COLUMBIA RIVER REGIONAL FORUM
TECHNICAL MANAGEMENT TEAM
YEAR END REVIEW

December 2, 2015
Facilitator's Summary
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The following Facilitator's Summary is intended to capture basic discussion, decisions and actions, as well as point out future actions or issues that may need further discussion at upcoming meetings. These notes are not intended to be the "record" of the meeting, only a reminder for TMT members.

Welcome and Introductions - *DS Consulting Facilitation Team*
The Facilitation Team, Emily Plummer and Charles Wiggins, welcomed the group to the Columbia River Technical Management Team Year End Review. Emily encouraged participants to use the YER as an opportunity to reflect and think critically about the impacts of the 2015 water year and to consider what operations and information would be useful moving forward. The DS Consulting Facilitation Team will provide a written summary of the session in order to capture lessons learned for future management and to inform later TMT discussion.

2015 Conditions Review
Water Year 2015 Overview **-** Tony Norris, BPA, reported on the 2015 water year, noting that through March of 2015 there was decent precipitation. However, from April onward, the basin experienced above average temperatures and below average precipitation. By April, flows were dramatically affected, as illustrated by the water supply forecasts:

- The Dalles April-August: 58.4 maf (67%)
- Lower Granite April-August: 10.8 maf (53%)
- Dworshak April-July: 1 maf (42%)

Tony reported that storage releases from reservoirs upstream included 4.1 maf from U.S. storage and 7.3 maf from Canadian reservoirs. Of the 7.3 maf total 5.8 maf was Columbia River Treaty Proportional Draft , 1.0 maf the BiOp Treaty Flow Augmentation and the remainder was the 0.5 maf of Dry Year Non-Treaty Storage. The volume of Proportional Draft released during the spring and summer contributed significantly to keeping the flows in the Columbia River from reaching extremes. Weekly flow targets were coordinated through TMT beginning in April. Required drum gate maintenance at Coulee in 2015 drafted Grand Coulee ~30 feet below the April 10 flood control elevation. The subsequent refill of Grand Coulee in June upon completion of the drum gate maintenance reduced flows in the lower Columbia by approximately 30kcfs.

In summary, 2015 saw average to above average precipitation in March, followed by above average temperatures and below average snowpack for the remainder of the year. Precipitation sharply declined in April through August and temperatures remained above average. Unregulated flows from April to August were consistently tracked below the 10th percentile ESP traces (WY 2014 used 55 traces; WY 2015 will begin using 66 traces soon). Releases from storage reservoirs cannot make a dry year a wet year but contribute significantly to keeping Lower Columbia River flows from reaching extremely low flows.

El Nino Weather Patterns Winter 2015-2016 Climate Forecast **-** Kyle Dittmer, CRITFC, reported on El Nino weather patterns and the winter 2015-2016 climate forecast. He noted that strong El Nino events typically occur every 17 to 18 years with 1982-1983 being the strongest El Nino recorded in the last 100 years. As a result of a pressure difference between Tahiti and the Darwin Islands, warm Pacific water moves eastward and results in warmer and drier weather patterns in the Pacific Northwest. Over the last two months, upwelling along the Oregon

coast has increased, which is beneficial for salmon.
Climate trends over the last fifty years indicate no clear pattern; from 1998 onward the Pacific Northwest region experienced a cold phase of the Pacific Decadal Oscillation. The November 3rd MEI index indicated a peak of El Nino, with no indication of if weather patterns will reverse or not. The closest analog year to the 2015-2016 forecast was 1997-1998, where the water supply forecast for that year was 90% of normal; 90% of normal is considered a good El Nino year compared to past El Nino years where the water supply forecast was in the 50-75% range. Kyle forecast the overall seasonal snowfall to be 90% of normal for Government Camp, Oregon. He noted that there is a high likelihood that 2015-2016 will experience a good level of snowpack which will remain intact throughout the spring. Kyle did not expect the temperatures to be as drastic as last year's warm temperature hold.

Review of 2015 Fish Passage

2015 Smolt Monitoring Program Juvenile Passage Data and Noteworthy Events **-** Brandon Chockley, Fish Passage Center, reported on the 2015 Smolt Monitoring Program. He noted that in his presentation, the 2015 passage data is compared to the 10-year average, based on the passage index. He continued that several factors affect juvenile timing at a project: (1) hatchery releases (both magnitude and timing), (2) flows, (3) temperatures, (4) spill volumes, (5) survival to point of interest. Brandon noted that for a clearer explanation of timing differences, a more detailed analysis is needed. That being said, it was clearly a low flow year; from January to July at Lower Granite Dam, the Snake River runoff volume ranked 74th out of the last 87 years. Additionally, Brandon shared, BiOp spring and summer flow objectives were not met and there was no spill in excess of the FOP. In July, the modified operation for adult Sockeye led to reduced spill as a result of operating turbine 1 priority. Brandon reported on the juvenile passage timing at Lower Granite:

- Yearling Chinook (hatchery & wild combined) appeared early this year, with 50% passage by April 26th and 90% passage by May 11th.
- Steelhead passage began as early as March 26th, with 50% passage by April 28th and 90% passage by May 20th.
- Sockeye passage occurred mostly in late April and May, with the first PIT-tag detection occurring on April 28th (wild). Passage timing was quick, occurring between May 9th (10% passage) and May 20th (90% passage). It is also noteworthy that a hatchery release (430 fish released) occurred on May 4-7th and a significant portion of the Sockeye counted at LGR were hatchery fish.
- Subyearling Chinook were released from the hatchery 2-3 days ahead of schedule in anticipation of low flows and warm water temperatures. However this early release did not impact timing and 50% of passage occurred by June 7th and 90% of passage occurred by July 19th.
- For lamprey, a few ammocetes and macrophthalmia were collected.

At The Dalles, the mid-Columbia runoff volume (January-July) ranked 68th out of the last 87 years. Brandon noted that BiOp flow objectives were not met and FOP spill provided flow at McNary for the entire passage season. He reported on the juvenile passage timing at McNary Dam:

- Yearling Chinook passage times were fairly normal when compared to past years, with 10% by April 28, 50% by May 7, and 90% by May 20.
- Steelhead passage times were similar to previous years, with 10% by April 28, 50% by May 10, and 90% by May 27.
- Sockeye passage: 10% by April 26, 50% by May 16, and 90% by May 26. It is noteworthy that Sockeye numbers were well below the 10 year average.
- In previous years passage gradually tapers off for subyearling Chinook, however this year the counts abruptly stopped. 10% passed by June 15, 50% by July 3, and 90% by July 9.
- There were no Pacific ammocetes counted this year, but it is likely due to the project not being able to capture ammocetes in the sample tank. Lamprey passage: 10% by May 20, 50% by June 13, and 90% by July 12.

Brandon noted that at Bonneville, the mid-Columbia runoff volume ranked 68th out of the last 87 years (1929-2015). He noted that BiOp flow objectives were not met and FOP spill provided flow for the entire passage season. Brandon reported on juvenile passage timing at Bonneville Dam:

- Yearling Chinook passage times were similar to past years with 10% by April 23, 50% by May 8, and 90% by May 22.
- Steelhead passage times were similar to previous years, with 10% by May 3, 50% by May 11, and 90% by May 25.
- Sockeye passage was 10% by May 14, 50% by May 22, and 90% by May 29.
- Subyearling Chinook passage was early with 10% by April 15, 50% by May 1, and 90% by July 12. On June 29th, temperatures at the SMP facility exceeded 70 degrees Fahrenheit, which, per the Fish Passage Plan, required sampling to be reduced to every other day. Brandon noted that it is worth noting that the high temperature sampling protocol ran for 68 days from June 29-September 5th; this is the earliest and longest since the protocol was instituted.

Other noteworthy events for 2015 that Brandon highlighted:

- The highest mortality, 5.8%, of subyearling Chinook at John Day Dam. The second highest mortality on record is 0.6%. Biologists have not yet pinpointed the cause for the increased mortality.
- There were also high mortalities for Chinook and Steelhead at Lower Monumental Dam.
- At Lower Granite, there was 5.5% descaling of Sockeye and 7.4% descaling of Coho at McNary Dam.
- Unlike analog year 2001, 2015 had voluntary spill at all projects during the entire migration season. The spill proportion from Little Goose to McNary was 46.6% compared to 0.62% in 2001.
- Travel times from Lower Granite to McNary averaged 15.6 days, similar to 2011 at 15.9 days.
- Compared to 2001, yearling Chinook traveled 42% faster and NOAA saw a 25% survival increase from Lower Granite to McNary Dam.
- Steelhead traveled 57% faster in 2015 and survival increased by 2.7% compared to 2001.
- Sockeye traveled 36% faster in 2015 and survival increased by 2.5% from Lower Granite to McNary Dam.
- In 2015, there were 600+ PIT tagged Sockeye, 300 of which were transported and 0 which made it to Lower Granite Dam.

