Migratory Life History of Redband Trout in the Donner und Blitzen River

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Abstract

Radio telemetry and PIT tags were used to track redband trout movement in the Donner und Blitzen River during the 2007 spring spawning season. The spawning migration lasted from March through June. Most fish migrated during late April and early May when the mean daily flows were between 200 and 400 cfs. Redband were observed to migrate as far as 90 km from near the mouth of the river to tributaries in the Steens Mountain. Most radio tagged redband, however, migrated up to the river section between River km 70 and 80. Migration delays and failed passage were observed in some cases at diversion dams. Movement tracking will continue through the summer and winter season. Additional activities planned for 2008 are intended to improved estimates of spawning locations and evaluate fish passage at three diversion dams.

Introduction

The Donner und Blitzen River (Blitzen River) has one of the few intact migratory populations of redband trout (Onchorynchus mykiss) in Oregon's Great Basin region. However, little is known about the movement patterns of this migratory population or of the factors that may limit or threaten the population's long-term viability. The purpose of the project is to determine the life-history characteristics of adult redband trout in the Blitzen River by assessing movement patterns and seasonal rearing locations and identifying potential fish passage problems that interfere with the natural expression of the migratory life-history.

Populations of redband trout with both migratory and non-migratory individuals within a river system may gain a long-term survival advantage (Meka et al. 2003, Northcote 1997). Also, migratory trout with a portion of the population that strays, or spawns in a stream other than their natal stream, can disperse to areas of suitable but unoccupied habitat, which can help create a metapopulation structure with an extinction-recolonization dynamic (Reiman and Dunham 2000). Furthermore, migratory salmonids often utilize highly productive feeding habitats and gain significant size and fecundity advantages over non-migratory individuals. For example, adfluvial female redband in the Catlow Basin were found to contribute over 5 times as many eggs as females that were non-migratory (Kunkel 1976).

The redband trout in Harney Basin are a naturally isolated population (Behnke 1992). Through a combination of broad scale climate shifts and tectonic activity, the Harney Basin redband trout were geographically isolated from the Columbia basin redband trout 8,000-10,000 years ago when the Voltage lava flows filled Malheur Gap (Behnke 1992, Bisson and Bond 1971). Redband trout populations in the basin were further fragmented as the once extensive Pleistocene Lake Malheur diminished to the smaller and more alkaline Malheur and Harney lakes, and many creeks dissipated onto the desert floor instead of feeding into the lakes (Bisson and Bond 1971). Receding lake levels gradually reduced the potential for lake dwelling populations to form a basin-wide metapopulation structure. The remaining smaller populations are left at greater risk of extinction, as these large-scale spatial demographic processes have been changed (Stacey and Taper 1992).

Human land use activities have further reduced the connectivity of the redband trout in the Harney Basin. Historical accounts from early in the 20th century recall high numbers of very large trout (up to 28 inches long and 5 lbs. in weight) in the Donner und Blitzen River (Hosford and Pribyl 1983). However, irrigation structures, habitat modification, overgrazing, and introduction of non-native species have all contributed to declines in abundance of Blitzen redband trout (Bowers et al. 1999, Hosford and Pribyl 1983). Given both natural and human caused changes to the conditions in the Harney Basin, the Blitzen River may be the only drainage in this system that supports an adfluvial life history of redband trout (Bowers et al. 1999, ODFW 2005). Even in the Blitzen River, this life history type may still be threatened by migration barriers, water quality problems, and non-native species (Bowers et al. 1999, Hosford and Pribyl 1983).

Fish passage on the Blitzen has been highly limited on the Blitzen River for most of the previous century. In 1999, the Malheur Wildlife Refuge installed Denil steep-pass fish ladders at each of the diversion dams on the Blitzen River and a diversion dam on Bridge Creek in order to improve passage conditions. In the two years following those passage improvements, the United States Fish and Wildlife Service (USFWS) caught many (over 350) redband trout in traps at the fish ladders on the Blitzen River diversion dams (USFWS unpublished) indicating that at least some of the fish were using the ladders. In 2000, the USFWS also used radio telemetry to track 14 redband trout. Redband trout were shown to move past each of the dams, but only two of the radio tagged redband were tracked above all human constructed barriers (USFWS unpublished). Although redband trout passage on the Blitzen has been improved, it is unclear whether or not fish passage could still be limiting the migratory life-history of redband trout in the Blitzen River.

