COLUMBIA RIVER REGIONAL FORUM TECHNICAL MANAGEMENT TEAM
2016 Year End Review
December 7, 2016

FACILITATORS' SUMMARY
Facilitator: Emily Stranz; Notes: Tory Hines, 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://www.nwd-wc.usace.army.mil/tmt/agendas/2016/

Welcome and Introductions
DS Consulting facilitator, Emily Stranz, welcomed the group to the Columbia River Technical Management Team's (TMT) 18th 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 2017. She encouraged the group to think critically and openly as they review 2016 and discuss options for the future.

2016 Conditions Review

Seasonal Overview of Weather and Hydrology
Kevin Berghoff, NWRFC, reported on the seasonal weather and hydrology findings for 2016. He noted that there was a very strong ENSO signal before the start of the 2016 water year. The Oceanic Nino Index (ONI) for sea surface temperatures was one of the strongest indexes on record since 1950, tying with 1998. The peak ONI for water year 2016 was 2.3. For precipitation, 2016 had greater amounts of precipitation compared to 2015. Average percentage of normal precipitation for 2016 was 88% in the Upper Snake River Basin above American Falls Dam, 94% in the Clearwater River Basin, 90% in the Snake River Basin above Ice Harbor Dam and 102% in the Flathead River Basin.

In 2016 there was strong precipitation December through March, however it dropped off dramatically in April. Temperature departures from January to April were less frequent than in 2015, however it was substantially warmer in February and April of 2016 compared to other years. Despite warming temperatures in April, the snow water equivalent (SWE) was better in 2016 than in 2015. Total water runoff for 2016 was near normal in the Upper Columbia and deficient in the Snake River Basin. The observed adjusted runoff volume at The Dalles was 94% and while precipitation percentages and runoff volume appeared decent, the timing of runoff was earlier than past years due to warm temperatures in February and March.

The April to September water supply forecast indicated that seasonal volumes were below normal at Libby, Hungry Horse, Dworshak and The Dalles. The ONI compared to historical water supply runoff may be a useful tool when assessing whether climate indexes are good indicators of runoff in various basins. In summary, there was a very strong ENSO signal prior to the start of the 2016 water year; however, the impacts on the Columbia River water resources remain unclear. Precipitation was slightly below normal for the 2016 water year, near normal in the Upper Columbia, 90% of average in the Snake River Basin and 95% of average in the Snake River Basin. There was above normal temperatures that resulted in early runoff and depleted snowpack in April and most areas were below normal seasonal runoff,

with The Dalles volumes at 89% from April-September. Upcoming 2017 water supply briefings are scheduled for January 5, February 2, March 2, April 6 and May 4. For more information go to https://attendee.gotowebinar.com/rt/8111931086353869315

- **Question:** The current winter we are experiencing is borderline La Nina, are you expecting better water conditions in 2017 as a result?
    - **Response:** We are not sure and are looking at experimental indexes before we make any predictions.
- **Question:** Is the climate outlook speculating warmer than average temperatures?
    - **Response**: Typically in borderline La Nina years in the Pacific Northwest mean a colder winter with increased variability.
- **Question**: There appears to be a trend of accelerated runoff in lower elevations (by a few weeks). Should we take this to be the new normal?
    - **Response**: There is not enough information yet to say this is a trend or the new normal. The last two years have been unique: 2015's early runoff was not related to sea surface temperatures like climate indexes suggested and 2016 was variable based on the ESP forecast. Unfortunately, data is limited to the SNOTEL sites, which means that we do not know what the runoff patterns look like below those sites.
- **Question**: Is there any effort to add more SNOTEL stations at lower to mid-elevations?
    - **Response**: That is a question for NRCS, they maintain the SNOTEL network; the mid to low-elevations are challenging due to location and cost of the stations. However, adding additional sites would be extremely helpful for forecasting.
- **Question**: Would satellite imaging be one way to determine lower elevation snowpack?
    - **Response:** Potentially. One issue in the Pacific Northwest is cloud cover, which prevents accurate satellite imagery at some sites. Also, satellite imagery does not show a fine enough resolution to allow for modeling.
- **Question**: Could you please comment on Clearwater drainage and how that is observed?
    - **Response**: Snow is observed on the ground and via the air, it is the only way we have been able to establish an accurate picture of snow in the basin. We are working to build models and exploring other options that may be more financially feasible (the cost of the equipment and surveys is high and limits what we can do).

2016 Fish Passage Review

Juvenile Migration Summary

Brandon Chockley, Fish Passage Center, presented on juvenile fish passage. He noted that the information that he shared is only timing data and does not account for factors that potentially impact timing, such as: hatchery releases, flows, temperatures, spill volumes and survival to point of interest. He presented smolt monitoring data from Lower Granite, McNary and Bonneville dams.

At Lower Granite Dam, Snake River runoff volume (January-July) ranked 52nd over the last 88 years. The spring and summer BiOp flow objectives were not met and there were two brief periods of spill in excess of the FOP. Three flow spikes were observed at Lower Granite and summer flows dropped off earlier than the 10-year average.

For both yearling Chinook and Steelhead, there were three passage peaks that coincided with high flows.

Both the 50% and 90% of total fish passage for yearling Chinook and Steelhead occurred earlier in the season than the 10-year average. Sockeye passage was fast. On May 17, 10% of Sockeye passed Lower Granite, 50% on May 22nd and 90% on May 28th. Sub-yearling Chinook passage numbers were consistent with the 10-year average. Brandon shared that there is not sufficient data to determine a 10-year average for juvenile lamprey, as data collection started in 2011.

At McNary Dam, mid-Columbia runoff volumes for January-July ranked 54th over the last 88 years. Average spring flows were slightly above the flow objective and summer flows were below the flow objective. Yearling Chinook and steelhead both experienced earlier passage than the 10-year average, with 90% passed within the first two weeks of May. Sockeye counts also appeared to be earlier than the 10-year average (90% on May 19th). Sub-yearling Chinook passage was brief with passage picking up on June 10th and finishing (90%) on July 2nd. For lamprey, no Pacific ammocetes were collected at McNary in 2016, but Pacific Macrophalmia numbers were strong in April through June (estimated collections as high as 3,200 in April).

At Bonneville Dam, mid-Columbia runoff volume ranked 54th over the last 88 years. The average spring flows at Bonneville were slightly above the McNary flow objective and summer flows were below the McNary objective. There was some excess spill in April, otherwise FOP spill was provided. Yearling Chinook, steelhead and sockeye passage was earlier than the 10-year average. Additionally, high temperature sampling occurred in the month of August.

For weighted average mortality, lamprey mortality is still the highest among target species at the mid-Columbia projects. Descaling averages were close to average, with the exception of sockeye at Lower Monumental which was the higher than 10 year average. Additionally, many sites reported the highest percentages of injuries compared to a 7 year average. To be considered an "injury", the wound needs to be fresh and attributed to the dam (e.g. cuts, abrasions, lacerations to the fin, etc. that have not acquired fungus).

In the Snake River, disease types appear to be species and timing specific. The Snake River common spring diseases include parasites, fungus and deformities, whereas, in the summer the most common disease is *Columnaris*. In the mid-Columbia, disease types appear to be less species and timing specific. The mid-Columbia spring diseases include parasites, fungus and deformities, while in the summer the most common disease are parasites.

On May 13th, per an SOR, spill was switched from bulk to flat spill at Lower Monumental; this was intended to increase spillway passage of juvenile sockeye. Flat spill was provided from May 13th to June 3rd. In reviewing the passage index at Lower Monumental, the first PIT-tagged Sockeye detected at Lower Monumental was detected on April 25th and the last PIT-tag was detected on June 19th. Based on PIT-tag detections, flat spill operation did begin after approximately 27% of PIT-tagged sockeye had passed Lower Monumental.

- **Question**: Could you elaborate on the switch from bulk to flat pattern spill? Is there a difference in volume between the two patterns?
    - **Response**: Bulk pattern occurs with the majority of spill coming through three bays; flat spill is spread out across the bays. Bulk spill gases up the river (gas cap is 25-28kcfs), while the flat pattern can push spill up to 35kcfs and be within the gas cap.
- **Question**: Is it possible that fin injuries are increasing due to an operational change or due to other

types of injuries decreasing? Do you have an aggregate of injuries across all species?

- **Response**: It is hard to say, however, more needs to be done to standardize how injuries are being assessed. Some crews were identifying sockeye with bad tail fins as injured, while other crews identified them as deformed. The injury should be the result of the hydro system, if the fish is injured in the hatchery this is not classified as an injury. We have not aggregated the injury data for all the species sampled.

Juvenile Salmon Transport

Steve Smith, NOAA, presented on smolt survival, travel time and transportation analyses for 2016. Spring conditions in 2016 consisted of above average flow early on, average spill percentages, warmer water averages (1-1.5C above average), short travel times in April and a small percentage of fish transported (<25%). In April, flow was well above average at Lower Granite Dam. Flow tapered off compared to the anticipated May increase, and was below average by the end of May.

