Data Summary & Analysis of McNary Dam TSW Operation for Fish Passage During the Summer

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Two Temporary Spillway Weirs (TSW) became operational at McNary Dam in 2007 to improve passage for downstream migrants. During 2007 the TSWs were operated in spillbays 20 and 22 for summer migrants and in 2008 and 2009 they were operated in spillbays 19 and 20. Historically the TSWs have been closed between June 7th and September 1st over the 14-years of operation. Decisions in the FFDRWG and FPOM forums led to closure and removal of the TSWs for summer migrants beginning in 2010 (FPP Change Form 12MCN001-TSW Operations). During the last 10-years the McNary TSWs are usually closed between June 7th and 10th. In 2020, the closure date was June 8th. Due to high flows in 2017 and 2018, an FPOM decision delayed removal of the TSWs until mid to late June to facilitate debris passage. The McNary Dam subyearling Chinook salmon passage index and TSW removal dates from 2007 through 2020 are presented in Table 1.

Background-Subyearling Chinook Salmon

Direct injury and survival for yearling Chinook salmon released into each TSW and conventional spillbays 21 and 22 was evaluated in 2007 (Normandeau et al. 2008). The joint probability of 48-hour survival and being malady-free (fish without visible injuries, scale loss, or loss of equilibrium) was not significantly different for fish passing the TSWs or conventional spill bays. However, the point estimates averaged 0.7% lower for fish passing through the TSWs compared to the conventional bays (Table 2).

McNary Dam subyearling Chinook salmon passage and survival were evaluated annually from 2005 through 2014 except in 2010, 2011, and 2013 when no studies occurred (Adams et al. 2006; Perry et al. 2007; Adams and Counihan, 2009; Adams and Liedtke, 2009; Adams and Liedtke, 2010; Adams et al. 2011; Hughes et al. 2013; Weiland et al. 2015). The passage and survival by route are presented in Table 3. Conditions during these studies are presented in Table 4. In general, the McNary Dam summer spill patterns were consistent across years for respective spill (40% and 60% spill). Spill pattern evaluations were examined during the spring 2006 operations but not during summer operations.

Temporal subyearling Chinook salmon passage and route specific survival was analyzed *post hoc* for the 2005-2009 McNary Dam studies (Adams et al. 2011). The analysis did not examine survival for TSW and deep spill separately, however, the authors provided the following conclusion for subyearling Chinook salmon passage and survival:

- Spillway passage was positively related to spill %
- Increased water temperature decreased passage through the spillway and JBS and increased passage through turbines
- Caution should be exercised when interpreting the results from the models that included the TSW factor due to annual variability
- For all passage routes, survival decreased as the summer migration season progressed and water temperature increased
- Unlike for spring migrants, operation of the TSW was not significant in explaining survival through the forebay for summer migrants
- The authors suspect that the TSW may have increased spillway passage probabilities, but cannot rule out other potential mechanisms that differed between years with and without TSWs

- Increasing spill volume may be an effective way to improve survival in the warmer summer months

Methods – Subyearling Chinook Salmon Passage and Survival
We examined the concrete survival for subyearling Chinook salmon using the data in Table 3 under hypothetical scenarios where the TSW were or were not operated for 2007, 2008, 2012 and 2014. Concrete survival was calculated as the sum of the product of passage and survival for each individual route. For years when the TSWs were operated (2007 and 2008) the non-TSW estimate of concrete survival assumed fish passing via the TSWs would have passed via the deep spill with the same survival ($\hat{S}$) as deep spill passage fish. In 2012, TSW passage and survival were estimated using the average of 2007 and 2008 passage rate and survival during the 60% spill treatment since the 2012 spill averaged 61%. In 2014, the TSW passage and survival were estimated using the average passage and survival of the 40% and 60% spill treatments in 2007 and 2008 because in 2014 spill averaged 49% (i.e., average of the 60% spill and 40% spill treatments would represent % spill). Data from 2009 was not used because the reported analysis lumped passage and survival of bays 16, 17, 18, with the TSW in bay 19.