In summary, 2015 saw warmer temperatures than the previous 10 years and adult survival was at an all-time low for both stocks. **Brandon noted some lessons learned in 2015: Sockeye transported as juveniles had lower survival rates than in-river migrants, as well as higher fall-back rates**. **Brandon noted that despite the challenging conditions, when compared to 2001, a similar dry year, juvenile survival increased and travel time decreased.**

- **Participant Question:** Total Dissolved Gas (TDG) gauges at John Day were problematic this year; we saw TDG levels drop very low and we were not sure why. Do you know when the high mortality of subyearling Chinook occurred at John Day and could the mortality rates be connected to the low TDG levels?
    - **Response:** We saw a 5.8% mortality rate at John Day, this occurred in June and early July. We thought it was possible that fish were entering the project already dead, however, that was not the case. The sample tank was found to be working properly, pathologists looked for signs of trauma and was clear that the fish died of brain hemorrhaging, however, the cause was never discovered. The majority of the fish were unclipped and it was hard to determine which were and were not hatchery fish.
- **Participant Question**: Will there be any opportunities to improve the index count?
    - **Response**: We have a population index which uses environmental variables like spill proportion and temperature to estimate daily populations. We run out of data below the Snake River sites, I am not sure when these sites will provide more data.
- **Participant Comment**: 100 adult sturgeon mortalities were observed this year in the lower river between

John Day and McNary Dams. When biologists examined the dead fish they found that sturgeon were filled with adult Sockeye. Additional monitoring in the lower river is needed for years similar to 2015.

- **Participant Question**: Is the John Day temperature string data publicly accessible?
    - **Response**: Laura Hamilton, USACE, responded, that the John Day temperature string data is not publicly accessible.

Smolt Survival and Travel Time and Seasonal Transportation Analyses – Steve Smith, NOAA, reported on smolt survival and travel time, and provided an analysis of seasonal transportation. Both analyses are based on fish PIT-tagged as smolts.

Steve Smith, NOAA, presented an update of his agency's smolt survival and travel time research, adding 2015 information to the time series that began in 1993. He noted that 2015 conditions consisted of low flows, high water temperatures (which were the highest in the dataset), high spill percentage, and a small percentage of transported smolts (<15%).

Steve noted that for most reaches, survival of yearling Chinook and Steelhead was below the 2002-2014 average. The overall hydrosystem survival was roughly 10% lower than average for both species and considerably lower than in 2010 (15-25%), another recent low-flow year. The percentage of spill for 2015 was higher than the previous five years and temperatures in the second half of 2015 were well above average.

Steve provided the preliminary survival estimates:

- Yearling Chinook from the Snake River Basin Hatcheries to Lower Granite Dam: 64.3% (2002-2015 average); 70.9% (2015);
- Yearling Chinook from the Upper Columbia River Hatcheries to McNary Dam: 55.2% (average); 51.2% (2015);
- Steelhead from Upper Columbia River Hatcheries to McNary Dam: 41.8% (average); 35.1% (2015);

Estimated survival from Lower Granite to McNary:

- Yearling Chinook: 73.6% (average); 69.4% (2015)
- Steelhead: 64.4% (average); 62.3% (2015)

Estimated survival from McNary to Bonneville for Snake River fish:

- Yearling Chinook: 70.5% (average); 62.9% (2015)
- Steelhead: 68.2% (average); 66.3% (2015)

Estimated survival from McNary to Bonneville for Upper Columbia fish:

- Yearling Chinook: 80.9% (average); 87.0% (2015)
- Steelhead: 75.0% (average); 57.0% (2015)

Estimated survival from Snake River Trap to Bonneville:

- Yearling Chinook: 49.5% (average); 39.7% (2015)
- Steelhead: 45.1% (average); 36.1% (2015)

Estimated survival of Snake River Sockeye:

- Redfish Lake Trap to Lower Granite: 45.4% (average); 48.3% (2015)
- Lower Granite to McNary: 68.2% (average); 70.2% (2015)
- McNary to Bonneville: 67.4% (average); 53.1% (2015)
- Lower Granite to Bonneville: 49.6% (average); 37.3% (2015)

Estimated survival of Columbia River Sockeye:

- Rock Island to McNary: 70.9% (average); 76.3% (2015)
- McNary to Bonneville: 66.4% (average); 44.6% (2015)
- Rock Island to Bonneville: 48.1% (average); 34.0% (2015)

Estimated transport percentages at Lower Granite Dam were dramatically lower in 2015 than in previous years:

- Yearling Chinook: 79.5% (average from 1995-2005); 34.3% (average from 2007-2014); 12.5% (2015);
- Steelhead: 86.9% (1995-2005); 38.7% (2007-2014); 13.2% (2015)

Steve presented an update on NOAA's analyses of smolt-to-adult returns (SARs) for transported and bypassed fish. Steve presented updated data that included adult returns through mid-November of 2015, and added smolt migration year 2013 to previous analyses.

Overall, Steve reported that the benefits of transportation for migration years 2006-2013 were lower than those observed for earlier years. This is likely because of improvements in migration conditions for fish that remain in the river, not decreased survival for transported fish. However, SARs for transported fish have still exceeded those for bypassed fish throughout most of the migration season in most years (an exception is wild Chinook in 2011).

The date of collection is known for all transported PIT-tagged fish. Seasonal analyses of transportation effects requires that the date of passage also be known for the in-river fish to which transported fish are compared. This is why the NOAA analysis uses bypassed fish. Steve shared that there is evidence that fish that remain in-river via spillway passage have higher SARs than bypassed fish, but spillway-passed fish do not have the requisite "time stamp" (without PIT-tag detection in spillways there is no way to know exactly when they passed). The NOAA analyses attempt to adjust for differential SARs by using a variety of standards to judge the pattern of transport:bypass ratios. At the request of Idaho, NOAA is working on standards that remove turbine fish from the calculations for in-river fish.

Steve presented a small amount of information, which he considered "very preliminary," related to transportation of sockeye smolts in migration years 2011 through 2013. The estimate of the proportion of sockeye transported in 2013 was roughly 50%. Most sockeye return as adults after two years in the ocean, but because of adverse conditions in the river, returns of migration-year (MY) 2013 fish to Lower Granite were very low in 2015. Transported sockeye appeared particularly affected, as none of them returned to Lower Granite in 2015.

Based on a total of 15 returning adults, annual SARs were nearly equal sockeye for transported and bypassed in 2010. For 2011 migrants, SARs were more than twice as high for transported than for bypassed fish. Looking at returns in both 2014 and 2015, SARs for MY 2013 sockeye are nearly equal for transported and bypassed fish.

- **Participant Comment:** For Chinook and steelhead tagged at Lower Granite, bypassed fish were tagged in April as we've done in previous years, there should be data from April on this. *[Steve noted later that he checked and NOAA did not tag fish at Lower Granite in April 2013.]*
- **Participant Question:** Is it possible to estimate what affect stopping transport all together will have on adult returns?
    - **Response:** It should be possible to create a model illustrating adult returns without transportation, yes. We have not done this analysis though.
- **Participant Question:** If the T:B ratio is > 1, it signals that transportation is beneficial to Sockeye, yet the previous presentation said that transportation survival was low for Sockeye.
    - **Response:** Sockeye transported in 2013 returned to Bonneville Dam in 2015 at a higher rate than Sockeye bypassed in 2013. The deficit in transported fish at Lower Granite Dam resulted from

losses between Lower Granite and Bonneville.

Lower Snake Temperature and Flow Operations

Dworshak Reservoir Regulation Water Year 2015 -Steve Hall, COE-NWW, reported on Dworshak reservoir regulation for 2015. He noted that the water supply forecast was not accurate as the year progressed due to issues with solar radiation data. There were a few flood control deviations in February and March to allow the project to operate above flood control in effort to prepare for forecasted dry conditions and the desire to maximize the Dworshak water. The reservoir was refilled by June 7th and temperature augmentation operations were initiated on June 17th. Typically, temperature augmentation starts on July 7th, but due to temperatures approaching 68 degrees Fahrenheit at Lower Granite in early June, augmentation started earlier. To counteract high temperatures in the Snake River, water was released from Dworshak. For 2015, spill percentages were much higher than 2001 which accounts for the temperature differences at Little Goose, Ice Harbor and Lower Monumental. There was a temperature exceedance in July, however, no TDG exceedances.

- **Participant Question:** Was there an opportunity to shift any of the flood control requirements from Dworshak to Grand Coulee with the drumgate maintenance occurring?
    - **Response:** The flood control deviations in February and March were for water supply purposes, not due to the drumgate maintenance. We could not shift the flood control space to Coulee due to flow.

Temperature Control Augmentation FY2015 Operations Review - Steve Hall, COE-NWW, reported on the temperature control augmentation for 2015. On June 6th, the Orofino gauge indicated temperatures were rising, on June 7th warmer temperatures arrived from the Upper Snake. By June 9th, the reservoir was full at 1,599.9ft and discharge was increased out of Dworshak. By June 16th, water temperatures continued to rise mostly due to solar radiation. On June 17th temperature augmentation commenced and we saw another temperature increase on June 29th. Temperature model runs from July 1st showed inputs going up, but water temperatures stabilizing at Lower Granite if operating at 12kcfs. TMT addressed the issue of warming water temperatures on July 1st, with consensus to hold as close to 68 degrees Fahrenheit as possible [TMT representatives clarified that the coordinated operation was to operate close to 68 degrees, however with a buffer of 1.5 degrees.]

Later on it was discovered that the Lewiston and Silcott weather gauges were providing corrupted data. Operating between 5-7kcfs was presumed to be sufficient until an exceedance occurred at Lower Granite and it was realized that the gauge data was incorrect. By July 11th, temperatures were still above 68 degrees and the operation increased to 12kcfs, the maximum TDG limit. Around July 15th, temperatures adjusted and we were below 68 degrees. Temperatures from the end of August through September were kept below 68 degrees.

Steve noted that a big takeaway this year is that there should be additional controls in data collection to determine if data, such as the solar radiation, is incorrect. Steve noted that he thinks spilling at Lower Granite increases downstream water temperatures due to the release of warm surface water. Also, when operating during critical passage times in low flow years, it is advisable to have a large temperature buffer, as the 1.5 degree buffer was not sufficient.