Fish passage at dams is clearly an important consideration for migratory fish, but dam management that includes storage, redirection, and control of stream flows may also affect stream temperature, fish habitat, and fish response to environmental signals (Thurow et al. 1997). The dams on the Blitzen River were originally used for agricultural irrigation and now to flood wetlands for migratory bird habitat on the Malheur National Wildlife Refuge (MNWR). The diversion dams have changed both the magnitude and timing of peak flows and volume of base flows of the Blitzen River by redirecting water down irrigation canals and across the valley floor. Most of the water usage is during the spring and summer season. The spring is the primary spawning season for redband trout (Muhlfeld 2002) and the summer is the period during which high temperatures are most likely to affect redband trout (Muhlfeld et al. 2001).

The spawning migration timing of many salmonids, including redband trout and other O. mykiss groups (e.g. steelhead trout), have been shown to correlate with stream flow and water temperature (Hogen and Scarnecchia 2006, Mellina et al. 2005, Muhlfeld 2002). Redband trout may rely on changes in discharge as an indication of suitable flow conditions at spawning locations as has been found in other salmonids (Robards and Quinn 2002). The water managed at the diversion dams may have the potential to mute or confound the environmental signals that initiate migration timing in the Blitzen River redband trout.

Stream temperature is known to directly influence the metabolic rates and physiological condition of redband trout (Feldhaus 2006, Gamperl et al. 2002, Rodnick et al. 2004). Although redband trout have been shown to be uniquely adapted among

salmonids to the high stream temperature conditions that occur naturally in high desert streams (Gamperl et al. 2002, Rodnick et al. 2004), human induced changes to the thermal regime may create temperature conditions that limit redband trout distribution by making once valuable habitat unusable (Bowers et al. 1999). The Blitzen River watershed has seven streams listed by Oregon Department of Environmental Quality (ODEQ) as water quality impaired due to high summer stream temperature (303d list ODEQ).

Many researchers have emphasized the importance of management strategies that preserve variability in life histories expressed by salmonids (Colyer et al. 2005, Fausch et al. 2002, Meka et al. 2003, Northcote 1997). In the Blitzen River, preservation of migratory life histories of redband trout may help create a stable and resilient population. In order to promote the migratory strategy, the effectiveness of recent and planned fish passage improvements in the Blitzen River should be evaluated. Also, information on the spatial and temporal patterns of redband trout movement in relation to stream flow and water temperatures can inform management strategies that balance water usage for the preservation of the many and diverse species that utilize the habitat in the Blitzen River valley.

The goal of the project is to describe the movement patterns of adult redband trout in the Blitzen River and to evaluate the potential impact of human constructed barriers on movement. Specific objectives are:

1. Examine redband trout spawning locations and spawning migration timing,
2. Evaluate fish passage at the diversion dams on the Blitzen River,
3. Investigate the seasonal distribution patterns of redband trout association with stream temperature dynamics on the Blitzen River system.

Study Area

The Blitzen River flows from the west side of the Steens Mountain north into Malheur Lake located in southeastern Oregon (Figure 1). Most of the basin is managed by the USFWS and the Bureau of Land Management (BLM). The watershed has a total area of approximately 1,970 km^2. Discharge in the stream ranges from 25 to 4,300 cubic feet per second (United States Geological Survey, Blitzen River Gaging Station). Peak flows, which typically occur between March and June, are primarily generated from snow melt and periodic severe thunderstorms (Hosford and Pribyl 1983).

The MNWR manages eight diversion dams, which are critical to the maintenance of the wetlands that many avian populations rely upon for their annual migrations; however, improving native fish passage at the dams is a high priority for the MNWR (Rick Roy personal comm.). There are six dams on the Blitzen mainstem including Sodhouse, Dunn, Busse, Grain Camp, New Buckaroo, and Page Dams, and two dams on tributaries, Bridge Creek and McCoy Creek. Only McCoy Dam does not have provisions for fish passage. Most of the dams have denil steep-pass ladders, but permanent fish passage improvements were completed at Page Dam in the spring of 2006. The MNWR evaluated the cost of upgrading the fish passage structures at the other dams and as well as screening each of the diversion points in the Blitzen River at $3.6-4.6 million (Roy et al. 2000).

