Preliminary Summary of Out-of-Basin Steelhead Strays in the John Day River Basin

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Introduction

The John Day River, located in northeastern Oregon (Figure 1), is unique in that it supports one of the last remaining wild populations of summer steelhead *Oncorhynchus mykiss* and spring Chinook salmon *O. tshawytscha* in the Columbia River Basin. No hatcheries nor hatchery supplementation occur in the basin and there are no hatchery releases of fish of any species into any flowing waters in the John Day River system. In 1999, the National Marine Fisheries Service (NMFS) listed the Middle Columbia River summer steelhead Distinct Population Segment (DPS), which includes John Day River summer steelhead, as threatened under the Endangered Species Act (ESA).

The Interior Columbia Technical Recovery Team (ICTRT) has determined that out-of-DPS hatchery strays pose a significant risk to many of Oregon's Mid-Columbia steelhead populations, particularly to the Deschutes and John Day populations (Carmichael and Hoffnagle 2006, Carmichael 2009). Viability assessments have identified that a significant proportion of spawners in the Deschutes and John Day River populations were out-of-DPS strays. In addition, these populations were rated at high risk for spawner composition due to the abundance of strays. Biologists remain especially concerned regarding the continuing detrimental impact of stray hatchery fish on the genetic traits and productivity of natural populations (Reisenbichler and Rubin 1999, Chilcote 2003, Carmichael 2009).

Stray hatchery steelhead have been observed in the John Day River since 1986 (ODFW 2007). Strays have been identified by the observation of fin-clipped adults on spawning grounds and the harvest of fin-clipped adults in fisheries. Until recently, identification of the source of these strays has relied on the collection and identification of coded-wire tags from harvested and collected fish. The recent operation of a Passive Integrated Transponder (PIT)-tag antenna array at McDonald Ford (rkm 33) has provided additional opportunity to monitor both the relative number and source of PIT-tagged fish entering the John Day River. This paper provides a preliminary summary of the known information concerning the abundance, distribution, and source of out-of-basin strays of primarily summer steelhead but also spring Chinook salmon in the John Day River basin.

Study Area

The John Day River drains 20,300 km2 of east central Oregon, the third largest drainage area in the state (Figure 1). From its source in the Strawberry Mountains at an elevation near 1,800 m, the John Day River flows 457 km, to an elevation near 90 m, to the Columbia River. It enters the Columbia River at river kilometer (rkm) 351 in the John Day Pool approximately 4 km upstream of the John Day Dam. The basin is bounded by the Columbia River to the north, the Blue Mountains to the east, and the Ochoco Mountains to the west. Five populations of summer steelhead and three populations of spring Chinook are currently recognized in the basin. The five steelhead populations in the John Day River (Lower John Day, Upper John Day, North Fork, South Fork, and Middle Fork), as determined by the Interior Columbia Technical Recovery Team (ICTRT 2005), are part of the Mid-Columbia steelhead DPS.

Methods

Spawning Ground Surveys

Index spawning ground surveys for both summer steelhead and spring Chinook have been conducted since 1959 to monitor the long-term trends in their spawning populations. Index survey reaches were not selected randomly and therefore, do not provide adequate information for assessing the status or abundance of these populations. Beginning in 2004, ODFW implemented a spatially balanced, probabilistic survey of steelhead spawning activity in the basin to better monitor both population trend and status (Wiley et al. 2005). Since 2000, spring Chinook spawning ground surveys conducted by ODFW census the entire known distribution of spring Chinook in the basin (Wilson et al. 2005). Each of these surveys observe adult fish on spawning grounds either as live adults (primarily steelhead) or carcasses (primarily Chinook).

PIT-tag monitoring

The PIT-tag antenna array at McDonald Ford, at river mile 20, on the John Day River was operational beginning in September 2007. This array was installed by Biomark, Inc. and NMFS as a test to determine the efficacy of this type of antenna array on a large stream system. Detections from this antenna can be queried at near real time using the PIT-tag information system (PTAGIS) data set. The detection efficiency of the antenna is as yet unknown but an ongoing study by NMFS suggests an efficiency of 86% at low flows typically encountered by adult steelhead during autumn and winter migrations. Without knowing the actual efficiency, we can only determine a preliminary estimate of the minimum number of tagged fish migrating past the antenna. However, we can compare the relative numbers of PIT-tagged fish being detected from known PIT-tag groups released in the Snake and Columbia rivers. PIT tags have been used since 1987 to monitor the movement and behavior of anadromous salmonids in the Columbia and Snake River basins. ODFW began PIT tagging natural-origin Chinook and steelhead in the John Day River basin in 2002 and currently targets 3-4,000 smolts of each species for tagging each year.

