COLUMBIA RIVER REGIONAL FORUM TECHNICAL MANAGEMENT TEAM

2017 Year End Review

December 12, 2017

Draft v.2 FACILITATOR'S SUMMARY

Facilitator: Emily Stranz; Notes: Charles Wiggins, DS Consulting

The following summary is intended to provide a brief recap of the TMT's Year End Review; however, is not intended to be a "record" of the meeting. Presentations and meeting minutes can be found on the TMT website: http://pweb.crohms.org/tmt/agendas/2017/ .

Welcome and Introductions

DS Consulting facilitator, Emily Stranz, welcomed the group to the Columbia River Technical Management Team's (TMT) 19th annual Year End Review (YER). She reminded the group that the review is an opportunity to step away from in-season management and reflect on conditions, operations, and data from the last year in order to inform process and operations for 2018.

Dworshak Operations and Fish Conditions

Dworshak Reservoir Regulation Water Year 2017

Steve Hall, Corps, recapped the Dworshak operations and water year in 2017. In 2017, powerhouse discharge was limited to 45% of normal because Unit 3 was out for maintenance. Additionally, the year saw record runoff in March, which equated to a "perfect storm" for river managers. October brought record rains, November and December were dry, however, by the end of December temperatures started to plunge and a cold snap hit the region, bringing record snowfall through March. Much of the snow fell in low elevations and melted fast, leading to a 3 million-acre-feet (MAF) water supply year; above normal but not spectacular, however, unique in shape and timing.

Despite the necessary high discharge levels in April, the project still met BiOp flow targets. Temperature augmentation, with 7 kcfs discharge, began July 1 and continued through the summer; however, temperature in the Snake and Clearwater exceeded 68 degrees Fahrenheit from June 29 through mid-August.

In hindsight, Steve felt that operations were managed well given the size and shape of the water year. Earlier discharge might have allowed for lower flow later in the season, producing lower TDG levels, but would have increased attendant risk and uncertainty. This year it may be appropriate to discharge more water earlier in the season, in order to avoid sustained high TDG later in the season (so long as the risk projections stay favorable). Dworshak is now discharging 4 kcfs. With higher discharge levels set for January 2018, TDG levels could be as much as 10% lower. It is very difficult to predict the customary big March rain event, and Steve said it was possible that the earlier peak water events may be "the new normal". He noted that the USACE is exploring changes to the duration of the water supply forecasts, shifting the time period earlier in the calendar year to include March and take out July.

2017 Dworshak Dam Effects on Clearwater In-River Fish

Jay Hesse, Nez Perce Tribe, discussed the effects of Dworshak operations on fish in the Clearwater River, specifically speaking to high TDG levels and fish mortality. Over half the fall Chinook redds in the Snake River as a whole occur in the 40 miles between Dworshak Dam and Lewiston, ID, and thus are impacted by Dworshak operations.

Several factors influence the impact of high TDG on fish: TDG levels, depth, duration of exposure, species, and life stage. Research findings also vary, however, generally show that there is low direct impact of TDG

on eggs in gravel, significant susceptibility of post-emergence fry to TDG levels of 120-125%, and variable impact on juveniles with 110-120% TDG. Adult salmonids are impacted by very high levels of TDG.

This season juveniles emerged from North Fork redds earlier than in the mainstem. This variance is attributable to temperature differences between the North Fork and the Upper Clearwater. TDG exceeded 120% between March 4 and April 14; the highest occurrence of TDG coincided with peak emergence. Jay estimated mortality to be between 0-4.5%; however, he expected mortality was likely less than 2%. Results from beach seining, while TDG was between 103-112%, indicated that most sampled fish exhibited gas bubble trauma (GBT) in the gills and lateral lines, and no GBT observed in the eyes or fins. These fish grew normally and consumed normal levels of food.

Jay listed the Nez Perce's priorities for the upcoming season of Dworshak operations as follows:

1. Maintain full pool for summer flow augmentation;
2. Maintain in-river TDG levels below 100% as much as possible;
3. Maintain in-hatchery TDG levels at or below 101%, with in-river levels below 115%; and,
4. Provide spring flow augmentation levels that follow the natural hydrograph as much as possible.

Dworshak Hatchery – Impacts from Elevated TDG Spring 2017

Dave Swank, USFWS, reported out on the in-hatchery impacts of the spring operations at Dworshak Dam. He reiterated the accumulative impacts of the Unit 3 outage, significant flows and spill, and resulting high TDG levels in the North Fork Clearwater and the Dworshak hatchery. While in-river TDG levels exceeded 125% for some time, the vacuum degassing system at the hatchery proved effective, maintaining TDG levels between 102-105% (a reduction of 9-22% from river water). Additionally, because System 1 has capability to mix reservoir water from the Nez Perce hatchery with dam discharge, TDG levels were lower than in other systems onsite.

Dave pointed to a strong correlation between exposure time and GBT symptoms, noting that although they did not see an increase in the number of mortalities or disease, regardless of the TDG percentage, fish had more GBT symptoms after two weeks of exposure. Additionally, fish feeding behavior was impacted with TDG levels at or above 104%.

In attempt to offset potential impacts of high TDG in the hatchery, they modified the release schedule for spring Chinook. A negotiated spill reduction in late March permitted the early release of spring Chinook and some steelhead during a window of lower TDG. The hatchery released its remaining steelhead on schedule (mid-April). Although early and preliminary, it appears that survival to Lower Granite was 10% lower for spring Chinook (compared to the 5-year average), and 5-6% higher for steelhead.

2017 Retrospective of Total Dissolved Gas and Juvenile Fish Passage/Conditions

2017 Flow, Spill, Debris, and TDG

Doug Baus and Dan Turner, Corps, reviewed the 2017 flow, spill, debris, and TDG conditions. Doug noted the early and high runoff season, which ended up being 254% of normal due to March precipitation that was 224% of normal. Doug attributed the high volumes to the March temperature spike that melted snow. Because there was a significant amount or runoff, there was also a lot of debris accumulation, likely affecting both juvenile salmon and steelhead. Debris flushes, bypasses, back-flushing and spills at the projects were used as a tool to minimize impacts. Additionally, the surface weirs at Lower Granite were noted to have helped move debris downstream. More information on the debris spills will be included in the annual TDG report.

Dan summarized spill and TDG conditions at several projects. As a result of the high runoff year, there was involuntary spill and high TDG at all of the projects. Another factor contributing to the high TDG was

the impact of multiple unit outages at the projects, limiting the ability to pass water through turbines and instead adding to the spill. TDG levels were higher than normal, with the highest in the system recorded at John Day at 136%. Dan noted, however, that there is uncertainty in predicting TDG and spill relationships, potentially due to difference in gauge locations.

For future similar years, Dan suggested that there may be opportunities to adaptively manage TDG by shifting contingency reserves from The Dalles to McNary and operate above 1%. This would allow for more turbine capacity at The Dalles and likely cut TDG by 1-3%. Operating the McNary turbines above the 1% would also increase McNary capacity and potentially lower TDG by 2-5%.

2017 Smolt Monitoring Program - Juvenile Passage, Fish Condition, & Gas Bubble Trauma Monitoring Data

Brandon Chockley, Fish Passage Center, presented data on juvenile passage and conditions. He reiterated the high runoff year, noting that Snake River runoff ranked 9th highest over the last 89 years and the Columbia at The Dalles ranked 8th highest over the same period. At Lower Granite, Lower Monumental, and Little Goose, spill greatly exceeded the FOP in the spring, and met FOP in summer; BiOp flow objectives were met in the spring, however, not all were met in the summer.