Chinook average survival from Snake River hatcheries to Lower Granite Dam was above 70% for the third year in a row. However, overall hydro-system survival was about 3-4% lower than average for steelhead and Chinook (top of Lower Granite reservoir to Bonneville Dam tailrace). McNary to Bonneville reach survival for Upper Columbia River fish was below average: yearling Chinook survival was 80.7%, compared to a 10-year average of 81.6%, and the lowest on record (2003-2016) for steelhead (10-year average 73%, 2016 mean 48.7%). Survival of Snake River fish was below average: Chinook survival was 67.2% in 2016 versus an average of 72.1%; and for steelhead 2016 survival was 60.8% versus an average of 71.6%. The Snake River trap to Bonneville reach survival for yearling Chinook and steelhead was below average. Snake River sockeye estimated survival was below average for all reaches, except for Redfish Lake trap to Lower Granite Dam (10-year average 46.0%, 2016 mean 54.3%). From Lower Granite to Bonneville, sockeye survival for 2016 averaged 11.9%, compared to the 10-year average of 46.6%.

- **Question**: In your assessment, are you looking at trends from 2007 onward to account for changes made to the hydro system?
  - **Response**: We have not done a statistical test on that question. However, we did see an increase in survival for Steelhead following the modifications made to the hydro system in 2007. Chinook were around 50% survival before the changes to the hydro system.
- **Question**: Can you expand on the 11.9% survival average for Snake River sockeye?
  - **Response**: That statistic accounts for the Lower Granite to Bonneville reach: of the 54% of sockeye estimated to have survived to Lower Granite Dam, an estimated 11.9% of those fish made it to Bonneville dam.

Steve presented on NOAA smolt transportation analyses, starting with results for PIT-tagged sockeye that were either transported from Lower Granite Dam (LGR) or bypassed at LGR in smolt migration years 2009-2014 (except 2010, when there was no data). For transported fish, adult return rates to Bonneville Dam have ranged from 0.8% to 5.0%. For bypassed fish, the range is 0.3% to 2.1%. Transported fish have had considerably higher return rates to Bonneville Dam every year: annual ratios of Bonneville return rates for transported fish versus those for bypassed fish (T:B ratios) have ranged from 2.0 to 3.1, with average 2.5.

Adult return rates to Lower Granite Dam are diminished by complications during the upstream journey for adult sockeye (conversion rates), and conversion rates have been lower for transported fish than for

bypassed. Annual ratios of Lower Granite return rates (T:B ratios) have ranged from 0.9 to 2.4, with average 1.4

Adult conversion rates from Bonneville Dam to McNary Dam have averaged 42% for transported fish and 57% for bypassed fish. From McNary Dam to Lower Granite Dam, the averages were 62% for transported sockeye and 67% for bypassed. In 2015, no adult sockeye that had been transported as smolts made it through the very warm Snake River water to Lower Granite Dam.

Steve also shared smolt transport data for yearling Chinook salmon and steelhead in migration years 2011 to 2014. He noted that in 2011 hatchery and wild Chinook were similar, with return rates for bypassed fish higher than for transported fish. In 2012 and 2013, return rates for transported wild Chinook were noticeably higher than for bypassed wild Chinook. Between 2011 and 2014, there were higher return rates for steelhead transported compared to bypassed.

- **Comment**: There is concern that the difference in migration success from Bonneville to Lower Granite is based off operations these fish encounter as juveniles. Additionally, hatchery steelhead are likely to be caught and harvested, and holding facilities may affect upstream passage as well.
- **Comment**: The region is struggling to figure out why fish that go through bypass have a lower SAR. Is it because we collect weak fish or is the collection weakening the fish? We see they are weaker, and we are trying to calculate how many more fish were collected due to the impact of transport on these fish. If bypassed fish are weaker, they are being preyed on by avian predators and other fish and only the healthier spilled fish return as adults. The conclusion that more adults are returning because of transport is likely an over estimation.
    - **Response**: This analysis does not move any fish from spill to bypass, it looks at fish already in bypass.
    - **Response**: If you bypass weaker fish, predators will eat them at a higher rate, reducing their numbers.

Sockeye Conversion and Passage

Russ Kiefer, ID, presented on Snake River sockeye conversion and passage. Last year (2015), conversion rates for sockeye were dismal due to cumulative temperature exposure in the Columbia and Snake Rivers. As water temperatures increased, adults who were transported as juveniles experienced homing impairment as they migrated. In 2016, there was concern that another passage emergency would occur as temperatures rose in June; however, two heavy rain events decreased water temperatures back down close to the 10-year average.

Overall, the total number of sockeye passed Bonneville was roughly 500,000 in 2015 and 342,000 in 2016. The total number of Snake River sockeye passing Bonneville was roughly 4,000 in 2015 and 1,348 in 2016. Conversion rates were good for 2016. Sockeye may be responding to warming river temperatures by migrating earlier in the season and potentially passing that early timing response on to their offspring. In 2016, the run was noticeably earlier than the 10-year average at all of the projects.

This year, improvements were made in the Lower Granite ladder to mitigate temperature. These included adding a 62 feet deep shroud to the diffuser 14 opening; 62 feet pump intake extenders and a ladder exit spray bar and shower. These modifications allowed for cooler water to be pumped from deeper levels in

order to encourage fish passage via the ladder. As a result of these modifications, water temperatures in July were significantly cooler near the ladder exit. At Little Goose Dam, rental pumps were installed for 2016 and 2017. By 2018, a permanent structure including a 90-foot shroud and spray head at the ladder exit will be constructed.

- **Question**: Did you encounter any Columbia River fish in the Snake River this year?
    - **Response**: We saw upper Columbia fish in 2015 (1/3 of the fish captured during emergency trap and haul were not Snake River fish), but we have not seen any of those fish yet in the adult returns to the Sawtooth Basin. Last year it was believed many upper Columbia fish strayed due to stress attributed to warming water temperatures. However, no upper Columbia fish strayed to the Sawtooth Basin on their own, if they had, we would consider including them in the stock since straying is natural.
- **Question:** Do you have any idea what water temperatures would be if the dams did not exist?
    - **Response**: There was some monitoring before dams were in place, that I recommend examining. Some reason that if water is slowed down and spread it out, it absorbs more energy from sunlight and heats up. How much has it heated up? That is hard to say. NOAA put out an after action report on sockeye passage which addresses temperature differences with and without dams.

Russ continued and moved on to Snake River sockeye smolt condition issues in 2015 and 2016. He shared that as a result of what is thought to be TDG injuries endured in 2015, Idaho Fish and Game (IDFG) amended procedures to reduce gas by watering up trucks the evening before and changing the transport routes. However, despite changes, problems persisted in 2016. Some of the issues observed on smolts included redness to the fin and fungus around the head, tail and center of the fish. It is not believed these injuries were caused by the dam. For 2017, the plan of action to address smolt conditions includes: adding a 6 inch pump to replace the 4 inch pump, transporting smolts in late April rather than early May, and additional TDG measures. Russ added that sockeye are a very fragile species and pumping them up and transporting them during peak smoltification likely contributed to the condition issues.

- **Comment**: The region should work to make to make injury/disease analysis consistent across the board. For instance, Brandon Chockley, shared that for Columbia River studies, pink fins is considered as a separate condition and is not considered as an injury. Additionally, his survey crews record the fungus depicted in the slides as disease, not TDG injury.
- **Comment:** Will IDFG produce an official report on the Sockeye smolt conditions? We heard earlier that there was a 12% survival rate, when we try to equate survival and outmigration, it would be nice to have a reference.
    - **Response:** Yes, IDFG will articulate what happened with smolt condition in our 2015 and 2016 annual Sockeye reports.

Lower Snake Upgrades and Operations

Upgrades to Lower Granite and Little Goose

Ann Setter, USACE, presented on fish ladder temperature improvement systems at Lower Granite and Little Goose Dams. At Lower Granite, three pumps were installed allowing cooler water to be provided to the adult trap and spray bar. On June 9, 2016, when the operation began, there were no passage issues due to water temperature. Monitoring was performed to understand fish distribution when exiting the

ladder. Preliminary monitoring results showed that summer Chinook appeared to stay within a similar depth upon exiting the ladder and moving into the forebay. Sockeye appeared to quickly move upstream and become more deeply distributed..

The Corps looked at installing a similar temporary and or permanent project at Little Goose Dam to address temperature blockages upstream. They found that cool water was available 80 feet below the surface that provided 2-4 degrees Celsius benefit. Additionally, the temperature of water approaching Little Goose was correlated to temperatures in the Lower Granite tailrace, both of which are regulated with flow augmentation from Dworshak Dam. Studies found that if 25cfs of water from 80 feet deep had been added to the ladder exit in 2015, there would have been a reduction from 32% to 16% in the amount of time water temperatures exceeded 68 degrees Fahrenheit. Additionally, there would have been no periods of temperature exceeding 72 degrees Fahrenheit and no average hourly temperature differentials greater than 4 degrees Fahrenheit. At Little Goose Dam, the cooling pump was turned on July 1st and turned off September 9th. During this time, hobo brand thermistors were used to monitor the ladder exit and data was uploaded weekly to the Fish Passage Center website (see Brandon Chockley's presentation below).