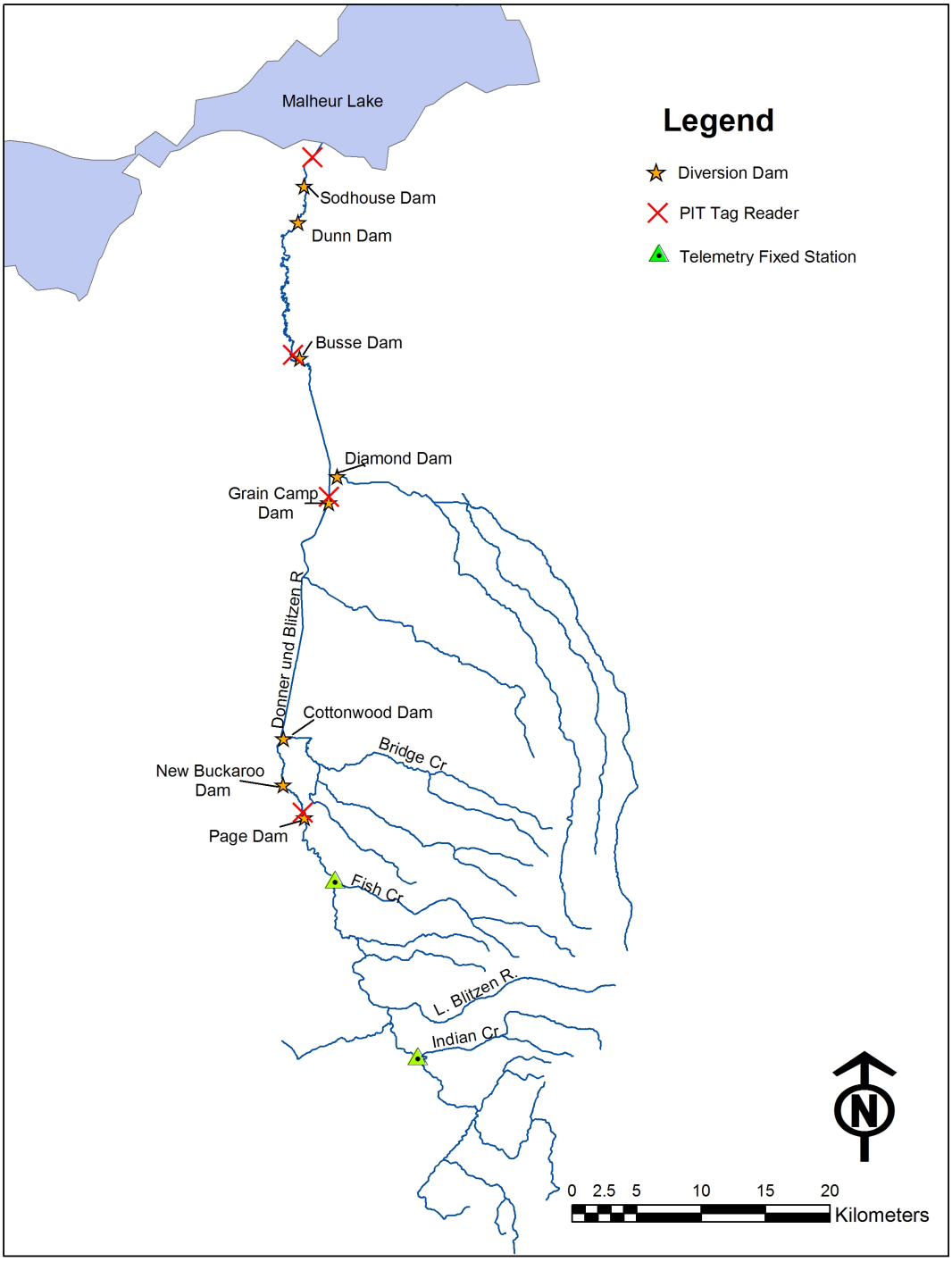

Figure 1. Blitzen River study area showing locations of diversion dams, PIT tag antenna arrays and fixed radio tag receivers.

