

Migration Timing and Survival to Bonneville Dam of Juvenile Spring Chinook Salmon in the
Deschutes Basin
Report for Migration Year 2010 (Brood Year 2008)

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Summary

A total of 14,907 Warm Springs NFH and 7,454 Round Butte hatchery brood year 2008 spring Chinook salmon juveniles were PIT tagged as part of a Deschutes basin spring Chinook salmon monitoring and evaluation program. At Warm Springs NFH, PIT tags were split into two raceways, raceway 21 which had a volitional release of juveniles between March 24 and April 21 of 2010, and raceway 29 which had an abbreviated volitional release between March 24 and March 29 of 2010. Round Butte juveniles were volitionally released between April 13 and June 3 of 2010. PIT tag antenna arrays were constructed to monitor the release of juveniles from each facility. The majority of Round Butte juveniles left their holding facility in the first three days of the volitional release, while the Warm Springs juveniles migrated out in a more variable pattern. Round Butte juveniles migrated downstream to Bonneville Dam the fastest, with a median migration time of 12.5 days, compared to 25 days for Warm Springs NFH raceway 21 juveniles and 33 days for Warm Springs NFH raceway 29 juveniles. Median day of passage of PIT tagged juveniles over Bonneville Dam was April 26 for Round Butte juveniles, May 2 for Warm Springs NFH juveniles from raceway 21, and May 4 for Warm Springs NFH juveniles from raceway 29.

Estimated survival from release to Bonneville Dam was similar for juveniles from each raceway at Warm Springs NFH, with a combined survival estimate of 57% (95% C.I. of 48%-66%). Estimated survival of Round Butte juveniles was 73% (95% C.I. of 58% to 84%). No statistical difference in survival between the Warm Springs NFH and Round Butte hatchery stocks was observed. Of the PIT tagged juveniles detected leaving each facility, 352 Warm Springs NFH tags and 239 Round Butte hatchery tags were recovered on the bird colonies on East Sand Island in the lower Columbia River in 2010.

Differences in size at release and release timing may have influenced the migration characteristics and survival of juveniles from the two hatcheries. Size at release differed between the two hatcheries, with Warm Springs NFH releasing fish at approximately 20 fish/lb and Round Butte releasing fish at 9.5 fish/lb. At Warm Springs NFH, juveniles that were released the earliest (raceway 29) had the slowest migration time to Bonneville Dam, while Round Butte juveniles had the fastest migration time. Mini-jacking rates differed between the two hatchery stocks, with 32 PIT tagged Round Butte mini-jacks detected at Bonneville Dam compared to three Warm Springs NFH mini-jacks. Adult age structure and return rates will be monitored for each stock.

Introduction

Long term monitoring of spring Chinook salmon hatchery populations in the Deschutes basin has primarily been accomplished by monitoring adult returns through creel surveys, counts of adults at hatchery racks, and evaluating coded-wire tag recoveries from returning adult fish. Relatively little information on juvenile survival has been collected due to technical and logistical limitations. The general assumption has been that all juvenile Chinook salmon in the Deschutes basin experience similar environmental variables during their downstream migration and therefore likely have similar freshwater survival rates; however, Warm Springs National Fish Hatchery (NFH) and Round Butte hatchery manage their stocks in different manners. Warm Springs NFH has tried to maintain wild traits in the hatchery population while Round Butte has been managed strictly for production purposes. The rearing and release strategies at the two hatcheries are also quite different, and have changed over the years, although each hatchery has generally been successful in meeting their respective production goals. The effect of rearing and release strategies on juvenile migration behavior and survival is unknown. In addition, how juvenile migration and survival of the hatchery populations in the Deschutes Basin compares to wild populations is unknown. The expansion of PIT tag detection systems throughout the basin has led to an opportunity to collect baseline information on juvenile survival for both hatchery and wild stocks. The Confederated Tribes of the Warm Springs Reservation of Oregon initiated a PIT tagging program with the wild population in the Warm Springs River in the fall of 2009. Tagging of both Warm Springs NFH and Round Butte hatchery fish will allow for comparisons to be made between Deschutes River populations. Additionally, different release strategies at Warm Springs NFH (forced release versus spring volitional release) can be evaluated.

This report summarizes the PIT tagging and juvenile monitoring of brood year 2008 spring Chinook juveniles at both Warm Springs NFH and Round Butte hatchery. The objectives addressed in this preliminary report are:

- 1) PIT tag representative numbers of juvenile fish at both Warm Springs NFH and Round Butte hatchery.
- 2) Monitor the release strategies at each hatchery.
- 3) Compare downstream migration speed and migration timing to Bonneville Dam.
- 4) Compare juvenile survival from release to Bonneville Dam.

It is anticipated that tagging and monitoring will continue at Warm Springs NFH and Round Butte hatchery for two more brood years. In addition, adult returns will continued to be monitored and will be addressed in a subsequent report.

Methods

Release

Warm Springs NFH

Brood year (BY) 2008 juveniles from Warm Springs NFH were PIT tagged on February 8 and 9 of 2010. Tagging was done in the USFWS marking program's PIT tag trailer. The tagging crew consisted of 4 people tagging fish, 4 people loading tags into needles, and two people scanning fish for tags and measuring lengths on a subsample of the fish. The goal was to PIT tag approximately 7,500 juveniles from each of two raceways, raceway 21 and raceway 29. All juveniles tagged at Warm Springs NFH were progeny of Warm Springs hatchery stock parents.