Noticeable benefits of the temporary pump installed at Little Goose included a delay in the average start date of when water temperatures exceeded 68 degrees Fahrenheit (July 4th in 2016 and June 20th in 2015). Other benefits included:

- Date of last day average water temperature exceeded 68 degrees Fahrenheit: August 29th vs. September 2nd in 2015;
- Number of days daily average water temperatures exceeded 68 degrees Fahrenheit: 15 days in 2016 vs. 58 days in 2015;
- Maximum daily temperature reached was 69.1 degrees Fahrenheit on August 4, 2016 vs. 71.9 degrees Fahrenheit on July 14, 2015.

Some limitations to the Little Goose rental pumps installed in 2016 were that they could not operate deeper than 66 feet in the forebay. The permanent system, which is scheduled for install January 2018, will perform better due to its capacity to pull water from 80 feet in the forebay. For next year's operation, another temporary system will be installed that will utilize the new permanent axial pump at 80 feet as well as a generator to provide power to the pump. Ann also noted that in 2016, ladder entrance and exit differentials of 2 degrees or greater resulted in immediate management action, even though there were no issues with adult passage when ladder differentials were 2 degrees or higher. She suggested further examining the data to determine when it is critical to look at differentials in order to make a change to management action.

- **Question:** What level is the diffuser located at?
    - **Response**: The diffuser entrance is located at 15-20 feet depending on pool elevation and the shroud/chimney will 80 feet deep at Little Goose Dam.

Ladder Temperature Monitoring and Reporting

Brandon Chockley, Fish Passage Center, walked the group through a tutorial on where to find ladder temperature data on the FPC website. He noted that in 2015, ladder temperature data for the Snake River projects was not readily available, so the Corps' Walla Walla and Portland Districts worked with FPC to upload data on a weekly basis to make it readily available to interested parties. The website,

http://www.fpc.org/river/Q_ladderwatertempgraph.php, provides hourly adult ladder temperatures at various projects. He noted that during the passage season (June 1 through September 30) data may be up to a week behind depending on collection efforts. Some projects provide north and south ladder temperatures and hourly temperatures are shown in two-week increments. Brandon encouraged participants to explore the website and follow up with any questions.

Dworshak Temperature and Flow Operations

Steve Hall, USACE, presented on Dworshak reservoir operations for water year 2016. He noted that runoff was early, BiOp targets were met, spring flow augmentation was near 15kcfs and temperature augmentation began on June 28th. Additionally, in 2016 Lower Granite tailwater temperatures were successfully kept below 68 degrees Fahrenheit all summer long.

In April, the project conducted TDG testing to provide information for the future unit 3 outage, during which there was only one deviation in TDG levels. Steve noted that the deviate is believed to be bad data due to high amounts of discharge. He continued that by June 28th temperatures out of the Snake River were 70 degrees Fahrenheit. Due to the early runoff and warming temperatures in June, augmentation was started on June 28th rather than July 4th as in previous years. Water temperatures continued to warm, with the Snake River seeing temperatures around 80 degrees Fahrenheit. Due to a mild August and a few rain events, operations were successful at keeping Lower Granite tailwater temperatures below 68 degrees throughout the summer.

- **Question**: A struggle at TMT is whether to maintain cooler temperatures in late June, which requires a higher level of discharge, or to hold on to that water for later in the season. How can temperature modeling be improved to inform operational decisions?
    - **Response:** We are constantly working to improve our modeling. One modeling change we hope to do this year is to separate out the RSW with the spill bays to see if turning the RSW on/off impacts project temperatures. Additionally, there was a request from FPOM that we model throughout the Snake River Basin, this is a parallel effort that we may or may not have done by 2017 summer operations.
- **Comment**: Please give us a quick update on the two new temperature stations added at Lower Granite.
    - **Response:** The two stations are being worked on now and will be operational soon; the floats have been secured, but the stations are not yet deployed. One of the stations is located 2 to 3 miles down from Silcott Island and centered in the middle of the pool.
- **Comment:** Was adopting the 67 degree Fahrenheit threshold a good decision in hindsight?
    - **Response:** It is hard to say what the right temperature criterion is at certain times of year. This year nature cooperated with us and we did not struggle to meet the temperature criteria for the summer. In past years, we have run in to problems in late August maintaining criteria below 68 degrees. Moving forward, it might be better to use more water in early July when the sockeye are migrating rather than potentially holding that water for the late August/early September fall Chinook and steelhead run.
- **Question**: Is it true that while summer releases were warm, spring releases out of Hells Canyon were cool?
    - **Response:** During the bulk of sockeye passage, water out of Hells Canyon is cooler than what comes in to Brownlee. There is an effort to move flow augmentation from Hells Canyon earlier in the year to avoid the issue of Idaho Power varying flows to match market

needs. What we've seen at TMT is when there is a fair amount of salmon in the river, flow augmentation is increased because warmer temperatures result in higher electricity demands.

Upper Basin Upgrades and Operations

Grand Coulee Drumgate, Flood Control and Operations

Mary Mellema, BOR, presented an overview of Grand Coulee operations for 2016. She noted that in 2015 drumgate maintenance was required and 2016 was an option year, however, BOR decided to conduct drumgrate maintenance in to 2016 based on the April-August water supply forecast at The Dalles. The decision on whether to do drumgate maintenance must be made in February in order to allow enough time to draft the pool down to 1,255ft by March 15. The February forecast was 95 percent of average with an April 30th flood control elevation of 1253.6 feet. Based on this April-August water supply forecast, Reclamation decided to go ahead with drumgate maintenance in 2016.

In 2016, elevations were drafted to about 1,255 feet by March 15. Inflows and outflows were around 100kcfs. If drumgate maintenance had not been done in 2016, the April 10th elevation would have been 1,264.4ft. In a water year like 2016 the March elevations would have been in the 1,275ft range and would have been drafted down to 1,264.4 by April 10 and to 1,243.8 by April 30th. After April 30th, refill operations were coordinated with the Corps and by then discharge was increased to 120-130kcfs as inflows increased.

- **Question:** Drafting to 1,243ft is based on the flood control rule curve – in retrospect it was not the right number. There was a lot of flow that occurred earlier, guarding against high runoff. The last few year's flows in February, March and April were higher than expected based on what the forecast suggests. A lot of water is going by Bonneville and the assumptions are that more will come earlier and earlier. This means you do not have to draft to 1,243ft based on observed volumes over the last few seasons.
    - **Response:** There are many factors to consider in the flood control system, including water coming out of Canada – we don't know if inflows are abnormal or standard, we go by the normal shape of the hydrograph. Other dams like Hungry Horse have more flexibility than Grand Coulee does.
- **Question:** We started refill sooner this year and Grand Coulee picked up after April 20th. Looking back at the season from here, it is easy to make that decision, but pieces are built in to flood control operations that anticipate early runoff and allow us to hit flow targets. In the long term if we have to shift to earlier runoff dates that are presently fixed, what does that mean for our system? This is something the Corps is grappling with, one year runoff is early and the next year it is late – how do you plan for that variability?
    - **Response**: Maybe extending the rule curves from April-August to January-August and adjust them so they are self-correcting.
- **Comment:** A question we must continue to look at is the biological tradeoff compared to the flood risk. For example, did we need to drop down and move water in April or would it have been better for the fish to drop down and move that water in to May and June? Having peak flows in April is good for smolts, but harmful to sockeye if temperatures warm in June and July.
- **Question**: What elevation is Grand Coulee at if a drumgate fails?
    - **Response**: If a drumgate failed the reservoir could not fill higher than 1,265ft.

Coordinating Variable Water Supplies Among Headwater Reservoirs & Summary of Libby Operations Study

Brian Marotz, MT, presented how we need to adapt to variable water supplies among headwater subbasins. He noted that Montana's dams contain 40% of U.S. storage in the Columbia River system. He continued that new tools like moisture mapping could improve system modeling and variable discharges. Flood management under the Columbia River Treaty provides some flexibility. However, if you draft reservoirs too deeply, it is difficult to refill the projects and ecological calamities occur at that site without providing additional flood protection downstream. The other extreme that may occur is flooding downstream and high TDG in the rivers.

The genesis of VarQ flood management operations was to accommodate the variation in runoff. When the Corps implemented VarQ at Libby and Hungry Horse dams, ecosystem services in the reservoirs and rivers benefited. VarQ did not require deep drawdowns and helped accommodate the tiered flow volumes released for white sturgeon with less impact to reservoir refill (currently only 12% refill probability). According to Brian, the entire system benefits when reservoir draft and refill targets are based on site-specific inflows, including the variable timing of those inflows from snow and non-snow precipitation. Brian shared that there is still room to improve VarQ and the white sturgeon operations. To provide maximum environmental protection, deep drawdowns should be avoided, and reservoir pools need to remain near full pool long enough to become productive.