Methods

Migrating redband trout were caught at fish traps at Sodhouse, Busse, Cottonwood, and Page Dams from 26 March to 15 June. Fish traps were operated an average of five days a week through most of the period and seven days a week during periods of peak fish movement. Additional fish were captured through hook and line sampling and opportunistically at Grain Camp Dam. In total, 512 redband trout were caught during the 2007 season (Figure 2).

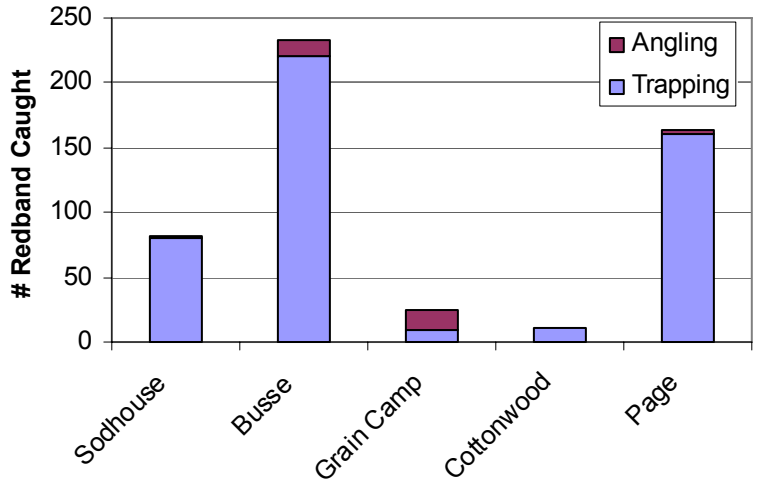

Figure 2. Number of redband trout caught at each location through passive trapping at irrigation diversion dams and angling downstream of dams.

The length and weight of each redband trout was recorded and scale samples were collected from a representative sub-sample. Each fish over 30 g was tagged with a 23 mm half duplex Passive Integrated Transponder (PIT) tag. In most cases, PIT tags were placed in the body cavity through a small abdominal incision, however for many larger fish, the PIT tags were inserted into the dorsal sinus through a small incision at the posterior base of the dorsal fin. Upon capture, fish were scanned with a handheld PIT tag detector in order to determine if the fish had been previously tagged. Recaptures were recorded and the length and weight at the time of recapture was recorded. Fish caught in traps were released upstream of the dam, and angled fish were released at the same location they were caught.

Radio telemetry tags were surgically implanted in 46 adult redband trout during the spring 2007 season. Two types of digitally encoded Lotek Wireless Inc. radio tags were used (Table 1). For the radio tag surgery, the fish were anesthetized with tricane methane sulfonate (MS-222) at a concentration of approximately 60 mg/l, combined with 120 mg/l of sodium bicarbonate buffer (Summerfelt and Smith 1990). Fish were placed on a surgical table with a foam lined, V-shaped tray designed to hold them in place, ventral side up. During surgery, a field assistant irrigated the gills of the fish continuously with a large syringe, alternating between fresh stream water and dilute anesthetic. A small incision was made anterior to the pelvic girdle. A cannula, shielded with plastic, was used to insert the whip antenna through the body cavity and through an

exit location anterior to the pelvic fin (Ross and Kleiner 1982). The antenna was angled toward the fish's tail to reduce resistance when swimming. The radio transmitter was placed inside the body cavity, and the wound was closed with 2 to 3 independent sutures using a monofilament absorbable suturing material (Wagner et al. 2000). Finally, a topical antibiotic was applied to the surgical site. Fish were held in freshwater for at least 15 minutes to recover prior to release.

Table 1. Description of radio tags implanted in redband trout

Model	# of Tags	Tag Dim. Dia x L(mm)	Tag Weight in Air(g)	Burst Interval (sec)	Operation life Estimate (days)
MCFT-3A	36	16x46	16	4	641
MCFT-3FM	10	11x59	10	5	441

Radio tags were deployed at four different dams throughout the spawning migration season in an attempt to representatively sample fish in different areas of the river and fish that migrate at different times (Figure 3).