All BY 2008 juveniles from Warm Springs NFH were scheduled to be released during the spring of 2010, with no fall release component. Fish from raceway 21 were scheduled to be released as part of a traditional volitional spring release, similar to procedures followed at Warm Springs NFH since the early 1990's. During the volitional release, eight inch diameter tubes are placed at the tail end of each raceway. Water flows down the tubes and exits out of the hatchery into the Warm Springs River. Any fish swimming down the tube enters the Warm Springs River and is unable to return back to the raceways. The release tubes are typically placed into the raceways in mid March and remain in place for approximately four weeks. At the end of the release period, the tubes are removed and the raceways are drained of water. Any fish remaining in the raceways once the tubes are removed are forced out into the Warm Springs River. During the 2010 release, a modified spring release procedure was initiated. In an attempt to allow more time for raceway cleaning in preparation for the coded wire tagging of BY 2009 juveniles, a sequential forced release was implemented in a series of raceways. Raceways 21 to 25 were released in the traditional release method, with tubes placed into the ponds for approximately four weeks (March 24 to April 20) before being removed, and the remaining fish being forced out (April 21). The release tubes in the other raceways were removed earlier, and fish were forced out, in a sequential pattern of two to four groups of raceways at a time with a two to three day interval between groups. Raceways 29 and 30 were the first group of raceways to be forced out, with a volitional release period between March 24 and March 29, and the force release occurring on March 30. The PIT tagged fish in raceway 29 were intended to be a treatment group in comparison to the control group of standard release in raceway 21. Evaluation of the sequential release will also be accomplished by the monitoring of differential coded wire tag groups (code 053483 for the traditional release in raceways 21-25, and code 054964 for raceways 26-30 on the sequential release) and a separate report will be written focusing on the release.

Two circular PIT tag antennas were placed on the inside of each release tube (raceway 21 and 29). A multiplexor and a computer were attached to the antennas that recorded the time when a PIT tagged fish passed through the tubes. During the spring release, flow conditions at certain times made it possible for fish to swim into the top section of the release tube without being forced down the tube and into the Warm Springs River. Because of this, the last detection time on the lowest circular antenna was used as the release time for PIT tagged fish. At the end of the respective volitional release periods, the release tubes were removed from raceways 21 (April 20) and 29 (March 29) and a stopper plug was placed into the tube opening to prevent

water from draining out of the pond. A series of 4 square PIT tag antennas were then placed into the raceways to scan for fish that had not left during the volitional periods. The antennas were left in place overnight to allow for 10-15 hrs of scanning time for detection of PIT tagged fish. The following morning, the stopper plug was removed and fish were forced into the Warm Springs River following standard procedures. All codes from PIT tags inserted into fish were classified into one of four different categories according to the detection history:

- 1) Mortality or shed tag- tag was either recovered from dead fish sometime between tagging and release or a bare tag was found on the bottom of the raceway.
- 2) Spring volitional release- tagged fish was detected leaving during the volitional release period by the circular tube antennas.
- 3) Forced release- tagged fish was detected in the raceways by the square antennas during overnight scanning prior to forced release.
- 4) Unknown- tag was not detected by any of the three previous methods.

Only fish with known release times (category 2 or 3) were used to calculate migration times, dates of arrival at Bonneville dam, and survival estimates.

Round Butte Hatchery

Brood Year 2008 juveniles from Round Butte hatchery were PIT tagged on October 26, 27, and 28 of 2009. PIT tagging was done in a hatchery outbuilding by USFWS personnel. The tagging crew consisted of two people tagging, two people loading tags into needles, and one person scanning fish for tags and measuring lengths on a subsample of the fish. The goal was to PIT tag approximately 7,500 juveniles from the hatchery raceways that were to be released from cell one (C1) in the Pelton fish ladder rearing area. The fish were to be moved from the hatchery raceways to the Pelton fish ladder rearing area one week after tagging. All juveniles tagged at Round Butte were progeny of Round Butte stock adults.

PIT tagged fish were held in C1 of the Pelton ladder from November 2, 2009 to April 12, 2010. Fish were released from C1 beginning on April 13 at around 9:00 am. During the release, boards were removed to allow fish to swim downstream through the Pelton fish ladder and into the Deschutes River near the base of the Pelton-Round Butte reregulating dam. All fish released from C1 had to pass through a fish sorter where hatchery staff could subsample fish as they migrated downstream. Two circular PIT tag antennas, similar to the antennas placed in the release tubes at Warm Springs NFH, were placed at the outflow of the fish sorter to detect tagged fish. Two additional square antennas were placed in the fish ladder downstream of the fish sorter to increase detection efficiency. The two antennas at the sorter were connected to one multiplexor and computer, while the two downstream antennas were connected to another multiplexor and computer. Fish were allowed to migrate out of the fish ladder between April 13 and June 3. On June 3, the water was drained from the fish ladder and any remaining fish were sacrificed. Sacrificed fish were not scanned for PIT tags. PIT tag codes were then classified into the same categories as at Warm Springs NFH, with the exception being mortalities and shed were not monitored at Round Butte. Again, only tags with known detection histories were used for analysis.

Downstream Migration

Detections of PIT tagged fish at Bonneville Dam were downloaded from PTAGIS on February 11, 2011. Data from the release detections were cross referenced with Bonneville Dam detections. Only tags with known release detections, either volitional or forced release, were used in the analyses. Min-jacks, sexually mature age 1+ fish, were also excluded from the downstream migration analysis. Mini-jacks were identified as fish migrating upstream over Bonneville dam after June 15th. The number of days from release to Bonneville Dam was calculated for each PIT tagged fish, along with the day of year that the fish was detected at Bonneville Dam. Median days were used for comparisons between groups of fish (raceway 21, raceway 29, and Round Butte) using Kruskal-Wallis Analysis of Variance (ANOVA). All statistical tests were performed using SigmaPlot 11.0.