Transport started on May 1st at Lower Granite, Lower Monumental, and Little Goose. At this point, according to the passage index, 56% of the runs had passed Lower Granite. Yearling Chinook, steelhead, and sockeye timing at Lower Granite was a little earlier than the 10-year average, in part due to early hatchery releases. Sub-yearling Chinook "just showed up," with a rapid increase compared to the ten-year average. At McNary, the timing of yearling and sub-yearling Chinook, and steelhead, was a little earlier than average. Sockeye were closer to typical passage dates. Few lamprey ammocetes were encountered this year. This is not uncommon for McNary. Brandon suspects that this has something to do with the project's ability to collect lamprey ammocoetes and not a lack of ammocoetes passing. And at Bonneville, the Chinook run had an earlier start; steelhead were a bit early; sockeye were much earlier than average; sub-yearling Chinook were similar to the 10-year average, and lamprey passage showed a double peak of macropthalmia, with few ammocetes.

The 2017 mortalities for sub-yearling Chinook and Coho were the highest among the last ten years for mortality at Lower Granite; similarly, steelhead mortalities in 2017 at Little Goose and McNary were also the highest for those species at those projects. Descaling rates for Chinook at Little Goose and coho at John Day were highest among the last ten years, at these projects for these species.. Weighted average injury rates were highest or next highest at several sites in the system, probably due to increased debris. Most injuries were to the fins, as in past years.

Brandon also presented results from gas bubble trauma (GBT) monitoring. Upstream of Lower Granite, where TDG levels remained above 120% for most of spring, 9 of 16 samples showed Rank 1 GBT. At Little Goose, where TDG exceeded 115% for most of the season, 7 of 21 samples showed Rank 1 or 2 GBT. At Lower Monumental, with spring season TDG higher than 115%, 7 of 18 samples showed GBT At McNary, where TDG exceeded 115% most of the spring, 3 of 33 samples showed Rank 1 or 2 GBT. Despite high TDG this year, there was only one instance where GBT at FCRPS projects exceeded the 15% action criterion (Lower Monumental on May 10th). TDG in the Lower Monumental forebay was around 132% at this time and high flows precluded ability to reduce spill at Little Goose.

Libby Sturgeon Operations and Habitat Restoration

2017 Libby Dam Kootenai Sturgeon Operations
Jason Flory, USFWS, reported that this year there was a double pulse operation for sturgeon in the Kootenai River. The first, from May 15th to 21st, introduced cold water to stimulate upstream migration and staging. The second, from June 2nd to 19th, introduced a pulse of warmer water intended to trigger further upstream migration and spawning, ideally near Bonners Ferry.

The result of these 2017 operations was "exciting." Idaho Fish and Game telemetry data show there was a 20% increase over the 5-year average of tagged adult sturgeon migration above Bonners Ferry. This increase could be attributed, at least in part to flow management and habitat restoration efforts. No data are available to show whether this operation led to higher sturgeon reproduction, as it is very difficult to sample juveniles. They have done some larve drift netting, however, sample sizes are very small and the real results of the efforts will have to be measured in 3-5 years.

Kootenai River Habitat Restoration Project 2017 Update
Jason also presented on the Kootenai River habitat restoration project, as Sue Ireland, Kootenai Tribe, was unable to attend the session. He described current results of habitat restoration program begun in 2011 on the Idaho portion of the Kootenai River. The program is reach-specific, and involves 10 different restoration projects focused on restoring the food web and river system complexity, including, pool forming and creation, side channel reconnection and creation, riparian enhancement and such.

The restoration project seems quite successful at this point, and there are plans to continue work for the next several years. The Kootenai Tribe recently established a peer review team to assess the remaining limiting factors and plan next steps. In the short term, they expect to continue work initiated in 2017 on the Lower Meander project and will plan to coordinate efforts with the TMT.

Transportation

Smolt Survival and Travel Time & Transportation Analyses
Steve spoke to NMFS' assessment of migration conditions, travel time and survival of PIT-tagged smolts through the hydropower system in 2017. Spring conditions included high flows and spill, especially early in the season, and higher than average water temperatures (0-1 degrees C). These conditions contributed to smolt travel times shorter than the 10-year average, especially for steelhead. Yearling spring Chinook had the fastest median travel time between Lower Granite and Bonneville for any year since 2001. This figure was 4-5 days longer than in 2015. Steelhead also moved through the system at a rapid pace.

Based on PIT-tag fish counts from 7 hatcheries in the basin, it was an average year overall for smolt survival. Chinook showed a 65% survival rate from the hatchery to Lower Granite. Endangered Sockeye survival from the Springfield hatchery to Lower Granite was only 16% compared to a mean of 46%. From Lower Granite to Bonneville, these smolt had an equally low17% survival rate. On the other hand, this year steelhead survival figures were excellent. For the hydro system as a whole, survival was about 6% lower than average for the 3rd or 4th consecutive year, at 44% for yearling spring Chinook in the lower Columbia. There was also substantial variation by reach in smolt survival. The lower survival figures for upriver hatchery sockeye this year are probably due to water chemistry differences between hatchery and river.

As in recent years, a relatively small number of yearling Chinook were transported this season from the Snake River dams to Bonneville. The overall figure this year is less than 20%. For the past decade, about 30% were transported. This compares to about 80% for the preceding decade. Steelhead barging was also low this year, at about 22%. For the past decade, the mean transport figure is about 33%, and for the previous decade the number is above 85%.

Looking Ahead

Winter 2017 - 2018 Climate Forecast

Kyle Dittmer, CRITFC, provided a climate forecast, noting that his prediction for the winter of 2017-2018 is for a weak La Nina and a neutral Spring 2018. The Water Supply Forecast is for 112.3 MAF, or 1 MAF above last year. Both NOAA and CRITFC projections are similar for the next 6 months, however, NOAA forecasts overall lower precipitation and higher temperatures for the year.

Kyle predicted that the Hood River area will experience cold temperatures and average precipitation, with snow events at 135% of normal. In the mountains, he predicts snow events to be 119% of normal, with a big accumulation later in the winter, potentially around 266 inches total. Spring conditions should be colder and wetter than normal. Kyle predicts 5 snow events for the Portland area in 2017-2018.

Group Reflections on 2017 and Aspirations for 2018

Participants were asked to reflect as a group on TMT conversations, coordination, operations and outcomes over the last year and to consider: What lessons would be helpful to carry forward into future years? What did TMT do well? And what would you like to do differently next year? The group shared the following:

What lessons would be helpful to carry forward into future years?

- Open, collaborative discussions and successful coordination.
- Lessons learned from 2017 Dworshak operations; the TMT will be better prepared for 2018 as a result of 2017.
- Flexibility is key; the region needs to adapt quickly and have back-up plans.
- Water quality and TDG management will be a challenge in 2018; it is vital that the region works as a team.
- The realization that shifts in conditions can be unexpected and quick as a result of changes in climate.
- Any year can set a new record; there is always a lot to learn from the season.

What did TMT do well?

- TMT representatives worked well together and sought to understand each other's needs.
- Everyone put in effort to find the best real-time solutions.
- Collaborative problem solving.
- Managed the Dworshak situation as best as possible, collaboratively.

What would you like to do differently next year?

- Identify a trigger for changes in operations needed as a result of adult delay to allow the region to be more proactive instead of reactive.
- Work to align the real-time, short term needs with longer term goals/vision of all regional partners.
- Communicate more efficiently at TMT meetings; do not repeat positions week after week, instead, keep the conversation moving forward by documenting the important aspects and keeping group memory of what is important to each entity.
- Broaden the scope of perspectives on TMT calls, reach out to get different perspectives in order to inform decisions.
- Closely follow TMT process and protocols to ensure that everyone comes to the table knowing what to expect from the process, this way TMT can work through the content issues and not have to deal with unneeded process challenges.
- Seek clarity between the TMT and RIOG as to where decisions are made.