Brian then discussed research to evaluate how the Mainstem Amendment Operations effect resident fish. He noted that Montana was asked to research dam operation impacts on native resident fish, while a similar project would evaluate anadromous fish. Brian explained that they knew there were limitations to the study. For instance, it would be difficult to draw conclusions from the few years since this operating strategy was implemented. Prior research established well documented effects of dam operations on lower trophic levels, but separating factors that impact to fish populations is more difficult. Thus far, the Montana study has not found a clear connection between fish populations and dam operations. He noted that it may be worthwhile to redefine the parameters of the study.

- **Comment:** Montana was legitimately concerned about double peaking and reducing river flows for refill, however, river flows have since been smoothed out by the mainstem amendments operation. At this point, we have reduced summer flow augmentation out of Libby and Hungry Horse and we rarely fill. Some are concerned about spreading out summer flow augmentation until the end of September. Most years when anadromous fish are migrating, more water is stored in Libby than is released in the summer period. It is a challenge to balance refill, the sturgeon pulse, and dropping down 10ft in September, and still have water available for the anadromous fish.
- **Comment:** One adaptive management option to consider would be to hit the target elevation by the end of August and gradually ramp flows down. Or, end the sturgeon pulse and do a normal ramp rate of 15kcfs, 13kcfs, 11kcfs, then 9kcfs. TMT should not worry about elevation, instead, we should ask why Libby cannot be refilled on a regular basis. If there is an adult passage emergency, as a region we should remember that in 2015, 90% of sockeye perished before reaching the Snake River. We could always do an emergency operation and draft Libby to dramatically increase flows from Grand Coulee to provide cooler temperatures in the Columbia during emergency actions.
    - **Response**: There are many opportunities to consider. The Columbia River Treaty Review made it clear that summer water does not come from Montana reservoirs; it comes from

our Canadian neighbors. Canada has their own perspective on how to operate Middle Arrow and it does not appear they will be changing that operation. If you were to release a large slew of water from Montana reservoirs, by the time it reaches the Columbia River it will have warmed and flattened.

Libby Sturgeon Operation

David Swank, USFWS, presented on Libby flows and Kootenai River white sturgeon. He noted that the 2016 Libby operations were routine. The May final April-August volume runoff forecast of 5.8maf resulted in a Tier 2 operation for Kootenai River white sturgeon: increase discharge from VARQ flow to 20kcfs upon the forecast of peak inflow into Lake Koocanusa; maintain discharge at 20kcfs for 2 days and then increase up to full powerhouse capacity, depending on the local conditions. Maintain peak discharge for a period of 7-10 days. After 7-10 days, decrease peak discharge toward stable summer flows until the sturgeon volume is exhausted to no less than bull trout minimums (7,000cfs). The minimum recommended release volume for sturgeon in Tier 2 is .93maf.

Dave continued that the number of adult sturgeon captured as well as the percentage of new fish captured since 2000 has fluctuated over the past fifteen years (Russ Kiefer, ID, added that while there are fluctuations over time, the long-term trend is that percentages of new fish are declining.). Successful spawning has been documented at three sites – Shorty's, Myrtle and Train Bridge. In 2014, 317 eggs were collected, and in 2015, 216 eggs were collected. Larval detection is less successful than the spawning events: in 2015 staff completed over 11,000 hours of sampling and collected 0 larval sturgeon. Efforts have also increased to find juvenile sturgeon; from July through October of 2015, a total of 26 sites upstream of Kootenai Lake were sampled using gill net, which produced 1,790 juveniles, of which 13 were wild juveniles.

A total of 1,749 juvenile sturgeon have been classified according to brood year dating back to 1992. Recapture frequency illustrates that the number of releases of a specific brood year correlates well with the number recaptured from that brood year. Finally, the number of wild juvenile Kootenai sturgeon, by year class, captured in the Kootenai River indicates that very few wild fish have been captured, and almost none from the 2009-2014 brood class. There were a few exceptionally strong brood years, such as 1961, 1962, and 1974.

- **Question:** When and where will the sturgeon spawn?
    - **Response:** The white sturgeon are just now starting to show up in the Kootenai River, it is an ideal place for spawning.
- **Comment**: Sturgeon recruitment may take up to ten years, this may be why there are so few wild sturgeon captured in the 2010-2015 cohorts.
- **Comment**: The last big recruitment occurred in 1974 and that is when Libby refilled for the first time.
- **Question:** Do you know what size is classified for adults compared to juveniles?
    - **Response:** Usually a sturgeon transitions from a juvenile to an adult once they hit their reproductive age, which can vary from 18-30 years of age.
- **Question**: Do you have any ideas where the 1981-1984 cohort came from if the dam filled in 1974?
    - **Response**: Those fish were recruited/spawned before the dam closed.

- **Comment:** There is an upward tick of 20,000 juveniles in the river that is on par of 7,000 adults. The hatchery is doing well, they spent $50 million restructuring the habitat and last year one female traveled all the way to Montana to spawn, which is very promising.
- **Question:** Any correlation with spawning success and the amount of sediment?
    - **Response**: There is a hypothesis that the substrate below Libby and large sections of the river were too sandy for reproduction. White sturgeon will die in too much sediment, compared to the Missouri River sturgeon, which uses silt to prevent eggs from sticking together.

Looking Ahead

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

What did TMT do well?

- Lower Granite and Libby temperature fixes;
- Provided fish ladder data – thanks to FPC and the Corps;
- The Lower Monumental spill change SOR was approved and implemented;
- There was a change in chum operation that hopefully will prove to be better for chum and project operations;
- The removal surface weir at Lower Granite was shut off at a good time for adults;
- We engaged with each other;
- Hungry Horse operations went well;
- The Dworshak temperature operations went well;
- Lamprey numbers were good; and,
- Grand Coulee drumgate maintenance completed without any snags.

What would you do differently next year?

- No dueling SORs (example, there were two SORs for Little Goose operations);
- Explore any opportunity for change in preparation for the new BiOp;
- There are a lot of changes needed outside of the scope of TMT, we need to identify what we can do within the TMT framework and what needs to happen in other forums;
- Consider an earlier transport start date, for instance, maybe when hydrograph decreases;
- Document TMT's final decisions more clearly in meeting notes and summaries;
- Have better quantitative data for decision making and allow more time to make decisions; and,
- Explore ways to be proactive on future operations, example, Dworshak Unit 3 outage.

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), Bruce Anderson (NWRFC), Leslie Bach (NPCC), Doug Baus (USACE), Scott Bettin (BPA), Brandon Chockley (FPC), Trevor Conder (NOAA), Amanda Connell (USACE), Peter Cooper (BOR), Erick Van Dyke (OR), Kyle Dittmer (CRITFC), Joel Fenolio (USACE), Stephen Hall (USACE), Laura Hamilton (USACE), Peter Hassemer (ID), Russell Kiefer (ID), Jim Litchfield (MT), Tom Lorz (CRITFC), Brian Marotz (MT), Aaron Marshall (USACE), Mary Mellema (BOR), Charles Morrill (WA), Mike O'Bryant (CBB), Logan Osgood-Zimmerman (USACE), Lynn Palensky (NWPCC), Christine Peterson (BPA), Scott Richards (Snohomish-PUD), Alfredo Rodriguez (USACE), Chris Runyan (BOR), Ann Setter (USACE), Steven Smith (NOAA), Dave Swank (USFWS), Pat Vivian (Contractor), Paul Wagner (NOAA), and Lisa Wright (USACE),

Tory Hines, Donna Silverberg, Emily Stranz and Charles Wiggins, DS Consulting Facilitation Team

Columbia River Regional Forum
Technical Management Team Official Minutes

2016 ANNUAL REVIEW OF LESSONS LEARNED
December 7, 2016

Minutes: Pat Vivian

1. Introduction

Representatives of BPA, the COE, NPCC, NOAA, Idaho, Washington, Montana, CRITFC, BOR, Montana, USFWS, Oregon, and others participated in the annual TMT retrospective of river conditions, hydro system operations and ESA-listed species in the Columbia basin. The all-day conference was facilitated by Emily Stranz, DS Consulting, with Doug Baus, COE, serving as TMT chair.

The purpose of the annual review is to give TMT members and other interested parties an opportunity to step out of the regular meeting format and review operations and management decisions of the 2016 season in search of knowledge that could expand the range of choices and enhance decision making in 2017.

2. Conditions Review

2a. Seasonal Overview of Weather and Hydrology. Kevin Berghoff, NWRFC, reported on precipitation accumulation for the year, as well as monthly precipitation and temperature departures from normal. This has been one of the strongest El Nino years on record. It started out with predictions of a strong ENSO signal for sea surface temperatures which proved correct.