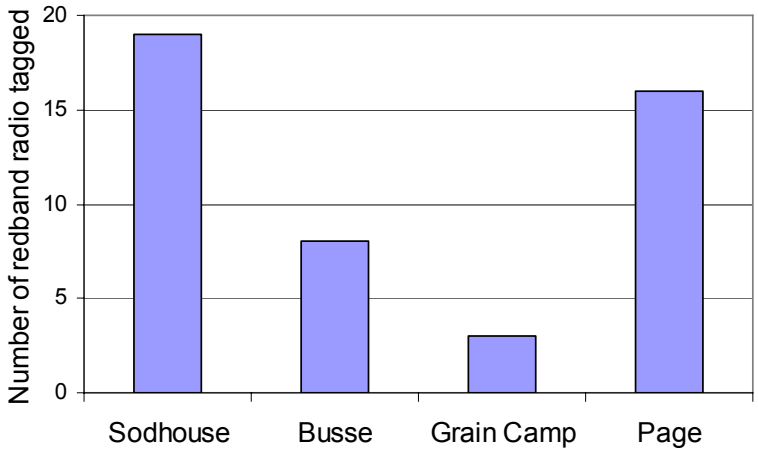

Figure 3. Number of redband trout implanted with radio tags at each trapping location.

Movement data of radio tagged fish was collected through a variety of methods including vehicle, foot and aerial tracking, and fixed-station installations. Vehicle tracking provided consistent detections of fish through most of the range in the lower 73 km stretch of the river located in the MNWR. Foot tracking was conducted as needed to track fish that moved above the Page Dam. Most of the foot tracking focused on the four mile stretch between Page Springs and Fish Creek since high flows and rugged terrain made long distance foot tracking inefficient. Aerial tracking was conducted at approximately 2-4 week intervals depending on the availability of Oregon State Police aircraft. A total of seven aerial tracking flights were conducted between April and October. Tracking flights allowed tracking over the entire watershed in about 2 hours and had 80-90% detection rates. Aerial flights also allowed monitoring over Malheur

Lake. The two telemetry fixed stations were located on the Blitzen River at the confluence of Fish Creek and at the confluence of Big Indian Creek (*see* Figure 1). Fixed station telemetry receivers powered by solar panels operated continuously through the monitoring period and helped ensure that radio tagged fish did not move upstream and back down beyond these points between mobile tracking detections.

Movement of PIT-tagged fish was monitored by recapture and detection at stationary PIT tag antennas. Fish captured in traps or by angling were scanned for PIT tags with a hand-held detector. Two rectangular PIT tag antennas constructed from ½" PVC pipe and 12-gauge copper speaker wire were placed in the Page Dam fish ladder at the entrance to the ladder and at the top of the ladder on 13 April and one such antenna was placed near the top of the Grain Camp Dam fish ladder on 16 May. Additional full stream-spanning antennas were deployed downstream of Page Dam, downstream of Grain Camp Dam, downstream of Busse Dam and at the Cato Bridge (R km 2) in early June (*see* Figure 1).

With the combined methods of tracking, radio tagged fish were detected an average of 12.4 times from April to October. PIT tagging efforts also provided information on fish movement. Of the 512 redband trout PIT tagged, 198 (39.4%) were redetected at lease once.

Results

Radio telemetry and PIT tag tracking of the Blitzen River redband has provided additional insight into the timing and patterns of migration as well as additional insight into the trout involved in the migration. The migration lasted at least from the end of March to the middle of June. The longest migration documented was over 90 km. Migrating fish ranged in size from 115 to 560 mm. There was a notable bimodal distribution in the sizes of migrating fish (Figure 4) possibly indicating different year classes or different life-histories. Planned analysis of scales collected from these fish will help elucidate the age structure. Although smaller fish did not show any external signs of sexual maturity, such signs may be less apparent in young fish. The length and weight of the migratory redband trout is reported below (Figure 5).

