Assessments to Determine the Effect of Current and Alternate Ladder Operations on Brood Stock Collection and Behavior of Hatchery Fall Chinook Salmon at Spring Creek National Fish Hatchery during 2003-2005

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Background - Spring Creek NFH

Spring Creek NFH traditionally operates an adult ladder, without closure, from the start of the tule fall Chinook salmon run in late August until the run ceases in early October. Ladder operation is continuous during the tule fall Chinook salmon run to receive all hatchery origin fish.

In recent years, Spring Creek NFH has recorded large returns of adult tule fall Chinook salmon (Table 1) often with several thousand fish entering the hatchery each day of the hatchery run (Figure 1). A minimum hatchery escapement of 7,000 adults, (4,000 females) is needed to maintain an annual production of 15.1 million juvenile Chinook salmon. Fish in surplus of the needed hatchery escapement are given to the Yakama Nation, when requested, or provided under contract to the Federal Prison System.

Table 1. Hatchery Escapement from 1998-2003 provided from Spring Creek NFH, hatchery manager records.

Return Year	Hatchery Escapement
1998	10,179
1999	14,690
2000	11,347
2001	48,649
2002	71,261
2003	62,253

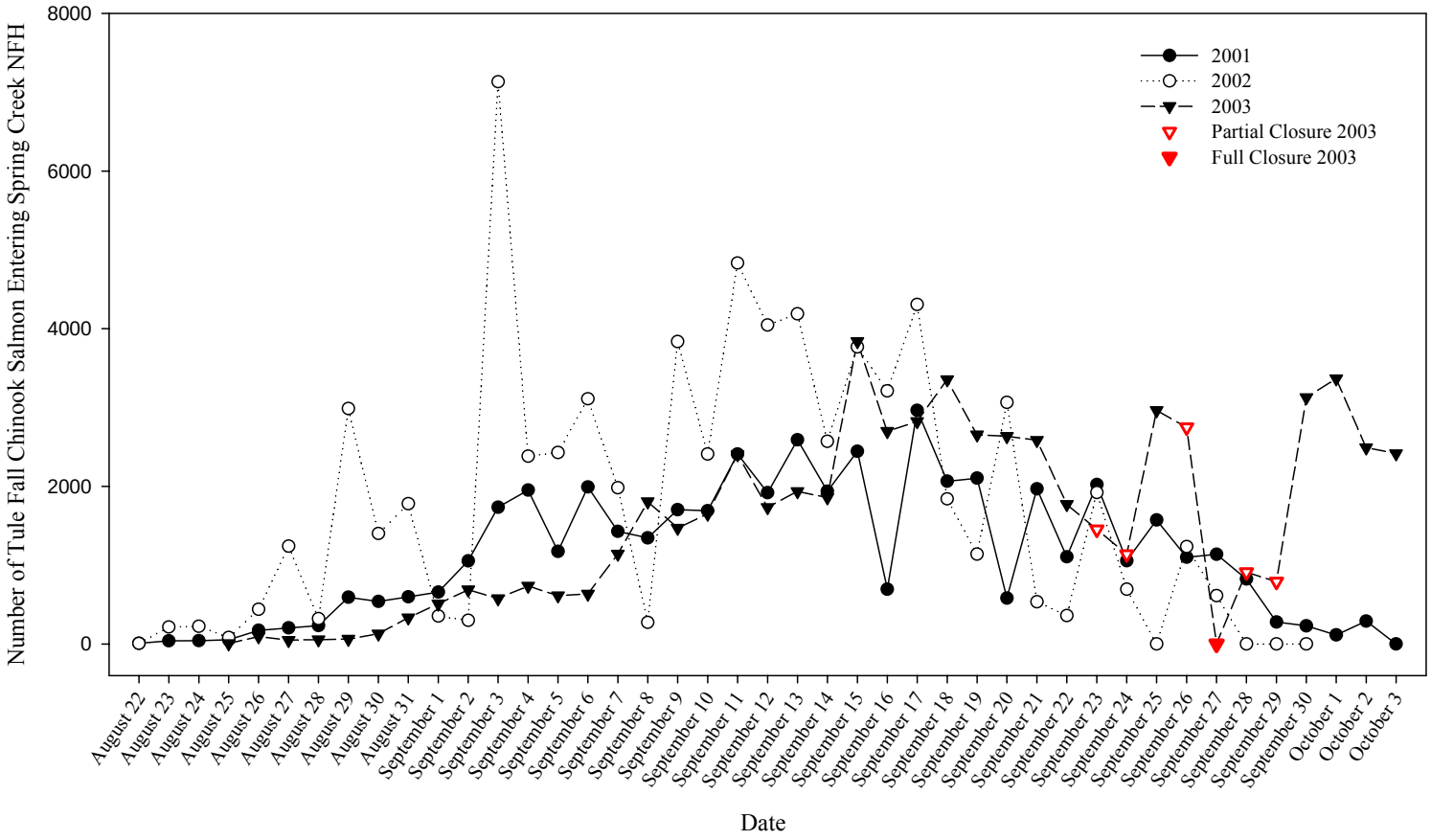

Figure 1. Spring Creek NFH tule fall Chinook salmon daily returns 2001-2003. Partial adult ladder closures occurred after the close of business on one day and lasted until the start of business on the following day. Only one full day (24 hours) in 2003 was the adult ladder closed.

An alternative approach to ladder operations at Spring Creek NFH was attempted in 2003 with several half day and one full day ladder closure near the end hatchery run (Figure 1). The purposes of the 2003 ladder closures were to increase opportunity for sport and tribal angler harvest, decrease hatchery personnel workload during spawning operations, and contribute to additional in-river nutrient enhancement.

Another large hatchery escapement (>40,000 fish) was expected during 2004 and during 2005 (>50,000). Service staff at Spring Creek NFH and the Columbia River Fisheries Program office sought and obtained permission to close the hatchery adult ladder for two short time periods during the hatchery return during 2004 and 2005. An assessment of the 2004-2005 ladder closures was planned with the following objectives.

> Objective 1. Determine if hatchery brood stock includes tule fall Chinook salmon not allowed access to the hatchery during a ladder closure.
>
> Objective 2. Determine if the behavior of tule fall Chinook salmon changes during intermittent ladder closure, specifically if intermittent ladder closure increases natural spawning and straying of Spring Creek NFH returning adults.

