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On the cover: Official visitor sign welcoming you to Warm Springs National Fish Hatchery, Oregon. USFWS Photograph.

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Abstract.-
Since start of production in 1978, Warm Springs National Fish Hatchery (NFH) has been managed with the goal of maintaining the stock integrity and genetic diversity of hatchery and wild spring Chinook salmon populations in the Warm Springs River, Oregon. The primary method identified to accomplish this is by regularly using wild fish in the hatchery broodstock. Due to low wild fish returns (<1,000 fish) in recent years, wild fish have not regularly been incorporated into the hatchery broodstock. The absence of wild fish in the hatchery broodstock greatly impacts the hatchery's ability to maintain wild fish genetic characteristics in the hatchery population. In 2010 we evaluated the feasibility of using live-spawned wild males to provide a genetic contribution to both the hatchery broodstock and natural production by live-spawning five wild males and releasing the fish back into the Warm Springs River. Milt was collected from four of the five males, however the amount of milt collected was generally smaller (2-3 ml vs >10 ml) than during the typical spawning process. The five males were radio-tagged and released into the Warm Springs River to swim volitionally upstream of the hatchery. While one fish never left the hatchery ladder after spawning and tagging, the four other tagged fish migrated 21-30 rkm upstream of the hatchery. We concluded that these fish could have contributed to natural spawning in the Warm Springs River basin. Overall, it appears that live-spawning of wild males may be a feasible method to include wild genetics into the hatchery broodstock while not compromising the overall wild production, although the amount of genetic contribution to both the hatchery and wild populations was not quantified. A more comprehensive evaluation is needed before such an action can be recommended as a regular hatchery practice.

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Introduction

Since start of production in 1978, Warm Springs National Fish Hatchery (NFH) has been managed with the goal of maintaining the stock integrity and genetic diversity of hatchery and wild spring Chinook salmon populations in the Warm Springs River, Oregon (CTWSRO and USFWS 2007). On average, the goal of the hatchery is to have 10% of the hatchery broodstock be of wild fish origin, using a sliding scale for wild fish retention based on projected wild fish returns. A predicted wild escapement of more than 1,000 adults is needed before wild fish can be incorporated as hatchery broodstock. Due to low wild fish returns, no wild fish have been incorporated into the hatchery broodstock since 2004. The absence of wild fish in the hatchery broodstock greatly impacts the hatchery's ability to maintain wild fish genetic characteristics in the hatchery population. Alternative methods for maintaining wild fish genetic traits may be necessary at Warm Springs NFH.

Male spring Chinook salmon are able to naturally spawn multiple times with multiple females (Baumsteiger et al. 2008). The feasibility of live spawning wild males at the hatchery, and then releasing these males to migrate up to the natural spawning grounds in the Warm Springs River is unknown. If live spawned males can provide a genetic contribution to both the hatchery and wild stocks, there may be potential for live spawning wild males during years of low wild returns, allowing for some level of wild fish gene flow to be maintained in the hatchery population.

In 2010, over 1,500 wild spring Chinook salmon returned to the Warm Springs River. According to the sliding scale, up to 75 wild fish were to be retained in the hatchery brood ponds and spawned with the hatchery stock. A study plan was put into place to take advantage of this opportunity and determine the feasibility of live spawning a small number of wild males. The objective of this feasibility study was to determine if wild males could be live spawned at the hatchery, released, and migrate to natural production areas in the Warm Springs River.

Study Area

Warm Springs NFH is located at river kilometer (rkm) 18 on the Warm Springs River, within the Warm Springs Indian Reservation, in north-central Oregon. The Warm Springs River enters the Deschutes River at rkm 135, which enters the Columbia River 329 rkm from the Pacific Ocean. The Warm Springs River has a drainage area of 1,364 km^2 (526.6 mi^2) with a mean discharge of 16.8 m^3/s (595cfs) near the mouth (Lovtang and Baker 2013).

Methods

The hatchery broodstock was collected according to guidelines outlined in the Operational and Implementation Plan (CTWSRO and USFWS 2007). Approximately 75 wild fish were collected proportionally throughout the run for inclusion in the hatchery brood ponds. The first hatchery spawn took place on August 19, 2010. During the second spawning event, on August 26th, five wild (unmarked) males were selected from the hatchery brood pond and placed into a holding net in the hatchery ladder waterway. Fish were anesthetized until equilibrium was lost in a solution containing tricaine methanesulfonate (MS-222). Anesthetized fish were lifted out of the tank and squeezed to extract milt for spawning. Milt was placed into a plastic bag and brought into the hatchery spawning room. A radio-tag was then gastrically inserted following the methods outlined in Conder et al. (2010), and the fish was placed into the hatchery ladder waterway. No scale samples were collected from the males, however all of the males were of adult size (Table 1). After tagging, the males were allowed to recover in the upstream end of the hatchery fish ladder and volitionally exit into the Warm Springs River.