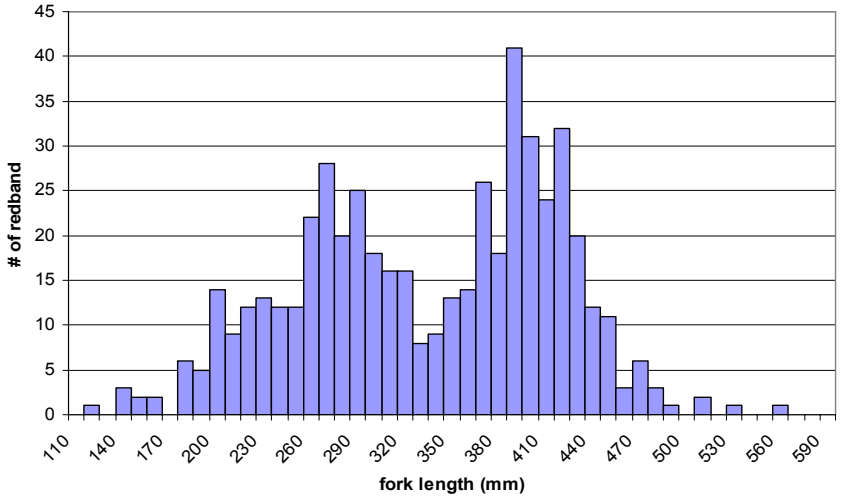

Figure 4. Histogram of lengths of Blitzen River redband trout caught in 2007

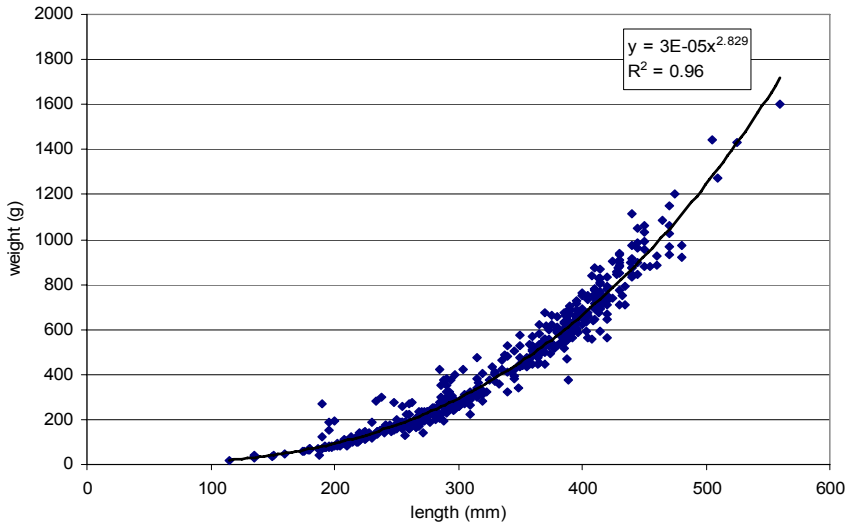

Figure 5. Weight (g) versus length (mm) of Blitzen River redband trout caught in 2007

The timing of redband trout movement during the spring coincided with the flow conditions associated with the spring snowmelt. Stream discharge peaked on 22 April, but most fish movement did not occur until the first two weeks of May. Fish movement was greatest when mean daily discharge at Page Springs was between 200 and 400 cfs (Figure 6).