Emily noted that they can revisit this list later at TMT to determine what next steps should be taken to improve on the upcoming year of coordination. She thanked those who prepared and presented information during the session, noting that it is always helpful to recap the year and to look back to determine what lessons can be carried forward. She also thanked everyone for staying engaged and contributing to meaningful dialogue throughout the day. And with that, the session was adjourned.

Present for all or part of the meeting:
Julie Ammann (USACE), Kenn Backholm, Doug Baus (USACE), Scott Bettin (BPA), Brandon Chockley (FPC), Eric Chow (USACE), Erin Cooper (FPC), Peter Cooper (BOR), Kyle Dittmer (CRITFC), Erick Van Dyke (OR), Kyle Dittmer (CRITFC), Joel Fenolio (USACE), Stephen Hall (USACE), Laura Hamilton (USACE), Jay Hesse (Nez Perce), Tom Iverson (Yakima Nation), Kim Johnson (BPA), Russell Kiefer (ID), Tom Lorz (CRITFC), Aaron Marshall (USACE), Charles Morrill (WA), Tony Norris (BPA), Mike O'Bryant (CBB), Christine Peterson (BPA), Chris Runyan (BOR), Gabe Schear (FPC), Ann Setter (USACE), Steven Smith (NOAA), Dave Swank (USFWS), Dan Turner (USACE), Pat Vivian (Contractor), Paul Wagner (NOAA), and Lisa Wright (USACE),

Colby Mills, Nancy Pionk, Emily Stranz and Charles Wiggins, DS Consulting Facilitation Team

Columbia River Regional Forum
Technical Management Team Official Minutes

2017 ANNUAL REVIEW OF LESSONS LEARNED
December 12, 2017

Minutes: Pat Vivian

1. Introduction

Representatives of BPA, USFWS, Nez Perce Tribe, the COE, BOR, NOAA, CRITFC/Umatilla, Idaho, Washington, Oregon and others participated in the TMT Year End Review, an annual retrospective of river conditions and hydro system operations over the past year. The goal of the conference is to spotlight operational successes and reflect on lessons learned going forward.

The 2017 TMT YER differed from past formats in that it focused intensively on a few operations and conditions rather than reviewing every operation implemented over the past year. The all-day conference was chaired by Doug Baus, COE, facilitated by Emily Stranz, DS Consulting, and hosted by CRITFC.

2. Dworshak Operations and Fish Conditions

2a. Spring, Summer and Fall Operations Review. One of the biggest challenges of 2017 was the prolonged outage of Dworshak unit 3, which limited powerhouse capacity to 45% of normal discharge in a year of record high runoff, Steve Hall, COE Walla Walla, said. Restricted powerhouse capacity and natural conditions collided in March to create the perfect storm of operational challenges.

Weather played an important role. Heavy rainfall in October 2016 was followed by a dry, warm November especially in the Clearwater. Then it snowed from early December through February. January on the Clearwater was dry, but southern Idaho got rain. This amounted to a false start in terms of water management. By February the situation on the Clearwater was problematic.

What made the 2017 water year most unusual was that, according to observed April-July runoff at Dworshak, it was a 2.9 maf year – above average but not excessive. However, runoff volume from March-June was consistent with flows for a 4 maf year. The significant disparity in seasonal runoff volumes is what led to the perfect storm. High-elevation snow levels were normal in 2017 but low-elevation snowpack was heavy, which is difficult to monitor. Low-elevation runoff early in the year set a record in March of 48 kcfs at Dworshak (the previous record was 42 kcfs on a daily average).

TMT's discussions in 2017 focused on Dworshak operations from mid-January through April. In retrospect, if Dworshak discharges had increased to 10 kcfs in January, later flood control releases could have been 15 kcfs, producing TDG levels of around 115% saturation, instead of 25 kcfs.

Nevertheless, BiOp operations in 2017 were fairly successful. Heavy spill in April probably benefited fish, although there were substantial hatchery and river impacts from high TDG saturation levels. Total dissolved gas management didn't go as well. While every effort was made to keep Dworshak releases below Oregon and Washington standards, there were multiple TDG exceedances in February-April.

Total dissolved gas standards limited Dworshak releases, which affected temperature management downriver. Temperatures in July and August exceeded the 68 degrees F limit at Lower Granite. Starting June 29, temperatures at Anatone gage on the Snake River exceeded 68 degrees F and increased rapidly. By July 13, TDG levels were above the state standard and stayed there until August 17. Temperatures rose again on August 24, and by August 31 temperature management was done for the year.

The 2018 water year could go either direction. According to the ENSO index, a slight La Nina tendency could lead to a large range of potential outcomes from very wet to dry. Like 2017, it will be a difficult decision early in 2018 to release lots of water when inflows could decline later.

Questions and comments:

- **Q:** Has the COE looked at the potential of adding low-elevation Snotel sites? **A:** It costs around $40,000 to install a fully automated weather monitoring station, plus ongoing data collection costs of $10,000-$15,000 per station. In recent years low-elevation stations have lost funding, which impairs the ability to monitor low elevation snowpack.

- **Q:** Due to TMT concerns, early last winter the COE recommended releasing more water than Dworshak was discharging. How much effect did that have on TDG levels at the end of the season? **A:** In January the COE recommended allowing TDG to go up to 113%, but there was reluctance to exceed 110% for much of the early season when it could have made a big difference. Of course, it was unknown that snowpack in 2017 would turn out to be abnormal. But waiting meant DWR releases were pushed to 25 kcfs, producing truly detrimental TDG levels. Hall's opinion is that DWR releases should be more aggressive in 2018.

- **Q:** Has the COE looked at percentages of inflows starting in October 2017? If we had done last year what the COE requested, what would the

result have been? If unit 3 had been available, how would that have affected TDG? **A:** Yes, the COE did a modeling run of inflows in October but the assumptions were questionable. In future we could look at this in terms of how to sustain flows effectively over several months. Having unit 3 in service would have reduced TDG levels by about 10%.

- **Q:** While total runoff in 2017 wasn't significantly above normal, the shape of the water volume in terms of peak inflows was abnormal. Should we consider this a new normal? **A:** We may be seeing a shift toward earlier runoff, but there have been similar events in the past. However, a growing body of knowledge suggests these events are becoming more frequent. Hall supports adding March to the modeled runoff period and deleting July, due to several events in the past 10 years. Climate change analysis suggests this pattern will accelerate.

- **Q:** Would it help to have a water supply line in the reservoir to provide estimates of water stored in snowpack? Perhaps graphic estimates of available snowpack would help. **A:** The COE will try to provide this, but the challenge is timing when the deepest part of the flood control curve is in late April, as was the case in 2017. That's why the COE is working to change the official water supply forecast process, a multi-year effort.

- **Q:** Although Dworshak didn't come close to meeting the flood risk level, it didn't greatly exceed refill capacity. If the reservoir had met the flood risk level, would it have refilled? **A:** Yes, it would have refilled, but for the most part TDG levels were below 100% during the refill period. Outflows could have been below 5 kcfs if the reservoir had drafted for flood control. Like Dworshak, Brownlee drafted extensively, then had to withhold water to keep the river below flood stage at Vancouver gage.

2b. In-River Impacts. Jay Hesse, Nez Perce Tribe, gave a presentation on management of the North Fork and mainstem Clearwater River from Ahsahka to Lewiston, Idaho in the context of Dworshak operations.

Certain species and life stages may be sensitive to elevated TDG levels. The tribe's assessment of exposure and risk included hatchery and in-river fall Chinook, steelhead and coho that were exposed to high TDG levels in 2017 as adults, eggs or juveniles emerging from gravel. Fall Chinook fry are highly TDG-sensitive from March-August. Vulnerability is based on TDG levels, the depth at which fish travel, and duration of exposure.