Results and Discussion

Spawning Ground Surveys

Index spawning ground surveys conducted annually since 1959, have indicated a significant decline ($P < 0.001$) in steelhead redd density while spring Chinook have shown a general but not significant ($P = 0.32$) increase in redd density throughout the basin (Figure 2). It is unclear why steelhead density has shown a significant decrease while Chinook have shown a general increase however, hatchery strays may be influencing the productivity of steelhead populations. Out-of-basin strays of both steelhead and spring Chinook have been consistently observed on spawning ground surveys in the John Day River for some time but the proportion of strays appears to be much greater for steelhead. Recently, we have begun to quantify the proportion and number of hatchery strays within the John Day River basin.

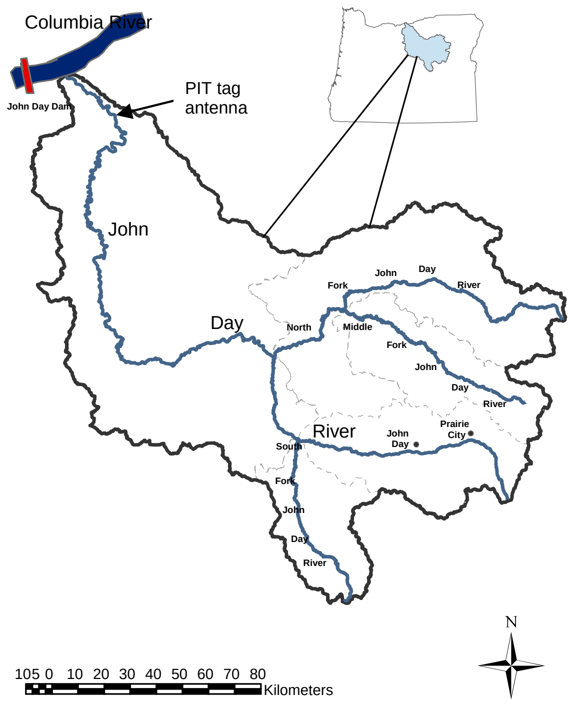

Figure 1. Map of John Day River basin showing the location of the PIT-tag antenna.

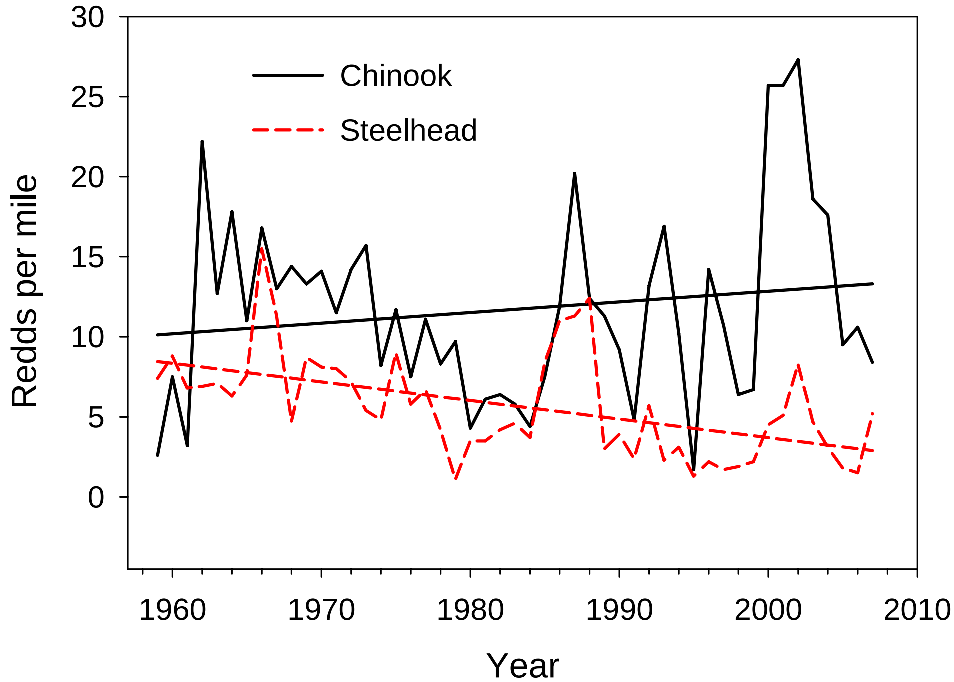

Figure 2. Trend in redd densities from index spawning ground surveys conducted in the John Day River basin, 1959-2007. Linear regression lines are fit to each data set.