The purposes of the 2004-05 ladder closures were the same as the 2003 ladder closures; increase opportunity for sport and tribal fisherman to harvest tule fall Chinook salmon, decrease hatchery personnel workload and contribute to in-river nutrient enhancement.

Assessment Methods and Experimental Design

Two closures were planned for the 2004 and 2005 hatchery return (Table 2). These closures were planned to occur during weekends near the beginning and peak of the hatchery return. Closures began near 1:00 PM on Fridays and ended near 1:00 PM on Sundays. Three groups of fish were tagged with Petersen Disc tags to assess the effect of each ladder closure (Table 3).

Tule fall Chinook salmon were captured for tagging at the ladder entrance using a long-handled 1.0 m diameter dip net. Captured fish were anesthetized and tagged with an individually numbered fluorescent pink Petersen Disc tag placed near the dorsal fin on one side of the fish.

Table 2. Ladder closures during 2004 and 2005 at Spring Creek National Fish Hatchery. Time of ladder openings and closures are also given.

	2004	2005
First Closure	September 3rd 1300 hours – September 5th – 1300 hours	September 9th 1300 hours – September 11th 1300 hours
Second Closure	September 17th 1300 hours - September 19th 1300 hours	September 24th 1300 hours September 26th 1300 hours

Table 3. Identification of tag groups for assessing ladder closures during the 2004 and 2005 tule fall Chinook salmon run at Spring Creek NFH.

Tag Group	Purpose	Tagging Day	Sample Size 2004 (n)	Sample Size 2005 (n)
Green	Treatment 1	At least five days prior to closure	30	45
Yellow	Treatment 2	One day prior to closure	30	45
Red	Treatment 3	Day of closure	30	45

A green, yellow or red disc tag, corresponding to tag group, was used as backing on the opposite side of the fish for secondary identification (Figure 2). A total of 30 radio transmitters, 15 for each of the closures, were placed on tule fall Chinook salmon for monitoring during 2004. All captured and tagged tule fall Chinook salmon were allowed to recover from anesthesia and released into the Columbia River approximately 100 meters upriver from the ladder entrance using the hatchery incidental species release tube. Fish presumably destined for the hatchery are visually seen in the area of the incidental release tube.

Recovery of tagged tule fall Chinook salmon occurred three ways; at the hatchery, on spawning ground surveys, or by fisherman. Tagged tule fall Chinook salmon that navigated the hatchery ladder were recovered during surplus or spawning activities. All attached tags were removed and the date of recovery recorded. Ponding records kept by hatchery staff allowed for calculation of entrance times for fish destined to be surplused or spawned. Spawning surveys conducted by Washington Department of Fish and Wildlife (WDFW) on the White Salmon River are conducted annually. The U.S. Fish and Wildlife Service coordinated with WDFW to assist with surveys and recover tagged tule fall Chinook salmon. Sport and tribal fisherman in the area of the Columbia River Gorge were encouraged to report any tagged tule fall Chinook captured through informative flyers placed at tribal and sport fishing areas in addition to the tag reporting information printed on the disc tags and radio transmitters.

Tag recovery ratios between treatment groups and recovery locations were examined using a chi-square test ($p<0.05$). Hatchery entrance time of tagged tule fall Chinook salmon was compared between treatment groups using an analysis of variance (ANOVA, $p<0.05$).

In 2004, tule fall Chinook salmon with radio transmitters were monitored by mobile tracking using a hand-held receiver. Mobile tracking occurred at least weekly with a search pattern of Spring Creek NFH, the White Salmon River below Condit Dam, 2 miles upriver of the Hood River Toll Bridge, the lower 2 miles of Hood River, Drano Lake, and the Washington shore of the Columbia River down to the Wind River. When a radio transmitter signal was detected in a tributary of the Columbia River, a visual verification of the tagged fish was attempted and the location of the fish was recorded.