Two background papers by Don Weitkamp address TDG-related mortality, one a 1980 summary of peer review and case study data, the other a 2008 update focused on the Columbia basin. Both studies report high variability in terms of TDG effects, although site-specific conditions were not

well documented. The take-home message is that eggs in gravel experience 0% risk but adults are impacted by very high TDG levels. Based on river depth and saturation, at 110-120% TDG, fry newly emerged from gravel experienced 68-75% mortality and newly hatched juveniles experienced 0-100% mortality.

Using helicopter flights, drones and underwater video, the researchers did an extensive redd count in the Snake River basin, focusing on ESA-listed Snake River fall Chinook because they spend their entire freshwater life cycle in the Clearwater River. Adults enter the Clearwater starting in mid-August and spawn from October through December. In 2017, just over 6,000 Snake River fall Chinook redds were established, with 51.3% of them in the North Fork Clearwater. Exposure to TDG levels varied, and 7.8% of the redds (about 241) in areas with no buffer were directly impacted by TDG from DWR releases.

Conversations are needed about how to bolster TDG data collection because there were gaps in reporting from the gages at DWR tailwater, Peck and Lewiston. These data are posted regularly to the TMT website.

Past years' data show that when unit 3 was in operation, the COE was able to keep DWR tailwater TDG levels consistently below 110%. This year, with unit 3 out of service, TDG levels exceeded 120% in the North Fork starting April 14 for the next 45 days. TDG levels at the Peck gage were around 115% in the summer. Due to the mixing effect of upper Clearwater drainage at Lewiston, levels were lower but still above 100%, occasionally exceeding 105%.

While the effect of TDG on eggs appears to be minimal, accumulation of temperature units affects emergence timing. The take-home message is that high TDG levels in the North Fork Clearwater coincided with emergence of fish that were directly influenced by high TDG releases from DWR. Of the 7.8% of redds directly exposed, Hesse estimated that about 4.5% of Clearwater juveniles experienced high TDG levels. Their estimated mortality was 0-4.5%, so probably fewer than 2% of fish died as a result of high TDG exposure.

Beach seining results indicate that fish incubated and hatched successfully in an environment of 103-112% TDG saturation. According to GBT samples taken on July 18 and September 7, feeding and growth appeared normal at these exposure levels. Almost all fish sampled had signs of GBT and 80-100% had bubbles in the gills. There were also plenty of bubbles in the lateral lines, but few had bubbles in the fins or eyes, a more serious symptom.

These findings say nothing about actual mortality directly or indirectly later in the life cycle. It's likely that elevated TDG exposure will ultimately make these fish more susceptible to other risk factors and stressors.

What could be changed in terms of future operations? Generally, fish in the Clearwater that hatched later in the season experienced lower risk from

TDG exposure. Water temperature has a strong influence on emergence timing. Juvenile production in the Clearwater will continue to be monitored.

The Nez Perce Tribe's priorities for 2018 Dworshak operations are:

1. Achieve full pool for summer flow augmentation by taking two actions: (1) increase the risk of not refilling from 5% to 10% for the end of December; and (2) target 1520 ft as an end of December elevation by managing flows up to maximum powerhouse capacity.

2. Maintain in-river TDG levels at 100% to the greatest extent possible. If powerhouse capacity must be exceeded, target periods with minimal impacts on juvenile production and adults.

3. Maintain hatchery TDG levels at or below 100% (equivalent to an in-river TDG cap of 115% or less).

4. Provide spring flow augmentation flows consistent with the natural hydrograph to the greatest extent possible. Note that the loss of unit 3 in 2018 is incompatible with this objective.

Questions and comments:

- **Q**: Do smolts in the North Fork Clearwater emerge earlier than in other locations due to the temperature of Dworshak releases? **A:** Yes.

- **Q**: What are the tradeoffs between a normal year and a high flow year like 2017 in terms of estimated fish losses, given TDG effects and the fact that higher flows inhibit predation? **A:** A number of factors influence redd survival, including the severity of TDG exposure.

- **Q**: Did cold water from snowmelt moving through DWR flatten out the emergence estimate? Has the COE looked at survival rates from fish tagged this year compared to previous years? How were fish with low-level GBT symptoms affected by PIT tagging? **A:** The flattening is the result of a lull in redd construction during a period when snowmelt washed over Ahsahka Island. The tribe has yet to study this effect. Because cold water releases from DWR tend to retard growth, few of those fish migrate to the ocean during summer.

- **Q:** Were any signs of GBT found in bycatch during beach seining? **A:** Bycatch was low at that time of year because few fish were present.

- **Q**: Were 4.5% of Clearwater juveniles exposed to TDG levels exceeding 120% in 2017? **A:** The 4.5% estimate refers to redd abundance in the

direct effluent zone of the North Fork Clearwater. In 2017, 231 redds in the North Fork were exposed to high TDG levels.

2c. Hatchery Impacts. Dave Swank, USFWS, gave a presentation on the effects of TDG at Dworshak National Fish Hatchery with unit 3 out of service in a year of heavy snowpack and high spring flows.

When the spring flows of 2017 forced spill and TDG supersaturation leading to GBT symptoms in fish, the COE installed new TDG meters in Dworshak National Fish Hatchery to facilitate real time data collection. Hatchery staff provided daily fish health reports and sampled 10 individual spring Chinook and steelhead every day for 2-3 weeks to track GBT symptoms. In March 2017, as coordinated at TMT, the COE reduced discharges for a few days so hatchery fish could be released early in relatively low TDG conditions.

When discharges increased and TDG levels peaked at over 125% for a few days, the degassing system in Dworshak Hatchery kept TDG saturation levels at 102-105% during the height of the crisis. In-river TDG levels exceeding 125% equated to about 105% in the hatchery. As TDG levels in the river increased, so did the effectiveness of the vacuum degassing system.

The Fish Health Center inspected 10 fish per day of each species for gas bubbles in the gills, lateral lines, fins and eyes. They also looked at food in the stomach as a way of measuring symptoms of GBT. Early on, spring Chinook had relatively few symptoms, mostly gas bubbles in the gills, then lateral lines. Food consumption increased as TDG levels decreased.

Hatchery steelhead in system 1 had an advantage because system 1 is able to mitigate high TDG levels with additional reservoir water, while systems 2 and 3 lack that ability. Steelhead in systems 2 and 3 had few TDG symptoms at first, then they cut back on feeding until spill decreased.

Hatchery staff learned that adding a foot of air space in the degasser increased its effectiveness by a 1-2% reduction in TDG. The other major hatchery response was to release fish early during the low-spill window negotiated at TMT. On March 20, 1.6 million spring Chinook were released into the mainstem Clearwater instead of the North Fork. On March 22-24 the hatchery released 300,000 spring Chinook.

The remaining 1.1 million steelhead were moved to system 1, and the water mix was increased to 53% reservoir water to keep TDG levels down. The steelhead were released on April 17 at their normal time. They experienced gas bubbles in the gills and lateral lines, with a lower incidence of gas bubbles in fins and only 1-2 days of gas bubbles in the eyes. At higher TDG levels there were symptoms of decreased feeding.

In summary:

1. The vacuum degassers reduced river TDG levels by 9-22% but it wasn't enough to avoid gas bubbles in hatchery fish over time.

2. The effectiveness of the degassers improved by 1-2% when air space in the degassing chamber was increased by 1 ft.

3. There is a strong correlation between exposure time to elevated TDG levels and observed GBT symptoms.

4. At in-hatchery TDG levels of 104% and above, feeding was impacted. There was no observed increase in mortality due to secondary diseases during periods of high TDG.

5. The existing data are not sufficient to establish a safe level of TDG exposure for fish produced at Dworshak Hatchery.

6. A fair amount of literature suggests that at TDG levels greater than 105%, fish experience impacts.

7. We learned the degassers are effective and there's a way to increase their effectiveness.

Questions and comments:

- **Q**: Were the oxygen diffusers running at the hatchery? **A:** They had been installed but weren't active at the time.

