Bull Trout Distribution, Movements and Habitat Use in the Umatilla River Basin

2013 Annual Progress Report

Prepared by:

Paul M. Sankovich
Donald R. Anglin
David M. Hines

Department of the Interior
U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office
1211 SE Cardinal Court, Suite 100
Vancouver, WA 98683

June 3, 2014

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Abstract

The goal of the U.S. Fish and Wildlife Service's studies in the Umatilla Basin is to provide information that can be used to develop recovery actions for bull trout *Salvelinus confluentus* listed as threatened under the Endangered Species Act. In 2013, our objectives were to 1) conduct an instream flow assessment to determine if the current minimum flow target for the Umatilla River (50 cubic feet per second [cfs] at the Dillon gage) is sufficient to provide passage for subadult and fluvial adult bull trout, 2) begin to evaluate bull trout and Pacific lamprey *Entosphenus tridentatus* passage conditions at instream diversion structures in the lower Umatilla River (lamprey were included because they are a priority species for the U.S. Fish and Wildlife Servide), 3) begin to construct a GIS-based recovery planning tool that describes current physical and hydrologic conditions in the Umatilla Basin and how they relate to spatial and temporal patterns of bull trout distribution and movement, and 4) continue to monitor the movement and origin of any bull trout trapped in the ladder at Three Mile Falls Dam (TMFD), near the mouth of the Umatilla River. We found the 50 cfs minimum flow target is likely sufficient to provide passage for subadult and adult bull trout in the reach of stream between Westland Dam and the Stanfield drain, a reach identified by local experts as likely to be the most limiting. We found no evidence the ladders at the instream diversion structures had ever been evaluated to determine if conditions within them were consistent with those anticipated based on the design of the ladders, or if the ladders were suitable for bull trout. Lamprey adult passage structures, or lamprey alternative passage structures (LAPS) had been added to Three Mile Falls, Maxwell, Dillon, and Feed Canal dams in recent years, and will be added to the remaining dams in the near future. Past evaluations of the fish screening and bypass facilities in the canals at the instream diversion structures had shown the rate of injury and delay in travel time of juvenile anadromous salmonids generally were within acceptable limits, as were the efficiencies of the screens in preventing fish passage into the canals. No evaluations were conducted using bull trout, but no evidence was provided indicating the results would have differed greatly for them. Evaluations for lamprey currently are being conducted by other agencies. We collected and began summarizing much of the information needed to construct the GIS-based recovery planning tool, which will be completed and available to managers by 2015. One bull trout PIT tagged at TMFD was not detected at any of the PIT tag detection sites in the Umatilla or the remainder of the Columbia Basin, so its movements were unknown. There also were no detections of bull trout either PIT tagged at TMFD (n=7) or already outfitted with a PIT tag when trapped at TMFD (n=1) in previous years. The genetic analysis required to identify the river of origin of the bull trout trapped in 2013 was not completed before the publication of this report.

Introduction

Bull trout *Salvelinus confluentus* were officially listed as a Threatened Species under the Endangered Species Act (ESA) in 1998. The U.S. Fish and Wildlife Service (FWS) subsequently issued a Draft Recovery Plan (U.S. Fish and Wildlife Service 2002) which included a chapter for the Umatilla-Walla Walla Recovery Unit (Chapter 10). This chapter was updated in 2004 (U.S. Fish and Wildlife Service 2004) and is the current guide for recovery actions in the Umatilla Basin. The goal of bull trout recovery planning by the FWS is to describe courses of action necessary for the ultimate delisting of this species, and to ensure the long-term persistence of self-sustaining, complex interacting groups of bull trout distributed across the species' native range (U.S. Fish and Wildlife Service 2004).

Bull trout in the Umatilla Basin exhibit two different life history strategies. Fluvial bull trout spawn in the headwaters and the juveniles rear there for one to four years before migrating downstream as subadults to larger main stem areas, and possibly to the Columbia River where they grow and mature, returning to the tributary stream to spawn (Fraley and Shepard 1989). Downstream migration of subadults generally occurs during the spring, although it can occur throughout the year (e.g., Hemmingsen et. al. 2001). These migratory forms occur in areas where conditions allow for movement from upper watershed spawning streams to larger downstream waters that contain greater foraging opportunities (Dunham and Rieman 1999). Stream-resident bull trout also occur in the basin, completing their entire life cycle in the tributary streams where they spawn and rear. Resident and migratory forms of bull trout may be found living together for portions of their life cycle, but it is unknown if they can give rise to one another (Rieman and McIntyre 1993). Bull trout size is variable depending on life history strategy. Resident adult bull trout tend to be smaller than fluvial adult bull trout (Goetz 1989). Under appropriate conditions, bull trout regularly live to 10 years, and under exceptional circumstances, reach ages in excess of 20 years. They normally reach sexual maturity in four to seven years (Fraley and Shepard 1989; McPhail and Baxter 1996).

When compared to other North American salmonids, bull trout have more specific habitat requirements. The habitat components that shape bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrates, and migratory corridors (U.S. Fish and Wildlife Service 1998). Throughout their lives, bull trout require complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Watson and Hillman 1997). Juveniles and adults frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). McPhail and Baxter (1996) reported that newly emerged fry are secretive and hide in gravel along stream edges and in side channels. They also reported that juveniles are found in pools, riffles, and runs where they maintain focal sites near the bottom, and that they are strongly associated with instream cover, particularly overhead cover. Bull trout have been observed over-wintering in deep beaver ponds or pools containing large woody debris (Jakober et al. 1998). Habitat degradation and fragmentation (Fraley and Shepard 1989), barriers to migration (Rieman and McIntyre 1995), and reduced instream flows have all contributed to the decline in bull trout populations in the Columbia River Basin.

In summary, bull trout need adequate stream flows and temperatures and the corresponding habitat for each of the different life history functions at specific times of the year in order to persist. Habitat conditions must be adequate to provide spawning, rearing, and migration opportunities, cover, forage, seasonal movement, and over-wintering refuges.

The goal of the FWS studies in the Umatilla Basin is to develop information and analyses to assist in assessing the relative merit of potential action strategies in making progress towards meeting the requirements outlined in the Umatilla-Walla Walla chapter of the Draft Recovery Plan (U.S. Fish and Wildlife Service 2004) for the recovery and delisting of bull trout. Specifically, FWS studies were designed to address the following recovery plan objectives:

- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and

- Conserve genetic diversity and provide opportunity for genetic exchange.

The habitat objective should be accomplished through a series of steps designed to restore and maintain suitable habitat conditions for all bull trout life history stages and strategies. The first step should consist of defining the physical conditions that comprise suitable bull trout habitat. The second step should be application of these habitat "criteria" to current conditions to determine the extent of the relevant stream that currently provides suitable habitat. The third step should consist of determination of the changes required to improve habitat in areas indicated in the recovery plan that do not currently provide suitable conditions. The fourth step should consist of implementing changes to restore and maintain suitable habitat conditions for all bull trout life history stages and strategies.