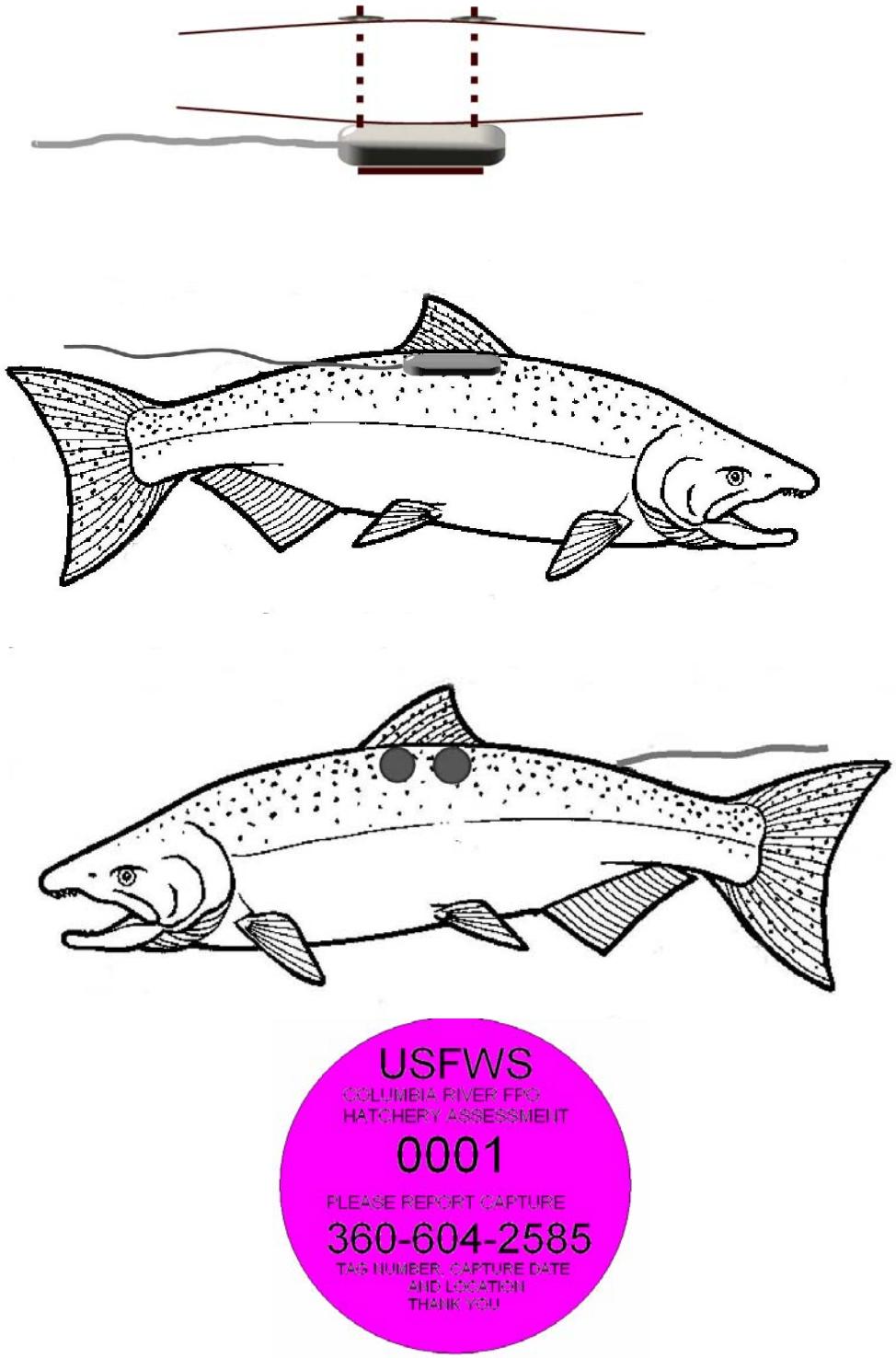

Figure 2. Attachment of radio transmitters using nickel pins and Petersen disc tags shown dorsally and ventrally. The top illustration (dorsal view) shows a horizontal cross-section of the tag placement. Fish tagged without radio transmitters (disc tags only) had only one Petersen disc on each side with tag reporting information printed on one side. Illustrations are by David Hand (USFWS).

Results

2004 Ladder Assessment

A total of 74,512 tule fall Chinook salmon entered the hatchery during the 2004 adult return (Figure 3). A total of 179 tule fall Chinook salmon were tagged with Peterson Disc tags for the 2004 ladder assessment at Spring Creek NFH. Radio transmitters were placed on 30 of the 179 tule fall Chinook salmon in the assessment. A total of 61 of 89 tagged tule fall Chinook salmon associated with the first ladder closure were recovered. A total of 72 of the 90 tagged tule fall Chinook salmon associated with the second ladder closure were recovered. Most recoveries occurred at Spring Creek NFH for both ladder closures with any other recoveries occurring within the White Salmon River (Tables 3 and 4). Only 1 tag was reported by a sport fisherman (Table 5). There were no tag recoveries reported by tribal fisherman. The ratio of hatchery recoveries for the tag groups in the first ladder closure is the same as the second ladder closure (χ^2, p=0.97). The ratio of tag recoveries at the hatchery and for the White Salmon River for the 1st ladder closure and the second ladder closure are also the same (χ^2, p=0.96).

Table 3. Location of tag recoveries by tag date of tule fall Chinook salmon tagged at Spring Creek National Fish Hatchery during the 1st of 2 ladder closures. Numbers in parentheses are radio transmitters placed on tule fall Chinook salmon.

Date Tagged	Tag Group	Number Tagged	Hatchery Recoveries	White Salmon River Recoveries	All Tags Recovered
8/30/04	Green	29 (4)	18	2	20
9/2/04	Yellow	30 (6)	18	1	19
9/3/04	Red	30 (5)	20	2	22
TOTAL		89 (15)	56	5	61

Table 4. Location of tag recoveries by tag date of tule fall Chinook salmon tagged at Spring Creek National Fish Hatchery during the 2nd of 2 ladder closures. Numbers in parentheses are radio transmitters placed on tule fall Chinook salmon.

Date Tagged	Tag Group	Number Tagged	Hatchery Recoveries	White Salmon River Recoveries	All Tags Recovered
9/10/04	Green	30 (5)	21	2	23
9/16/04	Yellow	30 (5)	22	1	23
9/17/04	Red	30 (5)	23	3	26
TOTAL		90 (15)	66	6	72

Table 5. Tag recovery by location of tule fall Chinook salmon tagged at Spring Creek National Fish Hatchery. Angler recovery reported by Washington Department of Fish and Wildlife (WDFW). White Salmon River tags recovered by WDFW carcass survey crew.

Recovery Location	Sum Of Recovered Tags
Angler Recovery (WDFW)	1
Spring Creek National Fish Hatchery	122
White Salmon River (WDFW)	10
Tags Not Recovered	45