Juvenile Survival

Fish swimming downstream to Bonneville Dam can take several different passage routes past the dam including the following: 1) passage through the power turbines, 2) through spillways when spill is occurring, 3) through the juvenile bypass system, 4) through the corner collector, 5) downstream through the adult ladder, and 6) through the shipping locks. PIT tagged fish can only be detected if they pass through the juvenile bypass, corner collector, or adult ladders. PIT tagged fish passing through any of the other routes will not be detected, therefore estimates must be made of the detection efficiency at Bonneville dam in order to estimate the total number of PIT tagged fish that survived to Bonneville Dam. The precision of the survival estimates is a function of the number of fish PIT tagged, the number of fish detected moving downstream over Bonneville Dam, and the number of fish detected at points downstream of Bonneville Dam. Downstream detection points include both fish detected at an estuary trawl and mortality recoveries of PIT tags from the Caspian tern and double-crested cormorant colonies in the lower river.

Detection histories for each tagged fish leaving the hatchery were created and were summarized into the following four categories: 1) fish detected leaving the hatchery but not detected anywhere else, 2) fish detected leaving the hatchery and detected at Bonneville Dam only, 3) fish detected leaving the hatchery, not detected at Bonneville Dam, and detected either at the estuary trawl or on the bird colonies, and 4) fish detected leaving the hatchery, detected at Bonneville Dam, and detected at the estuary trawl or bird colonies. Summaries of detection histories were then entered into program MARK, which calculated Bonneville Dam detection efficiencies and survival estimates for fish leaving the hatchery to Bonneville Dam using a Cormack-Jolly-Seber model.

Bird Colony Recoveries

The National Marine Fisheries Service leads an annual PIT tag recovery effort from bird colonies in the Columbia River Basin (Sebring et al. 2010). For this report, recoveries from East Sand Island, a double-crested cormorant and Caspian tern colony site in the lower Columbia River estuary, were analyzed to provide increased precision to the juvenile survival estimates (see above) as well as provide a minimum estimate of lower river predation. East Sand Island PIT tag recoveries were downloaded from PTAGIS on 2/10/2011. Minimum predation rates in the lower river, below Bonneville Dam, were estimated by dividing the number of PIT tags recovered from the bird colonies by the total number of PIT tagged fish estimated to survive to Bonneville Dam. Predation rates were not adjusted for island tag detection efficiency.

Mini-jack Returns

Mini-jacks were identified by querying the PTAGIS database for detections of upstream migrating fish over Bonneville Dam. All Bonneville Dam detections of Round Butte and Warm Springs Pit tagged fish after June 14th were mini-jacks. Mini-jack rate was calculated based on the estimated downstream survival to Bonneville and subsequent upstream detections. Fisher's exact test was used to compare mini-jack rates between Warm Springs NFH and Round Butte.

Results and Discussion

Release

The number of fish PIT tagged and detected during release from each hatchery are summarized in Table 1. Approximately 7,450 fish were tagged from each of Warm Springs NFH raceways (RW) 21 and 29, as well as from Round Butte hatchery cell 1. Fish released from Warm Springs NFH were much smaller than fish released from Round Butte hatchery; the Warm Springs fish were approximately 20 fish/lb at release compared to 9.5 fish/lb at Round Butte hatchery.

Table 1. Number of fish PIT tagged (excluding shed tags and mortalities prior to release), and detections of fish leaving the hatchery during the volitional release or forced release.

Group	Tagged	Volitional	Forced*	Total	
				Detected	Unknown
Warm Springs RW 21	7,452	6,668	311	6,979	473
Warm Springs RW 29	7,455	460	3,424	3,884	3,571
Warm Springs Total	14,907	7,128	3,735	10,863	4,044
Round Butte C1	7,454	6,947	0	6,947	507

* Number of PIT tagged fish during forced release in RW 29 is only the number of fish actually detected in the 16 hrs between volitional release and forced release. Antenna equipment was not able to detect all fish during forced release due to collisions from the large number of PIT tagged fish that remained in the ponds. Most of unknown tags in RW 29 are likely part of the forced release.

Detection efficiency during the volitional release period at Warm Springs NFH was high, with estimated efficiencies greater than 90% for both raceways. Very few fish left the hatchery during the six days of volitional release in raceway 29 (Figure 1). If two PIT tags are in an antenna's field at the same time, the data that each tag sends out can "collide", resulting in neither tag being detected by the antennas. Due to the large number of PIT tagged fish that remained in raceway 29 when the volitional release ended on March 29, the antenna detection equipment that was placed into the raceway was not able to detect all of the tagged fish that were in the raceway during the 16 hours between the end of the volitional release and the forced release on March 30 (Table 1). Using the estimated antenna efficiencies during the volitional release, and assuming migration patterns in raceway 29 were similar to those in raceway 21 during the first six days of volitional release (Figure 2), between 5% and 10% of the fish in raceway 29 exited the raceway during the six days of volitional release. In raceway 21, 96% of the fish exited the raceway during the traditional volitional release period between March 24 and April 20, with the remaining 4% of the fish being forced released on April 21 (Figure 2). At the time that fish were forced out of raceway 29, around 23% of the fish in raceway 21 had volitionally left. Small numbers of fish left raceway 21 during the initial two weeks of the release, until around 47% of the fish left between April 10 and April.