The genetic diversity objective should be accomplished by maintaining connectivity among local populations of bull trout to facilitate gene flow and genetic diversity. As the recovery plan discusses, connectivity consists of maintaining the fluvial component of each local population which includes providing conditions that allow fluvial adults to effectively move between spawning and wintering areas, and ensuring that movement of both fluvial adult and subadult bull trout can occur, at least seasonally, between local populations within each core area in the recovery unit. This includes establishing the physical conditions necessary for up- and down-stream fish passage, and providing a continuum of suitable physical habitat to ensure the persistence of fluvial life stages and provide the opportunity for genetic interchange between local populations within each core area.

The approach the FWS used to plan studies in the Umatilla Basin consisted of the following steps:

- Identify information needed to assess if criteria for recovery objectives are being achieved;

- To that end, design and implement studies to describe bull trout distribution, movement, and seasonal habitat use patterns;

- Use this information and results from these studies to assist in guiding actions that will make progress towards bull trout recovery.

We previously described what was known about the abundance, distribution, and migratory patterns of bull trout and potentially limiting physical conditions in the Umatilla Basin when we initiated our study there in 2004 (Anglin et al. 2008). To summarize, at that time, the only viable population of bull trout appeared to occur in the North Fork Umatilla River, and it appeared to be relatively small. Telemetry studies had shown fluvial adult bull trout did not migrate extensively, remaining within the upper Umatilla River and the North Fork to complete their life cycle (Sankovich et al. 2003, 2004; Oregon Department of Fish and Wildlife [ODFW], unpublished report). Little was known about the movement and seasonal distribution of subadults, but the available evidence suggested they also were not prone to undertake extensive migrations. Five bull trout had been captured in a ladder at Three Mile Falls Dam (TMFD) in the lower Umatilla River at river kilometer (rkm) 6 between 1995 and 2004. These fish were 254 to 330 mm in fork length (FL), indicating they were either subadults or first-time maturing adults when captured. Thus, assuming these fish originated in the Umatilla Basin, it appeared at least a small number of subadults produced there continued to migrate to and use the lower Umatilla and Columbia rivers. Although there were human impacts to the upper basin due to development, agriculture, and forest management, the major impacts occurred in the lower basin where there were six irrigation dams and diversions and sections of the river were sometimes dewatered seasonally. Five of the diversion dams had ladders, but they were designed for passage of salmon and steelhead, and it was not known if bull trout could negotiate them. The remaining diversion dam was passable without a ladder, except during periods of low flow, which coincided with unsuitably high stream temperatures for salmonids.

Between 2004 and 2013, the conditions in the Umatilla Basin that held the potential to negatively impact bull trout remained relatively unchanged. The population in the North Fork appeared to be small and stable or declining based on redd counts and mark-recapture abundance estimates (Budy et al. 2004, 2005, 2006, 2007, 2008, 2009; P.M.S., unpublished data). Because fluvial adult bull trout migrations had been studied previously and subadult migrations remained largely undescribed, we chose to focus on the latter when we began our study. Through 2009, we used a combination of trapping, snorkeling, telemetry, and fixed PIT tag detection sites to determine the subadult population was small and individuals exiting the North Fork (i.e., individuals migrating as subadults for the first time) remained within the upper 40 km of the Umatilla River during their first summer in it. We also determined some of these subadults and older subadults rearing in the upper Umatilla River undertook staged downstream migrations, for example, emigrating from the North Fork in spring and rearing in the Umatilla River for several months before again initiating downstream migration in fall. We observed no subadults utilizing the heavily impacted lower river. As a result, we were unable to describe the timing of use, seasonal distribution, and movement of subadults in the lower river and determine how subadults might be negatively affected by conditions there. Meeting those objectives seemed unlikely given the small size of the subadult population and the apparently low frequency with which subadults migrated to the lower river; therefore, in 2010, we transitioned to identifying potential bull trout spawning and rearing areas in the basin by conducting a patch analysis (FWS 2008) to begin to resolve uncertainty about the number and distribution of local populations. In 2010 and 2011, we collected water temperature data throughout the Umatilla Basin for use in the patch analysis, conducted the analysis to identify patches, and visited those we were unfamiliar with to eliminate any having no or insufficient stream flow. This process lead to the identification of seven patches, only one of which (the North Fork Umatilla River) was known to support a bull trout population. In 2012, we conducted bull trout occupancy surveys in five of the six remaining patches (the sixth was not sampled due to time constraints) and found no bull trout in any of them. Based on those findings and our professional judgment regarding the likelihood of the unsampled patch (Johnson Creek) supporting bull trout, we concluded the North Fork Umatilla River was the only stream in the basin likely supporting a viable bull trout local population.

Although our life history investigations were focused on subadult bull trout, larger, presumably mostly first-time maturing adults (all but one of 11 were between 300 and 400 mm FL) continued to be trapped occasionally at TMFD after we began our study, and we took advantage of this by tagging and collecting genetic samples from eight of them (those that could be handled under suitable stream temperatures) to identify their origin and fill in gaps in our knowledge of adult movement and distribution. We found all of these fish originated outside the Umatilla Basin, in the Walla Walla or Tucannon basins. A portion successfully negotiated the dams and ladders in the lower Umatilla River, and there was no indication the movements of the remainder were impeded by the dams and ladders. One individual, from the Walla Walla Basin, migrated onto the spawning grounds in the North Fork Umatilla River and was there during the spawning period, providing evidence for biological connectivity between populations in adjacent basins.

In addition to collecting stream temperature data for the patch analysis, we have been collecting existing data on other habitat conditions in the Umatilla River since 2010. This effort was undertaken so that we can relate physical conditions in and along the river to what is known about bull trout movements and distribution to identify potential limiting factors and provide information useful in the development, implementation, and evaluation of recovery actions.

For 2013, we established four objectives to be met over three years. The first was to conduct instream flow assessments in impacted sections of the Umatilla River. Water managers currently attempt to deliver a minimum flow of 50 cubic feet per second (cfs) to a gaging station downstream from Dillon Dam (rkm 40; hereafter termed the Dillon gage) during the irrigation season. The 50 cfs criterion was arrived at through professional judgment, and whether it was sufficient to provide fish passage had not been evaluated. There is currently a water rights settlement being negotiated between the Confederated Tribes of the Umatilla River Indian Reservation (CTUIR), the FWS, and other parties. Those negotiations could be better informed with an improved understanding of current flow and passage conditions in the Umatilla River, and those expected under various water management scenarios. In 2013, our objective for the instream flow assessment was to meet with local experts to identify the stream reach where passage conditions would most likely be limiting under the current management scenario, and to conduct a barrier survey in that reach at 50 cfs. As the irrigation season unfolded, it became evident water storage in McKay Reservoir was insufficient to maintain 50 cfs at the Dillon gage. Local managers determined that to minimize impacts to the various fish species in the lower Umatilla River, flow would be reduced to 10 cfs below Westland Dam (rkm 43) in July (with approximately 3 cfs of that being diverted to the Dillon diversion canal) then increased to 50 cfs at the Dillon gage in August. Stream temperatures in the reach of river between Westland Dam and the Stanfield Drain (rkm 35; approximately 10-20 cfs of inflow into the Umatilla River) are unsuitable for bull trout in July, with the exception of any cold water refuges. Thus, bull trout were unlikely to be impacted by the reduced flows. Migratory and juvenile Pacific lamprey *Entosphenus tridentatus* were more unlikely to be impacted, however, and since Pacific lamprey are viewed as a priority species by the CTUIR and FWS, we decided to conduct a general assessment of the impact of the reduced flows on Pacific lamprey and mesh the associated work with that in our first objective.