As part of a separate study looking at the distribution of wild fish in the Warm Springs River, aerial telemetry flights were conducted on September 9th and September 22nd. During the telemetry flights, an SRX600 Lotek receiver and antenna were used to scan for radio-tags. The flights originated in the town of Madras, and continued along the Deschutes River from approximately the mouth of Trout Creek to the mouth of the Warm Springs River. At the mouth of the Warm Springs River, the plane tracked up the Warm Springs River, Beaver Creek, and Mill Creek. Locations of radio-tags were recorded automatically using a built-in GPS system in the Lotek receiver. In addition, a fixed-site telemetry station was located just downstream of the hatchery to detect any tagged fish moving downstream after tagging. Radio tags were programmed to send out a "mortality" code if the tag did not move for a 24hr period. If the tag moved subsequent to sending out a mortality code, the code would revert back to a regular code.

Results and Discussion

Milt was collected from four of the five live spawned males, however the amount of milt collected was generally smaller (2-3 ml vs >10 ml) than during the typical spawning process. No milt was successfully collected from one male. The live spawned males were not relaxed and appeared to tense up during milt extraction. Since this was the first attempt at live spawning wild males, a light dosage of anesthetic was used which may have limited the amount of milt extracted. If live-spawning is attempted in the future, the anesthetizing process would need to be refined. Also, staffing requirements would need to be considered as this process was being performed at same time as other operations without increasing staff levels. Staff would need to be specifically dedicated to the spawning and recovery of live fish.

Final locations of radio-tags are summarized in Table 1 and Figure 1. One live spawned male (radio code 21) was found in the hatchery ladder recovery area on September 1st. This fish apparently never left the hatchery area. The fish was removed from the ladder and spawned according to standard hatchery spawning procedures (i.e. killed and milt removed). No live

spawned males were detected passing downstream of the hatchery at the fixed-site telemetry station. The first telemetry flight after the live spawning and radio-tagging occurred on September 9th, thirteen days post tagging. During this flight, three of the four remaining radio-tagged fish were detected at the following locations:

(1) code 16 was sending out a mortality signal and was located in the Warm Springs River approximately 1 rkm downstream of the confluence of Badger Creek (~25 rkm upstream from the hatchery),
(2) code 23, was also sending out a mortality signal and was in the Warm Springs River approximately 2 rkm upstream from the confluence of Badger Creek (~28 rkm upstream from the hatchery), and
(3) code 25 located in Beaver Creek, approximately 7.5 rkm upstream from the confluence with the Warm Springs River (~ 21 rkm upstream from the hatchery).

During the second telemetry flight on September 22nd, twenty-six days post tagging, the fourth remaining radio tag was located. Code 30 was sending out a mortality signal, located in Beaver Creek, 13 rkm upstream of the confluence of the Warm Springs River (~30 rkm upstream from the hatchery). During the flight on the 22nd, codes 16 and 23 were again sending out mortality signals and were located in the same areas as on the flight on the 9th. Code 25 was not located during the flight on the 22nd.

While one fish never left the hatchery ladder after spawning and tagging, the four other tagged fish appeared to migrate quickly upstream above the confluence of Beaver Creek. The presumption is that these fish would have been able to contribute to natural spawning in the Warm Springs River basin if they were able to find suitable mates. The fact that three of the radio-tags were sending out mortality codes should be viewed with caution. The sensitivity of the tags to movement may not have been sufficient to accurately reflect the status of the fish. For example, in the concurrent radio-telemetry study on wild fish, several tags were sending out mortality signals and subsequently switched back to sending out “live” signals.

Table 1. Summary of radio-tags placed into live spawned wild spring Chinook salmon males at Warm Springs NFH in 2010.