- **Q:** At approximately what depth were fish sampled? How deep are the raceways? **A:** About 3-4 ft, maybe more.

- **Comment:** It's clear that duration of exposure is a big factor, with increased symptoms and more bubbles in fins and eyes after 2 weeks of exposure regardless of TDG level.

- **Q:** Is there benefit in giving fish a break, say 2 days of lower TDG levels? **A:** Hatchery staff have yet to answer this question. It's unclear whether a few days of high exposure are better or worse than several days of lower exposure. While some studies indicate that fish recover quickly, others say changing exposure is hard on fish. No doubt a break from very high TDG levels is helpful.

- **Q:** How did USFWS estimate survival at LGR compared to previous years? **A:** Preliminary survey estimates indicate that the spring 2017

Chinook run had about 10% lower survival than the 10 year average. However steelhead had 5-6% higher survival than the 10 year average, no doubt because a large number of them were moved to system 1 and released at the normal time. It's not surprising spring Chinook fared poorly because they were released a month early.

- **Comments:** If fish need a break every 2 weeks, that needs to be spelled out in water management planning. Nez Perce and USFWS hatchery staff are investigating how atypical releases might confound the survival estimates in relation to TDG exposure. Idaho agreed that spring Chinook have higher survival rates with later release timing. Fish that were released at 130% TDG below Hells Canyon did surprisingly well in the near term, but long term effects are not well understood.

- **Q:** How early were steelhead and spring Chinook released in 2017? **A:** Both were released about a month ahead of their normal release dates. Because most steelhead were moved into system 1, USFWS is trying to figure out how to incorporate that into survival estimates because the adults might not return to their usual locations.

- **Q:** Are there preliminary survival estimates from birth to Lower Granite? **A:** It's the only reach estimate available now. At some point survival from Bonneville will be tracked.

- **Q:** What about releasing warmer water sooner in the year to accelerate release dates? If that's an option, tracking of temperature units needs to start now. **A:** That option would probably accelerate hatching time of in-river fish, which increases their risk of TDG exposure.

- **Q:** Does the hatchery have the ability to warm water separately from the river? **A:** Yes, it's the only way to get steelhead up to size for release in a year. With the existing warming capacity, temperatures in the Snake are 42-45 degrees F. Dworshak reservoir water is currently 47 degrees F. The only way to release warmer water would be in undershot mode, which isn't possible at present.

3. Retrospective of Total Dissolved Gas and Juvenile Fish Passage Conditions in 2017

3a. System-wide Look at TDG and Spill Conditions. Doug Baus and Dan Turner, COE, gave presentations.

Spill Conditions: Runoff at Lower Granite started early in 2017 due to heavy snowpack, rain, and warm temperatures Baus reported. March observed runoff volume was well above the 30 year average, and seasonal precipitation

was also above average. Temperature departures in March were the primary cause of early runoff.

March precipitation was 224% of normal in the Clearwater Basin and March runoff was 254% of normal at Lower Granite. Total runoff volume at Lower Granite for the month of March was was 8.5 maf. Peak flow at Lower Granite was 192 kcfs, and 134 kcfs on the Snake River as measured at the Anatone gauge. Flows on the Clearwater River at the Spalding gauge peaked at 102 kcfs. At Lower Granite, February-June runoff was 165% of normal, 38.2 maf total volume. April-July runoff was 145% of normal, 29 maf total volume.

High flows during the month of March mobilized a significant amount of debris that impacted operations at the Lower Snake River Projects (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dam). Juvenile salmon and steelhead experienced separator mortalities, transport loading mortalities and orifice blockages. In response, the COE scheduled debris spill and bypassed juveniles to the river, back flushing orifices to get them back to normal.

Questions and comments:

- **Q**: Has the COE summarized how many debris spills there were in 2017 compared to 2016? **A**: Yes, the number of debris spills was higher than normal. For details, see the annual TDG report on the TMT website.

- **Comment**: Since the surface weirs were installed at LGR, debris is passed downstream to subsequent projects instead of piling up at LGR.

Flows and TDG. Dan Turner gave a presentation on total flow, spill, generation, and TDG production at key projects in 2017. The goal of the water quality monitoring program is 95% data completeness at all stations. Gages malfunction for a number of reasons, which USGS and contractors address as needed. Starting in early April, LGR has fish passage spill of 20 kcfs in spring, then 18 kcfs in summer. Involuntary spill in spring this year was followed by flows beyond minimum generation of 12-15 kcfs in late June and early July. Generation flow was limited to the 1% range starting in April, a 50 kcfs drop.

Because fish passage spill targets are based on total river flow, spill volume increases as flows increase. Usually 4 units are available for generation at LGR in May, but from May 5-12, operation was limited to 2 units due to trash raking, debris and torn screens, creating more involuntary spill.

At Little Goose downstream, the fish passage spill target was 30% in the early morning hours to help alleviate adult delay, as coordinated at TMT. This resulted in little degassing at the next downstream forebay. Lower Monumental

had a uniform spill operation from April 3-June 26 for the safe passage of fish barges across the project tailwater.

In 2017, John Day had some of the highest TDG readings of all fixed monitoring stations, peaking at 136% on May 8-11. Spill bays 3 and 5 were out of service from April 19-May 22 due to brake failure. McNary also had periods of high TDG, with readings of 128-130% from April 1-14 and again from May 7-16. TMT discussed carrying contingency reserves outside of 1% at MCN and operating at the best operating point above 1%, which would have increased generation and spill. A 25 kcfs increase in generation at MCN would have decreased TDG values by 2-5% at JDA, Turner estimated.

The relationship between spill and TDG varies based on the project, and TDG predictions are uncertain, especially at some locations. While LGR had a well-behaved relationship between spill and TDG from April 30-June 20, that wasn't the case at TDA for unknown reasons. There was a dramatic difference between normal spill at JDA and spill with bays 3 and 5 closed so TDG values rose steeply from April 19-May 22.

Turner concluded his presentation with potential adaptive management tools that could be used to reduce TDG levels at sensitive locations:

- Shift contingency reserves from the upper 1% at TDA to MCN above 1%. Allowing TDA to operate in the upper 1% would create about 30 kcfs additional turbine capacity at TDA and produce 1-3% less TDG.

- Operate MCN turbines at best operating point above 1%. This would result in 28 kcfs additional turbine capacity (about 2 kcfs per unit) and produce about 2-5% less TDG.

Questions and comments:

- **Q:** Were turbines available at MCN in 2017? **A:** No.

- **Q:** If MCN is spilling 260-280 kcfs, what portion of fish is passing through the powerhouse? Would reducing spill and TDG levels on the spillway make the powerhouse environment less favorable? **A:** Keep in mind that gatewell condition is not as big an issue as initially thought. With the gates down, the gatewell gets half the volume it usually does.

3b. Smolt Monitoring Conditions, Juvenile Passage and Gas Bubble Trauma Monitoring Data. Brandon Chockley, FPC, covered juvenile passage, fish conditions, and results from the new GBT monitoring program. He addressed juvenile timing in 2017 relative to 2016 and the 10 year average.

Juvenile passage timing is affected by a number of factors – flows, temperatures, spill volumes, survival to the point of interest, and the sampling schedule used for index counts.

Changes in the timing and magnitude of smolt releases in 2017 may have affected juvenile timing in the Snake compared to the 10 year average. Snake River runoff at Lower Granite from January-July was the ninth highest in the past 89 years. Based on the April forecast, the spring BiOp flow objective at Granite was 100 kcfs, obviously met. However, for most of the summer, flows at Granite were below the 55 kcfs summer BiOp objective.