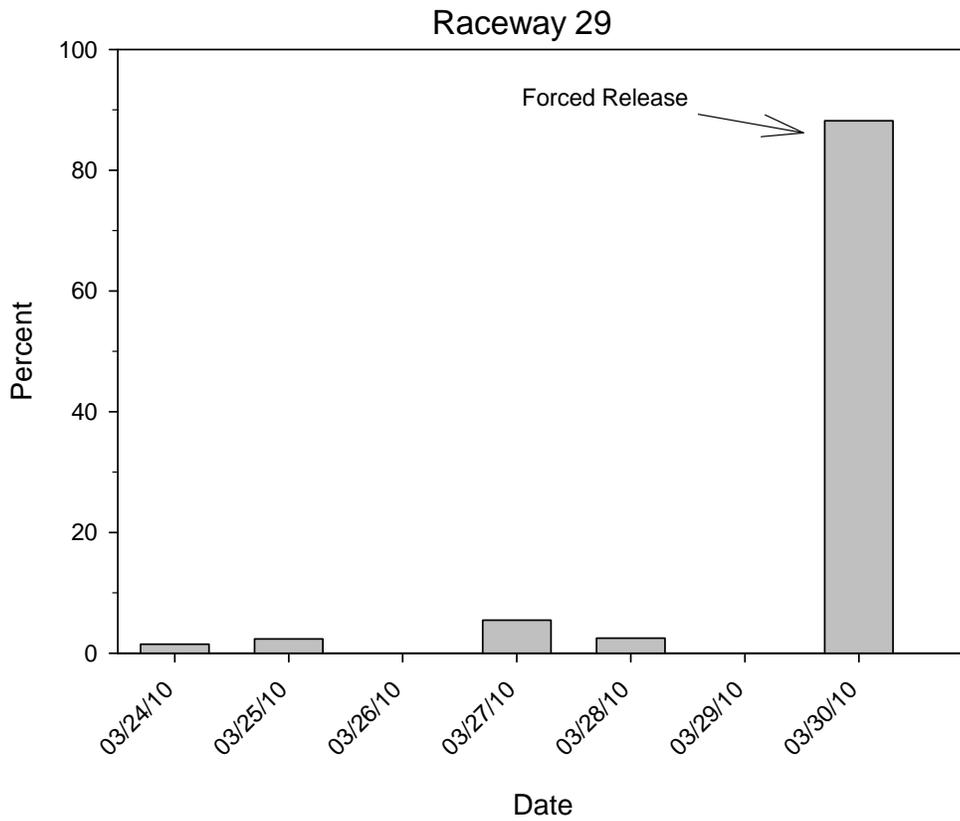


Figure 1. Percent of PIT tagged spring Chinook juveniles leaving Warm Springs NFH raceway 29 daily during the spring 2010 release. Volitional release started on March 24 and ended on March 29.

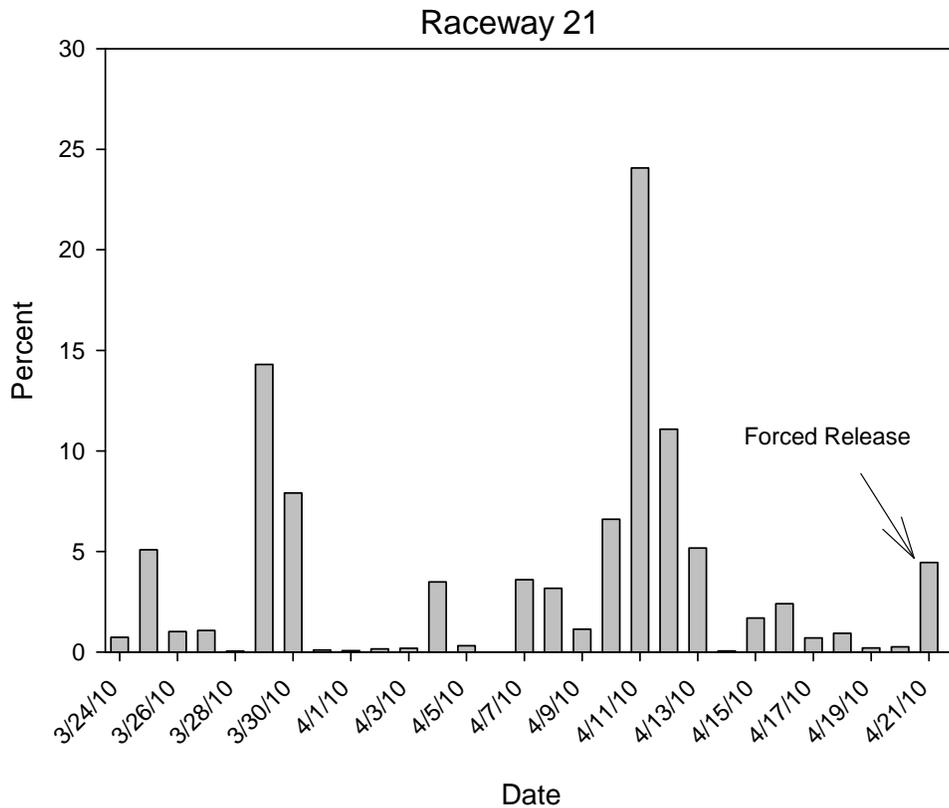


Figure 2. Percent of PIT tagged spring Chinook juveniles leaving Warm Springs NFH raceway 21 daily during the spring 2010 release. Volitional release started on March 24 and ended on April 20.