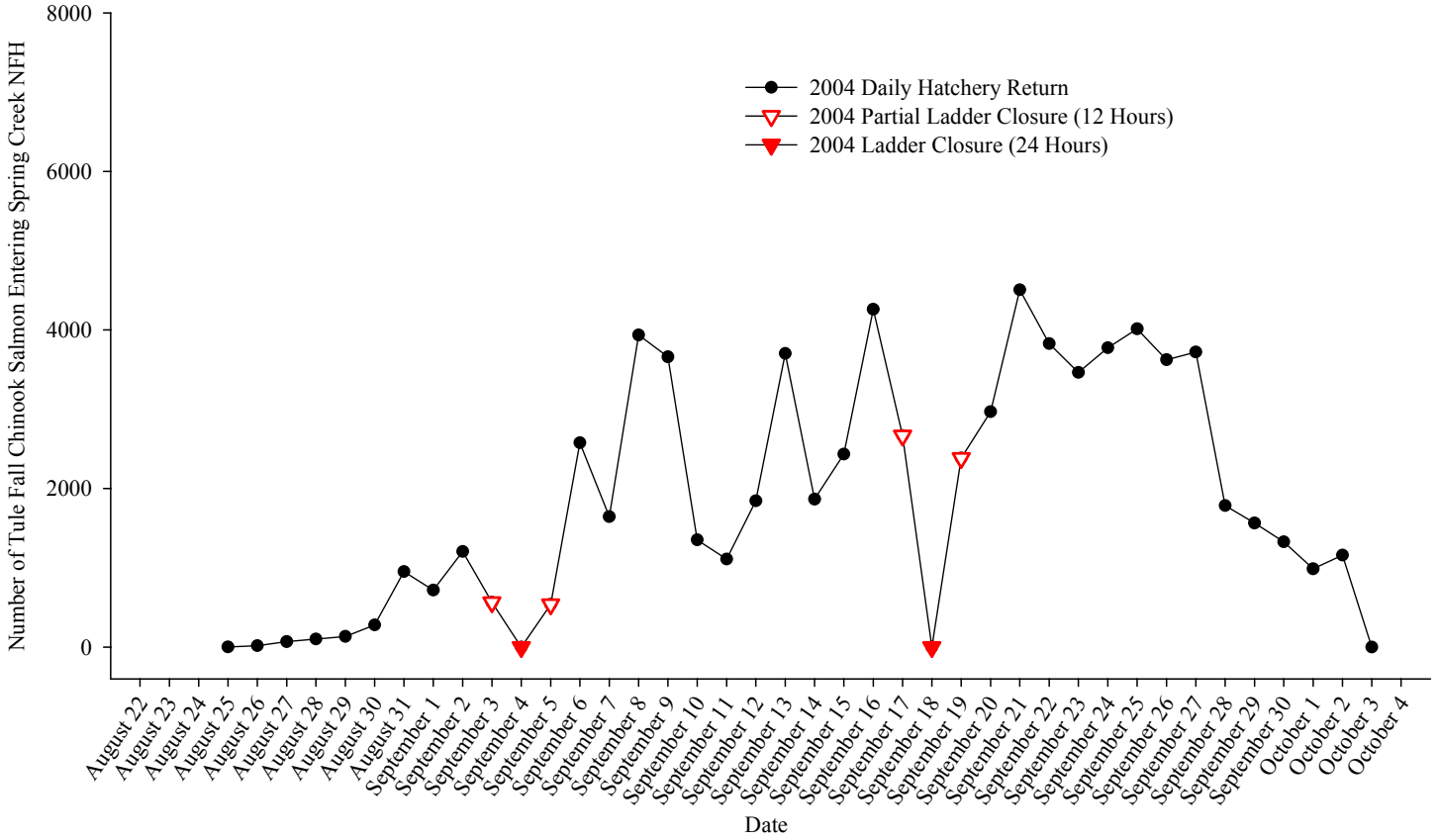

Figure 3. Spring Creek NFH tule fall Chinook salmon daily returns during 2004. The hatchery escapement was 74,512. The ladder closure dates and duration are also noted.

The average number of days until hatchery entry was calculated for each tag group for both closures (Figure 4). There was not a significant difference in the number of days until hatchery entry between the tag groups for the first ladder closure (ANOVA, $p=0.253$), or for the second ladder closure (ANOVA, $p=0.115$).

Of the 30 tule fall Chinook salmon with radio transmitters, 18 navigated the hatchery ladder to be recovered by hatchery staff. WDFW carcass survey personnel recovered 3 radio transmitters off tule fall Chinook salmon carcasses in the White Salmon River. One fish with a transmitter was captured by a sport angler in the White Salmon River. Five tule fall Chinook salmon with radio transmitters were tracked to the White Salmon River and were not recovered by carcass survey crews. Visual verification of the fish that entered the White Salmon River was attempted but some fish with radio transmitters were either in deep (>15ft) water or were not in navigable locations. A final destination was not determined for 3 of the 30 fish with radio transmitters.

An expansion of White Salmon River disc tag recoveries was possible due to the cooperation of Washington Department of Fish and Wildlife staff and mobile tracking of fish with radio transmitters. The WDFW carcass crew recovered 3 of the 8 tagged tule fall Chinook salmon that had radio transmitters while performing their weekly sampling of the White Salmon River spawning population. The probability of WDFW recovering a tule fall Chinook salmon with a radio transmitter from Spring Creek NFH was 37.5%. Considering this probability, there were potentially 13 total tagged tule fall Chinook salmon within the White Salmon River associated with the first ladder closure tag group, and 16 from the second. When recovery expansions at the White Salmon River are added to recoveries at the hatchery, 69/90 tagged fish for the 1st closure and 82/90 tagged fish for the 2nd closure can be accounted for.

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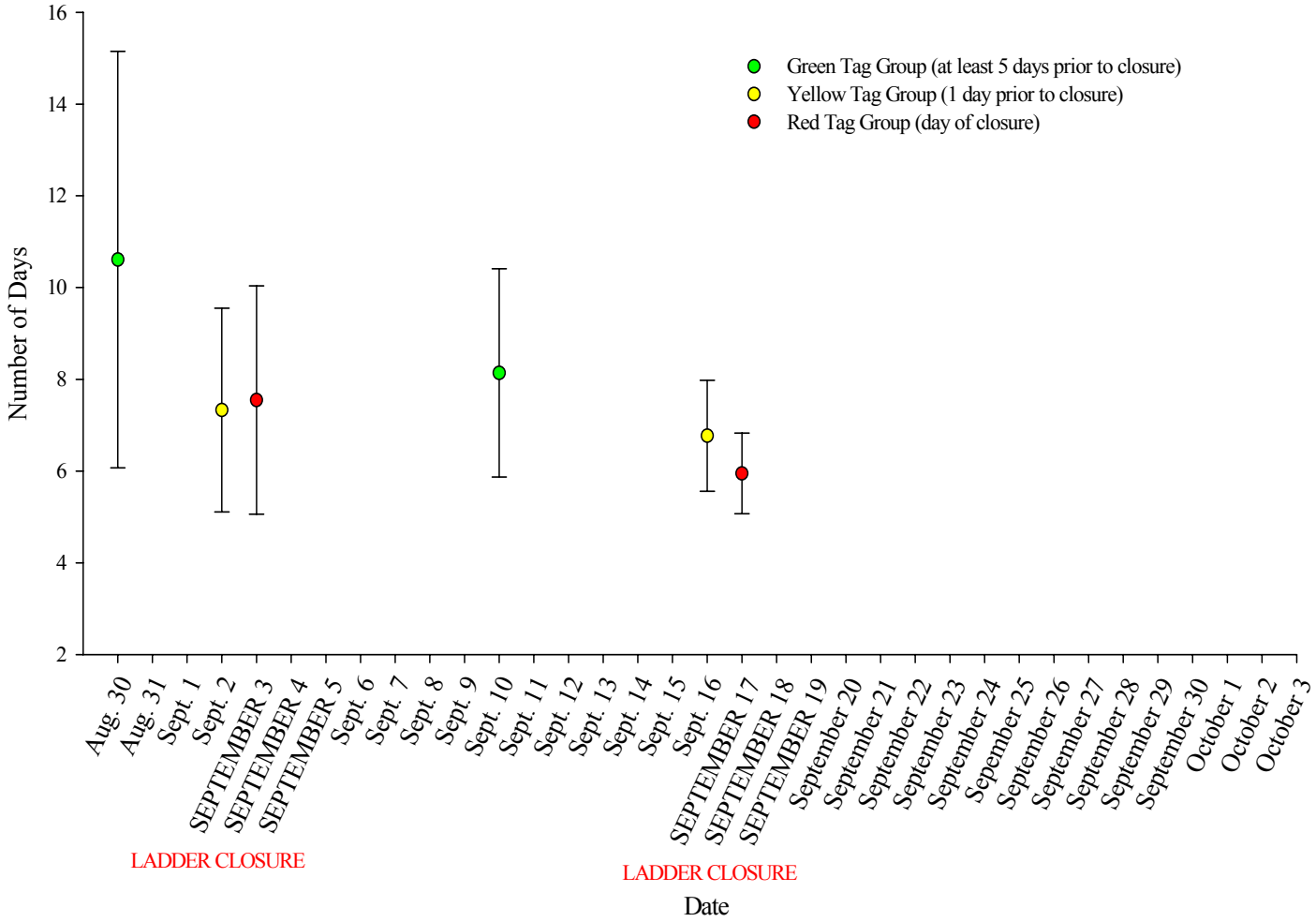