Code	Fork Length (cm)	Location Sept 9 (rkm upstream of hatchery)	Location Sept 22 (rkm upstream of hatchery)	Comment
16	79	WS River, just downstream of Badger Cr. (25 rkm)	WS River, just downstream of Badger Cr. (25 rkm)	"mortality" signal
21	74	--	--	Never left hatchery ladder
23	77	WS River, just upstream of Badger Cr. (28 rkm)	WS River, just upstream of Badger Cr. (28 rkm)	"mortality" signal
25	84	Beaver Cr (21 rkm)	Not located	
30	82	Not located	Beaver Cr (30 rkm)	"mortality" signal

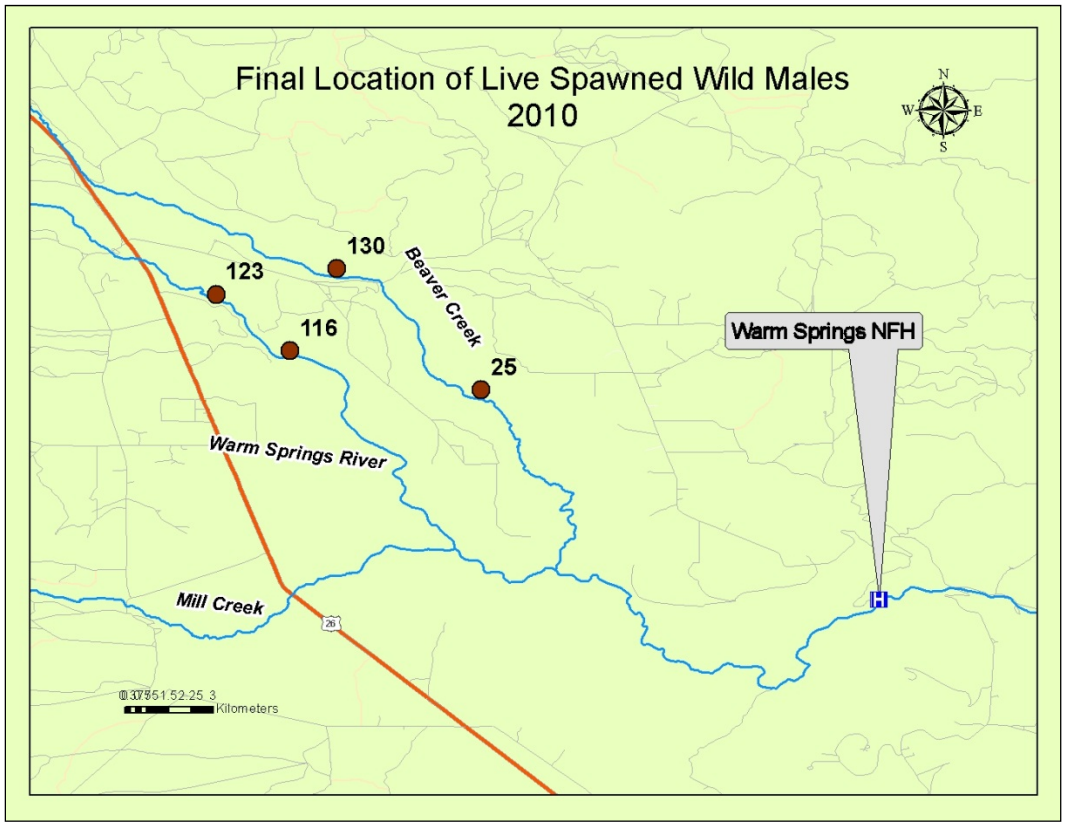

Figure 1. Location of radio-tags placed into live-spawned wild male Spring Chinook salmon at Warm Springs NFH. Live-spawning and tagging took place on August 26th, aerial telemetry flights took place on September 9th and September 22nd, 2010. A one in front of the code indicates the tag was sending out a mortality signal.

Management Implications and Recommendations

Overall, it appears that live-spawning of wild males may be a feasible method to include wild genetics into the hatchery broodstock while not compromising the overall wild production, although in our study the actual genetic contribution to both the hatchery and wild populations was not quantified. A more comprehensive evaluation is needed before such an action can be recommended as a regular hatchery practice. Future evaluations should consider the following:

- Level of genetic contribution of live-spawned males to the hatchery broodstock
- Level of genetic contribution of live-spawned males to the wild population
- Examining potential differences between holding early returning males in brood ponds until spawning time versus live-spawning of late arriving males
- Investigate ways to identify early-returning males (prior to development of external sexual characteristics)
- Verification of survival of live-spawned males in the wild spawning grounds
- Identification of fish health protocols for minimizing disease transmission
- Risks and benefits of male-only wild genetic contribution to hatchery broodstock
- Modifications to live-spawning procedures, for example redesign of live-spawning holding area/tank, additional personnel needs, tracking system for milt contribution to hatchery broodstock, fish health sampling, etc.

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Roger Sorenson and his staff at Warm Springs National Fish Hatchery initially proposed the study idea and provided valuable assistance in implementing this study. Mark Manion and CTWSRO staff assisted with radio telemetry surveys. This study was funded by the U.S. Fish and Wildlife Service.

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