At Round Butte hatchery, 93% of the PIT tagged fish were detected during the volitional release (Table 1). The volitional release at Round Butte began around 9:00 am on April 13. Two PIT tagged fish were detected passing downstream through Bonneville Dam prior to the beginning of the volitional release, indicating that some fish had escaped the hatchery rearing ladder prior to the scheduled release. Hatchery personnel described seeing fish jumping near the downstream screen in the hatchery rearing ladder on the morning of the scheduled release. It is likely that some fish were able to jump over the screen and swim downstream prior to the scheduled volitional release. During preparations for the volitional release, the downstream sections of the rearing ladder, which were dry for most of the rearing time, were watered up so that fish could swim downstream into the Deschutes River once the screen were removed from the sections of the ladder that held fish. When the sections were first watered up, water overflowed the area near where the PIT tag antenna multiplexors were housed. Water splashed into the electrical panel supplying power to the multiplexors and tripped the circuit breaker, turning off the antenna arrays during the first two hours of the release. PIT tagged fish that swam out of the rearing ladder and into the Deschutes River prior to 10:00 am on April 13 were not detected. Based on the PIT tag detection patterns observed once the system was fully functioning, fish appeared to swim around in the first sections of the ladder for several hours before exiting the Deschutes River. Since the volitional release began at 9:00 am, and the antenna system was operational by 10:00 am, it is likely that few fish exited the ladder without being detected by the antenna array.

Unlike the pattern observed during the volitional release at Warm Springs NFH, the Round Butte fish exited the rearing ladder almost immediately, with 95% of the fish exiting during the first three days of release (Figure 3). Two major differences between the hatcheries likely accounted for the differential release patterns; size of fish and timing of release. The Warm Springs NFH fish (20 fish/lb) were much smaller than the Round Butte fish (9.5 fish/lb). In addition, Warm Springs NFH started their release on March 24 while Round Butte started on April 13. In raceway 21 at Warm Springs NFH, 89% of the fish had left the raceway by April 13, if the release had been delayed until April 13 it is likely that most of those fish would have left the raceway within the first couple of days of the release, similar to the pattern observed for the Round Butte fish.

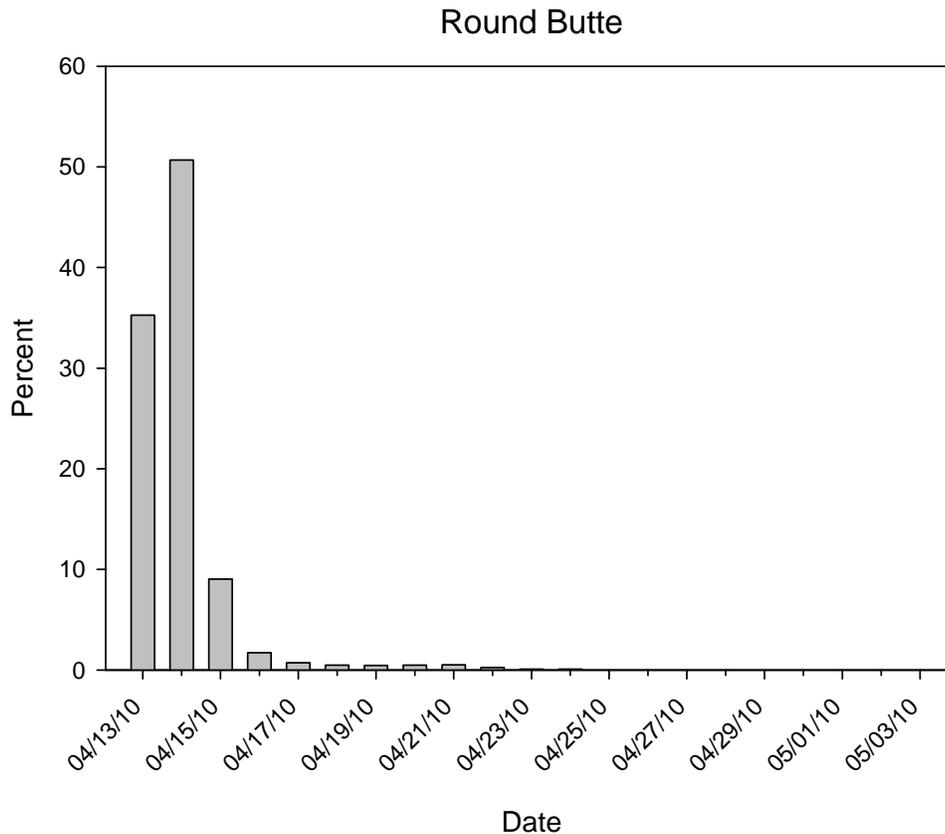


Figure 3. Percent of PIT tagged spring Chinook juveniles leaving Round Butte Cell 1 daily. Volitional release started on April 13 and ended on June 3. No PIT tagged fish were detected leaving after May 3.

Downstream Migration

Summary statistics for downstream migration can be found in Appendix A. Only PIT tagged fish with known release detections were used for migration analyses. Fish from Round Butte migrated downstream over Bonneville Dam over a shorter time period than fish from Warm Springs NFH (Figure 4). Median day of passage over Bonneville Dam was different for all three groups of fish (ANOVA on ranks, Dunn’s method, $p < 0.05$ for all comparisons), with fish from Round Butte having the earliest median day of passage on April 26, fish from Warm Springs NFH raceway 21 on May 2, and fish from Warm Springs NFH raceway 29 on May 4. The number of days from release to Bonneville Dam followed a similar pattern (Figure 5). The median number of days from release to Bonneville Dam was 12.5 days for Round Butte, 25 days for raceway 21, and 33 days for raceway 29 (ANOVA on ranks, Dunn’s method, $p < 0.05$ for all comparisons).