Summary of Adult Sockeye Migration Conditions, 2015 – Paul Wagner, NOAA, reported on the adult Sockeye migration conditions for 2015. For 2015, river flows and snow melt to streams were far below average. Water temperatures were well above average and the combination of below average runoff and above average temperatures created perilous passage conditions for fish.

Throughout the entire basin, all of the tributaries were hot and there was little relief for the fish. As a result, a low

percentage of Sockeye survived migration to spawning grounds. In early July water temperatures were as hot as 28 degrees Celsius in the Okanogan River. For the Salmon River, temperatures were 25 degrees Celsius compared to 20 degrees Celsius in 2014. Water temperatures at Bonneville in June were 4C˚ above the 10 year average. Temperatures below Grand Coulee Dam were roughly two degrees above the 10 year average (inflow temperature: 16.5C˚; outflow temperature: 14.7C˚). In the Upper Columbia River, when water temperatures reached 20C˚, survival rates fell to 20%. Paul stressed that when water temperatures exceeded 18C˚, Snake River sockeye survival rates plummeted.

When Sockeye approached in June and July flow from the Columbia was less than 50% of average. Sockeye passage numbers at Bonneville were very high with the peak occurring around June 25th, slightly earlier than the 10 year average, however, conversion rates upstream was weak. For PIT tagged fish, 100% were accounted for at Bonneville and that number dropped to 14.4% by the time they reached McNary Dam. For transported Sockeye, the survival numbers were poorer than non-transported fish

Passage success from Ice Harbor to Lower Monumental was higher than from Lower Monumental to Little Goose Dam. The forebay at Little Goose showed temperatures as high as 27C˚ at the 0-5 meter range; bearable temperatures (19C˚) were available at a depth of 20 meters. Paul noted that some potential causes of the low Snake River project passage include:

- Exhaustion, cumulative stress and disease due to prolonged exposure to high water temperature.
- Sockeye rejection of the fish ladder due to the temperature differential. The temperature of the fish ladder was higher than that of the tailrace because the ladder draws from a shallow depth in the forebay, which had at times exceeded 25C˚.
- Difficulty finding the entrance to the fish ladder because of tailrace hydraulic conditions.

As an effort to try to increase adult passage at Little Goose, TMT coordinated a spill operation. The objective of this operation was to possibly improve tailrace conditions in the Little Goose tailrace and decrease water temperature and increase adult passage success. The rationale for this action was based on a similar change in operations made at Lower Granite Dam in 2013. Spill was shut off during daytime hours on at Little Goose on July 23, 24, 27 and 28, with the goal of improving tailrace conditions and potentially reducing temperatures in the tailrace. Paul presented the adult numbers that passed during this operation. Paul thought it was hard to gauge the success of this operation because by delaying the operation until late July most of the fish had likely died once temperatures reached 22C˚ in the Little Goose pool. **Paul reiterated his lesson learned, noting that stabilizing temperatures is the key to resolving a similar crisis in the future, and that 20 degrees C water during passage needs to be avoided. He also noted that TMT should try to coordinate preemptive operations rather than reactive operations.**

- **Participant Comment**: Other metrics to consider in coordination: thermal unit accumulation, temperature and PIT tag data on travel time.
- **Participant Comment**: Part of this conversation should build around how we understand the problem, which involves real time data to develop clear patterns in season.

2015 Snake River Adult Sockeye Passage and Emergency Trap and Haul - Russ Kiefer, ID, reported on the Snake River adult Sockeye passage and the Emergency Trap & Haul operation. He noted that passage numbers from Bonneville to McNary declined in 2015 compared to the last four years. A noted difference in survival among transported juvenile returns was observed. Russ reflected that the focus this summer season was on aiding Sockeye passage in the Snake River system, however, 90% of the Sockeye run died before reaching Ice Harbor; only 60 PIT tagged Sockeye were detected at Ice Harbor. In past years, survival rates were consistent throughout the passage season, this year numbers dropped dramatically after July 16, with 0 PIT tagged fish surviving between Lower Granite and the basin between July 9th and August 16th. The majority of mortalities occurred in the lower Columbia

below Ice Harbor, thus efforts to transport and improve conditions in the lower Snake were limited. In summary, fish passing Bonneville between June 9th and 26th had higher survival rates than those that past after June 26th. No Sockeye that passed Bonneville after July 3rd made it to the basin. Survival estimates from Bonneville to The Dalles were relatively high and dropped off from The Dalles to McNary for the entire run. The Fish Passage Center found a strong relationship between cumulative temperature and survival. Russ noted that:

- An estimated 4,000 adult Snake River Sockeye made it to Bonneville Dam.
- The historic average survival from Bonneville to the basin was 44%.
- If 44% of Sockeye had made it to the basin, roughly 1,760 adults could have been trapped and hauled.
- The estimated survival of 2015 adult Sockeye was 1%.

Russ continued that the 2015 Emergency Trap & Haul operation was coordinated in response to the low flows and high water temperatures. The operation involved trapping for a four hour period in the morning; based upon PIT tag data, 30% of the run could be collected during this time. The operation was initiated on July 13th and ran through the end of the month, occurring Monday through Friday. The hours were extended if fish were observed in the viewing window. Fish were transported either the same day as collection or held overnight. The trap and haul started just after the peak of adult Sockeye at Lower Granite.

The trap & haul operation incorporated brood stock for future years. Of the fish collected at Lower Granite, 16 were identified as non-Snake River Sockeye Salmon, thus their genes were not incorporated into the program and were instead euthanized. If a fish was collected from Lower Granite, they went into the brood stock. If a fish was collected at Red Fish Lake, they went into the brood stock as well. If they were collected at Sawtooth hatchery, they were outplanted into Pettit Lake for natural reproduction. Roughly 85 fish were put in to brood stock.

Survival rates with the implementation of the trap and haul operation increased from 0% to nearly 30% for the last quartile of adults passing Lower Granite. Overall, the trap and haul operation captured 30% of what passed Lower Granite as pre-transport analysis estimated. Noticeable gains in survival were achieved and the operation increased survival for fish that would not have returned in-river due to poor conditions. Russ also noted that the Snake River Sockeye that were trapped and hauled are likely strong stock, as they had survived through very stressful conditions. **Russ reflected that one of the lessons learned from this operation is to develop triggers that allow the operation to start as early as possible in order to trap and haul the fish before it is too late and the majority of them have died.**

- **Participant Question:** If migration occurs earlier at Bonneville, how will this influence diversity of the stock?
    - **Response:** There is always a positive and a negative, you lose historic genetic diversity because later migrants will die and not be successful. But, the population as a whole may be moving to earlier migration times in response to the conditions they are experiencing.
- **Participant Question:** Do you have any profile on the non-Snake fish, or where they came from?
    - **Response:** We conducted genetic stock identification on each out-of-basin fish, and found them to be primarily Wenatchee fish with a couple from the Okanogan. We have never seen an out of basin fish at Lower Granite or above before this year.

Assessment of Experimental Spill Operations at Little Goose Dam – Dr. Steve Haeseker, USFWS, shared an assessment that he did on the effects of the July 2015 experimental spill operations at Little Goose Dam. Steve explained that there was a differential in Sockeye passage between Lower Monumental and Little Goose; potential causes of the passage differential include (1) tailrace eddy and hydraulic conditions, (2) ladder temperatures, and/or (3) tailrace temperatures. Steve reminded TMT that the experimental operation eliminated spill from 0400-2000 hours and provided spill from 2000-0400 hours. The treatment days occurred on July 23-24th and July 28-29th, and control days were July 21-22nd, July 25-27th and July 30-31st. Steve noted that statistical tests that he conducted

showed that there were no significant differences in sockeye passage between the treatment days and the control days. Similarly, statistical tests showed no significant differences in adult ladder temperatures between treatment and control days. There was, however, a 0.39 degree C increase in the Little Goose tailrace temperature on treatment days compared to control days. Steve explained that concurrent observations at the Lower Granite and Little Goose forebay temperature strings indicated that the experimental operation was not the cause of reduced temperatures in the Lower Monumental forebay following the first block of experimental operations. Steve concluded that sockeye passage rates and ladder temperatures were similar between treatment and control days, that temperatures at the Little Goose tailrace TDG station were higher during treatment days, and that downstream temperatures did not appear to decline as a result of the experimental operations, after considering upstream temperature patterns.

- **Participant Comment:** It typically takes 5 days of travel time from Little Goose to Lower Monumental, so you would not see any temperature difference for a few days.
    - **Response:** At certain depths, the water is denser and cooler and it may move faster than the typical observations of fish travel time.
- **Participant Comment:** Water can travel at different rates or take a different path. The lower path is generally longer than the surface path, so it is hard to say if cool water is traveling at a faster rate.
    - **Response:** We observed two temperature drops in the Lower Monumental forebay following the first two days of experimental operations, but no temperature drops following the second two days of experimental operations. What caused the reductions is unknown, but similar reductions were first observed at Lower Granite followed by Little Goose and Lower Monumental. .
- **Participant Comment:** You found an increase in the tailrace temperature with this operation, yet there is only one monitor in one location. Is it possible because we changed flow out of this project that we are sampling a different part of the outflow? Is it possible we are moving warmer water over to that monitor rather than heating up the pool? I would think the temperature monitor at the ladder entrance and the monitor in the tailrace downstream provide the most accurate data.
    - **Response:** We use the data that is available to us, it raises questions, yet the monitor at Little Goose is in a similar location as the monitor at Lower Granite, which is often used as an important management reference point.