Figure 4. Average number of days for tagged fish to enter Spring Creek National Fish Hatchery during 2004 ladder closures. Error bars represent 95% confidence intervals.

Table 6. Mobile tracking data recorded on radio-tagged tule fall Chinook salmon from Spring Creek NFH 2004. Contact locations of radio-tagged fish are the area of Spring Creek NFH (H), the brood stock or surplus ponds at the hatchery (Ponds), the White Salmon River (WS), Drano Lake (DL) located at the mouth of the Little White Salmon River, and Hood River Marina (HRM). Ladder closures occurred from September 3-5 and September 17-19.

Tagging Date	Tag #	9/3	9/7	9/10	9/14	9/20	9/22–28	Hatchery Entrance	Final Location
8/30	56	H	H	H	?	?	H	10/4	H
8/30	59	H	H	H				9/13	H
8/30	60*	?	WS	WS	H			9/16	H
9/2	18*	?	?	WS	WS	H	WS		WS
9/2	19	H	H	Ponds	Ponds	Ponds		9/9	H
9/2	20	H	?	WS	WS	WS	WS		WS
9/2	55	?	WS	WS	WS	WS	WS		WS
9/2	57	?	?	?	WS	WS			WS
9/2	58	?	Ponds	Ponds	Ponds	Ponds		9/7	H
9/3	14	H	H					9/8	H
9/3	17	H	?					9/9	H
9/3	150*	H	WS	WS	WS	?	H	9/24	H
9/3	152	H	H					9/9	H
9/3	153	WS	WS	WS	WS	WS	WS		WS
9/10	203				H	?	WS		WS
9/10	205					DL	?		Unknown
9/10	206				H	H		9/22	H
9/16	154					H	?		HRM†
9/16	210					H	H		WS
9/16	212					H	H		Unknown
9/17	151					?	H	9/24	H

*denotes movement back to a previously recorded location
† Final Location recorded in November 2004.

2005 Ladder Assessment

A total of 34,291 tule fall Chinook salmon entered the hatchery during the 2005 adult return (Figure 5). An increase in the number of fish tagged from 30 to 45 was attempted in 2005 for each tag group. During the period of tagging for the first ladder closure, only the "Yellow" tag group achieved that goal. Captures of fish for the "Green" and "Red" tag groups were difficult and were discontinued due to low numbers of fish entering the ladder during daylight hours. A total of 180 tule fall Chinook salmon were tagged with Peterson Disc tags for the 2005 ladder assessment at Spring Creek NFH. A total of 22 of 45 tagged tule fall Chinook salmon associated with the first ladder closure were recovered (Table 7) and 99 of 135 for the second closure (Table 8). Most recoveries occurred at Spring Creek NFH for both ladder closures with one reported recovery at the White Salmon River during carcass surveys (Table 9). Three (3) tags were reported by a sport fisherman. There were no tags reported by tribal fisherman although a tribal fisherman's gill net was located within 10 meters of the incidental release tube during tagging for both scheduled closures. The average number of days until hatchery entry was calculated for each tag group for both closures (Figure 6). There was not a significant difference in the number of days until hatchery entry between the tag groups for the second ladder closure (ANOVA, $p=0.333$). The first ladder closure was not sufficient in sample sizes to analyze.