As with the release analysis, the different rearing and release practices at the two hatcheries likely accounts for the differences observed in the downstream migration patterns. Larger fish likely are able to swim at a faster pace than smaller fish, although how spring

Chinook juveniles migrate downstream is also dependent on flow conditions. The timing of release may be an even more important factor. Previous PIT tagging at Warm Springs NFH has shown that fish leaving the hatchery later on in the migration season migrate at a faster rate (unpublished data). During the 2010 migration period, fish from raceway 29 at Warm Springs were forced out of the raceway the earliest, on March 30, and had the slowest migration time and arrived at Bonneville Dam the latest of the three groups. Fish from raceway 29 remained in the freshwater region upstream of Bonneville Dam on average 8 days longer than fish from raceway 21, and 20 days longer than fish from Round Butte. Over half of the fish from Warm Springs NFH remained in the freshwater above Bonneville Dam three and a half weeks after leaving the hatchery. This is similar to previous years PIT tagging, where average migration time to Bonneville Dam for spring released fish was 30-35 days (brood years 2005-2007, unpublished data). Longer freshwater residence time could lead to greater susceptibility to predation, which would translate into decreased freshwater survival. Continued monitoring of hatchery releases, migration timing, juvenile survival, and adult returns rates is recommended.

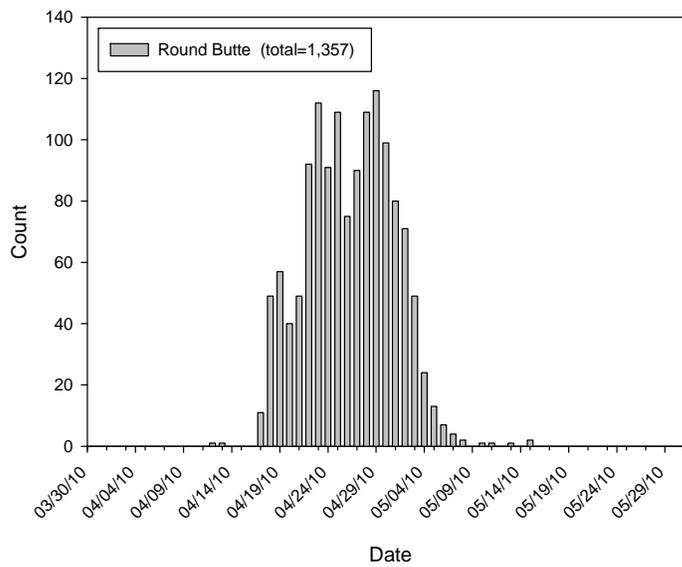
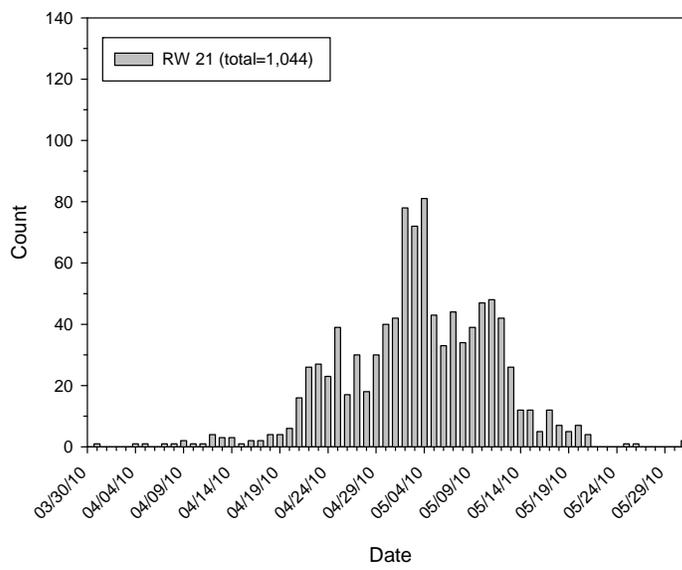
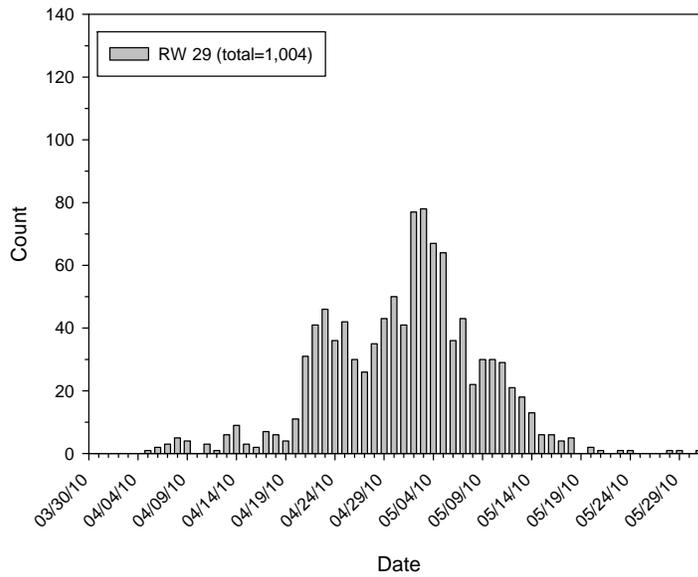


Figure 4. Daily count of PIT tagged fish passing downstream over Bonneville Dam in 2010 from Warm Springs NFH raceways 29 (RW 29) and 21 (RW 21), and Round Butte cell 1.