A small proportion of spawning spring Chinook in the John Day River basin appear to be out-of-basin hatchery strays. Of the 7,576 carcasses of spring Chinook examined on spawning ground surveys in the John Day River basin since 2000, 146 (1.9%) were identified as hatchery (fin clipped) strays. Since 2002, of the 22 fin-clipped Chinook carcasses that had coded-wire tags, all but two originated from Snake River stocks.

Recent evidence has indicated that a significant proportion of the spawning steelhead populations in the John Day River subbasin is composed of hatchery strays (Wiley et al. 2005). Since 1992, 5% of the adult steelhead observed on index spawning ground surveys had adipose fin clips (Table 1). Since 2000, 23% of adult steelhead captured in seines and rotary screw traps had adipose fin clips. Beginning in 2004, EMAP spawning ground surveys conducted throughout the basin have indicated that 27% of the live steelhead observed on spawning grounds had adipose fin clips and were therefore, out-of-basin hatchery strays. Hatchery steelhead composed 35% of live steelhead observed on EMAP surveys in the John Day River basin in 2007 where the presence (unmarked, presumed wild) or absence (marked, presumed hatchery) of an adipose fin could be determined. Many of these fish observed on spawning ground surveys were observed in the Lower John Day River, however, seining and trapping efforts were concentrated above the lower mainstem habitat and the composition of adult steelhead captured there was 37%—very similar to the EMAP composition. Since 2007, the proportion of hatchery-origin spawners appears to have declined in each subsequent year (Figure 3). This decline has coincided with a similar decline in the number of smolts transported from Snake River Dams (DART).

We estimate that thousands of hatchery steelhead are entering and spawning in the John Day River. Using the ratio of marked and unmarked steelhead (19% and 81%, respectively) observed on all surveys during 2007, and the spawner escapement estimate of 8,689 adults (95% CLs = 5,939 and 11,439), we estimate that 1,664 hatchery-origin steelhead spawners were present on John Day River spawning grounds during 2007. Using a similar approach, we estimate that 829 and 461 hatchery-origin spawners were present on spawning grounds in the John Day River during 2008 and 2009, respectively (Table 2).

Coded-wire tags recovered from hatchery steelhead collected on spawning grounds and from fisheries indicate that the majority of identifiable out-of-basin strays entering the John Day River originate from Snake River stocks (Wiley et al. 2005, Carmichael and Taylor 2007). Of the ten known origin, hatchery steelhead strays collected on spawning grounds in the John Day River since 1988, all were from Snake River stocks as identified from their coded-wire tags. Most (98%) of the 323 coded-wire tags recovered from fisheries in the John Day below Tumwater Falls from 1992–2003 were also from Snake River stocks. Five tags were from fish released in the Umatilla River. Similarly, 96% (68 of 71) of the coded-wire tags recovered in fisheries above Tumwater Falls since 1986 originated from Snake River hatchery releases.

Table 1. Annual number of fin-marked (hatchery) and unmarked (natural) adult steelhead observed on spawning ground surveys (Index, EMAP) and while seining and trapping smolts (trapping) on the John Day River since 1992.

	Marked			Unmarked		
Year	Index	EMAP	Trapping	Index	EMAP	Trapping
1992	1			112		
1993	1			18		
1994	0			8		
1995	0			4		
1996	2			7		
1997	0			8		
1998	0			1		
1999	0			17		
2000	0		1	24		11
2001	0		2	77		8
2002	16		13	173		20
2003	2		2	27		11
2004	1	13	6	12	21	16
2005	1	2	4	15	5	8
2006	4	8	5	22	11	8
2007	1	15	1	38	28	10
2008	2	3	1	28	14	19
2009	0	3	5	55	41	24
Total	31	44	40	646	120	135