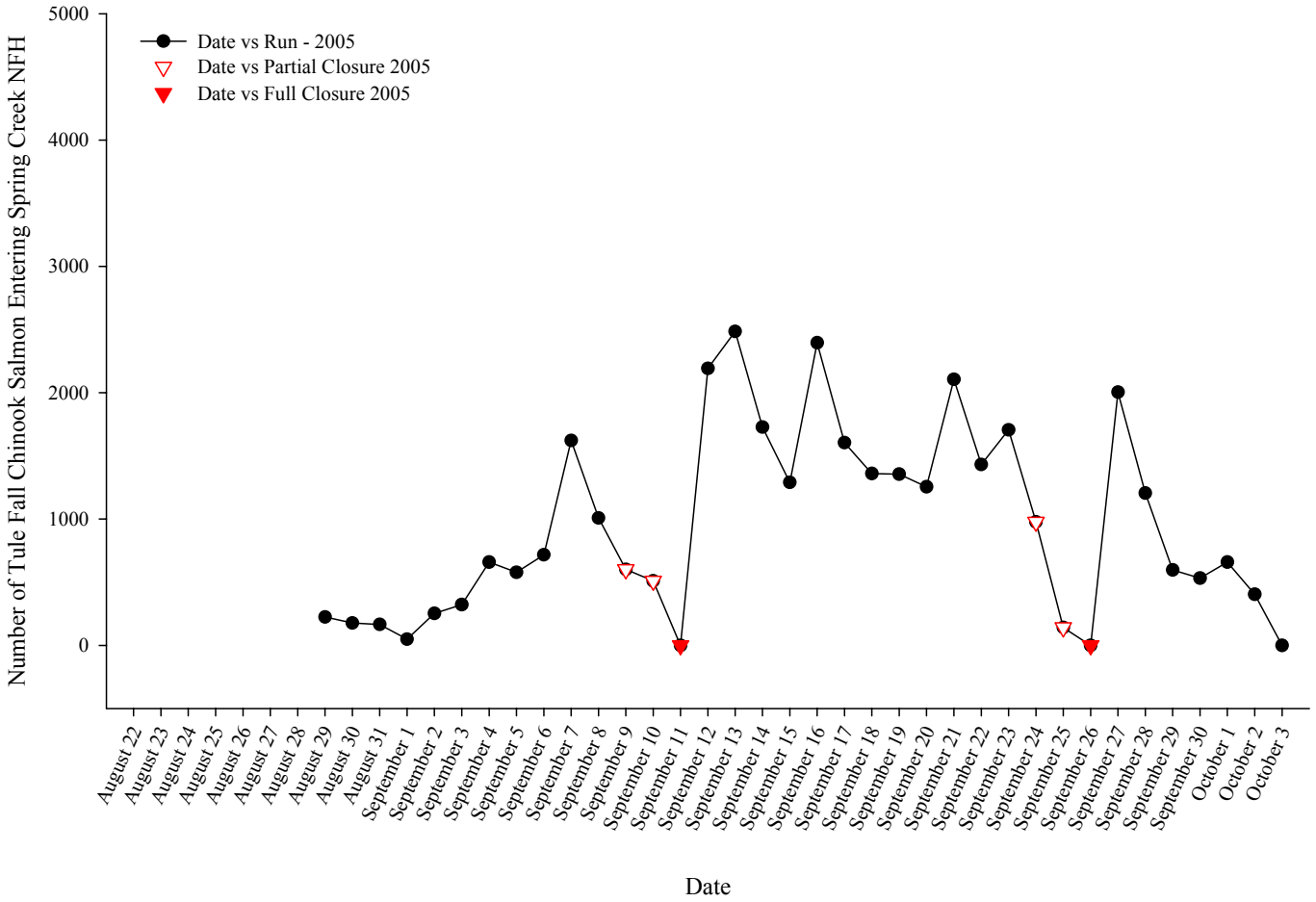

Figure 5. Spring Crek NFH tule fall Chinook salmon daily returns 2005. The hatchery escapement was 34,291. The ladder closure dates and durations are noted below.

Table 7. Location of tag recoveries by tag date of tule fall Chinook salmon tagged at Spring Creek National Fish Hatchery during the 1st of 2 ladder closures.

Date Tagged	Tag Group	Number Tagged	Hatchery Recoveries	White Salmon River Recoveries	All Tags Recovered
9/1/05	Green	NA			
9/8/05	Yellow	45	22	0	22
9/9/05	Red	NA			
TOTAL		45	22	0	22

Table 8. Location of tag recoveries by tag date of tule fall Chinook salmon tagged at Spring Creek National Fish Hatchery during the 2nd of 2 ladder closures.

Date Tagged	Tag Group	Number Tagged	Hatchery Recoveries	White Salmon River Recoveries	All Tags Recovered
9/16/05	Green	45	40	0	40
9/23/05	Yellow	45	32	0	32
9/24/05	Red	45	27	1	28
TOTAL		135	99	1	100

Table 9. Tag recovery by location of tule fall Chinook salmon tagged at Spring Creek National Fish Hatchery. Angler recovery reported by cooperating agencies or by anglers reporting captures. White Salmon River tags recovered by WDFW carcass survey crew.

Recovery Location	Sum Of Recovered Tags
Angler Recovery	3
Spring Creek National Fish Hatchery	121
White Salmon River (WDFW)	1
Tags Not Recovered	55