Libby Forecasting

Libby Dam Water Supply Forecast Update **-** Joel Fenolio, COE-NWS, reported on the Libby Dam Water Supply Forecast. He noted that 2012 was a big water year with extensive flooding in the Kootenai basin. The majority of Libby operations are based on the water supply forecast and following the flooding in 2012 we are looking for ways to improve forecasting measures. In 2011, the water supply forecast for March 1 was 7,111kaf; in 2012 the March 1st forecast was 5,635kaf. The QBO did not correlate and as a result we are looking at redefining the forecast based on physical parameters once we see more snowpack. The goals of redoing the Libby forecast include:

- Developing forecast equations that are consistent and use measurable physical estimators.
- Only consider climactic variables with a fully explained connection to the Kootenai Basin hydrology or show no deterioration of the forecast.
- Eliminating the November first of month forecast.
- Minimizing Errors- maximum, standard, and/or regression error.
- Enhancing geographic coverage of the snow stations.
- Improving forecast performance.

Joel explained that the training period is important and the previous forecast used a variety of training periods for different month's forecast. The period of record chosen for this update was from 1984-2013, which maximizes Alberta sites and the 1975-2013 inflow set, minimizes data extension and provides month to month consistency.

Reviewing the precipitation sites, West Glacier precipitation station is the best predictor of Libby inflow volume.

The Southern Oscillation Index somewhat correlates to the water supply forecast, yet the sites used were Sunshine Village, East Creek and Moyle Mountain to maximize geographical coverage. The same precipitation stations remain for each month and snowtel sites will begin operating in January.

For the December Libby forecast, if the forecast is greater than or equal to 5,900kaf, the target elevation is 2,411ft (2.0maf of space). If the forecast is less than or equal to 5,500kaf the target elevation is 2,426.7ft (relax to 1.4maf or 600kaf). If the forecast is between 5,500kaf and 5,900kaf, the draft is relaxed by interpolating between 600 and 0 kaf. For 80% of the years, there has been no relaxation. In 2012 the target elevation was 2,412.0ft, in 2014 the target elevation was 2,426ft where there was full relaxation. This forecast is not the best to predict what is going to happen this year with this much rain. For 2016, we may have relaxation from 3-5ft, but we are still waiting on data points.

- **Participant Question**: When you backcast, could you tell us how big the relaxation was?
    - **Response**: In four of the years, it was full relaxation. Two of the years we had partial relaxation.
- **Participant Question**: Did you take your data all the way through for flood controls from January to March to see what kinds of drafts occurred?
    - **Response**: We mitigated flood issues with new flood controls.

Small Group Discussion

The group was divided into small groups to discuss the following questions:

1. How did these 2015 operations respond to the dry year conditions? How did they contribute to meeting the biological goals for fish and water?
2. What was unique about these conditions and operations?
3. What questions still need to be answered?
4. Are there other tools or operations that might be available in the future to assist with meeting flow, temperature and passage goals during a dry year?

The following responses were provided by participants and recorded by the Facilitation Team. This list will be reviewed by the TMT at a later time to identify topics that need more exploration, discussion and coordination.

1. How did these 2015 operations respond to the dry year conditions? How did they contribute to meeting the biological goals for fish and water?

- It was a bad water year, yet we never needed to declare an emergency
    - Canada helped
- Lucky Canadian Treaty water was triggered
- Statistical forecasts for water supply and flood control have a balance point and remain restricted by willingness to take risks, re: flood control during low water years
- Action Agencies did a good job of looking/getting ahead for a deviation at Dworshak
    - When snow pack is low in February, plan for a low water year
- Fish Managers considered SOR's, but saw alternatives were slim to none
- Lesson learned is that we need to address actions/issues sooner than later
- Regarding biological and QZ goals for fish and water, we need more time to process and discuss, as evaluation is not possible for years.
- TMT was a good forum for discussions
    - We did take actions (e.g. Little Goose and Dworshak)
- Coordinated changes, provided a voice
- Sharing of new and different information
- Appreciated retrospective analysis, provided closure of an action and learning opportunity

- We have all learned from this

2. What was unique about these conditions and operations?

- Hot temperatures for prolonged periods, early in the season
- Peak flows in February/March – 2 months ahead of schedule
- Forecasts were unreliable, few analog years to compare
- No indication in January that we would see extreme conditions
- Challenging to project out with fish and flow data
- Hindsight is always 20/20
- Balancing act/tradeoffs and is a challenge when we do not know what is coming

3. What questions still need to be answered?

- Effect of FCRPS on water temperatures
- What are we going to do about ladder temperatures?
    - Monitoring to capture entrance deviations
- What explains conversion rates at BON vs JDA? (not just temperature?)
    - What are impacts on ALL species?
- How can we use available data to get real time answers to our questions in season?
    - Metrics do not line up to assist real time decision making. How can these be better aligned?
- The tangle between population analysis and subset analysis is a hurdle to overcome.
- Are we using transportation as effectively as we can? Particularly in a dry year?
    - Should we increase transport in low flow years?
    - Start transport earlier than May 1st?
    - Do we want to transport when Sockeye are in the river?
    - Are there opportunities to expand the available data re: efficacy of transport in low water years? Example: transport every other day?
- Conclusions of transport data unclear
- What else can we do with spill to increase survival and transport time?
- What is the impact of spill on juvenile, adults, and temperature?
    - Maximize temperature benefit by turning off spill at Lower Granite early in the season (July)
    - How do we balance spill for juveniles and temperatures downstream?
        - Reduce spill during nighttime hours when juveniles are not passing as much?
    - Are we creating temperature issues at the fish ladders by reducing water through the turbines (the coolest water available)?
        - Turbine water and deep spill water are about .5-1 degree C different
    - Consider additional temperature targets to manage to?
- Spill beneficial tool for all operations (e.g. Chinook travel time increased helpful for low flow years)
- Biological benefits downstream versus detriments upstream
- In a low water year is there any opportunity to use augmentation water to change the fishes' experience in the Snake and Columbia Rivers?
    - Work with Idaho Power?
        - More or less water from ID Power?
        - Timing of ID Power water?
        - Continue building relationships with ID Power?
- Influence of the Snake River temperature is greater when the Salmon River flows are lower.

    - DWR water also larger percentage of overall flows, so didn't take as much to influence temperatures.
- Different ways to run Lower Snake projects/DWR to improve temperatures?
- Explore TDG waiver from IDFG and Nez Perce for when more water (spill) is needed to augment temperatures.
- What other triggers could be identified (e.g. cumulative temperature) to help with operations running smoothly?
    - Is more information really helpful?
    - There will always be uncertainty
    - Difficult to quantify the risk of moving forward

4. Are there other tools or operations that might be available in the future to assist with meeting flow, temperature and passage goals during a dry year?

- Temperature accrual data for PIT tagged fish
- Temperature tags on fish
- Steve Hall's leave is allowed based on temperature units (perhaps begin training others?)
- Ice Harbor trap?
- Adult trap operation? Criteria on when and where to trap?
- New weather station downstream Dworshak (temperature modeling)
- Extend modelling downstream consider Dworshak effects
- Improve temperature modeling on Lower Snake River
- More water in the system if you change flood control curves?
- Draft additionally, change importance of what's in system (draft more in summer is a tradeoff no flows for power in the winter)
- Implications of deeper drafts

Large Group Discussion

The group reconvened and was asked to reflect on the last year of TMT conversations, coordination, operations and outcomes. The Facilitation Team asked participants to share their thoughts on what TMT did well and what they would like to do differently next year? The following chart was generated and will be revisited by TMT at a later meeting for reflection:

TMT 2015 Successes	Things to Change Moving Forward
• Recognize sometimes we don't have time to define success • Look back and assess lessons learned • We got creative, thought outside of the box • Good information, conversations, and decisions made at most meeting • Ability to communicate and work with each other have grown, we agree to disagree • Ability to interact with TMT reps, support staff and DSC • Participation in process meeting so we can share openly	• Define 'success' of experiments • Define measurements • Set up experiments so that we can measure and evaluate impacts o So that we can use the operations again if it would be helpful • Clarify methodology of experiments • What are the parameters of 'adaptive management' • Look ahead • Beware of 20 degrees C!

The Facilitation Team thanked everyone for coming to and participating in the 2015 TMT Year End Review. They also commended TMT representatives, alternates, and supporters for their hard work and dedication. With that, the meeting was adjourned.