Results - Subyearling Chinook Salmon Passage and Survival
Concrete survival averaged 0.6% lower (range 0.4% to -1.6%) if the TSWs were operated than if they were not (Table 5). Across 4 years and 2 spill conditions, concrete survival was higher without the TSWs operating in 5 of the 6 scenarios examined. The only scenario where concrete survival was higher with the TSW operating was in 2008 under the 60% spill condition where concrete survival was estimated to be 0.4% higher.

The estimated difference in concrete survival between TSW operation for summer migrants at McNary Dam were relatively small (<2% lower survival with TSWs operating). However, operation of the TSWs has provided fish passage benefit with regards to debris management. Debris management using the TSWs may offset the slightly lower estimated concrete survival particularly during years when debris loads are higher than normal.

Background-Adult Steelhead Overshoots

McNary Dam has a relatively high level of steelhead overshoots that are primarily comprised of John Day and Umatilla river stocks. Radio telemetry studies completed from 1996-2003 suggested that 17.9% to 54.2% of overwintering steelhead that fallback past McNary Dam were likely overshoots (Boggs et al. 2005; Keefer, M.L. and C. C. Caudill, 2012). Wilson et al. (2010) reported that of 46% of the 2008-2009 John Day River origin PIT-tagged adult steelhead passing Bonneville Dam were detected in the fish ladder at McNary Dam. Downstream passage for steelhead overshoots at dams is typically via turbines because it occurs outside the operation period of the juvenile bypass and voluntary spill for juvenile fish passage (Ham et al. 2012 a, b). Concerns over the fallback effects to steelhead overshoots at McNary Dam prompted the Corps to evaluate direct survival of steelhead passing through turbines and a TSW during the winter 2014 (Normandeau Associates 2014). Direct survival was significantly higher for steelhead passing through the TSW (97.7%) versus those passing through a turbine (90.7%). Operation of a TSW at McNary Dam may provide a passage survival benefit to adult steelhead that overshoot McNary particularly when the bypass system is out of service or during periods of no spill.

Methods - Adult Steelhead Overshoots

The number and passage timing for PIT-tagged adult steelhead overshooting McNary Dam was examined from 2010 through 2019. The TSWs at McNary Dam are typically removed from service in early June. Thus the timing of adult steelhead overshooting McNary Dam was used to estimate the portion of these populations which would be upstream of McNary Dam during the summer when the TSWs are out of service. The PIT-tag detections were not adjusted for tagging effort differences between years or drainages.

Results - Adult Steelhead Overshoots

PIT-tagged adult steelhead passing McNary Dam have ranged from 1,892 to 7,675 fish per year from 2010-2019 (Table 6). Of these, 3% to 8% (average of 5%) of the known origin PIT-tagged adult steelhead were overshoots whose natal rearing was in downstream tributaries. The majority (95%) of the overshoots originated from either the John Day or Umatilla rivers. Sixty-two percent of the overshooting steelhead passed upstream of McNary Dam in September or October (Table 7). Approximately, 30% of the PIT-tagged adult steelhead overshoots passed McNary Dam between June 9th and August 31st (Table 8). Adult downstream passage efficiency or survival for conventional spill versus the TSWs has not been evaluated thus it is unknown if operation of the TSWs during the summer voluntary spill would provide additional benefit for steelhead overshoots.

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Table 1. Subyearling Chinook salmon passage index and date the TSWs were removed from service. Passage Index for 2020 was estimated using the Columbia Basin Research passage index tool on July 21, 2020.

