chinook as long as they were not exceeding criteria for GBT.

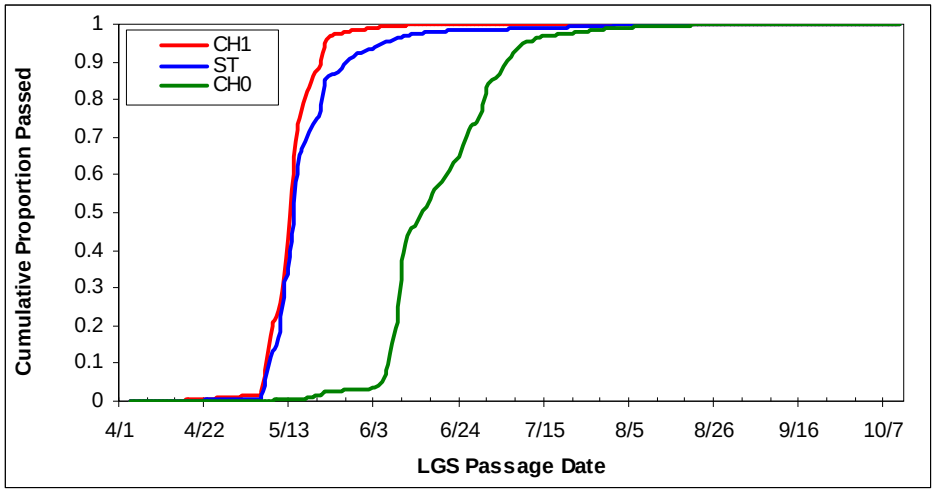

Figure 3. Cumulative proportion of yearling and subyearling Chinook and steelhead passing Little Goose Dam. The GBT incidence in steelhead was first observed on June 5, 2007 at Little Goose Dam.

Fish Travel Time Conditions in 2007

From laboratory studies that had been conducted (Mesa et al., 2000) it had been shown that up to 80% of Chinook would display minor signs of GBT at low levels of TDG if left sufficiently long in the water at that exposure. There were no mortalities in this group throughout the duration of the experiment, which lasted for 22 days. Given this information the Salmon Managers began to consider the flow and fish travel time conditions that existed in 2007.

As pointed out above, flow at Lower Granite Dam during June was significantly less than observed in 2006, or as represented by the ten year average. Steelhead juvenile migrants are particularly sensitive to changes in flow as expressed by their fish travel time estimates. The hypothesis was that steelhead travel time was longer during June of 2007 due to extremely low flows, and the few late migrating steelhead were displaying minor signs of GBT because of the long exposure to these sub-lethal levels of TDG.

The hypothesis was evaluated by plotting travel time of steelhead smolts between Lower Granite and Little Goose dams as a function of their arrival timing at Little Goose Dam. From the graph (Figure 4) it can be seen that the later arriving fish in 2007 had much longer travel times in 2007 than observed in 2006. This is consistent with the hypothesis that a higher incidence of signs of GBT in steelhead juveniles at Snake River projects in 2007 was a result of longer travel times between projects. These long travel times were most likely due to the low flows seen in 2007 as steelhead tend to residualize late in the season when flows are low.

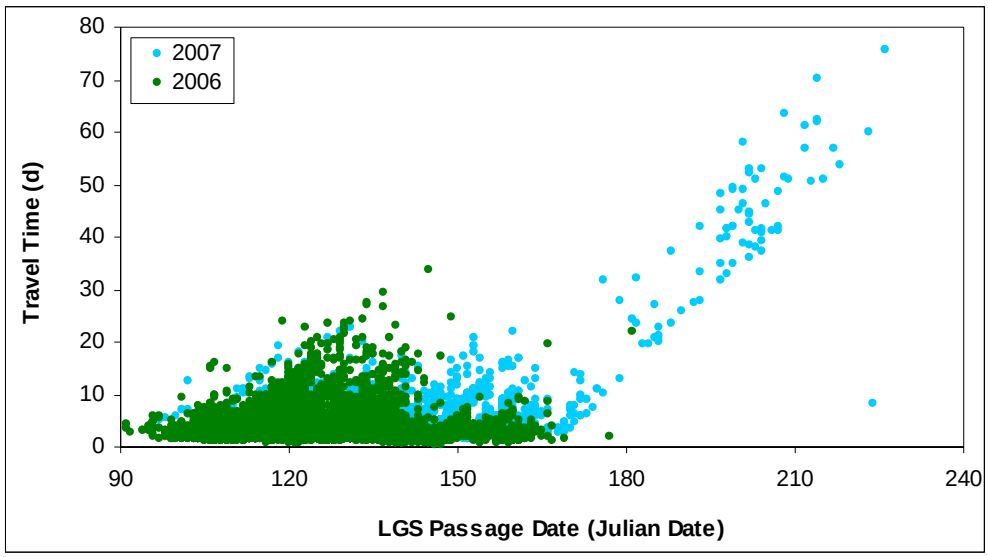

Figure 4. Travel time of steelhead juveniles migrating between Lower Granite and Little Goose Dam in 2007 as a function of arrival time at Little Goose Dam.

Steelhead Survival

Finally, it is worth mentioning that, despite the higher incidence of GBT in steelhead at Little Goose and Lower Monumental dams in 2007, in-river survival for steelhead juveniles in 2007 was higher than recent years and not significantly different from the high survivals seen in 2006 (Table 7).

Table 7. Reach survival (s.e.) for juvenile Snake River steelhead (data from NOAA Technical Staff Memo released August 31, 2007)

Reach	2001	2002	2003	2004	2005	2006	2007
LGR-MCN	0.168 (0.006)	0.536 (0.025)	0.597 (0.013)	0.379 (0.023)	0.593 (0.018)	0.702 (0.016)	0.695 (0.020)
LGS-BON	0.042 (0.003)	0.262 (0.050)	0.309 (0.011)	N/A	N/A	0.455 (0.056)	0.386 (0.069)

Discussion

GBT sampling was successfully accomplished for the 2007 migration season. In general, the incidence of GBT in migrating salmonids was low in 2007, with the exception of a short time period in the Snake River where higher incidence of mostly Rank 1 GBT signs were observed among late arriving steelhead. The higher levels were observed for steelhead smolts passing in the tail of the migration (>95% passed) when TDG levels were generally below the 110% standard for TDG in the forebay of the projects where fish were sampled. From the observations presented above, it is clear that the high incidence of GBT among steelhead juveniles in 2007 was likely due to the prolonged exposure to non-lethal TDG due to longer travel times, as a result of low flows in the Snake River. Finally, according to survival studies conducted by NOAA Fisheries juvenile steelhead survival in 2007 was comparable to the high levels of survival observed in 2006 and among the highest observed in recent years.

References:

Matthew G. Mesa, Lisa K. Weiland, and Alec G. Maule, 2000. Progression and Severity of Gas Bubble Trauma in Juvenile Salmonids. *Transactions of the American Fisheries Society* 129:174–185.

Preliminary survival estimates for passage during the spring migration of juvenile salmonids through Snake and Columbia River reservoirs and dams, 2007. *Memo* from John Ferguson to Bruce Suzumoto, August 31, 2007. NOAA-National Marine Fisheries Service.