Present for all or part of the meeting:
Doug Baus (USACE), Tim Belden (USACE), Scott Bettin (BPA), Brandon Chockley (FPC), Erin Cooper (FPC), Rob Dies (?), Kyle Dittmer (CRITFC), Joel Fenolio (USACE), Jim Fredericks (ID), Stephen Hall (USACE), Steve Haeseker (USFWS), Laura Hamilton (USACE), Peter Hassemer (ID), Tom Iverson (Yakima Nation), Russell Kiefer (ID), Jim Litchfield (MT), Tom Lorz (CRITFC), Sara Marxen (USACE), Mary Mellema (BOR), Charles Morrill (WA), Tony Norris (BPA), Mike O'Bryant (Columbia Basin Bulletin), Logan Osgood-Jacobs (USACE), Christine Peterson (BPA), Kasi Rodgers (USACE), Bob Rose (Yakima Nation), Eric Rothwell (BOR), Jim Ruff (NW Power Council), Chris Runyan (BOR), Joe Skalicky (USFWS), Steven Smith (NOAA), Daniela Todesco (USACE), Joel Turkheimer (Energy GPS), Erick Van Dyke (OD), Pat Vivian (Contractor), Paul Wagner (NOAA), Lisa Wright (USACE),

DS Consulting Facilitation Team: Robin Gumpert, Tory Hines, Emily Plummer, Donna Silverberg, and Charles Wiggins

Columbia River Regional Forum
TECHNICAL MANAGEMENT TEAM—OFFICIAL MINUTES

Review of Lessons Learned in 2015
December 2, 2015

Minutes: Pat Vivian

1. Introduction

The annual TMT retrospective of river conditions, hydro system operations and ESA-listed species in the Columbia basin was facilitated by Emily Plummer and Charles Wiggins, DS Consulting. Doug Baus, COE, served as TMT chair. The purpose of the review is to give TMT members and interested parties an opportunity to reflect on operations throughout the year in search of lessons learned that could inform future decisions. Representatives of the Umatilla Tribe, COE, USFWS, Idaho, BOR, BPA, Montana, NPCC, NOAA, Washington, Oregon, Yakama Tribe and others participated in the conversation. This summary is an official record, not a verbatim transcript.

There was discussion of what went well and what didn't in 2015, a drought year with record-setting high temperatures. TMT considered how to manage these types of conditions if they should become the new norm. Each presentation was followed by a question-and-answer session for clarification. The review concluded with small-group sessions and a wrap-up, looking forward to 2016.

2. Conditions Review

2a. Seasonal Overview of Weather and Hydrology. Tony Norris, BPA, gave a presentation on weather and river conditions throughout the 2015 spill season. Precipitation was steady through March 31, when the water supply dropped off throughout the basin and stayed low. Above-average temperatures led to a lack of snowpack at higher elevations over winter. Temperatures were higher than normal all season long, approximately 5-7 degrees F above average in many locations. Although precipitation was excellent early in the year along the Snake River and in Canada, warmer temperatures meant less snowpack.

By April 1, the regional water supply looked grim. During this period the RFC was still basing its water supply forecasts on 55 historic ESP traces. The protocol has since increased to 60 traces and will include 66 traces for 2016 forecasts. The observed January-July 2015 water supply forecast was 83.7 maf, 83% of normal. Then the April-August forecast showed a significant decline due to snow drought.

The low flows of 2015 revealed the limitation of using historic ESP traces to forecast water supply in an atypical year. BPA's hydro regulation studies indicated that flows at TDA would be 90 kcfs for the month of August, but it didn't work out that way. The final water supply forecast of 58.4 maf in the mainstem Columbia was only 67% of normal. The January-July

forecast for unregulated monthly average flows at LGR was 18.5 maf, 68% of normal. And things got worse: the April-August forecast of 10.8 maf in the mainstem was 51% of normal, and the April-July forecast for unregulated monthly average flows at DWR was just over 1 maf, which is 42% of normal for the Snake River. There were record lows at GCL and TDA in July and August.

Although April-September runoff flows were well below average through August 31, there was help from storage upriver. Total storage releases were 11.4 maf, of which 4.1 maf came from U.S. reservoirs and 7.3 maf from Canadian reservoirs. That includes 1 maf of flow augmentation from treaty storage and 5.8 maf of proportional draft. Flow augmentation began to be released in May per provisions of the treaty with Canada. At that point, the amount of proportional draft was not yet known. When streamflows subsequently dropped, the U.S. portion of the basin received 140 kaf of flow augmentation in July and August as a result of proportional draft under the treaty.

Beginning April 10, the Action Agencies operated to weekly flow targets established at TMT. Drum gate maintenance at Grand Coulee required approximately 5-6 ft of elevation to be drafted out of the reservoir. The actual impact of drum gate maintenance was 30 kaf in June because the subsequent releases were limited by low streamflows.

In summary, the year was marked by much lower observed flows than ESP traces predicted. Above average precipitation through March at above average temperatures produced below average snowpack. The increase from using 55 to 66 historic ESP inflow traces in future weather predictions will improve forecasting accuracy. Calculations for 2016 forecasting will include ESP traces of the record low flows of 2015. Releases of treaty storage helped maintain regulated flows in the river, particularly in July and August.

Questions and comments:

- **Q**: Did the 5.8 maf of proportional draft come out of Canadian reservoirs? **A**: Yes, that water was drafted for flood control and power production under provisions of the 1965 treaty. The system proportionally drafts to meet load in the Northwest. It's water that will eventually be paid back to Canada, but low streamflows entitle the U.S. to proportional drafts for up to 3 years in a row (Tony Norris, BPA).

2b. El Nino and Long Term Weather Trends. Kyle Dittmer, CRITFC/Umatilla meteorologist, gave a presentation on weather and climate patterns. The 2015-16 water year is currently in a "Godzilla" El Nino weather pattern even stronger than in 1997-98. El Nino disrupts atmospheric and ocean flow patterns in the tropical Pacific, producing warmer and drier weather in the Northwest and wetter, stormier weather across the southern U.S., northern British Columbia and Alaska. The El Nino effect is close to peaking now and will probably suppress upwelling along the Oregon coast, although there are no signs of suppression yet. This is a good sign for salmon, as upwelling affects their food supply.

The latest 30-90 day weather forecast from NOAA predicts warmer than normal temperatures, with below normal precipitation in January and February. Dittmer also uses Pacific decadal oscillation (PDO) as a predictive tool. Since 1998 the ocean has been in a cold phase; 1977-88 brought a warm phase, with more frequent El Nino events. The past few years have been warm according to the PDO index, and the warm phase tends to enhance the effects of El Nino. The closest analog year is 1997-98, which this year is tracking very closely. The water supply in 1997-98 was 90% of normal, which is good for an El Nino year. Water supplies in the range of 50-75% of normal are more typical.

To produce a long-range winter climate forecast, Dittmer bases his calculations on a set of similar water years. This year he modeled a series of moderate to strong El Nino years. His prediction: temperatures will be 0.5-2.5 degrees F above normal this winter, with about 90% of normal snowfall for the season. By comparison, temperatures were 1.0 degrees above normal in December 2014, 5.7 degrees above normal in January 2015, 6.2 degrees above normal in February, and 7.2 degrees above normal in March. Those temperatures caused peak flows in tributaries to occur two months early, in February-March instead of May-June.

This winter probably won't be as bad as last winter in terms of high temperatures and early runoff. Water supplies will be less than normal but not outrageously so. The key determinant of runoff timing will be temperatures. Dittmer predicted 92 maf in January-July 2016, 90% of normal. That's about the same as the 1997-98 El Nino.

3. Review of 2015 Fish Passage

3a. Juvenile Salmon Review. Brandon Chockley, Fish Passage Center, reported on juvenile passage timing in 2015 in relation to the past 10 years. Salmonid timing is based on the passage index for salmonids at smolt monitoring program (SMP) sites, while lamprey timing is based on collection of sample counts.

Several factors affect juvenile timing. Hatchery releases are a large proportion of the population migrating downriver, so any change in hatchery practices (such as ending the Spring Creek Hatchery March release) impact juvenile timing data. Another factor that influences juvenile passage timing is the condition of the river—flow levels, water temperatures and spill volumes. Later in the passage season, if flows are low and survival rates to a point of interest drop accordingly, that can cause timing to appear early. Detailed analysis of timing this year compared to previous years is needed.

From January to July 2015, Snake River runoff volume at Lower Granite was 74th out of the last 87 years. Flows were so low that FOP spill couldn't come close to meeting BiOp flow objectives for either spring or summer, according to SMP data for hatchery and wild fish combined. In many years, the freshet is strong enough to allow spill in excess of FOP objectives, but this year that wasn't the case. Lower Granite Dam spilled 20 kcfs in all of spring 2015.

Summer spill was below FOP levels because turbine operations were modified to aid adult sockeye passage. The normal operation using unit 2 would have resulted in more spill. Chockley made the following points about this year's fish runs:

- Yearling chinook appeared early, but that could be a function of survival rates to LGR or other factors.

- Sockeye typically pass LGR in March and early April, but the counts might include kokanee that overwintered in Redfish Lake. The first wild PIT tagged sockeye of 2015 arrived at LGR on April 28. The hatchery released about 430 sockeye on May 4-7 adding a significant portion to passage numbers.

- Because of anticipated low flows and high temperatures, most subyearling chinook were released from hatcheries a few days to a week earlier than usual. Earlier timing could be expected as a result, but that didn't seem to happen for the first 50% of the run passing LGR.

- At LGR, lamprey passage this year was mostly macropthalmia, with just a few ammocoetes. Lamprey data are only available back to 2011, the year lamprey became a species of interest. The lamprey counts have no 10 year average for the sake of comparison.

At other dams besides LGR, it was the same story. Runoff at TDA was 68th out of the last 87 years, and neither spring nor summer BiOp flow objectives could be met. MCN had FOP spill throughout the year. Yearling chinook and steelhead passage was normal at MCN, but sockeye passage was low compared to the 10 year average. As for lamprey, not a single amocoete passed MCN; passage was mostly macropthalmia.

Mid-Columbia runoff volume at BON was 68th of the last 87 years. Like other projects this year, MCN couldn't meet its BiOp flow targets but did touch them on occasion. Yearling chinook, steelhead and sockeye passage was similar to previous years. In the case of subyearling chinook at BON, timing data don't mean much because Spring Creek Hatchery ended the March release in 2009, and the 10 year average for passage timing includes years with the March release. BON generally passes more Pacific macropthalmia than ammocoetes. Often there's a double peak in macropthalmia passage.