Year	Fall Chinook Passage Timing							TSW Removal
	First	5%	10%	50%	90%	95%	Last	
2020	2-Jun	2-Jun	4-Jun	12-Jun	12-Jul	18-Jul	2-Oct	8-Jun
2019	2-Jun	4-Jun	6-Jun	24-Jun	14-Jul	22-Jul	28-Sep	10-Jun
2018	1-Jun	2-Jun	3-Jun	30-Jun	18-Jul	24-Jul	26-Sep	18-Jun
2017	2-Jun	4-Jun	8-Jun	2-Jul	22-Jul	28-Jul	30-Sep	26-Jun
2016	2-Jun	12-Jun	20-Jun	26-Jun	2-Jul	4-Jul	28-Sep	8-Jun
2015	2-Jun	12-Jun	16-Jun	4-Jul	10-Jul	10-Jul	30-Sep	8-Jun
2014	2-Jun	18-Jun	24-Jun	4-Jul	26-Jul	5-Aug	30-Sep	9-Jun
2013	2-Jun	14-Jun	18-Jun	4-Jul	22-Jul	30-Jul	30-Sep	10-Jun
2012	2-Jun	20-Jun	24-Jun	16-Jul	19-Aug	24-Aug	1-Oct	7-Jun
2011	2-Jun	14-Jun	26-Jun	23-Jul	10-Aug	25-Aug	30-Sep	7-Jun
2010	2-Jun	12-Jun	18-Jun	4-Jul	2-Aug	18-Aug	1-Oct	17-Jun
2009	2-Jun	16-Jun	20-Jun	6-Jul	22-Jul	31-Jul	1-Oct	1-Sep
2008	2-Jun	22-Jun	24-Jun	8-Jul	9-Aug	19-Aug	25-Sep	1-Sep
2007	2-Jun	18-Jun	24-Jun	6-Jul	26-Jul	5-Aug	14-Sep	30-Aug

Table 2. Joint probability of 48-hour survival and malady-free (fish without visible injuries, scale loss, or loss of equilibrium) for juvenile fish released into TSWs and conventional spillbays 21 and 22 at McNary Dam, 2007 (Normandeau et al. 2008).

Release Location	TSW1 (Bay 21)	TSW2 (Bay 20)	Average of TSWs	Conventional (Spillbay 21)	Conventional (Spillbay 22)	Average of Conventional Spillbays
48-hour survival and malady-free	97.50%	95.89%	96.7%	96.96%	97.86%	97.4%

Table 3. McNary Dam subyearling Chinook salmon passage and survival, 2005-2014. Shaded cells indicate survival estimates < 93%.

			Deep Spillbays		TSW 1 (SB19[2])		TSW 2 (SB20)		Juvenile Bypass		Turbine		Concrete
Year	**Spill Treatment**	**Study Period**	**Passage**	**Ŝ**	**Passage**	**Ŝ**	**Passage**	**Ŝ**	**Passage**	**Ŝ**	**Passage**	**Ŝ**	**Ŝ**
2005	Involuntary Spill	6/22-6/30	15%	106%	---	---	---	---	55%	88%	30%	87%	91%
2005	Court Ordered Spill	7/1-8/9	79%	101%	---	---	---	---	6%	89%	16%	87%	98%
2006[1]	40% Spill	6/19-7/25	16%;31%	97%;98%	---	---	---	---	24%	96%	29%	78%	92%
2006[1]	60% Spill	6/19-7/25	31%;36%	101%;102%	---	---	---	---	11%	98%	22%	78%	96%
2007[2]	40% Spill	6/18-7/26	25%	95%	13%	96%	11%	84%	30%	93%	22%	78%	90%
2007[2]	60% Spill	6/18-7/26	41%	101%	23%	95%	9%	95%	13%	96%	14%	84%	96%
2008	Early Season (Involutary)	6/19-7/4	57%	103%	5%	96%	5%	88%	19%	93%	15%	98%	99%
2008	Late Season 40% Spill	7/5-8/9	33%	98%	12%	97%	9%	99%	15%	87%	32%	77%	90%
2008	Late Season 60% Spill	7/5-8/9	60%	100%	10%	98%	9%	105%	8%	95%	13%	76%	97%
2008	Season-Wide	6/19-8/9	50%	101%	9%	97%	8%	99%	14%	91%	20%	82%	96%
2009	Season-Wide	6/18-8/5	37%	95%	14%[3]	90%[3]	13%	92%	17%	93%	19%	73%	89%
2012	Season-Wide	6/14-7/16	78%	98%	---	---	---	---	13%	101%	9%	88%	97%
2014	Season-Wide	6/11-7/11	54%	97%	---	---	---	---	27%	88%	19%	86%	92%