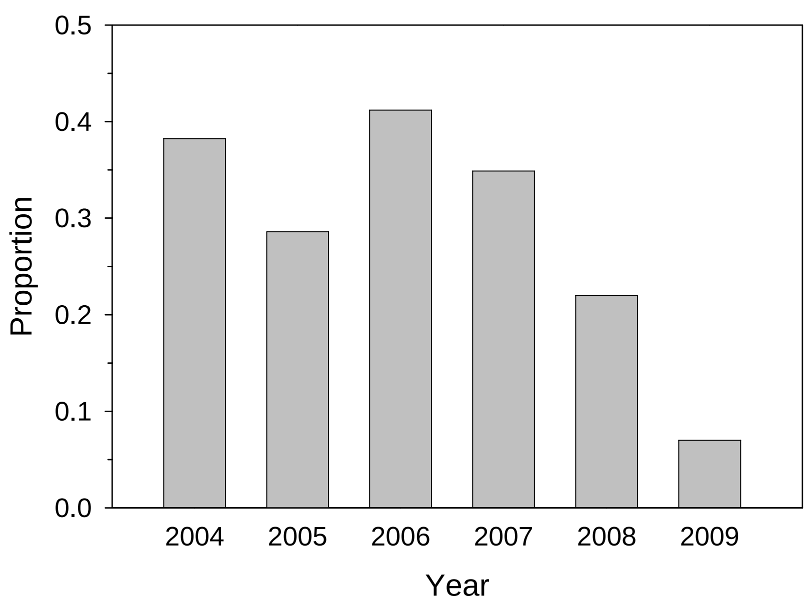

Figure 3. Proportion of steelhead spawners observed during EMAP spawning surveys in the John Day River subbasin that were identified as hatchery origin from 2004 to 2009.

Table 2. Estimated total number of redds, fish per redd estimate from Deer Creek, and spawner escapement with 95% C.I., proportion of observed spawners with adipose clips, and estimated hatchery escapement for the John Day River basin from 2004 to 2009.

Year	Total Redds	Fish/Redd	Spawner Escapement	Hatchery Fraction	Hatchery Escapement
2004	3,071	1.46	4,484 (1,657-7,310)	0.31	1,394
2005	1,681	2.20	3,698 (1,261-6,137)	0.22	822
2006	3,202	1.66	5,315 (2,189-8,441)	0.28	1,506
2007	7,758	1.12	8,689 (5,939-11,439)	0.19	1,664
2008	2,277	4.07	9,260 (4,742-13,775)	0.09	829
2009	1,934	3.81	7,368 (3,642-11,099)	0.06	461

PIT-tag monitoring

During the 2007 adult migration, there were 90 detections of PIT-tagged steelhead at the antenna installed on the John Day River at McDonald Ford. Forty of these detections were John Day River fish and 33 were of out-of-basin hatchery fish. The remaining 17 were out-of-basin fish that were unmarked and presumably natural origin. All but one of these out-of-basin hatchery and natural PIT detections of steelhead at McDonald Ford were Snake River origin fish.

NOAA has been PIT tagging steelhead smolts collected at Lower Granite Dam on the Snake River since 2001 as part of a transport survival study. Transportation history of PIT-tagged steelhead can be difficult to determine unless they were part of a transport study. Forty five of the 50 (90%) strays detected at McDonald Ford during this adult migration were from the NOAA transport study. Four of the 50 strays were from Snake River stocks with unverified transport history but some of these were also likely transported. The only other out-of-basin fish detected was captured and PIT tagged and then released as a fall-back adult at Priest Rapids Dam during the summer of 2007. Due to tagging as an adult, the origin and transport history of this fish is unknown. Of all known transport history fish detected at McDonald Ford (45), only one was not transported from Lower Granite Dam. It was a return to the river fish released as part of the transport study at Lower Granite Dam. However, it appears that even this fish was later transported at Lower Monumental Dam. Similarly, all detections of these transport study fish during 2008 and 2009 at the McDonald Ford antenna were transported as smolts.

A comparison of LGRRBR (Snake River transported; BR) tag codes with LGRRRR (Snake River return to river; RR) tag codes detected at McDonald Ford indicated a significantly greater proportion of transported fish strayed into the John Day River (z-test, $z = 2.27$, $P = 0.024$) compared to the return to the river group during the 2007 adult migration year. Group size was determined as the number of unique group detections of returning adults at Bonneville Dam. Proportion is the rate of detection of these tags at JD1 (McDonald Ford array, John Day River). BR = 44/1259 = .0349, RR = 1/228 = .0044. Although transported fish strayed at higher rates than non-transported, hatchery and wild transported fish strayed into the John Day River at similar rates to each other (z

= 0.856, P = 0.392). This comparison includes only adult steelhead detections from 2007–2008 as of 4/15/2008. However, during the 2008 and 2009 adults migration years, no return to the river fish were detected at the McDonald Ford array despite the detection of 83 transported adults (Table 3). Without significant additional work, it is not possible to include the other tag groups of Snake River origin fish for a transport/no transport comparison because it is difficult to determine their transport history unless they were part of this transport study.