Our second objective was to evaluate bull trout and lamprey passage conditions at instream diversion structures, including Three Mile Falls, Maxwell, Dillon, Westland, Feed Canal, and Stanfield dams. As noted above, five of the dams (all but Maxwell Dam) have ladders, but they were designed for adult salmon and steelhead. All of the irrigation canals associated with the dams have screening and bypass facilities.

Our third objective was to construct a GIS-based recovery planning tool that describes current physical and hydrologic conditions in the Umatilla Basin and how they relate to spatial and temporal patterns of bull trout distribution and movement. This tool is intended to be a database of information that will link to relevant recovery actions to assist Ecological Services in moving forward with implementation of the Umatilla-Walla Walla recovery unit plan.

Our fourth objective was to continue to monitor the movement and origin of any bull trout trapped at TMFD. This included any bull trout trapped in 2013 and those trapped and tagged in previous years.

Methods

Instream Flow Assessment

To identify a stream reach in which to conduct an instream flow passage assessment, we consulted with local experts from the ODFW, CTUIR, Bureau of Reclamation (BOR), Umatilla Basin Watershed Council (UBWC), and Oregon Water Resources Department (OWRD). The consensus opinion was the most limiting reach under the current water management scenario would likely be in the 8 km of river between Westland Dam and the Stanfield Drain (Figure 1). Two of the local experts noted a 1.6 to 4.8 km reach downstream from Maxwell Dam (rkm 24) might also deserve consideration. For 2013, we chose to focus on the reach between Westland Dam and the Stanfield Drain.

We used methods similar to those of Thompson (1972) to identify critical areas (all riffles in our study) that did not meet minimum water depth and maximum water velocity criteria necessary for passage of trout (a surrogate for subadult bull trout), large trout (a surrogate for fluvial adult bull trout), and adult Chinook salmon *Oncorhynchus tshawytscha*. In that methodology, a riffle is deemed passable if 25% of its total wetted width and a continuous portion of at least 10% of its wetted width meet the minimum depth and maximum velocity criteria. Those criteria are 12 cm and 1.22 m/s for trout, 18 cm and 2.44 m/s for large trout, and

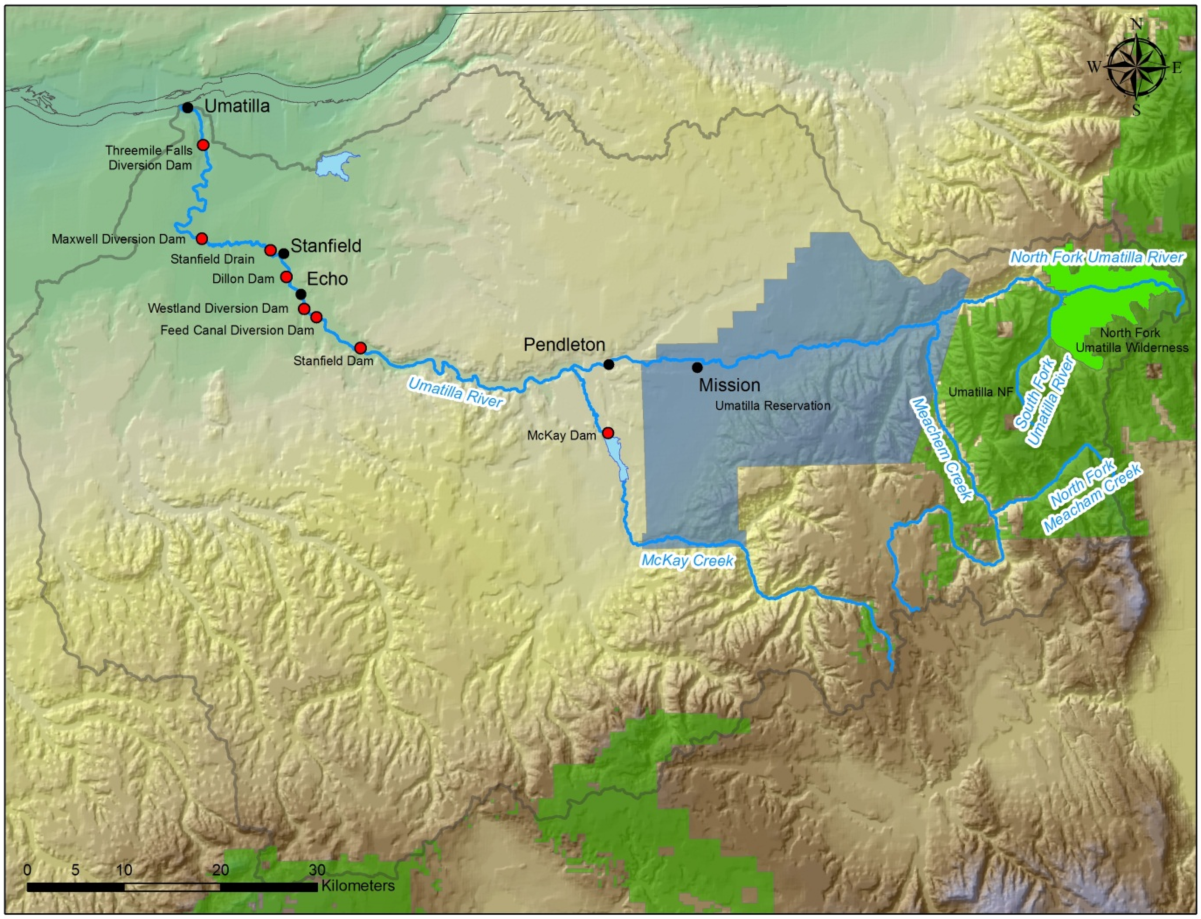

Figure 1. Location of instream diversion structures and other landmarks in the Umatilla Basin and the study reach between Westland Dam and the Stanfield Drain where fish passage surveys were conducted in July and August 2013.