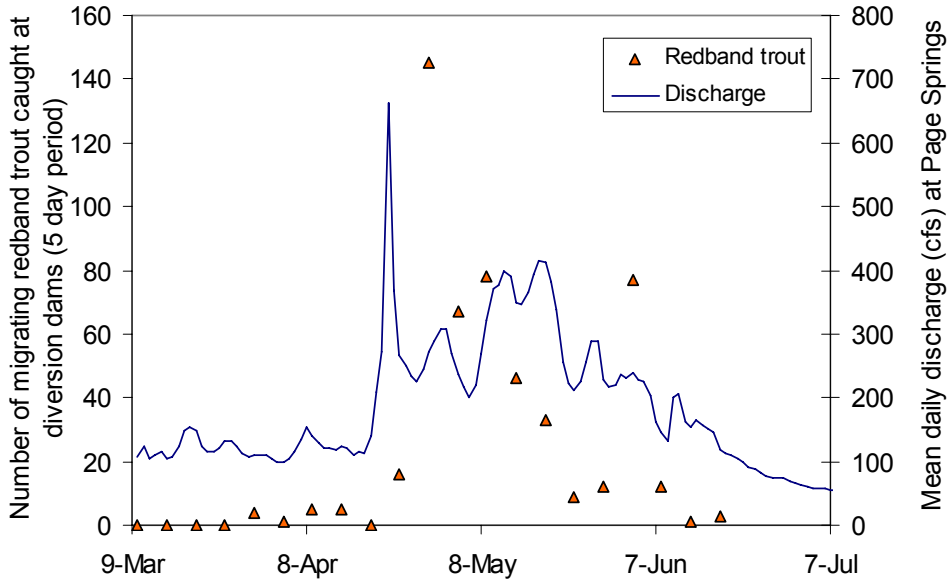

Figure 6. Number of redband trout caught at diversion dams in 5 day periods (Δ) and Blitzen River stream flow gauged at the USGS station near Frenchglen, OR.

The flow patterns in the Blitzen River during the month of May have a regular daily oscillation due to the freeze-thaw cycles on Steens Mountain. Daily discharge during spring melt is highest at about 0300 and is lowest around 1900. Based on PIT tag detections at an antenna located at the top of the Page Dam fish ladder, it appears that redband trout tended to move during the declining and lowest stage of the daily hydrograph.

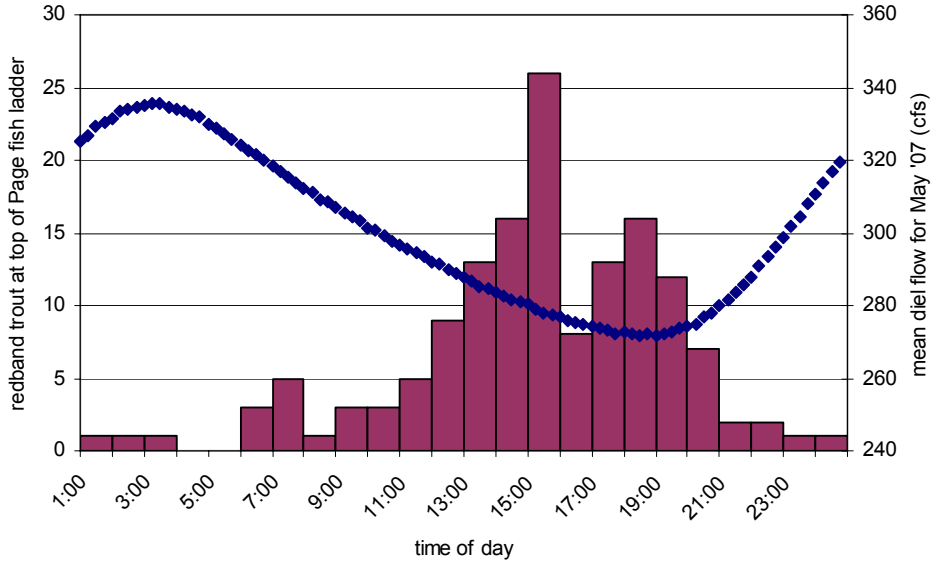

Figure 7. Histogram of the first daily detection of PIT-tagged fish at the top of the Page Dam fish ladder and mean diel discharge pattern for May 2007. Flow measured at the USGS station near Frenchglen, OR.

Evidence from both the PIT tagged fish and the radio tagged fish suggest that a large number of redband in the lower section of the river make large-scale, upstream movements. Radio telemetry data provides more detailed information on relatively fewer fish, whereas PIT tag data provides less spatially explicit data on many more individuals. Table 2 shows the percentages of redband trout PIT tagged at three different locations that were confirmed to migrate as far or farther than the listed upstream detection locations. Redetections are based on both recaptured fish and fish detected by stationary PIT tag antennas. This confirmed proportion of migrating fish likely underestimates the actual percentage of long distance migrants.

Table 2. Percent of redband trout known to migrate from at least the capture location (left column) to the detection location (top) based on PIT tag detections (Sodhouse N=82, Busse N=233, Grain Camp N=24).