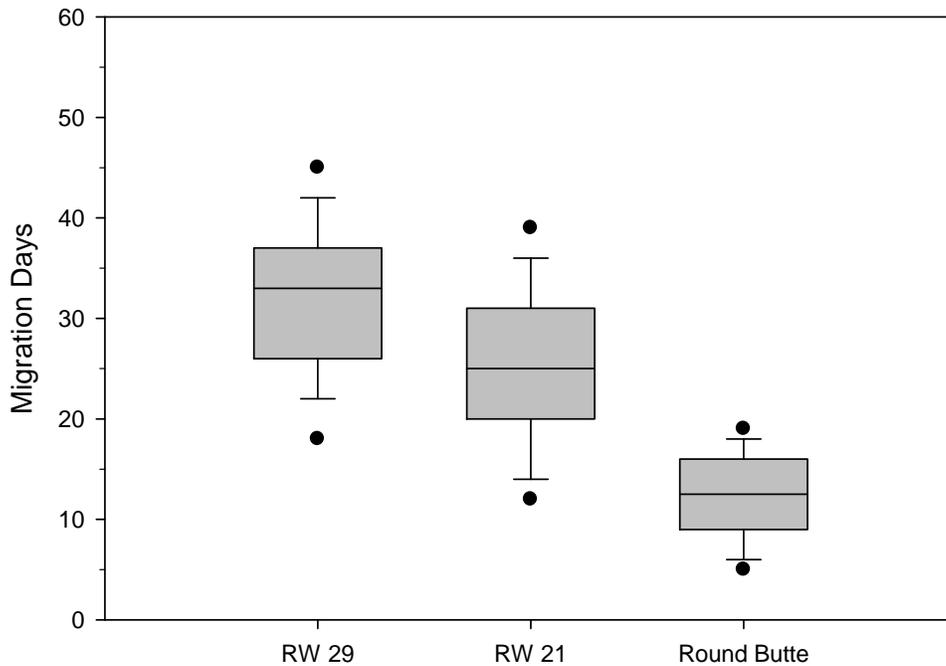


Figure 5. Number of days from release to Bonneville Dam for PIT tagged juvenile spring Chinook salmon from Warm Springs NFH (RW 29 and RW 21) and Round Butte hatchery in 2010. The volitional release at Warm Springs NFH started on March 24, with fish from raceway 29 being forced out on March 30 while fish in raceway 21 were forced out on April 21. The Round Butte volitional release started on April 13 and ended on June 3. No Round Butte PIT tagged fish left after May 3. Line is the median number of days, box is 25th-75th percentile, whiskers are 90th and 10th percentile.

Survival

Summary data for downstream detections are reported in Table 2. Detection efficiency for PIT tagged fish passing Bonneville Dam ranged from 20% to 30% for both Warm Springs NFH and Round Butte fish. Fish from raceways 21 and 29 at Warm Springs NFH had similar survival from release to Bonneville Dam, with a combined survival estimate of 57% (95% C.I. of 48% to 66%, Figure 6). Estimated survival to Bonneville Dam of Round Butte juveniles was 73% (95% C.I. of 58% to 84%, Figure 7). No statistical difference in survival to Bonneville Dam was detected between Warm Springs NFH and Round Butte stocks. Using the number of tagged fish detected at release and the estimated survival rates to Bonneville Dam for each hatchery, approximately 6,191 Warm Springs NFH and 5,071 Round Butte PIT tagged fish survived to Bonneville Dam.

Table 2. Summary of 2010 PIT tag detections for brood year 2008 and estimated survival from release to Bonneville Dam. Bonneville survival, bird colony recoveries on East Sand Island, and mini-jack detections at Bonneville Dam are only for fish detected during the release at each hatchery. Data downloaded from PTAGIS on 2/10/2011.

	Tagged	Detected at Release	Bonneville Survival (95% C.I.)	Estimated Number to Bonneville (observed)	Bird Colony	Mini-Jacks
WSNFH	14,907	10,863	57% (48%-66%)	6,192 (1,470)	352 (5.7%)	3 (0.05%)
Round Butte	7,454	6,947	73% (58%-84%)	5,071 (1,338)	239 (4.7%)	32 (0.63%)

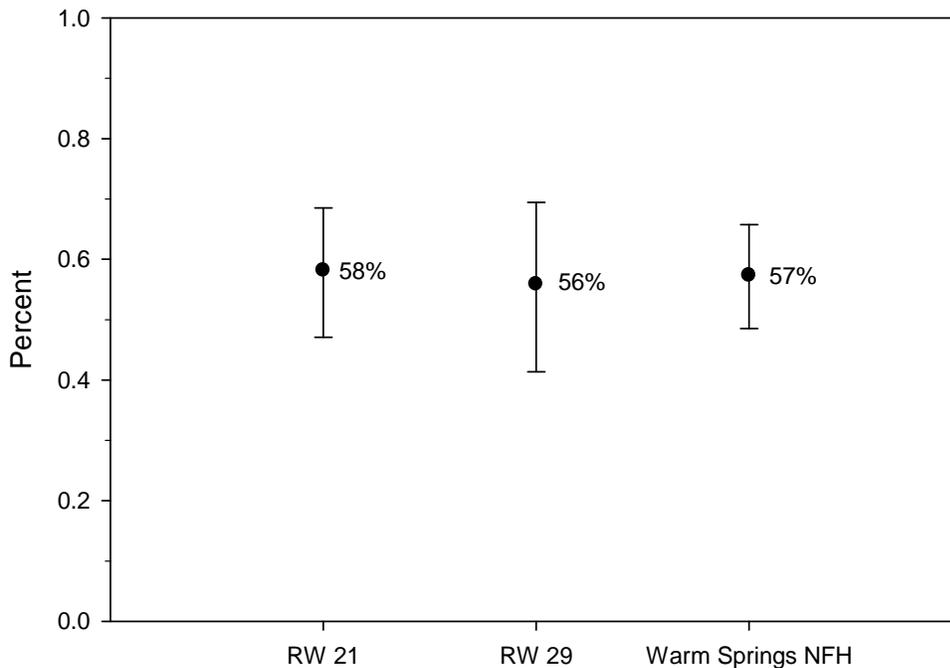


Figure 6. Juvenile survival estimates from release to Bonneville Dam for brood year 2008 spring Chinook released from raceways 21, 29, and combined Warm Springs NFH . Survival estimates are based on detections at Bonneville Dam, estuary trawl, and bird colony recoveries downloaded from PTAGIS on 2/10/2011. Whiskers are 95% confidence intervals.