24 cm and 2.44 m/s for adult Chinook salmon. Although Chinook salmon are not a focus of our study, we present information for them here because it may be useful to managers and required little additional effort to provide. We do not specifically address adult steelhead *O. mykiss* and coho salmon *O. kisutch*, which also occur in the basin, because the passage criteria for them are the same as for large trout (Thompson 1972); thus, our findings for fluvial adult bull trout are directly applicable to them. For a similar reason, we also do not specifically address trout-sized salmonids other than subadult bull trout that are present in the basin.

On 23-24 July, we conducted a reconnaissance survey between Westland Dam and the Stanfield Drain to identify riffles that appeared to have the potential to be barriers. During the survey, flows were between 12.34 and 25.55 cfs between Westland and Dillon dams (depending on the method of calculation; see below) and 8.78 cfs between Dillon Dam and the Stanfield Drain. We also assessed the impacts of the reduced flows on lamprey during the reconnaissance survey, noting any stranded or desiccated individuals and recording the location and estimated length and width (to estimate area) of Types 1 and 2 habitat (Slade et al. 2003) and the degree to which that habitat was de-watered.

Based on our results from the reconnaissance survey, we determined potential barriers were not so numerous as to require subsampling. Thus, on 29-30 July (under reduced flows) and 22-23 August (after flows had been restored) we measured the wetted width at each riffle identified as a potential barrier and collected water depth and velocity measurements at nine equally spaced points (stations) along a transect within the wetted width of the riffle. We also measured the depth and width of the thalweg. To determine if the water depth and velocity criteria were met, we assumed depth and velocity were constant from each station to the midpoints between it and the two adjacent stations (Figure 2). We also assumed there was no water depth or velocity between the stream margins and the midpoints between them and stations 1 and 9 (Figure 2). This assumption would be invalid if either of the margins was bounded by a physical structure (e.g., a rock wall) that created water depth at the margin, but there were no such physical structures at the riffles we sampled. Given the above assumptions, there were 10 “cells”, two half cells at the margins and nine cells between them (Figure 2), with assumed

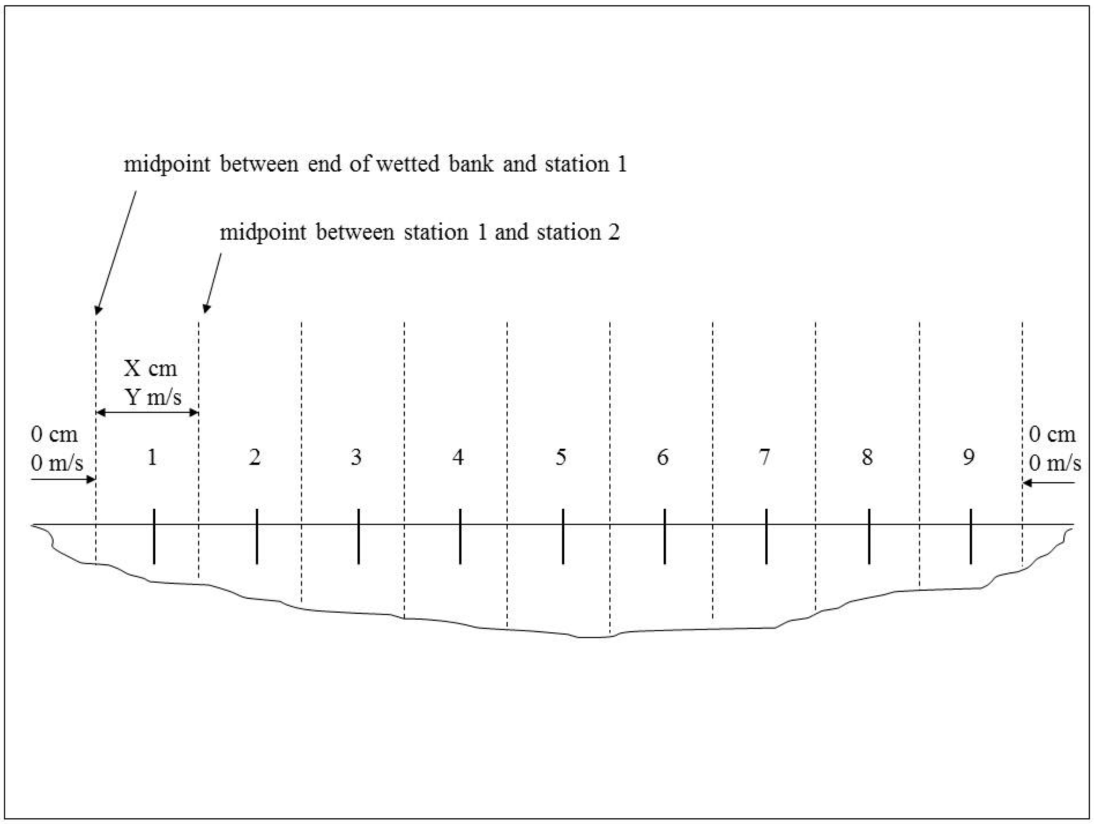

Figure 2. Schematic of a stream cross section where water depth and velocity measurements were taken at nine equally spaced stations along a transect within the wetted width of the stream, and “cells” (bounded by dashed lines) within which water depth and velocity were assumed to be constant and equaled the measurements taken at the midpoint of each cell. Water depth and velocity were assumed to equal zero between the end of each wetted bank and the midpoint between it and the adjacent station.

constant depth and velocity conditions within them along each transect. Thus, for a continuous portion of at least 10% the wetted width of each riffle to meet the minimum depth and maximum velocity criteria, those criteria had to be met in at least one of the 10 cells (or at one of the stations). As noted above, Thompson's (1972) other standard was for 25% of the total wetted width to meet the water depth and velocity criteria. Given our methodology, which resulted in there being 10 cells, we had to modify that standard to either 20% (2 cells) or 30% (three cells) of the total wetted width, and we chose the former.

We initially planned to conduct the barrier surveys at three different discharge levels so we could develop a relationship between discharge and the number of barriers present that might further inform water management in the future. However, water managers were not able to increase flows incrementally and provide us that opportunity.

To estimate discharge on the days we conducted the barrier surveys, we used data collected at gaging stations below Feed and Dillon dams and in the Westland and Dillon canals (Figure 3). Discharge between Westland and Dillon dams could be calculated in two ways, neither of which we knew to be most accurate: 1) by subtracting the discharge in the Westland Canal (WESO) from the discharge below Feed Canal Dam (UMUO) (method a), and 2) by adding the discharge in the Dillon Canal (DLEO) to the discharge below Dillon Dam (UMDO) (method b). We report results obtained using both methods of calculation herein. The discharge between Dillon Dam and the Stanfield Drain was simply the discharge recorded at the Dillon gage (UMDO).

Fish Passage at Instream Diversion Structures

In 2013, we limited our evaluation of fish passage at each of the diversion structures in the lower Umatilla River to determining what type of passage structures were present and whether any assessments had been conducted to determine if the passage structures were performing as designed. We will eventually relate diversion operations and upstream and downstream passage conditions at each site to passage criteria for bull trout and lamprey.