Precipitation: This year was better than 2015, with around 90% of normal in the upper Snake above American Falls and Ice Harbor; close to 100% of normal on the Flathead and Kootenai rivers; and 95% of normal for the whole Columbia basin as measured at The Dalles.

Temperatures: This year was more moderate than 2015, but substantially warmer than normal especially in February and April. Snowpack was slightly deficient in the upper Snake but mostly good despite the high temperatures. April's warmth caused rapid loss of snowpack, making 2016 a record year for spring runoff in much of the basin. At the other end of the spectrum, some upper Columbia areas along the Continental Divide got less water than they did in 2015. Nevertheless, conditions for fish in 2016 were considerably better than in 2015. In general, it was a more balanced water year, with more parity between seasonal flows and better retention of snowpack than in 2015.

Runoff timing patterns in 2016 were similar to 2015 with strong precipitation in December through March, then dropping off dramatically. This was a deviation from the norm, especially in the Columbia basin above The Dalles, where warm temperatures caused heavy runoff in February through April 2016, leaving the region short of water in the late summer

months. Libby, Hungry Horse, Dworshak and The Dalles all had 85-90% of normal ESP predictions for April-September 2016.

Berghoff used Hungry Horse Dam as an example of the effect El Nino had this year on Columbia River water resources because HGH has a clear relationship between observed characteristics and runoff. These data are available on the NWRFC website and can be downloaded for further analysis.

The effects of such a strong ENSO signal on Columbia River water resources are unclear, with strong effects in some areas but not in others. Precipitation was slightly below normal for 2016 overall, with near-normal conditions in the upper Columbia, 90% of normal in the Snake basin and 95% of normal above The Dalles. Higher temperatures than normal led to early runoff and depleted snowpack in many areas of the Columbia basin. Seasonal runoff was 89% of the April-September forecast at The Dalles. For those who are interested, the NWRFC has scheduled online water supply briefings for January 5, February 2, March 2, April 6 and May 4, 2017.

Questions and comments:

- **Q:** When ENSO conditions are borderline, especially in a La Nina or ENSO-neutral year, has the Forecast Center found more variable weather and snow dumping at higher elevations? **A:** Not yet, but an experiment using various indices is underway.

- **Q:** What is the climate outlook forecast for 2017 and how is it weighted? **A:** It's based on projected sea surface temperatures, which are borderline La Nina at this point. That generally means colder, wetter weather and increased variability.

- **Q**: Is acceleration of runoff for two years in a row the "new normal" or just an anomaly? **A**: Two years don't necessarily constitute a trend. Snowpack depth at lower elevations is currently unknown, and data collection is limited to Snotel sites. The past two years have been unusual. Because ESP-based forecasting doesn't look any further than a year, it can't identify trends. To date, no monitoring stations have been added at lower elevations because a communication network would also need to be installed. It's hard to justify the cost because Snotel stations are unproductive for most of the year.

- **Q**: How does the RFC monitor drainage in the Clearwater late in the season? **A:** Monitoring snow-water equivalents (SWEs) is an evolving science. One tool the COE uses is snow flights i.e. visual surveys of how much snow remains in the Clearwater basin. Helicopter flights cost $5,000 each. The COE also operates a lower elevation Snotel station which cost $40,000 to install, plus another $10-15,000 a year for data collection. The flights are done around the same time every year to comply with a flood control requirement that space in Dworshak reservoir be reserved if more than 10% of snowpack remains.

- **Q**: What about monitoring the water supply at Libby Dam? **A**: Monitoring snow water equivalents there would mean flying in Canadian airspace. We can't get a good picture

of mid- or high-elevation snowpack in the Kootenai basin with only four Snotel sites in an area of 4,000 square miles.

3. Review of 2016 Fish Passage

3a. Juvenile Migration Summary. Brandon Chockley, FPC, reviewed the 2016 smolt monitoring program and conditions for juveniles, including migration timing. Chockley compared the 10%, 50% and 90% passage dates for listed species in 2016 with the 10 year average based on data collection from smolt monitoring sites at Lower Granite, McNary and Bonneville dams. (The Fish Passage Center also has data collection sites at Little Goose, Lower Monumental, John Day and Rock Island dams but they were not covered in today's presentation.) The timing curves are based on the passage index, which assumes a 1:1 ratio of fish to the proportion of water passing through the powerhouse. Several factors affect timing at each project – hatchery releases, flows, temperatures, spill volumes and survival to the point of interest. More detailed analyses of run timing would be needed to explain differences in timing between years.

Lower Granite Dam: Runoff volume on the Snake River for January-July ranked 52nd of the past 88 years or slightly below average. Neither the spring or summer BiOp flow objectives for Lower Granite were met. The spring objective was 96 kcfs; actual was 84 kcfs. The summer objective was 50.4 kcfs; actual was 31 kcfs. The freshet mostly occurred in April instead of the typical late May to early June. Spring flows in excess of powerhouse capacity resulted in two brief periods of spill that exceeded the Fish Operations Plan. Then summer flows dropped off earlier than usual, with volumes below the 10 year average.

- Yearling chinook passage at Granite in 2016 serves as an example of how flows can affect passage timing. The 10% passage date was close to the 10-year average, but the 50% and 90% passage dates were early and clearly coincided with peaks in flow.

- Steelhead passage followed the same principle, with three clear peaks in passage and accelerated 50% and 90% passage dates that also coincided with peaks in flow. The 10% passage date was April 15; 50% was April 26; and 90% was May 13.

- Sockeye counts are often complicated by overwintering kokanee migrating out of Dworshak reservoir. The first wild PIT tagged Snake River sockeye was detected at Granite on April 24. The hatchery release total of 635,000 sockeye smolts in 2016 far exceeded the 10 year average of 260,000 smolts. 2016 sockeye passage dates were 10% on May 17; 50% on May 22; and 90% on May 28.

- The timing of subyearling chinook hatchery releases at Granite was in line with the 10 year average. The 10% passage date for subyearlings was May 29; 50% was June 11; and 90% on July 7.

- Because juvenile lamprey were added to the smolt monitoring program in 2011, there aren't enough years of data to compute a meaningful average. Pacific macrophthalmia counts were high at Granite this year.

McNary Dam: Runoff volume for January-July ranked 54th of the last 88 years. The BiOp spring flow objective of 243 kcfs was met by actual average flows of 247.5 kcfs. Summer flows, however, were below average at 149 kcfs and didn't meet the 200 kcfs target. April's heavy rains caused spill in excess of the FOP, likely due to lack of market or hydraulic capacity.

- Yearling chinook passed MCN earlier this year than the 10 year average. The 10% date was April 23; 50% on May 3; and 90% on May 14.

- The steelhead run was close to the 10 year average on the 10% passage date of April 20 at MCN, but the 50% date (May 1) and 90% date (May 16) were early.

- Sockeye migrated earlier than usual, with 10% passage on April 29; 50% on May 11; and 90% on May 19.

- The subyearling chinook 10% passage date was June 10; 50% on June 26; and 90% on July 2.

- For unknown reasons, Pacific lamprey ammocoetes are rarely collected at MCN. Zero ammocoetes were collected at MCN in 2016. They could be present but aren't being collected by the juvenile bypass system at MCN. Although Pacific ammocoetes were not collected in 2016, Pacific macropthalmia were collected. Peak collections occurred in April and May.

Bonneville Dam: Runoff volume was 54th of the last 88 years. Flows at BON slightly exceeded the spring BiOp objective of 243 kcfs at MCN, but didn't meet the summer objective of 200 kcfs. Like the other projects BON passed excess spill in April. Similar to other projects, run timing was generally earlier in 2016 than 10-year average. The high-temperature sampling

protocol to protect fish from added stress was implemented later this year than last. Not many ammocoetes passed BON but quite a few macropthalmia did.

Chockley also presented data on mortality, descaling and diseases observed at fish collection facilities in 2016. These data are weighted by the passage index so days of higher passage get more weight in the analysis. This was an average year in terms of mortality rates at most collection sites, but there were injuries attributable to dam operations. The weighted average mortality rate for Pacific macropthalmia at MCN was 1.9; at JDA 1.0; and at BON 5.3, which were higher than any salmonid species and these three projects. This is a common occurrence for Pacific macropthalmia at these sites. The most common diseases of spring migrants at Granite are parasites, fungus and deformities; in summer migrants it's *Columnaris.* Like the Snake, the most common diseases of spring migrants on the mid-Columbia are parasites, fungus and deformity. Among summer migrants, parasites are common but *Columnaris* is rarely seen at the mid-Columbia projects.