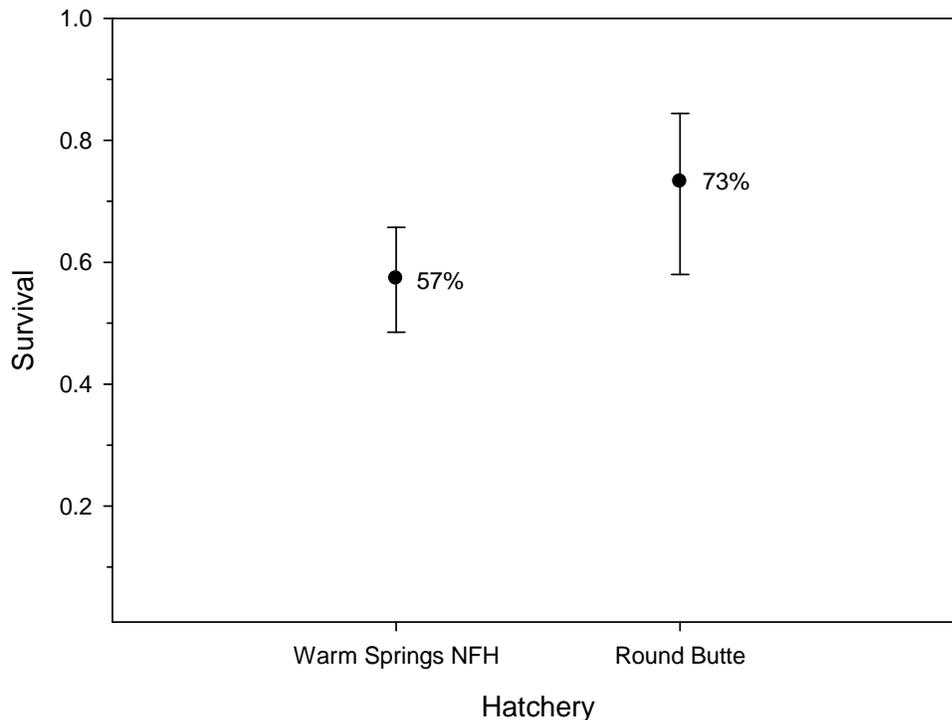


Figure 7. Juvenile survival estimates from release to Bonneville Dam for brood year 2008 spring Chinook released from Warm Springs NFH and Round Butte in 2010. Survival estimates are based on detections at Bonneville Dam, estuary trawl, and bird colony recoveries downloaded from PTAGIS on 2/10/2011. Whiskers are 95% confidence intervals.

Bird Colony recoveries

Of the tagged fish detected leaving their respective hatchery, a total of 352 Warm Springs NFH PIT tags and 239 Round Butte PIT tags were recovered from the double-crested cormorant and Caspian tern colonies on East Sand Island in 2010. Using the estimated number of PIT tagged fish reaching Bonneville Dam, approximately 5.7% Warm Springs NFH and 4.7% Round Butte hatchery fish passing through the lower Columbia River were consumed by birds on East Sand Island.

Mini-Jack Returns

Mini-jacks, sexually mature males that return during the summer of the year of their downstream migration, from Round Butte began moving upstream over Bonneville Dam on June 15, 2010. A total of 32 PIT tagged Round Butte mini-jacks migrated upstream through the Bonneville Dam adult ladders. Two of the Round Butte mini-jacks were later detected in the adult ladder at Warm Springs NFH. Warm Springs NFH stock fish, by contrast, had three tagged mini-jacks moving over Bonneville Dam. All three tagged Warm Springs NFH mini-jacks were subsequently detected at the adult fish ladder at Warm Springs NFH. Mini-jacking rates were

significantly different between hatcheries ($p < 0.001$). Survival and age structure of adult returns, based on detections at the Bonneville Dam adult fish ladders, will be monitored through 2013.

Acknowledgements

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Works Cited

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Appendix A

Summary Statistics for Migration to Bonneville Dam

Migration Days: Release to Bonneville Dam

	Number					Std.
	Observed	Median	Min	Max	Mean	Dev
WSNFH RW 21	963	25	5	62	25.4	8.33
WSNFH RW 29	509	33	6	60	32.2	8.31
Round Butte	1338	12.5	3	31	12.4	4.52

Day of Year: Passage Downstream Through Bonneville Dam

	Number					Std.
	Observed	Median	Min	Max	Mean	Dev
WSNFH RW 21	963	124	90	151	123.4	7.81
WSNFH RW 29	509	122	95	149	120.9	8.23
Round Butte	1338	116	107	135	116.2	4.55

Appendix B

Number of brood year 2008 fish PIT tagged, and downstream detections of Warm Springs NFH and Round Butte hatchery spring Chinook juveniles in 2010. Detections downstream **only** include fish that were detected at release. Data downloaded from PTAGIS on 2/10/2011.

	Tagged	Detected at Release	Detections Downstream			
			Bonneville	Estuary Trawl	Bird Colony	Mini-jacks
WSNFH	14,907	10,863	1,470	160	352	3
Round Butte	7,454	6,947	1,338	67	239	32

Data Categories for Program MARK Survival Estimates to Bonneville Dam Data Downloaded from PTAGIS 2/10/2011

	PIT Tag Detections			
	Release Only	Release and Bonneville	Release and Trawl/Bird Colony	Release, Bonneville, and Trawl/Bird Colony
WSNFH RW 21	5,762	884	251	78
WSNFH RW 29	3,239	467	134	41
WSNFH Total	9,001	1,351	385	119
Round Butte	5,351	1,256	223	80