This year sampling crews at BON and MCN went to the high-temperature sampling protocol on June 20, when water temperatures exceeded 70 degrees F. They reducing sampling from every day to every other day to limit stress on fish exposed to high temperatures. This year was the earliest the high-temperature protocol went into effect, and it continued through September 5 for 68 days, the longest on record.

Weighted average mortality for subyearling chinook at JDA was 5.8% in 2015, by far the highest rate ever seen. High subyearling chinook mortality rates continued at JDA for over a month with no clear explanation. LMN also saw high weighted average mortality for yearling

chinook and steelhead, and at MCN the rate was 2.2%, the highest in 14 years. Weighted average mortality rates for lamprey have been tracked since they became a target species in 2011. For the fifth year in a row, macropthalmia had higher weighted average mortality than salmon at BON, but the same pattern didn't persist for lamprey at JDA despite 5.8% weighted average mortality for subyearling chinook.

Estimated water transit time from LGR to MCN was 15.6 days in 2015, which was similar to the rate of 15.9 days in 2001, another notorious low flow year. What's not similar between the two years is spill proportions from LGS and LMN: 0.62% spill in 2001 compared to 46.6% spill at those projects in 2015. So although water travel time was similar in both years, yearling chinook traveled about 42% faster than in 2001 thanks to higher spill. Juvenile survival from LGR to MCN increased by about 25%. Steelhead travel time was 57% faster than in 2001, with a 2.7% increase in survival from LGR to MCN. Travel times were 36% faster for sockeye juveniles with a 2.4% increase in juvenile survival from LGR to MCN. Although flows were low this year, increased spill clearly improved conditions for in-river fish.

The precipitous loss of adult Snake River sockeye in June and early July was documented in a NOAA survival memo dated October 28, 2015, available on the TMT website. The memo says that temperatures were higher in 2015 and rose earlier than usual. This year brought the lowest survival rates for adults traveling from BON to LGR, not only for Snake River sockeye but all target species. This was true throughout the basin, including the intermediate reaches of the Snake and upper Columbia.

A noteworthy finding this year is that adult Snake River sockeye transported as juveniles in 2013 had lower survival rates from BON to MCN and from MCN to LGR than adults that migrated in-river as juveniles. None of the more than 300 transported fish made it back to LGR as adults. Snake River fish that were transported as juveniles had much higher fallback rates in 2015 than upper Columbia fish, which are not transported. Upper Columbia sockeye adults tend to arrive at BON about a week earlier than Snake River sockeye adults, which skews adult survival data for these groups. Accounting for transport and timing changes explains a lot of the differences in adult survival rates between Snake River and upper Columbia sockeye.

Questions and comments:

- **Q**: The JDA water quality gage was particularly problematic this year because it consistently gave low TDG readings. The cause is not clear. Could there be a connection between low TDG readings and high mortality rates at JDA? (Laura Hamilton, COE) **A**: The fish came into the sample tank dead with signs of brain hemorrhaging, and the cause was unknown (Chockley and Joe Skalicky, USFWS).

- **Q**: Do you foresee any possibility that limitations on the index count will change? (Doug Baus, COE) **A**: The population index presented here assumes a ratio of 1:1 for fish passing, but PIT tag detection probabilities are low downstream due to lack of monitoring sites below the Snake River (Chockley).

- **Q**: Is temperature gage information publicly accessible for the lower Columbia as it is for the Snake? (Erick Van Dyke, Oregon) **A**: Laura Hamilton, COE, will follow up on this.

- When approximately 100 adult white sturgeon died this summer between JDA and MCN, they were found to have been gorging on adult sockeye. Perhaps the region should consider monitoring water temperatures and survival on the lower river in exceptional years like 2015 (Jim Ruff, NPCC).

3b. Juvenile Salmon Survival. Steve Smith, NOAA, covered two topics: juvenile survival in 2015 based on PIT tag data through November 24, 2015, and an analysis of 2015 transport data.

Juvenile survival analysis: This was the third year of analyzing juvenile survival based on PIT tag data. NOAA plans to include data on yearling chinook, steelhead and sockeye in the survival analysis. Because FOP spill generates certain volumes, low flow years such as 2015 end up with high percentages of water spilled and correspondingly low percentages of smolts being transported. Fewer than 15% of smolts were transported in spring 2015, which was similar to 2001 and 2010 in terms of spring flow volumes at LGR. Spring survival for yearling chinook and steelhead was lower than average in most reaches, with overall survival about 10% lower than average for both species. Hydro system survival was 15-25% lower than in 2010.

In some ways this was the lowest flow year seen in 23 years of collecting PIT tag data, as there was virtually no spill in 2001. In terms of temperatures 2015 stands alone, particularly the second half of the year. The last half of May had higher temperatures than anything on record. Median fish travel time from LGR to BON ranged from 30 days for the earliest runs to about 13 days by the end of 2015. Travel time for chinook was similar in 2010 and 2015, but for steelhead it was a few days longer than in 2010. In general, increased spill results in decreased travel times, but steelhead in 2015 had the longest travel times of the past 6 years due to low flows.

Yearling chinook from Snake River hatcheries had an estimated survival rate of 70.9%, the highest recorded. For 2002-15 the estimated survival rate was 64.3%. For yearling chinook from upper Columbia hatcheries, survival was 51.2%, a bit lower than the average of 55.2% over the last 23 years. Steelhead survival was the second lowest in the years NOAA has been able to estimate reach survival and 10% lower than in recent years. Nevertheless, steelhead survival was higher from LMN to MCN than in previous years. Yearling chinook survival numbers were low in virtually every reach, particularly from LGR to MCN (69.4%) and in most of the Snake River (73.6%).

One adverse effect of higher spill percentages and lower PIT tag detection probabilities for smolts is wide confidence intervals and less reliable survival estimates. This was particularly true for yearling chinook reach survival in 2015. Upper Columbia yearling chinook migrating from MCN to BON had slightly higher than average survival, but steelhead in the

same reach had below average survival. Chinook released from the Snake River trap had 40% survival, about 10% lower than the long term average. Snake River steelhead had about 9% lower survival than the long term average. From LGR to MCN, the steelhead survival estimate was the lowest since 2006.

Transport analysis: In 2001 there was no spill and 100% of smolts were transported. Over the past 23 years, NOAA has typically transported 80% of chinook and 87% of steelhead. From 2007-2014 those averages dropped by a third due to higher spill. In 2015 only 13% of smolts were transported, the least on record.

For sockeye released from Redfish Lake in spring 2015, fewer than 50% survived, which is typical. Sockeye juvenile survival followed yearling chinook survival patterns closely, which is also typical. The survival rate for 2015 chinook was 38%, which is 10-12% lower than the long term average of 50%.

Since 2006 transported fish have generally had higher returns than bypassed fish, but there are exceptions. In recent years, the benefit of transport has declined to the point that comparison depends on the standard applied. SARS for transported fish tagged upstream of LGR exceeded those of bypassed fish except 2011 wild chinook. Annual estimates of SARs for hatchery steelhead indicate that about 50% more in-river fish return as adults than fish that were collected and transported. Estimated SARs in 2015 were 39% for wild steelhead, 22% for hatchery chinook and 14% for wild chinook.

NOAA has transport data for sockeye starting in 2011. For migration year 2013, approximately 50% of sockeye were transported, a higher rate than for yearling chinook and steelhead. This is because yearling chinook began arriving in significant numbers before transport started on the Snake, so none were transported. Hatchery sockeye all passed LGR as a group in May, when transport was in progress. NOAA did not attempt to estimate non detected fish at LGR, but it was noteworthy that none of the transported sockeye adults detected at BON returned to LGR in 2015. All told, the data indicate that transported sockeye may return as adults at a lower rate than bypassed fish, except in 2011 when the rates were 50-50.

Questions and comments:

- **Q**: When did temperatures on the Snake River exceed daily averages in 2015? (Charles Morrill, Washington) **A**: The weekly mean temperatures at Little Goose intersected the long term average on May 10. By late May, temperatures were the highest on record (Smith).

- **Q**: Are there data from fish that were tagged, transported and bypassed starting in April of 2013? (Russ Kiefer, Idaho) **A**: NOAA will investigate this.

- **Q**: Why aren't the graphs analyzing the benefits of transport displayed on a logarithmic scale? (Erick Van Dyke, Oregon) **A**: NOAA has considered doing that, but audiences

are not accustomed to it, and in terms of displaying visual information, most of the T:B ratios are close to or above 1 (Smith).

- **Q:** Is it possible to stop transport for a few years in order to measure the effect on steelhead and chinook? (Jim Litchfield, Montana) **A**: It's possible COMPASS could do this; NOAA will follow up.

- **Q:** Is the ratio constant for the variability between never detected and bypassed fish from year to year? (Steve Hasaeker, USFWS) **A**: It may be worthwhile to revisit that question, and NOAA has the data on hand (Smith).

- **Q:** Do this year's findings indicate that fallback was bad for sockeye in 2015? (Doug Baus, COE) **A**: NOAA will follow up on this.

4. Lower Snake Temperature and Flow Operations

4a. Dworshak Spring and Summer Operations. Steve Hall, COE Walla Walla, reviewed DWR operations including BiOp provisions, flood control measures and flow augmentation. The reservoir drafted to 1535 ft elevation by end August and to 1520 ft by end September. The water supply declined as the year wore on. Foreseeing this, RCC requested flood control deviations on February 28 and March 31, allowing DWR to operate above the required flood control elevation and conserve water. As a result, the reservoir refilled by June 7 instead of the end of June. On June 17, Dworshak began releasing flow augmentation instead of the typical start date around July 7.