On May 13, the Salmon Managers submitted two separate system operational requests (SORs) to the Action Agencies re: sockeye passage at Lower Monumental Dam. Both SORs requested a change from bulk spill to a flat pattern to aid juvenile sockeye, differing only in how long flat spill should last. The Action Agencies switched LMN to flat spill from May 13-June 3. When the flat spill operation ended, the Salmon Managers asked Chockley to assess how well it served the needs of juvenile sockeye in 2016. Based on the Passage Index, the timing of the flat spill operation encompassed the 10%, 50% and 90% passage dates at LMN. However, based on PIT-tags, the early portion of the run was missed by the flat spill operation. The first wild PIT tagged sockeye was detected at LMN on April 25, and the first hatchery sockeye was detected on May 18. Because the SORs were based on PIT tag data, about 27% of sockeye passage occurred outside the period of flat spill.

Questions and comments:

- **Q**: What's the difference between flat and bulk spill? **A**: Bulk spill (which is typical at LMN) means spilling through bays 1-3, while flat spill (also called uniform spill) spreads the volume across the entire spillway. Bulk spill tends to produce higher TDG levels, making it harder to meet the 120% TDG requirement in the LMN tailrace and the 115% TDG requirement at Ice Harbor forebay downstream. Bulk spill limits the gas cap to 25-28 kcfs, while a uniform pattern allows spill of up to 35 kcfs.

- **Q**: It appears from the data that fin injuries have been on the rise since 2012. Is that a function of changes in operations, or do fin injuries appear to have increased because other types of injuries have diminished or been eliminated? **A**: Sockeye had a number of fin injuries in 2016, and crews differed in whether they reported these as injuries or hatchery deformities. Chockley wants to standardize the protocol for reporting fin injuries so this doesn't happen again. See Russ Kiefer's presentation (section 3c of these notes) for more information.

- **Q**: Do the data include aggregate injuries for all species? **A**: Yes, the one for all salmonids at LGR is an example. Fin injuries are the most common and seem to be increasing.

- **Q**: How do crews determine whether injuries are caused by the projects or by natural migration? **A**: If fungus is growing over a wound, they call it disease not injury.

3b. Juvenile Salmon In-river vs. Transport Ratios and Reach Survival. Steve Smith, NMFS, gave a presentation on smolt survival rates, travel time and the effects of transportation. More information on the effects of transport on steelhead and yearling chinook is available this year than in the past, with new data on sockeye transport and subyearling fall chinook. NMFS findings on 2016 survival times and travel rates are summarized in a September 26, 2016, draft report to BPA. The data pertain only to juveniles migrating in-river.

Flows in 2016 were above average early in the season, mostly in April, then dropped off in May. Temperatures were 1-1.5 degrees C warmer than the 10 year average. This resulted in the shortest travel times ever seen in April for both steelhead and yearling chinook. Such early migration meant that less than 25% of juveniles in the Snake basin were transported because they arrived after transport started May 1. Later today, TMT identified as a lesson learned in 2016 that transport should start earlier than May 1.

Average survival for steelhead and yearling chinook from hatcheries in the Snake basin to LGR was above 70% for the third year in a row and the highest seen since 1993. Reach by reach, however, 2016 was a mixture of higher and lower than average survival rates. Steelhead and yearling chinook survival estimates throughout the hydro system were lower than average by 3-4%, with most of the disparity in the lower Columbia River. Lower Granite, Little Goose and Lower Monumental spilled about the same average percentages of river flows as in recent years. Average temperatures were consistently higher than 2015 until the end of April and continued above the mean throughout the rest of passage season.

Smolt survival rates and travel times: Yearling Chinook median travel times from LGR to BON were the shortest in 2016 since PIT tag data were available. Steelhead had the fastest migration and shortest travel times in April. Estimated survival rates of yearling chinook released from Snake River hatcheries to LGR was the highest seen, following two years of high survival. Estimated survival rates of yearling chinook released from upper Columbia hatcheries was 61% which is relatively high. Steelhead survival from the upper Columbia was

average at 41.6 %. Yearling chinook survival from LGR to MCN was equal to the 15 year average. Steelhead survival from LGR to MCN was above average. From MCN to BON, however, estimated survival rates for Snake River fish were below average and the lowest on record for upper Columbia steelhead. From the Snake River trap to BON tailrace, estimated survival was 47.3% for yearling chinook and 44.3% for steelhead.

Estimated transport rates and survival rates of transported fish: The percentage of juveniles transported was higher in 2016 (20% of yearling chinook and 22% of steelhead) than in 2015. Transported Snake River sockeye released from the Redfish Lake trap had an estimated 54% survival rate in 2016, higher than average. However, estimated survival rates declined for these fish as they moved downstream – 52.3%; from LGR to MCN; 22.7% from MCN to BON; and only 11.9% for fish from all 7 reaches at LGR to BON.

Focusing on sockeye survival in 2016, Smith presented data on transported vs. bypassed smolts that returned to BON as adults. Transported sockeye returned to BON as adults at about 2.5 times the rate of in-river sockeye for all years available. However, return rates were lower for smolts that returned as adults to LGR. In 3 of the past 5 years, whatever advantage transported sockeye had at BON disappeared by the time they reached LGR. This implies transported fish don't travel as successfully through the hydro system as fish that migrated in river (the mean is 1.4). Sockeye adult conversion rates from BON to MCN averaged about 42%, meaning 42% of the fish transported as smolts at BON arrived as adults at MCN. In general, the deficit in survival rates for transported fish was greater from BON to MCN than from MCN to LGR.

Smolt to adult return rates (SARs) for wild and hatchery chinook and steelhead that were tagged upstream of LGR in 2011-2014 indicate that a higher percentage of transported fish than bypassed survived. The effect increased over the years with the highest rate seen in 2014. NMFS will soon release a 250-page report on transport of subyearling fall chinook.

Questions and comments:

- **Comment:** The region is struggling to understand whether bypassed fish have lower SARs because they are weaker fish, or does collection for transport weaken them? Would they have died anyway if they were spilled? Does this mean survival rates for transported fish are overestimated? We need answers.

- **Q**: Has NMFS looked at any trends since the hydro system started changing significantly in 2006 and 2007? **A**: Survival rates for steelhead increased in the years following the changes. Survival rates were generally around 50% before 2007.

- **Q**: Does it appear that impairment of homing ability may be affecting fish upstream of LGR? **A**: There is a hypothesis that fish who spend more time in the lower river trying to find their way upstream because they were transported as juveniles are more likely to be harvested as hatchery broodstock when they return as adults.

3c. Sockeye Conversion and Passage. Russ Kiefer, Idaho, gave a presentation on adult sockeye passage in 2016 and the condition of sockeye smolts over the past two years. This year, sockeye passage was on everyone's mind after a dismal 2015 passage season, with poor conversion rates for Snake River fish due to cumulative temperature exposure. The FPC report found that transported adults with homing impairment suffered increased exposure to high temperatures, which probably increased their vulnerability to fallback and fishery harvesting.

By early June 2016, temperatures were approaching 2015 levels, and preparations began for another emergency trap and haul operation. But two cold water rain events intervened, resetting temperatures to the 10 year average and making 2016 a better year for fish than 2015. The total sockeye run size for 2015 was around 500,000 at BON with a forecast of 110,000 sockeye in 2016. In 2016 the total run size at BON was 342,000 sockeye. The Snake River sockeye return to BON was around 4,000 in 2015 with 1,348 forecast for 2016. The updated Snake River sockeye run size at BON is 1,032 for 2016. Sockeye responded to warm temperatures this year by surviving at higher rates the earlier they migrated. These early migrants will pass that timing to their offspring, making subsequent runs earlier than usual.

The Action Agencies responded to the sockeye crisis of 2015 by implementing ladder temperature improvements at Lower Granite. These include a shroud to pull water from a deeper, cooler level in the reservoir; pumps to draw cool water into the ladder; and a fountain to spray cool water into the ladder exit. The goal is to keep sockeye from turning around because they've hit a temperature differential of a few degrees. It was clear the pump worked well because the ladder temperature shot up when the pump went out of service in July.

IDFG is working with the COE on modeling temperature trends during sockeye passage season. At Little Goose, rental pumps cooled the ladder this year, and will next year. A permanent structure should be in place at Goose for 2018 passage. Conversion rates for sockeye this year were 80-90% at all Snake River dams except LGR, which is better than the conversion rates of 2015. In short, 2016 brought cooler temperatures than 2015, fewer adult sockeye, improved cooling of ladders, and earlier migration than usual.

This year there were sockeye smolt condition issues at LGR, raising the question of whether injuries caused by dam passage were reported as disease because the injuries were coated with fungus by the time the fish arrived. In 2015, the primary issue was probably TDG. This year measures were taken to address TDG impacts, such as transporting juvenile sockeye via a route with a lower elevation change. Nevertheless the problems persisted. The plan for 2017 is to increase the ladder pump size from 4 inches to 6 inches and transport hatchery smolts in late April instead of early May.

Questions and comments:

- **Q**: Did IDFG distinguish between conversion rates for transported vs. non-transported sockeye? **A**: No.

- **Q**: Did IDFG find that Columbia River fish strayed into the Snake basin as they did in 2015? **A**: Genetic analysis of emergency trap and haul fish in 2015 found that about a third were not Snake River fish but from the upper Columbia. Because there was no trap and haul effort this year, it is unknown whether any of those fish made it to LGR. The stray rate might have been excessive in 2015 due to high temperatures.