[1]Analysis grouped Spillway as Spillbays 1-15; Spillbays 16-22

[2]TSW1 was in SB22 during 2007

[3]Reported passage and survival grouped spillbays 16, 17, 18, with the TSW in bay 19

Table 4. Average and range of conditions during McNary Dam subyearling Chinook salmon passage and survival studies, 2005-2014. Because some of the parameters were not available in the contract reports the conditions were reproduced for the study period from the University of WA, Columbia Basin Research website and may differ from those in the reports.

			Flow (kcfs)		Spill (kcfs)		% Spill		Water T (°C)		TDG (%)	
Year	**Spill Treatment**	**Study Period**	**Average**	**Range**	**Average**	**Range**	**Average**	**Range**	**Average**	**Range**	**Average**	**Range**
2005	Involuntary Spill	6/22-6/30	205	185-221	35	20-57	17%	10-28%	17	17-17	111%	109-114%
2005	Court Ordered Spill	7/1-8/9	179	135-230	124	80-175	69%	59-76%	20	18-21	111%	107-112%
2006	40% Spill	6/19-7/25	215	162-304	90	64-128	42%	39-47%	19	16-21	112%	107-117%
2006	60% Spill	6/19-7/25	226	178-323	127	99-163	56%	50-60%	19	16-20	111%	107-118%
2007[2]	40% Spill	6/18-7/26	187	155-223	77	62-95	42%	39-45%	18	15-21	110%	107-113%
2007[2]	60% Spill	6/18-7/26	185	156-215	107	94-128	58%	54-60%	19	16-21	110%	108-111%
2008	Early Season (Involuntary)	6/19-7/4	332	290-360	167	151-187	50%	46-56%	16	15-16	116%	113-119%
2008	Late Season 40% Spill	7/5-8/9	181	105-267	77	49-128	43%	40-49%	19	17-21	110%	105-115%
2008	Late Season 60% Spill	7/5-8/9	184	130-275	105	68-162	57%	52-60%	19	17-21	109%	106-113%
2008	Season-Wide	6/19-8/9	228	105-360	115	49-187	50%	40-60%	18	15-21	112%	105-119%
2009	Season-Wide	6/18-8/5	186	112-290	92	55-145	50%	40-57%	19	16-22	110%	105-114%
2012	Season-Wide	6/14-7/16	354	308-414	218	161-303	61%	52-73%	16	14-18	117%	111-120%
2014	Season-Wide	6/11-7/11	261	207-299	128	86-150	49%	40-50%	17	15-19	111%	106-115%

[1]TSW1 was in SB22 during 2007

Table 5. Estimated concrete survival for subyearling Chinook salmon under hypothetical conditions where the TSWs were operated or not operated for 2007, 2008, 2012 and 2014. Concrete survival was calculated as the sum of the product of passage rate and survival for each route: [(JBS passage × JBS Ŝ)+(Turbine passage × Turbine Ŝ)+(Deep Spill passage × Deep Spill Ŝ)+(TSW1 passage × TSW1 Ŝ)+(TSW2 passage × TSW2 Ŝ)]. Shaded cells indicate estimates for hypothetical scenarios because the TSWs were or were not operated during the associated study.