By early June, temperatures in the Lower Granite tailwater had already exceeded the 68 degrees F augmentation trigger, and DWR releases were ramped up accordingly. Low flows and spill produced low TDG levels this year, so there were no exceedances of state water quality standards due to flow augmentation releases.

Questions and comments:

- **Q:** Was any of the system flood control shifted from DWR to GCL for drum gate work? (Jim Ruff, NPCC) **A:** There was no opportunity to shift flood control space because the requirements kept dropping due to low flows. Deviation requests in February and March were a separate process (Hall).

4b. Temperature Augmentation Flows on the Lower Snake. Hall gave details of how Dworshak operated to counteract high temperatures in the Clearwater and Snake rivers. As a result of lessons learned in previous years, the COE supplemented its weather stations this year with a station at LGR tailwater. Using the same dashboard graphic that illustrated last year's operation, Hall described efforts in summer 2015 to use DWR flows to moderate temperatures out of Hells Canyon on the Snake and Salmon rivers.

Temperatures rose faster this year than in previous years, partly the result of increased spill. Since 2001, project operations on the lower Snake have changed dramatically, passing warmer water because of increased spill. On June 6, water surface temperatures were rising at the Peck gage where the Orofino and Clearwater rivers mix. On June 7, warm flows started coming from the upper Snake as well. The COE increased DWR outflows to 4.5 kcfs on June 9. On June 16, a heat spell began, mostly due to solar radiation in the LGR pool although the Snake River itself was not yet warm. By June 17, LGR tailwater was heating up, and augmentation flows began on June 23, which decreased temperatures by 4-5 degrees F at the Peck gage.

On July 1, Snake River temperatures were approaching 68 degrees F, and TMT considered what to do. There were differing opinions on whether to operate DWR to a temperature buffer of 66.5-68 degrees F at LGR tailwater, or manage as closely as possible to 68 degrees F in the interest of conserving water. In retrospect, the decision to hug 68 degrees F was not the best decision for sockeye. A plan to ramp down DWR releases to a steady 7.5 kcfs wasn't the best either. As it turned out, two of the weather gages corrupted solar radiation data, and 7.5 kcfs was not enough to avoid temperature exceedances downstream. The 2-4 days of travel time from DWR to LGR didn't help.

On July 11, LGR tailwater was still exceeding 68 degrees F, so DWR releases were bumped up to the 12.5 kcfs spill cap and by July 15 temperatures were safe again. By July 22, DWR was back to releasing 7.5 kcfs with no temperature exceedances downstream. The maximum temperature at Anatone gage was 75 degrees F in late August, yet LGR tailwater temperatures remained below 68 degrees F throughout the month. Despite low flows, DWR continued to provide releases through the end of September without running out of water.

As a result, the COE is instituting additional modeling controls to help identify parameters that might cause problems like erroneous solar radiation data. Another lesson learned is that operating DWR to provide a temperature buffer is a good idea in a year like 2015.

Questions and comments:

- **Q:** Would there have been sufficient water for augmentation at the end of August if DWR had released 12.5 kcfs instead of 7.5 kcfs at the end of June? (Tom Iverson, Yakama Tribe). **A:** It might have been possible to keep temperatures below 68 degrees F by operating DWR differently, but it's not clear whether that would have left any water by the end of August (Hall).

- We did the best we could with bad conditions this year. It might not have been possible to operate DWR in a way that would have had a major impact on the Snake (Charles Morrill, Washington).

4c. Adult Sockeye Passage Issues. Paul Wagner, NOAA, summarized adult sockeye passage in 2015. Conditions this year were so poor that a very low percentage of sockeye

survived to spawn. By April all areas throughout the basin had below average precipitation. Temperatures were warmer than usual starting in early January; by June they were 6 degrees F above average. Below average runoff and above average temperatures created perilous passage conditions especially for Snake River sockeye.

With almost no snow in the Cascades, fish died everywhere because all the tributaries became hot as well as the mainstem Columbia and Snake. Early in the season fish started dying in the Columbia. With 83 degrees F on the Okanogan River by early July, temperatures rose above survival levels. For the sake of comparison, temperatures from June 15-July 15, 2014, were 16 degrees F above the standard; for the same dates in 2015, they were 20 degrees F above the standard.

Temperatures downstream of GCL were hot as well. The average temperature of inflows at GCL in June was 16.5 degrees C and releases were 14.7 degrees C. The reservoir had a cooling effect through June, but by the time sockeye approached LGR in late June/early July, flows were less than 50% of the 10 year average.

Sockeye passage timing at BON peaked around June 25 in a phenomenal return of more than 3,000 Snake River sockeye. But high temperatures doomed the run, with temperatures at TDA running 4 degrees C above the 10 year average and ultimately exceeding 20 degrees C, which was lethal. When temperatures hit 18 degrees C, fish started dying. Transported fish did more poorly this year than in-river fish, which further depressed the survival statistics.

In recent years, transported fish have had considerably lower survival rates from BON to MCN when they return as adults. But this year, there was so much mortality by July that fallback was no longer a reliable indicator of how well transported fish fared in comparison to in-river fish. According to PIT tag detections, 62% of Snake River sockeye adults survived to TDA and only 14.4% survived to MCN. By July 9, surface temperatures at LGS hit 22 degrees C and sockeye passage was zero. There are several theories of what stalled sockeye passage in 2015:

- Adults got caught in eddies and died due to cumulative stress.
- Fish rejected the ladder due to a temperature differential between the forebay and the ladder itself, which was 25 degrees C or higher.
- Hydraulic conditions in the tailrace made it difficult for adults to find the fish ladder entrance.
- All of the above.

To address these problems in season, TMT advised the COE to change turbine operations to unit 1 preference and close the removable spillway weir at LGR. This reduced spill and improved tailrace conditions. The effect of the July 20-31 operation was to pass 2.8

fish per hour vs. 0.38 fish per hour using unit 2, as was the case in 2013. By mid July the temperature at LGS from the surface to 20 meters (the depth of the spill gates) was 21-22 degrees C. Elimination of spill for several days in late July drew cooler water of 19 degrees C at 30 meters. However, the first two days of this operation did not yield great results. It's possible that no fish moved because they had already died, with air temperatures hitting 114 degrees F in Lewiston.

Generally, transported sockeye have not done well in recent years. While this year's in-river migration didn't survive, the captive broodstock program released approximately 500 fish to Redfish Lake for natural reproduction.

Comments:

- We should look closely at the biological effects, both current and long term, of thermal unit exposure on sockeye mortality (Charles Morrill, Washington).

- Part of the conversation is trying to build a better way of understanding problems as they arise in season (Erick Van Dyke, Oregon).

4d. Emergency Sockeye Trap and Haul Operation. Russ Kiefer, Idaho, gave a presentation on IDFG's emergency trap and haul at LWG. This year nearly 4,000 Snake River sockeye adults arrived at BON, a stellar return as noted earlier. Arrival timing at BON was typical, but the fish encountered hot water as they moved upstream and experienced a dramatic decline. Survival was best between BON and TDA, with the biggest population loss between TDA and MCN. From MCN to LWG there was a bit of a drop. By the time the run passed LWG, only 60 of the 679 PIT-tagged fish were detected. This was consistent with other estimates that only 10% of the run survived from BON to LWG. A lack of arrays in the lower river make it difficult to estimate upstream survival rates. It appears that only 7 PIT tagged Snake River sockeye made it to the basin on their own. Survival during the fourth quartile of passage season was zero.

In retrospect, most of the mortality probably occurred in the lower Columbia below MCN. Because transportation impairs homing ability, the FPC found that transported Snake River fish experienced further delays and higher cumulative exposure to temperature units than mid-Columbia sockeye. Survival dropped significantly after June 25, and no Snake River sockeye passing BON after July 3 made it all the way upriver. In past years, survival from BON to the Snake basin has averaged 44%; this year it was estimated to be 1%. A 44% return in 2015 would have meant approximately 1760 adult sockeye returning to the Snake basin.

In July by regional consensus, Idaho instituted an emergency trap and haul operation. Based on timing over the past 4 years, the morning hours appeared best, so beginning July 13 IDFG carried out the operation from 7-11 am daily through the end of July. Sockeye found in the juvenile separator were held overnight in the holding tank and transported the next day to the Redfish Lake broodstock program.

One lesson learned was that any trap and haul operation at LWG should start early in the season for maximum effectiveness because later migrants are less likely to survive.

Questions and comments:

- **Q:** How are the quartiles broken out? (Tom Lorz, CRITFC/Umatilla). **A:** They are divided by the number of PIT tags into four even groups (Kiefer).

- **Q:** Are all hatchery fish pit tagged? (Scott Bettin, BPA). No, just a proportion of them (Kiefer).

- **Q:** How will a shift to earlier migration at BON affect diversity in captive broodstock? (Erick Van Dyke, Oregon). **A:** There will probably be a loss of historic genetic diversity if later migrants are not successful. However, the population may have to migrate earlier to survive the conditions they are facing (Kiefer). The 50% passage date this year was July 3, and only the first 50% of the run survived past BON (Pete Hassemer, Idaho).