GIS-based Recovery Planning Tool

To collect existing data for the GIS-based recovery planning tool, we queried a number of sources, including but not limited to the CTUIR, ODFW, OWRD, U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (USACE), and our own agency. Our intent was to collect all the existing data we could locate on bull trout population status, trend, and distribution; the seasonal distribution and movement of migratory bull trout; water temperature, stream flow, and riparian conditions within the past decade; the locations of irrigation diversion structures, physical barriers, and flood control modifications; and soil types, land ownership and cover, and climate. To locate the data, we conducted internet-based searches and contacted personnel within the various agencies. We obtained FGDC metadata when available. Otherwise, we developed our own records to describe the data sets.

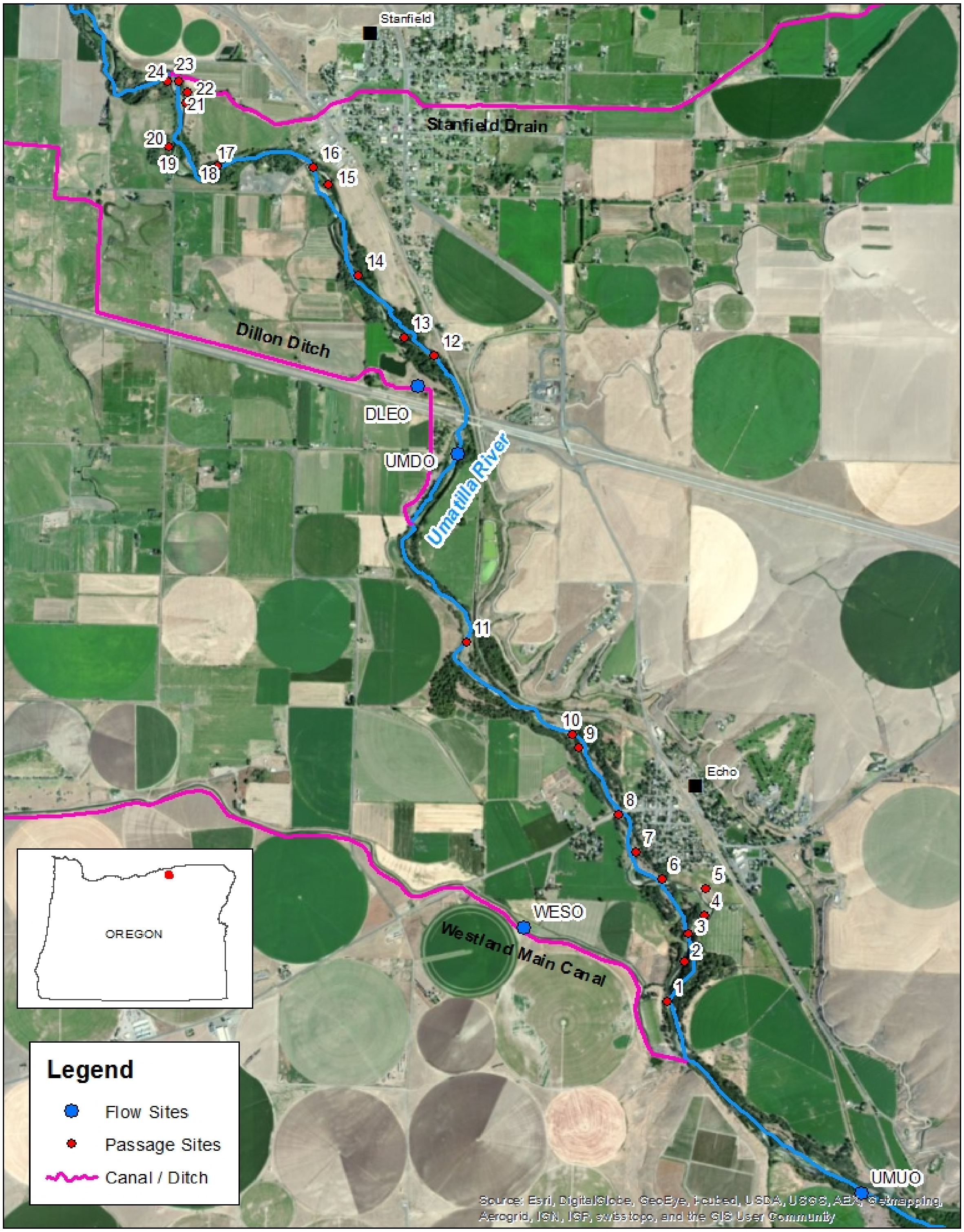

Figure 3. Location of sites where water depth and velocity measurements were taken (Passage Sites) in the Umatilla River during fish passage surveys in July and August 2013, and location of gaging stations (Flow Sites) used to determine stream flow in the Umatilla River below Westland and Dillon dams during the surveys.

Movement and Origin of Bull Trout Captured at Three Mile Falls Dam

Personnel from CTUIR and ODFW annually operate a fish trap in the east bank ladder at TMFD. We supplied them with the equipment and training needed to PIT tag and collect genetic samples from bull trout captured in the trap. The PIT tagging methods followed those described by Anglin et al. (2008), except the tags were inserted under the skin rather than in the abdomen through an approximately 4-mm wide incision made with a surgical blade anterior to the pelvic girdle and slightly off the mid-line. The PIT tags were 23-mm long. Duplicate fin tissue samples were collected from each fish for genetic analyses, to determine if they originated in- or outside the Umatilla Basin. The samples were stored in vials in 95% ethanol. All tagged fish were released in the pool upstream from TMFD following their recovery from anesthesia.

To monitor the movement of bull trout captured at TMFD, we queried the Pacific States Marine Fisheries Commission's PTAGIS data base to determine if bull trout PIT tagged at the dam were detected at any PIT tag detection sites in the Columbia River Basin. The detection site of primary interest on the Umatilla River was Feed Canal Dam, at rkm 45. Detection of fish there would indicate successful passage through all of the dams in the lower river, except for Stanfield Dam. Two routes of passage at Feed Canal Dam—a ladder and a notch in the dam—were outfitted with PIT tag antennas. Fish may also pass the dam by jumping it, but this appears to occur infrequently (B. Duke, ODFW, personal communication), so detection efficiency presumably was high.

Results

Instream Flow Assessment

During the reconnaissance survey on 23-24 July, we identified 13 riffles between Westland and Dillon dams and 11 riffles between Dillon Dam and the Stanfield Drain that were potential passage barriers under lower stream flows (Figure 3; Appendix Table A1). Based on the gaging station data, average daily discharge in the Umatilla River below Dillon Dam was 8.78 cfs and that below Westland Dam was either 12.34 or 25.55 cfs, depending on the method of calculation (Table 1).