														Concrete Ŝ	
				Deep Spillway		TSW 1 (SB19)		TSW 2 (SB20)		JBS		Turbine		w/TSWs	No TSWs
Year	Flow (kcfs)	Timing	Spill (%)	Passage	Ŝ	Passage	Ŝ	Passage	Ŝ	Passage	Ŝ	Passage	Ŝ	Ŝ	Ŝ
2007[1]	149-211	6/18-7/26	40%	25%	95%	13%	96%	11%	84%	30%	93%	22%	78%	89.5%	90.6%
2007[1]	149-211	6/18-7/26	60%	41%	101%	23%	95%	9%	95%	13%	96%	14%	84%	96.2%	97.8%
2008	105-275	7/5-8/9	60%	60%	100%	10%	98%	9%	105%	8%	95%	13%	76%	96.5%	96.1%
2008	105-275	7/5-8/9	40%	33%	98%	12%	97%	9%	99%	15%	87%	32%	77%	89.9%	90.5%
2012	308-414	6/14-7/16	62%	52%	98%	17%	96%	9%	100%	13%	101%	9%	88%	96.8%	97.1%
2014	207-299	6/11-7/11	50%	30%	97%	15%	96%	9%	96%	27%	88%	19%	86%	92.4%	92.7%
Overall 2007-2014														93.5%	94.1%

[1]TSW1 was in SB22 during 2007

Table 6. Annual adult steelhead PIT-tag detections passing McNary Dam by origin relative to the dam, 2010-2019.

Year	PIT-tagged Adult Steelhead Passage	Origin Upstream of McNary Dam	Origin Downstream of McNary Dam	Origin Unknown	Overshoot Rate
2010	7,590	6,157	210	1,223	3%
2011	7,675	5,747	166	1,762	3%
2012	6,253	4,032	134	2,087	3%
2013	5,542	3,421	214	1,907	6%
2014	6,845	4,827	230	1,788	5%
2015	5,138	4,047	339	752	8%
2016	3,707	2,461	145	1,101	6%
2017	2,951	1,727	111	1,113	6%
2018	2,121	1,425	78	618	5%
2019	1,892	1,189	101	602	8%
Total	49,714	35,033	1,728	12,953	5%

Table 7. Monthly PIT-tagged adult steelhead overshoots passing McNary Dam, 2010-2019.

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
2010	2		12	13			52	44	48	34	4	1
2011	1		2	3			8	79	34	34	5	
2012	2	1	4	2		1	15	44	29	34	1	1
2013	1	1		2	1		27	42	62	72	4	2
2014	1		2	1		2	50	26	87	45	12	4
2015		1	4	3	1	1	29	31	131	121	16	1
2016			4	3	1	6	24	7	48	47	5	
2017		1	2				7		64	33	4	
2018			1				7	3	40	24	3	
2019			4	1			4	4	50	35	2	1
Total (%)	7 (<1%)	4 (<1%)	35 (2%)	28 (2%)	3 (<1%)	10 (<1%)	223 (13%)	280 (16%)	593 (34%)	479 (28%)	56 (3%)	10 (<1%)

Table 8. Annual adult steelhead overshoot PIT-tag detections passing McNary Dam by natal drainage, 2010-2019. The number and % passing between June 9th and August 31st when TSWs are not operating is also shown.

Year	**Deschutes River**	**Fifteenmile Creek**	**Hood River**	**John Day River**	**Klickitat River**	**Mill Creek**	**Rock Creek**	**Umatilla River**	**Wind River**	**Overshoot Total**	**Number (%) of overshoots passing McNary Dam from 6/9-8/31**
2010	1	8		167				34		210	96 (46%)
2011	1	4		106	1		1	53		166	87 (52%)
2012	1	4		82	8			39		134	60 (45%)
2013	1	3	1	161	13		4	31		214	69 (32%)
2014		1		146	1	2	6	74		230	78 (34%)
2015	1	1		157		2	8	168	2	339	61 (8%)
2016		1		58	2			84		145	37 (26%)
2017	1	1		49				60		111	7 (6%)
2018	2	4		44		1	1	26		78	10 (13%)
2019	4	1		70			1	25		101	8 (8%)
Total	12	28	1	1,040	25	5	21	594	2	1,728	513 (30%)