Some of the out-of-basin strays detected at McDonald Ford apparently migrated back downriver and exited the John Day River because they were detected on separate dates at the antenna. During this initial year, twelve of the 50 out-of-basin fish were subsequently detected again at the McDonald Ford antenna suggesting they migrated back out of the John Day. However, several of these fish migrated out after the spawning season started on the John Day River (suggesting they may have spawned) and only three were subsequently detected migrating back upstream on the Columbia and Snake rivers. Further, of the 37 unique detections of transported fish at McDonald Ford during 2008, 81% were fish that had previously fallen back from McNary Dam or further upriver of the mouth of the John Day. At least two of these fish fell back over both Ice Harbor and McNary dams and subsequently entered the John Day River.

Table 3. Detections of adult steelhead from two tag groups from the NOAA transport study. Tag codes include: LGRRBR (Snake River transported; BR) and LGRRRR (Snake River return to river; RR).

Migration Year	Bonneville Dam		Sherars Falls		McDonald Ford	
	LGRRBR	LGRRRR	LGRRBR	LGRRRR	LGRRBR	LGRRRR
2007	1,254	227	74	1	45	1
2008	2,196	239	--	--	38	0
2009	3,424	654	185	4	59	0

During the 2009 adult migration year, NMFS has developed a preliminary estimate of the detection probability of the McDonald Ford array on the John Day River using a double-tag approach. Adults were captured in the John Day below the antenna by angling and tagged with both a PIT tag and a radio telemetry tag (Sandy Downing, unpublished data). This study indicated that the PIT array was 86% efficient at detecting adults as they migrated past the antenna during low flows but likely lower during higher flows. Using this detection probability, and the number of out-of-basin adults detected, a preliminary minimum estimate of 219 adults from the Snake River tag groups entered the John Day River since 2007 when the antenna was installed. This estimate should be further expanded to estimate the number of all adults represented by these tag groups but we currently lack some of this information. However, the actual number is likely 1-2 orders of magnitude greater than the estimate of 219 PIT-tagged adults. Millions of smolts are transported each year from the Snake River while only 4-5% of these are PIT tagged as part of the transport study.

PIT tag detections at Sherars Falls on the Deschutes River during 2007 show similar results to John Day detections at McDonald Ford (Table 2). All but one detection of out-of-basin fish were from Snake River stocks during 2007. This lone detection was a John Day River origin fish. Seventy-five detections were transported fish from the NOAA transport study. All but one of these was transported from Lower Granite Dam. A comparison of the proportions of these tags detected at Sherars Falls (Table 2) indicates a significantly greater proportion of transported fish strayed into the Deschutes River past Sherars Falls during 2007 (z-test, $z = 3.32$, $P < 0.001$) and again during 2009 (z-test, $z = 5.25$, $P < 0.001$). When comparing the proportions of PIT-tagged transported fish from the NOAA transport study and wild fish from the John Day (the only known non-transported tag group detected at Sherars Falls) that were previously detected at Bonneville Dam during 2007, there was a significantly greater proportion of these known transported fish (z-test, $P = 0.04$) detected at Sherars Falls. We only use the John Day fish for this comparison because this was the only known, non-transport history tag group detected at Sherars Falls during 2007.

Conclusions

Out-of-basin strays appear to be a significant component of the steelhead spawning population in the John Day River basin. Evidence from tags suggests that most of these fish originate from Snake River stocks and that many of these are straying hatchery fish. Further, PIT tag detections indicate significantly more transported steelhead from the Snake River stray into the John Day River compared to fish that emigrated to the ocean without the aide of barge transport.

It is still unclear why steelhead density has shown a significant decrease in the John Day River while Chinook have shown a general increase, however, out-of-basin hatchery strays may be influencing the productivity of steelhead populations in the John Day River. Chilcote (2003) has shown that a spawning population composed of 50% hatchery fish has a productivity that is only 63% of one composed of only wild fish. This suggests that the current mixture of spawning steelhead in the John Day River basin has lower productivity as a result of steelhead straying from out-of-basin hatchery stocks. If the proportion of hatchery spawners is significant as our results suggest, then this would help to explain the downward trend of steelhead redd density over the past 50 years.

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