Juvenile Timing at Lower Granite. Some yearling Chinook hatchery releases occurred a few weeks to a month earlier than usual due to DWR operations. Collection for transport started May 1 at LGR, LGS and LMN with no staggered start dates this year.

Based on the passage index, about 56% of yearling Chinook had already passed when transport started at LGR. If a yearling Chinook passed LGR, it was probably subject to transport at LGS and LMN. Passage timing was about a week early for the 10%, 50% and 90% dates compared to the 10 year average.

Steelhead hatchery releases also occurred early this year. There was a double peak in passage similar to the 10 year average. While some steelhead were moved to system 1 and released at their normal time, others were released early. By the time transport started May 1, about 58% of steelhead had already passed LGR. The 10% passage date (April 9) was earlier than the 10 year average, as were the 50% (April 28) and 90% (May 14) passage dates.

Most of the sockeye collected at LGR in March and April were probably kokanee from DWR, which spilled from January 2017 through spring and summer. This was also the second year Snake River sockeye were reared and released from the Springfield hatchery early this year on April 17. The 10% and 90% passage dates (April 14 and May 21) were close to the 10 year average, but the 50% date (May 9) was early.

Subyearling Chinook passed LGR quickly due to high flows. The 10% date of May 28 matches up with the 10 year average, the 90% date of July 14 is close, and the 50% date of June 5 is not far off. The screens were removed on August 3-4. Sampling at LGR stopped on September 1 due to construction (normally it continues through October 31). While not many fish pass in September and October, it still means a smaller sample than other years.

Because 2017 is only the seventh year of juvenile and larval lamprey sampling at FCRPS projects, no 10 year average is available for comparison. At LGR in 2017, mostly larval lamprey were collected.

Juvenile Timing at McNary. Mid-Columbia runoff volume at TDA was eighth of the last 89 years. The project met its spring but not summer BiOp flow objectives. Spring spill exceeded FOP levels, as did summer spill except for a few days. Yearling Chinook were early, with the 10% (April 22), 50% (May 6), and 90% (May 19) passage dates all a few days before the 10 year average.

Steelhead followed the same pattern, with a 10% passage date of April 19, 50% date of April 30, and 90% of May 19. Sockeye were closer to the 10 year average, with passage dates of 10% on April 28, 50% on May 13, and 90% on May 25. Subyearling Chinook were early with a 10% passage date of June 4 as compared to June 14 for the 10 year average, but the 50% (June 30) and 90% (July 22) dates were closer to the 10 year average.

Juvenile lamprey (ammocoetes) aren't sampled much at MCN, but that doesn't mean they're not present. A few were seen this year. Macropthalmia are usually collected throughout the season.

Juvenile Timing at Bonneville. The project met its BiOp spring flow objective but not for summer. Yearling Chinook were early with a 10% date of April 16, but the 50% date (May 5), and 90% (May 19) were close to the 10 year average. Steelhead followed the same basic pattern, with the early part of the run ahead of schedule and less discrepancy later. The 10% date was April 23, 50% May 6, and 90% May 24. Sockeye were quite a bit early with a 10% date of April 22 compared to the 10 year average of May 7. The 90% date (May 25) was earlier than the 10 year average, but the 50% date (May 15) was close.

This is the last year the 10 year average for subyearling Chinook will include a March release because those ended in 2008. The 10% date in 2017 was April 11, 50% on June 27, and 90% on July 20.

As for juvenile lamprey, macropthalmia passage at BON typically follows a double peak with one peak early in spring and another in May. When the FPC started sampling in early March, macropthalmia were already present, but only a few ammocoetes showed up in the samples.

Juvenile Conditions. The smolt monitoring program tracks mortalities and descaling on every fish that enters the sample tank. Compared to the past decade, there were some noteworthy events in 2017.

The FPC has been monitoring GBT since 1995 as a measure of juvenile exposure to harmful levels of gas at six projects: LGR, LGS and LMN on the Snake; Rock Island on the upper Columbia; and BON and MCN on the lower Columbia. Injury rates are stated per 100 fish, which requires collecting 100 for each sample. Symptoms of GBT in fins or eyes are quantified and ranked, and rank 3 or 4 indicates serious health problems. The FPC doesn't monitor bubbles in the gills because that requires a lethal sample.

If 15% or more of the fish sampled on a given day show signs of GBT, or 5% show severe signs (rank 3 or 4 bubbles), that serves as an action criterion for the FPC to ask the Action Agencies to curtail spill if possible.

In 2017 the highest rates of weighted average mortality compared to the past 10 years were 1.7 for subyearling Chinook at LGR and 1.3 for coho. Steelhead had the highest mortality at LGS in the past 10 years, but 0.2 is low. Steelhead mortality at MCN was 0.7, the highest in 10 years. Sockeye mortality at Rock Island was 0.8, also the highest in 10 years. Typically lamprey have the highest mortality of all species, which was true at MCN but not at BON.

Weighted average descaling rates were not excessive compared to the past 10 years, even though 2017 flows churned up a lot of debris. Descaling was worst at LGS, with 2.3 per 100 yearling Chinook, the highest rate in the past 10 years. Coho descaling at JDA was 6.9, also the highest in 10 years. Coho and steelhead at Rock Island had the lowest descaling rates.

Weighted average injury rates for salmonids in 2017 were the highest or second highest since 2009. The lowest injury rate was zero for macropthalmia at MCN, with a rate of 2.7 per 100 at JDA and 3.6 per 100 at BON. Most fish injuries in 2017 were fin injuries, defined as any cut, abrasion, laceration, swelling or other injury. A very small portion had eye injuries.

Because 2017 was unusual, the crew at LGR started GBT sampling early and continued through the end of July, which included sampling subyearling Chinook once they predominated. Subyearling Chinook are not normally sampled for GBT at LGR. Of 16 GBT samples at LGR, 9 had signs of GBT, all rank 1 and all 16 samples were below the 15% action criterion. At LGS, fish are exposed to TDG in LGR tailrace, with levels above 120% for most of spring 2017. Of 21 GBT samples at LGS, 7 had signs of GBT, all rank 1 or 2 and all 21 samples were below the 15% action criteria. At LMN, TDG levels hovered around 120% for most of spring, with a high of 130%. LMN forebay TDG levels exceeded 115% for most of spring. Of 18 GBT samples, 7 of had signs of GBT, one of which met the 15% action criterion (May 10th). Of 100 fish examined, 22% had symptoms of GBT, after exposure to levels of 132% in the forebay on May 10. Of the total 44 fish that exhibited signs of GBT at LMN over the entire season, with 3 had severe signs (all were rank 3).

For most of spring 2017, fish arriving at MCN experienced TDG levels over 120% in the Ice Harbor and Priest Rapids tailraces. At MCN forebay, TDG levels exceeded 115%. Of 33 GBT samples at MCN, only 3 had fish with signs of GBT, all of which were below the 15% criterion, rank 1 or 2.

For fish arriving at BON, the tailrace monitor at TDA exceeded 120% for most of spring, according to both the Washington and Oregon methodology. Of

33 GBT samples at BON, 24 had fish with signs of GBT, all below the 15% criterion, rank 1 or 2.

Over past 20+ years, GBT sampling has occurred at a wide range of tailrace TDG levels. When water transit time is taken into account, some noteworthy patterns emerge. Of the 2,771 samples taken over the last 20+ years, 35 (1.3%) have had GBT levels exceeding the 15% action criterion. Of these, 27 have had corresponding tailrace TDG of >125%. However, of 303 total GBT samples conducted with corresponding tailrace TDG levels ≥125%, 27 (8.9%) exceeded the 15% criterion.

Questions and comments:

- **Q**: What caused elevated rates of injury this year? **A**: The injuries are not surprising given the amount of debris. While a high rate of fin injuries isn't good news, they're less serious than bodily injuries. Crews count only fresh injuries.