- **Q**: What would water temperatures be if dams didn't exist? **A**: There are differing opinions on this. On the plus side, dams moderate peaks in temperature and store cool water for release when needed. However, dams constrict river flow, which increases heat absorption.

4. Small Group Discussions

Conference attendees brainstormed in small groups their responses to the question: *What lessons can we take from this season to inform future management? Does anything stand out?* People made the following observations:

- "Unexpected" events should be expected and will influence reach survival, transport and adult conversion rates.

- Consider more flexible management in terms of how reach survival data are interpreted, how the start of transportation is scheduled, and the timing of harvesting specific stocks.

- Teamwork helped the development and implementation of an effective cooling system at the LGR adult ladder this year.

- Increased variability in precipitation is causing forecasting problems. Solutions may include more Snotel sites at mid to low elevations, which will cost money. We need lower elevation SWEs. Having no mid-elevation Snotel sites makes forecasting difficult.

- Is earlier runoff in our future? Does that mean more rain and less snow accumulation?

- Earlier migration impacts the scheduling of transport. Should we consider setting a new start date based on runoff predictions?

- Does faster travel time for early migrants mean they should be allowed to migrate in-river?

- Does it benefit downstream migrants to reach the estuary earlier in the year?

- What should we do about the growing injury rate of sockeye smolts?

- What's the best response to river temperatures for adults?

- We have no effective plan for protecting adult sockeye migrating from BON to MCN.

- Early runoff tends to cause early out-migration (except for Chief Joseph Dam).
- Because transport didn't start until May 1 this year, we missed the bulk of fish migrating downstream. Should we transport earlier?
- Fixed dates are problematic in planning operations around variable runoff conditions.
- Do we need to improve communication with hatcheries re: timing smolt releases with peak flows?
- Fish adapted to early runoff this year (they may be smarter than we think!).
- Don't assume that runoff patterns will be normal.
- El Nino is equivalent to low water supplies throughout the basin.
- Ladder modifications made at LGR this year were effective
- Look at the impacts of hatchery release dates on sockeye smolt condition.
- Keep in mind that survival rates in the lower Snake were 10% higher this year than in the lower Columbia.
- Consider the effect of El Nino or La Nina ocean trends on runoff.
- The lower Snake upgrades were right-on.
- Steelhead travel times correlated to flat flows throughout the region.
- Earlier runoff in April meant flows later in the season were depleted.
- Anticipate the effects of earlier snowmelt and warmer temperatures on migration timing.
- Think about how to manage hatchery releases and river flows in light of an apparent tendency toward earlier snowmelt and runoff.
- Consider the effects of earlier runoff on travel time, passage timing and survival rates.

5. Lower Snake River Upgrades and Operations

5a. Upgrades at Lower Granite and Little Goose. Ann Setter, COE Walla Walla, gave a presentation on fish ladder temperature improvements in 2016. In terms of retrofitting, Lower Granite had the advantage of three pumps that were already installed for flood control, which could be used to spray cool water into the ladder. At Little Goose, the pumps need to be acquired.

The Lower Granite pumps ran from June 9-September 8, 2016, with no passage issues due to temperature differentials in the adult ladder. Monitoring results are preliminary at this point. The configuration of Granite and Goose are similar in that both dams have only one fish ladder. The COE needs justification to move ahead with construction of a cooling system at the Little Goose ladder. It appears that a layer of cooler water around 24 degrees C is available at 80 ft and deeper in the Goose forebay. The pump at Granite pours 25 cfs of water into the ladder exit, which comes from diffuser 13 or 14 into the fish ladder. In 2015, a similar ability to pump from 80 ft deep in the Little Goose forebay would have reduced the time that temperatures in the ladder exceeded 68 degrees F from 32% to 16% of passage season. This finding provides strong justification for installing a permanent cooling system.

The Little Goose rental pumps operated from July 1-September 9, 2016. The only monitoring was thermistors at the ladder entrance and exit. The installation in 2017 should be more effective, with one pump drawing from 80 ft deep in the forebay instead of three rental pumps drawing from 66 ft deep. Data from 2016 indicate there are often differentials of more than 2 degrees C in the Little Goose ladder. Once the installation is permanent, passage benefits like those seen at Granite can be expected. A generator is needed to run the pumps at Goose, but direct power will be available by August 2017.

Questions and comments:

- **Q**: If the pump pulls from 80 ft deep in the Little Goose forebay and the diffuser entrance is below that, as what elevation is the diffuser? **A**: The chimney is 80 ft deep. The diffuser 13 intake is 15-20 ft deep in the forebay depending on pool elevation. With so much similarity between Granite and Goose, the COE wanted time to study the performance of the permanent ladder cooling system at Granite before moving ahead with permanent installation of a similar system at Goose.

5b. Lower Snake Ladder Temperature Monitoring and Reporting. Brandon Chockley, FPC, gave a presentation. The sockeye migration crisis of summer 2015 made it clear that temperature data being collected at Lower Snake fish ladders needs to be disseminated more quickly. So the COE worked with the FPC to post ladder temperatures in a format that users can download in real time (linked to today's agenda). Once a week, hourly temperature data from the adult ladders are sent to the FPC where they are made available via query. During fish passage season, the FPC may be up to a week behind in reporting ladder temperature data.

Questions and comments:

Q: Which projects lack a temperature probe at the ladder? **A**: John Day, Bonneville and The Dalles, which have probes only at the counting station and ladder entrance. Walla Walla District projects all have temperature probes at the ladder entrance and exit.

5c. Dworshak Temperature and Flow Operations. Steve Hall, COE, gave a presentation on Dworshak operations, including the water supply forecast, BiOp operations, a flood control space shift to GCL, spring flow augmentation, refill operations, summer temperature management and total dissolved gas at Dworshak.

Spring runoff came early in 2016, and Dworshak provided around 15 kcfs of flow augmentation in April and more in May. Small TDG excursions at the end of April and early May were probably the result of bad data because flows were not high at the time. Summer augmentation flows successfully kept water temperatures below the 68 degree trigger at Lower Granite tailwater. According to weekly temperature modeling (as measured at Anatone gage below Hells Canyon), June started off cool, with Dworshak releasing 1.8 kcfs. On June 15 the project refilled to 1600 ft elevation. Temperature augmentation doesn't usually start before the Fourth of July, but with water temperatures around 78 degrees on the Snake this year, Dworshak started releasing augmentation flows on June 28. Temperatures peaked at almost 80 degrees on July 27 but dropped after that and stayed manageable for the rest of the summer.

Questions and comments:

- **Q**: Does temperature modeling provide a sufficient quantitative basis for decision making when TMT is rationing cool water in the face of rising temperatures, or is it still a judgement call? **A**: The COE is working to improve the efficiency of Cequal W-2 modeling and is investigating whether to extend modeling all the way down the Snake, as well as studying the effects of turning removable spillway weirs on and off to manage temperatures. A longer term effort involves two- and three-dimensional modeling at LGR that could be fed into Cequal W-2.

- **Q**: What's the status on communications issues at Little Goose? **A**: The COE is testing two new weather stations that will be added at Lower Granite, one at the entrance to the navigation lock and another 2-3 miles downstream.

- **Q**: Would it be advisable to adopt a trigger of 67 degrees F at the Lower Granite tailwater instead of 68 degrees F? **A**: It might make sense to release more water from Dworshak in early July for migrating sockeye than to hold it for fall chinook and steelhead passage in late August and early September. But better conditions for sockeye would probably come at a cost of higher temperatures in late summer. This year mild weather in August helped, but it's always a gamble.

- **Q**: What about the influence of Hells Canyon releases? **A**: Relations between COE and Idaho Power staff are good. Unfortunately, it's in Idaho Power's best interest to release hot water when air conditioning demand is high and fish migration conditions are poor.

6. Upper Columbia Basin Upgrades and Operations

6a. Grand Coulee Drum Gate Maintenance, Flood Control and Operations. Mary Mellema, BOR, reported on drum gate maintenance in 2016. This is the second year in a row

drum gate maintenance was performed. It is essential because if the drum gates fail, Lake Roosevelt can go no higher than 1265 ft elevation.

The challenge in scheduling drum gate maintenance is that a decision must be made in February whether to start drafting the pool down to 1255 ft by March 15 so work can begin. But February is too early for a reliable water supply forecast, and the March forecast is too late to inform the decision.