During the first barrier survey on 29-30 July, average daily discharge was 5.82 cfs below Dillon Dam and either 8.39 or 12.76 cfs below Westland Dam (Table 1). Ten riffles qualified as barriers to subadult bull trout, fluvial adult bull trout, and adult Chinook salmon, and 14 qualified as barriers to all but subadult bull trout (Table 2). Ten of these latter 14 riffles were passable to subadults along at least 30% of their wetted width (Table 2). Water depth was the limiting factor at riffles classified as barriers. Water velocity was suitable at all measured stations. Based on the number of usable stations at each site, passage conditions generally were better between Dillon Dam and the Stanfield Drain than between Westland and Dillon dams for subadult bull trout, and about equally poor in the two reaches for fluvial adult bull trout and adult Chinook salmon.

During the second barrier survey on 22-23 August, average daily discharge was 50.76 cfs below Dillon Dam and either 65.91 or 65.82 cfs below Westland Dam (Table 1). One site

Table 1. Average daily discharge in the Umatilla River between Westland and Dillon dams and Dillon Dam and the Stanfield Drain during reconnaissance and barrier surveys in July and August 2013. Two methods of calculating average daily discharge between Westland and Dillon dams (a and b) were used and are described in the Methods section. Average daily discharge on the day each reach was surveyed is listed in bold.

	Average daily discharge (cfs)					
Stream reach	23-Jul	24-Jul	29-Jul	30-Jul	22-Aug	23-Aug
Westland Dam to Dillon Dam(a)	24.53	**25.55**	**12.76**	7.18	65.09	**65.92**
Westland Dam to Dillon Dam(b)	16.49	**12.34**	**8.39**	8.57	56.13	**65.81**
Dillon Dam to Stanfield Drain	**8.78**	7.27	5.74	**5.82**	**50.76**	60.25

sampled during the first survey (no. 11) was omitted during the second survey because it was difficult to access and unlikely to qualify as a barrier given the data collected during the first survey and flow conditions during the second survey. All 23 riffles were passable for subadult bull trout under the elevated flow conditions, and 15 of the 23 were passable along their entire wetted width. Only one of the 23 riffles qualified as a barrier for fluvial adult bull trout, and the remaining 22 riffles were passable along 30% or more of their wetted width (Table 2). Sixteen riffles were passable for adult Chinook salmon, and 12 of those were passable along 30% or more of their wetted width. The single riffle that was a barrier to both adult bull trout and adult Chinook salmon did not meet passage criteria at any of the stations, although the thalweg was 23 cm deep and 80 cm wide. The thalweg was uncharacteristic of the remainder of the riffle, but some level of passage through it may have been possible for fluvial adult bull trout, if not adult Chinook salmon. Based on the number of usable stations at each site, passage conditions were generally better between Westland and Dillon dams for fluvial adult bull trout, and slightly better between Dillon Dam and the Stanfield Drain for adult Chinook salmon.

During the reconnaissance survey, we observed no stranded lamprey and identified only 10 sites where larval lamprey habitat was present (Table 3). Those sites were all Type 1 habitat. They ranged in estimated area from 56 to 669 m^2 and were all fully or partially submerged under water.

Fish Passage at Instream Diversion Structures

The upstream passage facilities at all of the diversion dams in the lower Umatilla River were constructed to meet National Marine Fisheries Service (NMFS) design standards. All of the dams except Feed Canal and Maxwell dams have vertical-slot ladders to provide upstream (and unintended downstream [Cameron et al. 1997]) passage. The ladder at Feed Canal Dam was modified recently into a series of rock weirs and pools (B. Duke, ODFW, personal communication). Maxwell Dam has no ladder because it is notched near its northern end. The notched section may be inaccessible at reduced flows, but managers determined providing a ladder for passage was not necessary because stream temperatures unsuitably high for salmonids coincide with the reduced flows. We found no evidence of any evaluations conducted to determine if conditions in the ladders are consistent with those anticipated given the design criteria. If such evaluations were conducted, they probably would not have been documented (J. Brown, NMFS, personal communication).

Table 2. Number of stations meeting minimum depth critera ("usable stations") along transects in the Umatilla River during barrier surveys in July and August 2013. Transect locations are given in Figure 1 and Appendix Table A1. Subadult BT, Adult BT, and ChS = minimum depth criteria required for passage of subadult bull trout (12 cm), adult bull trout (18 cm), and adult Chinook salmon (24 cm). S1 and S2 = Surveys 1 and 2.

		Number of usable stations					
		Subadult BT		Adult BT		ChS	
Stream section	Site no.	S1	S2	S1	S2	S1	S2
Westland Dam to Dillon Dam	1	1	9	0	4	0	0
	2	3	8	0	5	0	2
	3	2	9	0	8	0	2
	4	0	9	0	8	0	7
	5	0	9	0	8	0	4
	6	0	9	0	3	0	1
	7	0	9	0	9	0	7
	8	4	9	1	8	0	3
	9	0	5	0	4	0	2
	10	2	9	0	7	0	1
	11	6	-	1	-	0	-
Dillon Dam to Stanfield Drain	12	0	6	0	0	0	0
	13	3	9	0	8	0	1
	14	2	7	0	5	0	1
	15	4	8	0	7	0	5
	16	1	9	0	5	0	4
	17	0	9	0	5	0	1
	18	0	7	0	4	0	2
	19	5	9	0	8	0	5
	20	3	6	0	5	0	3
	21	5	9	0	8	0	7
	22	2	5	0	4	0	4
	23	4	9	0	9	0	7
	24	4	9	0	8	0	7

Table 3. Location and estimated area of larval lamprey habitat in the Umatilla River between Westland Dam and the Stanfield Drain in July 2013. The coordinates are in map datum NAD83.

		Coordinates		Estimated
Stream reach	Site no.	Easting	Northing	area (m^2)
Westland Dam to Dillon Dam	1	329475	5067090	56
	2	329512	5067240	93
	3	328600	5068370	56
	4	328376	5068377	139
Dillon Dam to Stanfield Drain	5	327924	5070160	186
	6	327568	5070862	167
	7	327145	5071447	186
	8	327148	5071497	418
	9	327150	5071508	669
	10	326134	5072381	98

Lamprey adult passage structures, or lamprey alternative passage structures (LAPS) have been added to Three Mile Falls, Maxwell, Dillon, and Feed Canal dams in recent years (A. Jackson, CTUIR, personal communication). The remaining dams will also be outfitted with LAPS in the near future, as funds become available. There is an ongoing study to evaluate the effectiveness of the LAPS and other passage facilities at each of the dams (A. Jackson, CTUIR, personal communication).