- **Q:** One symptom of GBT in juvenile fish is deformities. Would that be classified as an injury? **A:** Deformities are categorized by causes, GBT separately from diseases. Some injuries are considered deformities.

- **Q:** While debris might cause injury, isn't it possible fish also might be injured in the spillway? **A:** That depends on how long it takes a spillway injury to look old and be discounted. The goal is to qualtify fresh injustied caused by the bypass system.

- **Q:** If there were 303 samples from greater than 125% TDG, has the FPC looked at whether there's a critical threshold above 125% TDG at which injuries occur? Fish can form a slime layer in a few days, making the injury look old and be discounted. **A:** In quantifying exposure, the FPC considers the estimated transit time from the previous tailrace, assuming that fish follow water transit. A PIT tag is needed that measures TDG exposure as fish move downstream.

- **Q:** If samples from the mid/upper Columbia projects were included, would the incidence of GBT have been higher? **A:** Yes, fish are sampled at Rock Island, but the estimates are hardly comparable. Most of the other FCRPS projects sample directly from the separator, while at Rock Island fish remain in a shallow tank for up to 24 hours before being examined, which tends to exacerbate GBT. Pilot study of trying to sample fresh fish have been unable to meet criteria of 100 fresh fish at Rock Island. Continue to work with staff to increase number of "fresh" fish in GBT sample at RIS.

4. Libby Sturgeon Operations and Habitat Restoration

4a. 2017 Kootenai Sturgeon Operations at Libby Dam. Jason Flory, USFWS, reported. In May, the final April-August runoff volume at Libby was predicted to be 8.19 maf, 139% of average. This made 2017 a tier 5 year under the Libby BiOp with a 1.2 maf sturgeon pulse and bull trout minimum flows of 9 kcfs. In past years, if the inflow forecast was higher than normal, a double peak operation has worked well when the first peak coincides with low elevation runoff. The intent is to cue sturgeon to migrate above Kootenai Lake without triggering them to spawn.

The first pulse of cold water lasted May 15-21 and was intended to trigger upstream migration. Then Libby outflows dropped to VARQ flows of about 18-20 kcfs, which continued until higher elevation snowmelt began to run off and water elevations rose. The second pulse began on June 2 with colder water released at the beginning of the pulse and warming toward the end. When the second pulse started, Libby flows were reduced from full powerhouse of 25 kcfs to 22 kcfs due to flood risk concerns at Kootenai Lake. After June 11, the sturgeon pulse gradually ramped down until the volume was exhausted on June 19.

This operation resulted in conditions that were conducive to spawning above Bonners Ferry. IDFG telemetry data indicate a 20% increase from the previous 5 year average in the number of tagged adult sturgeon that migrated upstream of Bonners Ferry, a highly encouraging result.

Questions and comments:

- **Q:** Was there any response in the number of juveniles captured in the sampling effort? **A:** It's difficult to sample juveniles in the Kootenai River because of the pulse and accumulated debris at high flows. It could take 3-5 years to document an uptick in sturgeon production and survival.

- **Q:** Did you monitor water temperatures compared to previous years? **A:** Temperatures are intensively managed during the sturgeon pulse using the selective withdrawal system at Libby. Water temperatures toward the end of the pulse have picked up over the past 4 years, differing from the years before 2012, which was the last year a trigger of 8-10 degrees C was used to initiate the pulse.

- **Q:** Is it conjecture that sturgeon successfully migrated upstream of Bonners Ferry to spawn in the Braided Reach? **A:** We know they were spawning but the shallow channel makes it difficult to count egg mats.

- **Q:** What were natural river conditions during normal spawning above Bonners Ferry before Libby Dam was built? **A:** The river was colder, and spawning was almost double what it is now. Most of the Kootenai Valley flooded regularly, which was one of the main reasons for building Libby Dam. The goal of the habitat project is to recreate the natural flow regime as closely as possible.

4b. Kootenai Tribe Habitat Restoration Project Update. Jason Flory, USFWS, reported on this work being done in cooperation with the Kootenai Tribe. The multi-year habitat restoration project includes data collection, analysis and modeling for specific projects that address factors limiting the production of Kootenai river sturgeon and other native fish.

The treatments include formation of pools, islands and structures that encourage fish to migrate upstream, as well as side channel reconnection and flood plain creation to enhance the food web. Since Libby was built, there has been a reduction in the number of pools and the depths of key spawning and migration reaches, especially upstream of Bonners Ferry. As a result, sturgeon tend to turn around and zigzag until the end of the pulse.

The first habitat restoration treatments began in 2011, and the tribe intends to continue the improvements. Toward the end of summer 2018 phase 2 of the Lower Meander project will begin, pending TMT's approval of an SOR like the one approved in 2017. Flory thanked TMT for its support of SOR 2017-1 which allowed phase 1 to proceed.

Questions and comments:

- **Q:** For how many more years will this work continue? **A:** There's no targeted end date. A few projects are planned over the next two years. Beyond that, the tribe is convening a peer review advisory team to determine what still needs to be done.

5. Transportation

5a. Juvenile Salmon Transport: In-River vs. Transport Ratios and Reach Survival Estimates (Updated with 2017 Data). Steve Smith, NOAA, gave a presentation on juvenile in-river vs. transport survival ratios and reach survival. He covered migration conditions, travel time, and survival odds updated with 2017 information. A draft report to BPA is being prepared.

We now have 25 years of continuous survival study of juvenile listed salmonids, and 2017 was one of the highest flow years among them. By contrast, 2015 was one of the lowest. The inflows of 2017 created not only the highest spill volume but the highest spill percentages of total river flow in the

past quarter century. These conditions, combined with temperatures of 0-1 degree C warmer than average throughout the season, led to shorter than usual travel times for yearling Chinook and steelhead.

Chinook survival from hatcheries upstream to LGR was 65%. But hydro system survival for both species was 6% below average, and this is the third or fourth consecutive year it has been below average. Survival estimates are based on PIT tag detection at dams on the Snake and Columbia rivers and the PIT trawl in the estuary.

Yearling Chinook migrating from LGR to BON had some of the fastest migration and shortest travel times seen, although not markedly different from 2016, an average flow year. Chinook moved downstream about 4-5 days faster than in 2015, and the same was true for steelhead traveling from LGR to BON. Early surviving steelhead moved much faster than the earliest surviving Chinook and, like Chinook, had the fastest travel times recorded.

Yearling Chinook survival from Snake River hatcheries was 65%, which is close to the average of 64.8% although lower than in recent years. Yearling Chinook from upper Columbia River hatcheries had lower than average survival (58.2%) than in the Snake (56.5% is average). Reach survival estimates this year were confounded by loss of the Snake River trap at high flows. Steelhead survival was a 74% for 2017, which is higher than average.

Survival estimates from MCN to BON are 7-10% lower than average for both species, although the estimate for yearling Chinook is imprecise. Fish originating in the upper Columbia had lower survival from MCN to BON than Snake River fish did.

Estimated survival rates from the headwaters of LGR reservoir to BON in 2017 were 44% for Chinook and 42% for steelhead, with two caveats: (1) It's possible that fish passed MCN without being detected; if so, that can be corrected. And (2) a data error in tagging was corrected for 2015. The past 3 years have seen the lowest percentages of fish transported because they arrive early at LGR before transport starts. The current trend is to transport 40-50% of the fish passing in May.

Sockeye in the Columbia River had an average year in terms of estimated survival. However, Snake River sockeye had low survival rates from Springfield Hatchery to LGR as well as downstream. The current theory is that differences in water chemistry between the hatchery and the lake are responsible. Mitigation methods are being sought to make the transition less stressful.

Questions and comments:

- **Q:** How much weight does the lower survival estimate for spring Chinook from MCN to JDA have? What about steelhead from JDA to BON? **A:** One objective is to get survival estimates all the way down the river. There could be some anomaly in the JDA tailrace.