- **Q**: Were successful migrants that made it back to spawning basins incorporated into broodstock for future years, or were some of those able to spawn naturally? **A:** Approximately 85 fish collected at LWG or Redfish Lake went into the broodstock program. Fish that were collected at Sawtooth Hatchery were transported per agreement with the Shoshone-Bannock Tribe for natural reproduction (Kiefer).

- We need to look at PIT tag data for individual thermal unit exposure (Charles Morrill, Washington, and Russ Kiefer, Idaho).

4e. Assessment of Experimental Spill Operation at LGS. Steve Hasaeker, USFWS, summarized the experimental LGS spill operation of 2015 and its effects on temperature and adult passage. The experiment was an attempt to rectify a differential of 300 fish in adult sockeye counts between LMN and LGS. Possible causes of the differential were a tailrace eddy, hydraulic conditions, tailrace temperatures, and high temperatures in the LGS adult ladder.

TMT agreed on an experimental operation to eliminate spill for 16 hours, from 4 am to 8 pm, then operate a single unit with spill and minimum generation for the remaining 8 hours of 8 pm-4 am. Two blocks of two treatment days each were scheduled on July 23-24 and on July 28-29.

Hasaeker analyzed the data from two perspectives, one that defined the experiment as starting the first two days before treatment and ending July 31, the other starting with the first treatment on July 23 and ending July 29. He reviewed three data sources from both perspectives. From July 21 until the month ended, there appeared to be a downward trend in survival. An evaluation found no indication of any difference in ladder temperatures between treatment days and control days. However, there was a significant increase in terms of TDG

and temperatures in the tailrace when the treatment days were 0.39 degrees C warmer than the control days.

One intent of this operation was to cool temperatures in the lower Snake River. Temperature string data from LMN showed that water at depth is cooler and the temperature is more stable. Results suggest these experimental operations did reduce LMN forebay temperatures. There were two dips in temperature at LGR followed by dips at LGS and LMN with the first treatment, but the second treatment seemed to have no effect on temperatures at LMN or the other lower Snake projects.

Passage rates appeared similar on treatment and control days, as were ladder temperatures. However, tailrace temperatures were higher on control days than on treatment days. The experiment did not appear to reduce temperatures downstream.

Questions and comments:

- **Q:** Wouldn't the 5 day travel time from LGS to LMN under these flows mean a lag time of a day or two before any temperature difference was seen? (Paul Wagner, NOAA) **A:** At depth, cooler water behaves almost like a river, traveling faster than typical water travel time (Hasaeker). Spill would need to stop for several days so the gages can equilibrate to document the difference (Tony Norris, BPA).

5. Libby Forecasting

5a. Update on Libby Water Supply Forecast Procedure. Joel Fenolio, COE Seattle, gave a presentation on recent changes in the Libby water supply forecast procedure. After significant flooding of the Kootenai basin in 2012, the COE began looking for ways to improve Libby water supply forecasting accuracy.

There were several goals involved in revising the forecast procedure. The December forecast uses precipitation totals for October-November and is based on averages. Foremost was the need to establish a forecast based on physical parameters, with a single training period to establish statistical continuity from month to month. Precipitation data were included because they estimate potential snowpack in areas such as British Columbia, where only a few SNOTEL sites measure snowpack in an area of 7,000 square miles. The November forecast was eliminated from the calculations because it served no purpose. The period of record was 1984-2013, beginning when SNOTEL sites were installed along the Continental Divide. Climatic variables were taken into account, particularly the southern oscillation index (SOI) in December and January.

Use of the new method has improved Libby forecasting accuracy, with the biggest improvement seen in 2012. In March 2015, Libby had 120% of average snowpack, dropping to about 6 maf below average in April. The main problem this year was Pacific decadal oscillation (PDO), which caused instability in monthly forecasts.

Questions and comments:

- **Q:** Does West Glacier show some variable correlation with LIB and HGH forecasting? (Jim Litchfield, Montana). **A:** It is included, but the COE has not looked at this closely (Fenolio).

5b. Review of Libby Variable End of December Draft. Fenolio continued the review of Libby operations. Under BiOp specifications, a variable end of December draft has been in place since 2004. The RPA allows relaxations of the typical 2411 ft Libby flood control elevation target at the end of December if flows are low. If the volume forecast is 5.9 maf or greater the end of December elevation target is 2411 ft. A forecast of 5.5 maf or less relaxes the end of December elevation by about 600 kaf, which can raise the end of December reservoir elevation as high as 2426.7 ft. If the volume forecast is between 5.5 and 5.9 maf, the end of December flood control target is interpolated between 0 and 600 kaf.

The December water supply forecast is based on averages due to lack of physical information available at that time of year, making it less reliable than other forecasts. Starting in 2004, the probability of a flood control relaxation was around 20% of years. In 2010, the forecasting procedure was revised to increase the chance of a relaxation to 53% of years. The current equation calls for a full relaxation in 60% of years, which is considered more reflective of actual basin hydrology.

Since 2002 there have only been 4 years of full flood control relaxation and 2 years of partial relaxation. By 2014 the new equations went into effect, and the forecast of 5.5 maf led to a full relaxation in December 2014. This year will probably bring a 3-5 ft relaxation, or up to 2416 ft elevation at LIB depending on precipitation in December.

Questions and comments:

- **Q:** What is the take-home message? Will there be more flood control flexibility next spring? **A:** The past 4 years have brought big rallies in the LIB water supply in March, which runs the risk of forcing more powerhouse operations and spill in April (Fenolio).

- **Q:** What would the flood control operation in prior years have looked like using the new equations? (Tony Norris, BPA) **A:** A lot of the flooding issues are mitigated in the 2014 forecast. The COE hasn't reviewed what the 2014 LIB operation would have looked like with a full relaxation (Fenolio).

6. Small Group Discussion

TMT broke into small groups to discuss four questions in the context of lessons learned from 2015 in season management. This generated a range of responses:

1. How did these 2015 operations respond to the dry year conditions? How did they contribute to meeting the biological goals for fish and water?

- It was a bad water year but Canadian Treaty water helped.
- There are limits on risk-taking associated with water supply and flood control forecasts in low water years.
- The Action Agencies did a good job this year in requesting flood control deviation at DWR.
- Temperature and flow issues should be addressed sooner rather than later in the season.
- When snowpack is low in February, we should plan for a low water year.
- More time is needed to discuss biological goals for fish and water, as full evaluation may not be possible for years.
- The retrospective analysis provided closure and a learning opportunity.

2. What was unique about these conditions and operations?

- Temperatures were hot for prolonged periods early in the season.
- Peak flows generally occurred 2 months ahead of schedule.
- Forecasts were unreliable, with few analog years for comparison.
- There was no indication in January that we would see such extreme conditions.

3. What questions about these conditions or operations still need to be answered?

- What is the effect of the FCRPS on water temperatures?
- How should ladder temperatures be addressed?
- What explains the conversion rates at BON vs. JDA?
- What are the impacts of high temperatures on all species?
- How can we better use available data to get real time answers to questions regarding in-season management?
- Are we using transportation as effectively as we can, particularly in a dry year? Should we increase transportation in low flow years? Start transporting earlier than May 1?

- Should transportation take place when sockeye are in the river?
- Are there opportunities to expand the data available re: the efficacy of transport in low water years?
- Conclusions of transport data are still unclear.
- What is the impact of spill on juveniles, adults, and river temperatures? How can spill be used to increase survival and transport time?
- We could maximize temperature benefits by turning off spill at LGR in July.
- How to balance spill for juveniles and temperatures downstream?
- Does reducing the amount of water passed through the turbines and releasing the coolest water available create temperature issues at fish ladders?
- Should we consider managing to additional temperature targets?
- Are there opportunities to use augmentation water in a low water year to help fish in the Snake and Columbia?
- Can we work with Idaho Power to manage river temperatures better?
- The influence of Snake River temperatures increases when flows from the Salmon River are low.
- DWR water was a larger percentage of overall flows this year, so it didn't take much augmentation to influence temperatures.
- We should consider pursuing a TDG waiver from IDFG and the Nez Perce Tribe when more spill is needed for temperature control.
- What other triggers could be identified to help operations run smoothly?

4. Are there other tools or operations that might be available in the future to assist with meeting flow, temperature and passage goals during a dry year?

- We should review temperature accrual data for PIT tagged fish and temperature tags on fish.
- Should there be a regular trap and haul operation at ICR?

- A new weather station downstream of DWR is needed for temperature modeling.
- Temperature modeling on the lower Snake needs improvement.
- Will there be more water in the system if flood control curves are changed?
- What are the implications of deeper drafts?

After working in small groups, TMT reconvened to answer the following questions: *What went well? What might be done differently next year?*

- For experiments, define beforehand what success looks like and clarify the methodology. Defining success ahead of time would reduce dissent. Knowing what we're trying to accomplish and how it could be measured fosters creativity and makes the results easier to evaluate (Tom Iverson, Yakama Tribe). Before changing the LGS operation, we could have defined whether success means a 25% increase in fish counts, a 50% increase, or higher (Brandon Chockley, FPC). It's important to clarify the methodology that's being applied to an experimental design (Erick Van Dyke, Oregon).
- This year we got creative, which is a plus (Tom Iverson, Yakama Tribe).
- What are the parameters of adaptive management? (Erick Van Dyke, Oregon).
- We need to always keep in mind that 20 degrees C in the river is lethal to fish (Paul Wagner, NOAA).
- TMT's ability to work together and communicate is growing. People can "agree to disagree" which makes for effective teamwork (Charlies Morrill, Washington).
- Process meetings are a useful venue for TMT members to share information with each other (Scott Bettin, BPA).

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