The irrigation canals associated with all six of the diversion structures in the lower Umatilla have screening and bypass facilities that meet NMFS design criteria. Past evaluations of those facilities in all but the Dillon Canal showed the rate of injury and delay in travel time of juvenile anadromous salmonids were within acceptable limits, as were the efficiencies of the screens in preventing fish passage into the canals (Cameron et al. 1997). No evaluations have been conducted for bull trout or Pacific lamprey ammocoetes or macropthalmia. Personnel from the U. S. Geological Survey (USGS) and CTUIR are involved in a cooperative study to estimate rates of entrainment of juvenile lamprey at various screen sites in the Umatilla Basin, and to develop velocity and operational criteria for the passage of juvenile lamprey at different types of diversion screens.

GIS-based Recovery Planning Tool

We collected information on bull trout population status, trend, and distribution; the seasonal distribution and movement of migratory bull trout; water temperature, stream flow, and riparian conditions; and the locations of irrigation diversion structures, flood control modifications, and physical barriers. We located recent data on riparian conditions only for the reach of river passing through the boundaries of the CTUIR, and we found very limited data on flood control modifications, even though it was evident from aerial photographs and discussions with local experts that much of the Umatilla River has been straightened and diked. We summarized the water temperature and stream flow data, and in addition to obtaining the data noted above collected numerous GIS layers of fish habitat, dams, diversions, barriers, gaging locations, hydrography, soils, land ownership, land cover, and climate.

Movement and Origin of Bull Trout Captured at Three Mile Falls Dam

One bull trout was captured at TMFD in 2013. It was 355 mm FL and was caught, PIT-tagged, and released on 5 May. There were no subsequent detections of this fish in the Umatilla River or at PIT detection sites elsewhere in the Columbia River basin. That it was not detected at Feed Canal Dam, at rkm 45 on the Umatilla River, suggests it did not migrate upstream out of the lower river. There also were no detections of seven bull trout PIT tagged at TMFD in 2007-2012 or of one bull trout captured at TMFD in 2012 that had been tagged previously in the Walla Walla River. The genetic samples collected from the individual captured in 2013 have not yet been analyzed.

Discussion

Our results indicate passage conditions in the Umatilla River between Dillon Dam and the Stanfield Drain were suitable for subadult bull trout when average daily discharge at the Dillon gage was 50 cfs, the minimum flow target managers currently attempt to meet. For fluvial adult bull trout, passage conditions were suitable at all but perhaps one riffle. That riffle may not have been totally impassable to fluvial adults given the depth of the thalweg, but it qualified as a barrier under our criteria and might at the least delay any fluvial adults attempting to pass it at 50 cfs.

The two methods we used to calculate discharge between Westland and Dillon dams indicated an average daily discharge of approximately 66 cfs was in that reach the day it was surveyed for the second time. Average daily discharge at the Dillon gage was 60.25 cfs on the same the day, whereas it was 50.76 the previous day when the Dillon Dam to Stanfield Drain reach was surveyed. There was a rain event between the two days of the survey, but it was minor (<0.25 cm); thus, the increased discharge may have been due to the vagaries inherent in river flow management or measurement or both. Whatever the cause, the result was that we did not conduct the second barrier survey between Westland and Dillon dams when average daily discharge at the Dillon gage was near 50 cfs, as we had intended to properly evaluate the minimum flow target. Under the given conditions, we identified no barriers to passage of subadult and fluvial adult bull trout between Westland and Dillon dams. Based on our professional judgment, at least one riffle (site no. 1) might have qualified as a barrier to fluvial adult bull trout at the minimum flow target. That riffle was relatively wide (30.1 m) and transverse to the river channel, with a 22-cm deep, 1.8-m wide thalweg. The channel morphology was such that relatively small reductions in flow would have led to relatively large reductions in depth across the riffle. We are uncertain whether the riffle would have been impassable or passable with some difficulty at the minimum flow target.

Except in some small, scattered, cold water areas and the plume downstream from McKay Creek, stream temperatures in the lower Umatilla River are unsuitably high for salmonids during the warmer months of the year (Contor et al. 1997). As the river is currently managed, the high temperatures coincide with relatively low stream flows, and both conditions typically occur in July and August when fluvial adult bull trout would not be expected to be in the lower river. Thus, that some impassable or difficult-to-pass riffles may exist between Westland Dam and the Stanfield Drain when there is 50 cfs or less of discharge at the Dillon gage may not be an issue for bull trout under current management conditions. Far in excess of 50 cfs of discharge generally has been provided at the Dillon gage in the recent past during periods when bull trout could be present in the lower river (http://www.usbr.gov/pn/hydromet/arcread.html). Our findings might be most relevant in the future if the water supply becomes more limited and reductions in flow are required during periods of bull trout use in the lower river. Two questions might then arise: 1) Is the goal of the minimum flow target to provide subadult and fluvial adult bull trout entirely unimpeded passage, or is some delay or other difficulty in passage acceptable at a small number of locations? and 2) What is the minimum flow target that will achieve the desired goal? Our results suggest 50 cfs of discharge at the Dillon gage is sufficient to provide passage from Westland Dam to the Stanfield Drain, but potentially with some impediments. We cannot presently identify what the minimum flow target would need to be if unimpeded passage were desired, but it could be established relatively easily through future work at the potentially problematic sites we identified.

The criteria we used to identify potential barriers to the passage of fluvial adult bull trout were the same as those recommended for adult steelhead and coho salmon (Thompson 1972), which are also present in the Umatilla Basin. Thus, our findings also may be used in combination with information on adult steelhead and coho salmon life history to assess the effects of different water management scenarios on adult steelhead and coho salmon. Our findings regarding subadult bull trout could similarly be applied to smaller salmonids.

We found seven riffles between Westland Dam and the Stanfield Drain where passage criteria were not met for adult Chinook salmon when average daily discharge at the Dillon gage was 50-60 cfs. As with bull trout, this may not be an issue under current management conditions because adult Chinook salmon would not be expected to be in the lower Umatilla River in July and August when stream temperatures are relatively high and flows relatively low. Also as with bull trout, our findings might be most relevant in the future if water supply becomes more limited and managers need to alter water management practices.

During the barrier survey in July, when river discharge had been reduced to 5.74 - 5.82 cfs at the Dillon gage, we found numerous riffles between Westland Dam and the Stanfield Drain that were barriers to the passage of fish subadult bull trout-sized and larger. When flows were increased in August, managers were unable to increase them incrementally so we could conduct a barrier survey at a discharge level between those existing during the first and second barrier surveys and develop a relationship between discharge and the number of barriers present. We believe this would be a valuable exercise. It would, for example, provide information that would allow managers to evaluate the effects of a lower minimum flow target(s), which could become necessary if the water supply were to become more limited. We will consult with local managers to determine if they would like us to conduct work along these lines in the future, and, if so, whether and how an appropriate discharge level might be achieved.