- **Q:** Is there a rationale for using East Sand Island as a collection site for reach survival estimates? Have you looked at not using the PIT trawl data? **A:** PIT trawl data are used because the site is representative of the estuary. Birds are more likely to feed on fish that were detected at BON when they passed, which probably means that fish traveling closer to the surface are more vulnerable to predation.

- **Q:** Could a major difference in timing explain the big discrepancy between survival rates of upper Columbia and Snake River fish? **A:** Good question. This year's data had a wide confidence interval, contrary to previous years. Over the years, upper Columbia fish have generally had better survival rates than Snake River fish.

5b. Smolt Transport Seasonal Analyses. Smith gave a presentation on yearling Chinook and steelhead migration in 2013-2015, updated with adult return data through November 21, 2017. He focused on smolt-to-adult return ratios for transported vs. in-river fish at the three Snake River collector dams, Lower Granite, Little Goose and Lower Monumental.

The basic question addressed by the research is the difference over time in the number of transported vs. bypassed fish (T:B ratio) who return as adults. This requires a time stamp that identifies when a smolt was detected entering the Granite juvenile bypass. The data provide a seasonal analysis of smolt to adult return rates through the season. Because a lower percentage are transported at LMN than at LGR and LGS, LMN has lower T:B ratios. About 75-80% of transported fish come from LGS and LGR.

In 2013 wild Chinook did not benefit much from transport at any of the dams. In 2014 the T:B ratio for Chinook was above 4 at LGR for the whole season, and for steelhead, 2-3 at all three dams. In May 2015 return rates were 1% for transported wild Chinook and 0% for wild Chinook that were returned to the river from the bypass. Wild steelhead returns in 2015 were generally poor.

There was a big contrast in adult returns for transported vs. bypassed fish in 2014 vs. 2013. For wild Chinook in 2014, the ratio was 4-5 for the season, the biggest benefit of transport for wild Chinook ever seen. For wild steelhead, the benefit of transport was 2 to 3 times the survival of in-river fish.

Often the benefits of transport are greater for fish migrating early in the season. T:B ratios tend to flip around May 1 to less than 1, or lower relative benefits of transport.

Flows in 2015 were so low that few PIT tagged fish returned as adults. No 2015 juvenile Chinook or steelhead released from LGR have returned except for those released the first week of May 2015. No bypassed wild Chinook came back from MCN in May and hardly any wild steelhead. Of wild Chinook released in May, 680 were transported from LGR and 8 have returned, for a smolt to adult return ratio (SAR) of 1.2. For wild steelhead, only 1 returned for a SAR of 0.16. Of 873 fish returned to the river in 2015, none have returned, with a SAR of 0.04. About 60-70% of the wild steelhead run migrated before transportation started in May. The data for LGS are similar for both Chinook and steelhead.

Smith explained the concept of "adult currency" which refers to the number of adult fish returned in a given year. Adult currency is based on smolt monitoring program estimates of the number of wild and hatchery fish that entered the juvenile bypass system.

Questions and comments:

- **Q:** When will the final fall Chinook report be available? **A:** It's the highest priority after the spill report.

- **Q:** Weekly releases of barged fish at LGR continue from April until full transport starts. Have you considered using that data to look at seasonal dates? **A:** Yes, this work continues from April until the start of transportation.

6. Looking Ahead

6a. CRITFC's 2018 Forecast and NOAA's Long Range Forecast. Kyle Dittmer, CRITFC, gave weather and climate predictions for 2018. He noted that 2018 will be the 40th anniversary of CRITFC, the largest Native American science center in the U.S. CRITFC's first director, Roy Sampsel, recently died.

A borderline condition of ENSO-neutral and La Nina in 2017 indicated colder winters. There were five snow events in Portland with as much as 20 inches in hilly areas. The prediction was 250 inches of snow in the mountains; 264 inches actually fell. In spring the weather was moving toward ENSO-neutral conditions, yet precipitation resembled a full blown La Nina. The water supply forecast of 111 maf for January-July 2017 was actually 137 maf.

Dittmer does forecasting based on regression analysis of historic TDA runoff and the MEI index for 20 past analog years. His water supply forecast for 2018 is 112 maf, very close to the NWRFC forecast of 113 maf. According to NOAA's long term outlook, La Nina will peak in December and slowly fade in spring 2018, with continued cooling. Sunspot counts are near zero, which is favorable for La Nina conditions. The Pacific sea-surface temperatures are colder than normal. These conditions are good for salmon in the Columbia basin.

However, the NWRFC 30 and 90 day forecasts both suggest warmer than normal temperatures and below normal precipitation. NOAA's ENSO forecast shows a 65-76% probability of a La Nina winter, with ENSO neutral conditions kicking in by May 2018 and normal precipitation in summer.

CRITFC's forecast is for a colder, wetter and snowier winter than usual, with the coldest months being December and February, and 135% of normal snowpack (266 inches). Spring 2018 also looks to be colder and wetter than usual, holding snowpack in place for a more controlled runoff this year than last. Five snow events are predicted for the Portland/Vancouver area in 2018, two minor and two moderate (3-4 inches apiece). Despite using different methods, the NOAA and CRITFC forecasts are quite similar.

6b. Large Group Reflection. Participants shared their observations of hydro system operations over the past year. Several commented that TMT members gained valuable experience in working together.

- Dworshak temperature management needs to be discussed sooner rather than later.

- Spill management at Dworshak in 2017 indicated that TMT representatives can work together more effectively than in the past.

- TMT will need collaborative, open discussions to develop an appropriate approach to the court-ordered spill operation in 2018.

- We are seeing amazing shifts in snowpack and river flows even with the influence of La Nina, probably due to climate change.

- We're looking forward to getting DWR unit 3 back in summer 2018.

- Water quality updates will be more intensive in 2018 as part of working collaboratively on TDG management and spill.

- 2017 was unusual in focusing more on Dworshak operations than Libby.

- This year brought the second highest runoff at upper Snake projects of any year on record. There is much to be learned here.

- 2017 had many challenges – high flows, unit outages, flood risk management and fish issues. 2018 will be challenging in a different way

- Over the past year, we've faced a changing landscape for energy marketing, and fish management results are below long term objectives. While finding a solution each year is a good thing, if we don't achieve long term viability in each of those interests, annual efforts are for naught. Collaboration in the near term is important, and so is aligning near term actions with long term vision.

- In managing DWR operations, we learned that we have to be flexible, willing to change plans on the basis of new information. The value of having backup plans was apparent.

- Weekly and seasonal breakdowns of survival were appreciated, as well as the collaborative problem-solving approach TMT took to DWR and other issues.

- It's difficult to say how coordination for 2018 spill operations will play out. TMT will need to continue to collaborate effectively in order to resolve challenges and engage in a process that takes us forward.

- We need to identify adult delays in Snake River fish and develop a trigger for making changes. Little Goose adult passage and spill patterns warrant special attention. One challenge will be developing a trigger for adjusting spill for juveniles so it doesn't adversely impact adult passage.

- As we deal with issues that call for extended problem-solving or implementation, we need to communicate efficiently and avoid repeating positions. Understanding what's important to others and documenting these goals will help build trust and allow TMT to be more efficient in the number of calls. This will take extra effort outside of the calls but it will reduce the number of calls needed.

- At times we may want to broaden the scope of inclusion in TMT calls. In 2017, TMT reached out to include those who weren't participating but whose perspective was relevant to the decision at hand (e.g. Idaho re: Dworshak operations).

- There will probably be hard discussions in 2018 like there were in 2017. When this happens TMT should stick to protocols such as polling that are useful for working through challenges.

- TMT needs to work on establishing a better connection with RIOG, which is where some of these operational decisions are supposed to be made.

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