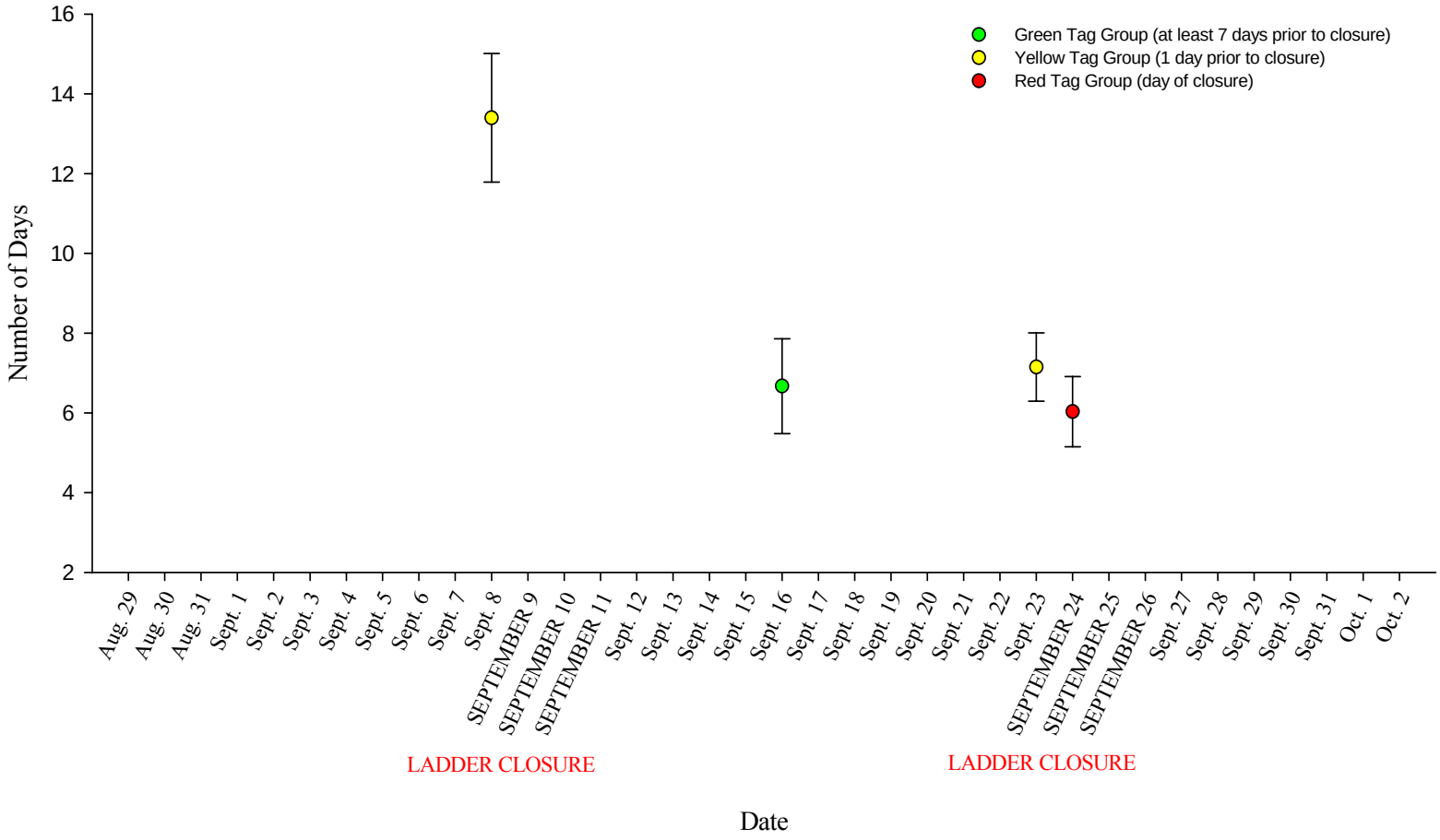

Figure 6. Average number of days unitl hatchery entry for the Green, Yellow, and Red tag groups for the two ladder closures at Spring Creek NFH in 2005. Error bars represent the 95% CI. The average number of days unitl hatchery entry was calculated from adult ponding records kept at Spring Creek National Fish Hatchery. Ladder closures are indicated below the date they occurred.

Discussion and Management Implications

Ladder closures were attempted during 2003-05 due to large escapements expected at the hatchery, five to ten times the amount of fish needed for brood stock. The collection of hatchery brood stock at Spring Creek NFH using continuous ladder operations had not changed until the 2003 ladder closures. The purpose of those closures was to increase opportunity for sport and tribal angler harvest, decrease hatchery personnel workload during spawning operations, and contribute to additional in-river nutrient enhancement. With the 2004 and 2005 ladder closures, two of the three purposes were met. The closure of the ladder did provide the hatchery staff with a needed reprieve of workload during spawning and surplus operations. Additionally, tagged fish from the closure provided nutrient enrichment by presumably spawning in the White Salmon River. The potential benefit of ladder closures to increase sport and tribal angler harvest did not likely occur in either 2004 or 2005. Often the gill nets of tribal fisherman are not in the immediate area of the hatchery, or the entrance to the White Salmon River. During 2005, the tribal nets placed near the incidental release tube were the only nets seen between the hatchery and the White Salmon River. These were the two most frequented areas according to radio tracking and disc tag recoveries. For tribal fisherman to harvest fish from action of ladder closures, gill nets could be placed between these two locations, maximizing the potential for capture. Although sport anglers reported catch of a tagged tule fall Chinook salmon associated with ladder closures, the amount of captures recorded in two years (4) does not meet the expected increase of sport and tribal harvest that the closures were thought to provide. More recoveries would have been expected if harvest during ladder closures was high.

Objective 1. Determine if hatchery brood stock includes tule fall Chinook salmon not allowed access to the hatchery during a ladder closure.

The results of this assessment conclude that fish not allowed access to the hatchery during ladder closures are represented in hatchery brood stock therefore, hatchery brood stock collection for the years of ladder closures was representative of the return. Furthermore, fish that are presumably not allowed access to the hatchery during a closure appear to enter at similar rates to those that were not susceptible to the period of ladder closure. The implementation of ladder closures did not affect the rates of entry for fish exposed to a closure.

Objective 2. Determine if the behavior of tule fall Chinook salmon changes during intermittent ladder closure, specifically if intermittent ladder closure increases natural spawning and straying of Spring Creek NFH returning adults.

In the past few years, returns of tule fall Chinook salmon to Spring Creek NFH have been large (Table 1). The escapement estimates of tule fall Chinook salmon to the White Salmon River have also been large but may be due to the combination of ladder closures and the magnitude of fish returning to the hatchery.

From 1980-2002, White Salmon River estimated escapement of tule fall Chinook salmon was linearly related to Spring Creek NFH returns (r^2=0.77, Figure 7) During the 2003 and 2004 ladder closures, the estimated escapement of tule fall Chinook salmon in the