The April 30 flood control elevation at Grand Coulee is based on the River Forecast Center's April-August water supply forecast for The Dalles. In 2016 the April 30 flood control target at Coulee was 1243.8 ft. Drum gate maintenance was required in 2015, a dry year, but in 2016 it was optional. This year the April 10-30 elevation forecast for the BiOp pushed more water into April, but drum gate maintenance requires drafting the reservoir to 1255 ft. When Coulee reached 1255, discharges were about 100 kcfs and the project began passing inflows. The April 10 target BiOp elevation at Coulee would have been 1264.4 ft without drum gate maintenance. But releases increased in early March when the project was drafting to 1255 ft for drum gate maintenance. Because the project is limited to a draft rate of 1 ft per day, Lake Roosevelt would probably have had to drop below its April 10 BiOp elevation in order to make the required flood control draft to 1243.8 ft. By April 30, discharges were 120-130 kcfs and inflows were increasing. The net effect of drum gate maintenance this year was lower elevations at Coulee during the first 10 days of April.

Questions and comments:

- **Comment**: In retrospect, drafting GCL to the flood control refill curve of 1243.8 ft was unnecessary because a lot of volume actually passed in the February-April timeframe. We have work to do on predicting and setting flood control elevations when flows in February-April are higher than expected. **Response**: The final GCL April-August volume was predicted to be 95% of average and turned out to be over 100% of average. While the hydrograph for headwater projects is more predictable than for downstream projects, system flood control is subject to many variables. Coulee started refilling early this year when inflows picked up on April 20. This raises the question of how to proceed if long-term runoff patterns are actually shifting.

6b. Coordinating Variable Water Supplies among Headwater Reservoirs (summary of Libby operations study). Brain Marotz, Montana, gave a presentation oriented toward managing the hydro system holistically. He noted that projects in the upper and lower Columbia operate differently, and 40% of U.S. storage in the Columbia basin is in Montana. The Columbia River Treaty Review clarified that flood control management has some flexibility that could be used to restore ecosystem function. New tools are becoming available all the time to enhance that opportunity – better computing systems, moisture-mapping tools, and the ability of system models to interact. These tools will be needed to move beyond present configurations and improve conditions for fish and wildlife. In general, forecasting tools are good at predicting runoff volumes but can't predict precipitation beyond a few days.

In an effort to balance flood control and refill requirements, the region has resorted to two basic scenarios:

1. Draft deep and hold as much as inflow as possible. This strategy tends to produce good flood control downstream, but if upstream projects don't refill they are subject to ecological calamity.

2. Draft too shallowly and flood prematurely. This strategy carries the risk of inflicting TDG problems on downstream sites.

The VARQ operation was implemented to assimilate variations in runoff. It improved reservoir operations from an ecosystem perspective because projects don't draft as deep in dry years, while high-inflow reservoirs draw down for local flood control. Under VARQ, high-volume water years have a greater probability of reservoir refill. But the most important thing ecologically is to keep reservoir shoreline elevations steady. Variable dam operations tend not to keep upstream reservoirs full long enough to be biologically productive. By not refilling upstream reservoirs, the region is missing opportunities to manage flows more effectively for spring and summer passage.

Canadian utilities dislike VARQ, possibly because they don't understand the implications yet. VARQ was blamed for high flows in years when the Action Agencies were legally required to do a spill test at Libby because precipitation was more than 500% of normal. The entire system would benefit from a more holistic view of the timing and volume of releases for optimal benefits.

Montana Department of Fish and Wildlife has been asked to summarize the effects of the NPCC mainstem amendments on upstream fish populations. This has been difficult to measure. Montana's view is that the effect on flows is so subtle it will be difficult to pick up a signal at the fish population level. Montana is open to more sophisticated means of measuring the results of the amendments, but is skeptical because the findings might not justify the cost. Research to date tends to support past findings for sites west of the Rockies, and Montana has been focused on research east of the Rockies in recent years. Montana's first priority is maintaining the genetic integrity of species that are essential to biological diversity in upstream reservoirs.

Idaho's view is that the mainstem amendments have reduced summer augmentation from Libby, Russ Kiefer said. The amendments may have spread out augmentation to the end of September, causing Libby to store more water than it releases in summer. The combination of meeting BiOp refill requirements, providing a sturgeon pulse and drafting 10 ft in reservoir elevation by end September doesn't leave much water for anadromous fish.

Questions and comments:

- **Comment**: The mainstem amendments have most likely hurt flows for summer migrants. Idaho wants the region to consider an alternative in dry years: ramping Libby releases down gradually after reaching full in August to 17 kcfs, then 15 kcfs, 13 kcfs, 9

kcfs and finally bull trout minimums. Another option is to follow normal ramp rates until outflows are 17 kcfs and operate Libby that way for two weeks, then ramp down to bull trout minimums. This way of coordinating Libby releases to supplement Coulee operations could provide optimal river and reservoir conditions while also providing flow augmentation for endangered Snake River sockeye. **Response**: In 2018, sturgeon and bull trout operations will be synchronized. The Columbia River Treaty Review clarified that a lot of the water reaching U.S. projects in summer comes from Canada. Ultimately we need to work with the Canadians on this.

6c. Libby Sturgeon Operation. David Swank, USFWS, gave a presentation on releases from Libby Dam to support white sturgeon spawning. Libby operations were fairly routine with a 5.8 maf forecast for April-August inflow volume. This made 2016 a Tier 2 year, with a sturgeon pulse of 0.93 maf. Discharges were increased to full powerhouse, following ramp rates in the USFWS BiOp. Peak discharges of 20-25 kcfs were maintained for 10 days, then ramped down to stable summer flows and finally bull trout minimums of 7 kcfs.

Swank reviewed RPA flows for sturgeon operations, then reviewed the results of a 2015 sturgeon spawning study. The sturgeon recovery team sought to answer the question: Are BiOp releases for sturgeon having an actual impact on the population? Swank looked at spawning mats, occurrence, larval sampling and juvenile gillnetting. The latest data available are from 2015 when the Kootenai Tribe captured and tagged approximately 25% of adult sturgeon. In terms of spawning occurrence, 216 sturgeon eggs were planted in 2015 and 317 eggs in 2014. In 2014 and 2015, thousands of hours of sampling brought scant results so larval sturgeon counts are probably not meaningful.

Juvenile sampling in 2015 at 25 sites upstream of Kootenai Lake identified 1,790 juvenile sturgeon and 13 wild juvenile sturgeon, including 8 wild juveniles not tagged previously. Juvenile assessment efforts have been relatively stable and distribution has been good over the past 10 years. The 2015 results, correlated to release years, suggest that survival is decent for juvenile sturgeon on the Snake. Wild sturgeon have been scant over the past 10 years with annual counts of less than 200 fish. In recent years, wild sturgeon counts have been small. Flow augmentation seems to have resulted in documented spawning but not survival beyond the egg stage. The last spawning recruitment was in 1974, when Libby filled for the first time. Libby Dam is considered a primary factor in the decline of Kootenai white sturgeon. Habitat restoration will continue for another year. There are also plans for a large modeling exercise to characterize sturgeon recovery.

Questions and comments:

- **Q**: When are sturgeon next expected to spawn? **A**: Probably 6 years from now but that's unknown.

- **Q**: Is there any correlation between spawning success and the amount of sediment in the river? **A**: In some places there's a strong correlation with sediment and total river flow which is not well understood. One hypothesis is that the substrate below Libby Dam is too sandy for habitat restoration.

- **Q**: Has there been further research on the layer of silt that could be keeping white sturgeon eggs in the Missouri River from sticking together? **A**: White sturgeon operate differently from the norm. In Missouri they spawn in sand. They generally don't like shallow water. But Kootenai white sturgeon tend to choose hiding places for their eggs. This year a fish ladder was built with holes for them to spawn in, a strategy that seems to be working.

7. Looking Ahead (Large Group Reflection)

TMT members gathered to identify things that went well this year, as well as opportunities for positive change.

What went well in 2016:

- Ladder temperature differentials at Lower Granite and Libby dams were successfully addressed.
- The FPC provided Lower Granite fish ladder data in time to aid operational decision making.
- The SOR to change the spill pattern at Lower Monumental to flat spill was implemented.
- The Bonneville tailwater elevation range for chum spawning was changed to 11.5-13 ft.
- Shutting off the surface spillway weirs at Lower Granite and Little Goose provided timely benefits for juvenile and adult passage.
- TMT members engaged positively with each other.
- Hungry Horse operation went well this year.
- Dworshak temperature augmentation went well.
- Lamprey counts were unusually high.
- Drum gate maintenance at Grand Coulee was completed without any problems.

Opportunities for change in 2017:

- Dueling SORs, such as those presented at the May 13 TMT meeting re: the transition to flat spill at LMN, should be avoided.
- The region needs to explore opportunities for change in the new BiOps.

- The authority to make operational changes in response to new biological recommendations sometimes lies outside of TMT's scope.

- Earlier transport start dates than May 1 should be considered, perhaps using decreases in the hydrograph as a trigger to initiate transport at Lower Granite. Consider documenting this in the BiOp.

- Final decisions made in response to TMT discussions need to be more clearly documented in meeting notes.

- Better quantitative data would improve decision making, particularly in relation to temperature modeling. Allow sufficient time for operational changes.

- Explore ways to be more proactive in planning future operations, such as the Dworshak unit 3 outage.

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