The results from the barrier survey will remain valid only as long as channel morphology between Westland Dam and the Stanfield Drain is not altered considerably relative to what existed during the survey. The survey was not labor intensive, requiring only two days for two people to complete, so it could be replicated relatively cheaply in the future if managers desired. Future work might also include conducting a barrier survey downstream from Maxwell Dam when average daily discharge at the Dillon gage is 50 cfs. Two of the local experts we consulted when identifying potentially limiting stream reaches noted a 1.6 to 4.8 km reach downstream from Maxwell Dam might deserve consideration. In August 2013, after flows had been increased, average daily discharge at the Dillon gage ranged from 45.67 – 65.73 cfs, while those at a gage downstream from Maxwell Dam ranged from 42.61to 63.93 cfs (http://www.usbr.gov/pn/hydromet/arcread.html). Given the similarity in discharge within the two reaches, and that we found potential impediments to fish passage in the Westland Dam to Stanfield Drain reach with an average daily discharge of approximately 50 – 60 cfs at the Dillon gage, potential impediments to fish passage might also be present downstream from Maxwell Dam, assuming channel morphology is similar in the two reaches.

We found no evidence the reduction in river discharge in July had a detrimental impact on Pacific lamprey between Westland Dam and the Stanfield Drain. No stranded or desiccated Pacific lamprey of any life stage were observed in that reach, and there was only a small amount of larval lamprey habitat, and it was largely not de-watered. Other ecological impacts to lamprey our coarse assessment did not include might have been important to consider had larval lamprey habitat not been so limited.

Through past telemetry studies, we have shown fluvial adult-sized bull trout are capable of passing the dams in the lower Umatilla River (Sankovich and Anglin 2008, 2011). Formal passage evaluations have not been conducted, however, and whether passage conditions are optimal for bull trout, both subadult and fluvial adult, remains unknown. Adult anadromous salmonids pass the dams not only by ascending the ladders, but also by jumping them and passing through other structures (e.g., slot weirs; Contor 2012). Bull trout might behave similarly; thus, any future evaluations should include all potential routes of passage, not just the ladders, and should relate passage conditions associated with the various routes to passage criteria for subadult and fluvial adult bull trout developed from the literature, as has been done elsewhere (e.g., Anglin et al. 2013). Because upstream passage structures for lamprey have been added, or will soon be added to the dams in the lower river and evaluations are ongoing under CTUIR's re-introduction program, we will not direct any future activities toward evaluating upstream lamprey passage at the dams.

Given there are screening and bypass facilities that meet NMFS design criteria at each of the diversion structures in the lower Umatilla River, and that past evaluations of those facilities showed they were suitable for the passage of juvenile anadromous salmonids (Cameron et al. 1997), we believe there is no need to conduct downstream passage evaluations for subadult and adult bull trout, except perhaps at TMFD. The Draft Bull Trout Recovery Plan notes the facilities there might pose downstream passage problems for adult bull trout (U.S. Fish and

Wildlife Service 2002), although no specifics are given as to the nature of any problems. Evaluations of downstream passage of juvenile Pacific lamprey at the screening and bypass facilities are warranted given screening criteria have only recently begun to be evaluated for juvenile Pacific lamprey (e.g., Rose and Mesa 2012) and juvenile anadromous salmonids likely serve as a poor surrogate for juvenile Pacific lamprey due to marked differences in morphology, behavior, and swimming performance. Since there is an ongoing cooperative effort between USGS and CTUIR personnel to conduct such evaluations, our role in the future will be to support that effort in whatever capacity is within our means.

There is little we can conclude about the single bull trout trapped at TMFD in 2013 because it was not detected at any PIT tag detection facilities in the Columbia River Basin, and the genetic samples collected from it have not been analyzed. Given this fish was not detected at Feed Canal Dam (39 km upstream from TMFD), it may have died in the section of river between TMFD and Feed Canal Dam or returned to the Columbia River and continued its migration elsewhere. Unless it located a cold water refuge, remaining in the lower river through the summer would not have been possible given the high stream temperatures there. A final possibility is it jumped Feed Canal Dam and avoided being detected there, but as noted previously, this type of behavior appears to occur infrequently (B. Duke, ODFW, personal communication). We will continue to query the PTAGIS database to attempt to track this bull trout and others trapped at TMFD in 2007-2012.

Small et al. (2012) determined all eight of the bull trout we sampled at TMFD in 2002-2012 originated outside the Umatilla Basin, in either the Walla Walla or Tucannon basins. One of those fish migrated onto the spawning grounds in the North Fork Umatilla River and remained there during the spawning period (Sankovich and Anglin 2011), providing evidence of biological connectivity between bull trout in the Umatilla and a neighboring basin. Given the importance of biological connectivity to the persistence of local bull trout populations (Rieman and McIntyre 1993), we recommend the movement and origin of bull trout trapped at TMFD continue to be monitored. We also recommend continued monitoring because, as we have noted before, the bull trout population in the North Fork Umatilla River is small, and managers may need to consider the trade-off in risks between inbreeding and outbreeding depression for that population in the future (Sankovich and Anglin 2013). Information on the origin and fate of bull trout trapped at TMFD would be critical to assessing such risks.

Acknowledgements

We would like to thank Marshall Barrows of the U.S. Fish and Wildlife Service, Greg Silbernagel and John MacPherson of the Umatilla Basin Watershed Council, and Wes Stonecypher of the Oregon Department of Fish and Wildlife for their assistance with portions of the field work. Bill Duke of the Oregon Department of Fish and Wildlife, Brian Zimmerman and Craig Contor of the Confederated Tribes of the Umatilla Indian Reservation, Chet Sater of the Bureau of Reclamation, Paul Hendricks of the Oregon Water Resources Department, and Greg Silbernagel of the Umatilla Basin Watershed Council provided valuable input in the selection of the study reach for the barrier and lamprey surveys. Individuals too numerous to list either provided or helped us locate data for use in the GIS-based tool. Mike Richards and other staff of the Confederated Tribes of the Umatilla Indian Reservation and Wes Stonecypher of the Oregon Department of Fish and Wildlife tagged and collected genetic samples from bull trout at Three Mile Falls Dam for us. This study was funded by the U.S. Fish and Wildlife Service.

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Appendix Table A1. Location of sites where water depth and velocity measurements were taken in the Umatilla River during fish passage surveys in July and August 2013. The coordinates are in map datum NAD83.

		Coordinates	
Stream section	Site no.	Easting	Northing
Westland Dam to Dillon Dam	1	329219	5066554
	2	329327	5066805
	3	329351	5066986
	4	329447	5067097
	5	329458	5067273
	6	329186	5067328
	7	329029	5067500
	8	328916	5067740
	9	328671	5068158
	10	328637	5068244
	11	327979	5068829
Dillon Dam to Stanfield Drain	12	327978	5070242
	13	327940	5070382
	14	327781	5070642
	15	327312	5071153
	16	327187	5071529
	17	326443	5071841
	18	326172	5071886
	19	326221	5072107
	20	326136	5072422
	21	325438	5072965
	22	325098	5072952
	23	324932	5073144
	24	324631	5073301