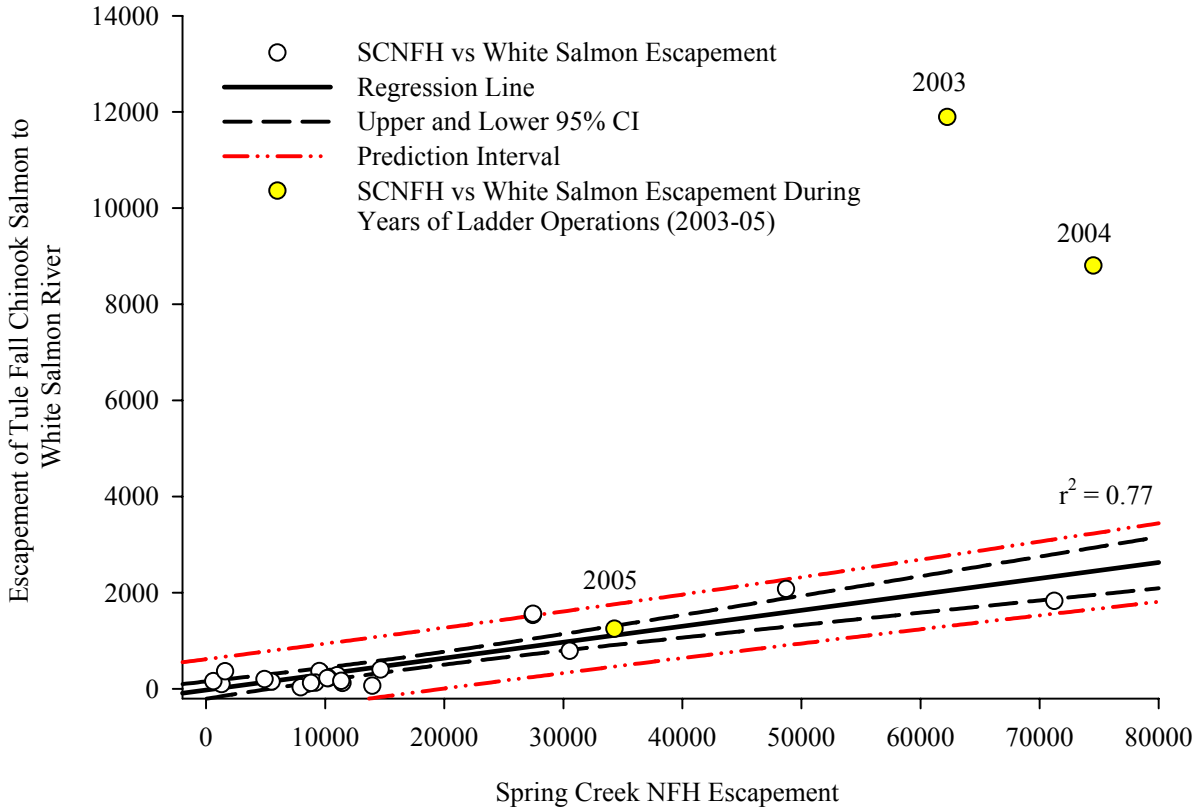

Figure 7. Regression of tule fall Chinook salmon escapement to the White Salmon River to Spring Creek National Fish Hatchery escapement from 1980-2002 with the years of ladder closure (2003-2005). Upper and lower confidence intervals as well as prediction interval are given.

White Salmon River was larger and well outside a prediction interval for the linear relationship. The 2005 relationship between the White Salmon estimated escapement and the hatchery escapement fell within the prediction interval and confidence interval for the relationship. This may be explained by the amount of fish returning in 2005 (34,291) being lower than the 2003-04 returns (74,512 and 62,253, respectively). In years of high returns and ladder closures, tule fall Chinook salmon may be more susceptible to moving to the White Salmon River than years where returns are moderate and ladder closures occur, such as 2005. Ladder closures are not planned for future years but closures during larger returns should be examined carefully for their potential to increase adults on the White Salmon River spawning grounds. Washington Department of Fish and Wildlife has estimated that Spring Creek NFH origin fish make up the bulk of carcasses recovered during September and October in the White Salmon River (Table 10). Further study is needed to determine if hatchery tule fall Chinook salmon within the White Salmon River, the point of origin for this stock, is a positive or negative ecological interaction.

Obviously, tagged tule fall Chinook salmon did stray from the area of the hatchery to the White Salmon River but an increase of straying and spawning of tule fall Chinook salmon strictly due to closures cannot be fully determined.

Table 10. Escapement estimates fall Chinook salmon within the White Salmon River from 1998-2005 during October and November (Kelly Jenkins, Pacific States Marine Fisheries Commission, personal communication). Surveys conducted by WDFW and PSMFC staff during October and Early November and coincide with tule fall Chinook salmon spawning in the White Salmon. Recovery of coded wire tags is expanded based on tagging records and applied to escapement estimates. Unknown Origin fish may include wild fish. Clackamas Hatchery recoveries in 2001 and 2002 are spring Chinook salmon stock. Recovery of Little White Salmon NFH, Klickitat and Bonneville Hatchery stock are upriver bright fall Chinook salmon.

Origin	1998	1999	2000	2001	2002	2003	2004	2005
Snake River Hatchery (unknown)				5				
Clackamas Hatchery					28			
Ringold Hatchery						5		
Bonneville Hatchery						407		56
Klickitat Hatchery						5		
Little White Salmon NFH						156	42	199
Spring Creek NFH		344		1,702	1,385	10,202	5,750	1,249
Unknown Origin	242	57	167	370	446	1,696	3,054	
Total Escapement	242	401	167	2,077	1,859	12,471	8,846	1,504

Movement of tule fall Chinook salmon from the hatchery to the White Salmon River does not indicate a definitive fidelity to the White Salmon River. Two females tagged prior to the first ladder closure in 2004 were recorded in the White Salmon River after the closure and then returned to the hatchery and were recovered (Table 6, tag numbers 60 and 150). One female tagged prior to the first closure was recorded at the White Salmon River after the first closure, returned to the area of the hatchery after the second closure, and then returned to the White Salmon River. Overall, the most likely recovery of a tagged tule fall Chinook salmon was either at Spring Creek NFH or the White Salmon River. Movements or recoveries of tagged tule fall Chinook salmon outside these two locations was very low.

Management Implications and Future Operations

Condit Dam, located 3 miles from the confluence of the White Salmon River with the Columbia River, is slated for removal during October of 2008. Removal of Condit Dam will increase spawning habitat for adult salmon in the White Salmon River (Normandeau Associates 2004). Spring Creek NFH tule fall Chinook salmon are one of the stocks identified for reintroduction when the dam is removed (USFWS 2004).

To answer questions to the relatedness of Spring Creek NFH stock with any naturally produced tule fall Chinook salmon in the White Salmon River, a large cooperative project was proposed and is currently under review within the Northwest Power Planning and Conservation Council (NWPPC Proposal - 200712200). During 2006 and 2007, a rotary trap is being operated by the U.S. Geological Survey during the fall Chinook salmon outmigration in the White Salmon River to collect genetic samples for future analysis and to estimate Chinook salmon production. The results of the proposed study and smolt trapping project would determine the applicability of using Spring Creek NFH stock in restoration efforts within the White Salmon River. This information is not currently known and would benefit planning and future conservation efforts in the White Salmon River both before, and after, removal of Condit Dam.

Acknowledgements
This assessment was possible from funding provided by the U.S. Army Corps of Engineers – Portland District and project support from NOAA-Fisheries. Cooperation between Washington Department of Fish and Wildlife, Pacific States Marine Fisheries Commission and the U.S. Fish and Wildlife Service was integral in completing this assessment. Special thanks to Spring Creek NFH staff for tag recovery and additional record keeping needed for this assessment.

Literature Cited

Normandeau Associates. "White Salmon Subbasin Plan". In Draft Intermountain Subbasin Plan, prepared for the Northwest Power and Conservation Council. Portland, Oregon, May 2004.

USFWS (U.S. Fish and Wildlife Service). 2004. Hatchery and Genetic Management Plan – Spring Creek National Fish Hatchery: tule fall Chinook (*Oncorhynchus tshawytscha*). Submitted to NOAA-Fisheries Sustainable Fisheries Division.

This assessment addresses U.S. Fish and Wildlife Service objectives relating to operation, monitoring and evaluation of Spring Creek National Fish Hatchery tule fall Chinook salmon program. This assessment also addresses Performance Standards and Indicators identified within the Spring Creek National Fish Hatchery, Hatchery and Genetic Management Plan (2004) submitted to NOAA-Fisheries Sustainable Fisheries Division.

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