Capture Location (river km)	Detection Location (river km)		
	Busse (34)	Grain Camp (45)	Page (73)
Sodhouse (6)	39%	27%	21%
Busse (34)	-	39%	9%
Grain Camp (45)	-	-	25%

One of the primary purposes of the radio tagging effort was to determine the spawning location of migratory redband trout. During the spring of 2007, redband trout movement was monitored, but there was no attempt to directly verify spawning locations. However, the farthest upstream location that a fish was detected provides some insight into the destination of the spawning migration. Figure 8 shows the frequency distribution of the farthest upstream location reached by redband grouped by tagging location. The data show a greater spread in the highest location for fish tagged further downstream, but the range of highest detection locations of fish tagged at both Sodhouse and Busse fish encompasses the range of fish tagged at Page Dam. These results suggest that there is overlap in the spawning locations of fish that over-wintering in different parts of the river.

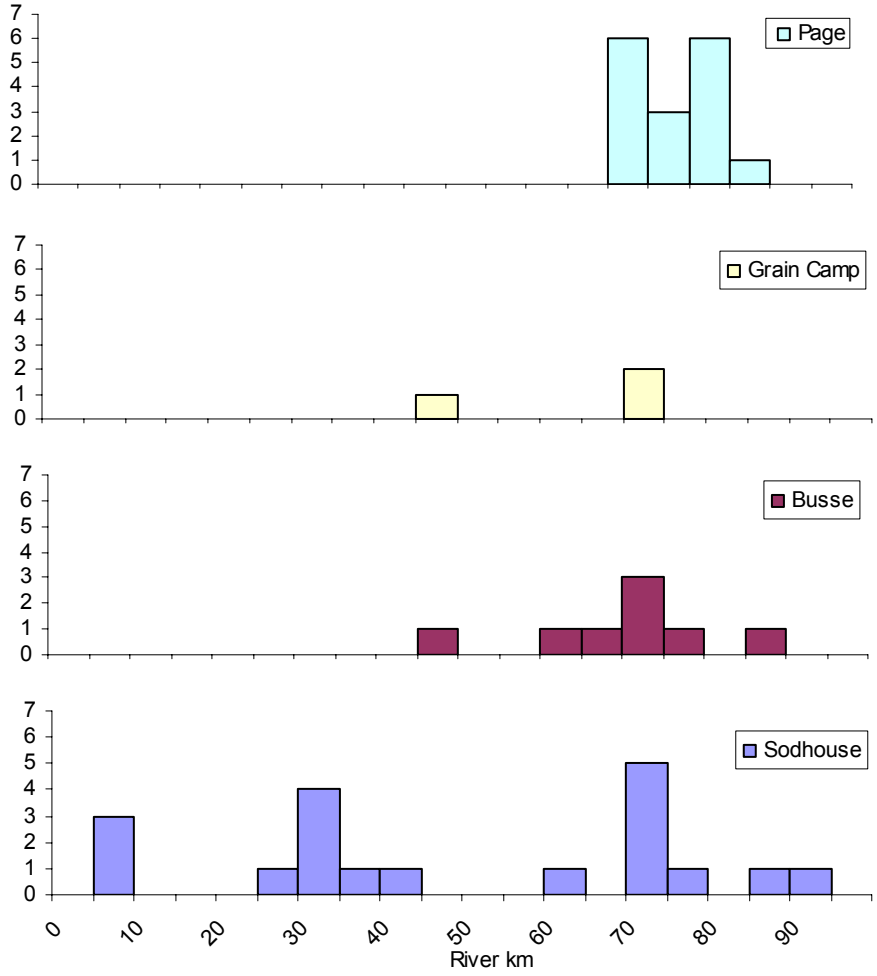

Figure 8. Frequency histograms most upstream observation locations of radio-tagged redband trout, 2007. The vertical axis is the number of fish and the horizontal axis is river km from the mouth of the river in 5 km reaches. The different histograms are based on the location fish were tagged.

Examples movement pattterns of individual fish based on radio telemetry detections are shown in Figure 9. Numerous trout made long-distance migrations over a short period of time such as #16 and #22. In other cases, rapid upstream migration alternated with residency periods that ranged from days to weeks. Prolonged residency periods were often associated with the location of diversion dams, as in the example of #15, which could be related to fish passage problems. In some cases, such as #52, redband trout encountered a dam and never passed.

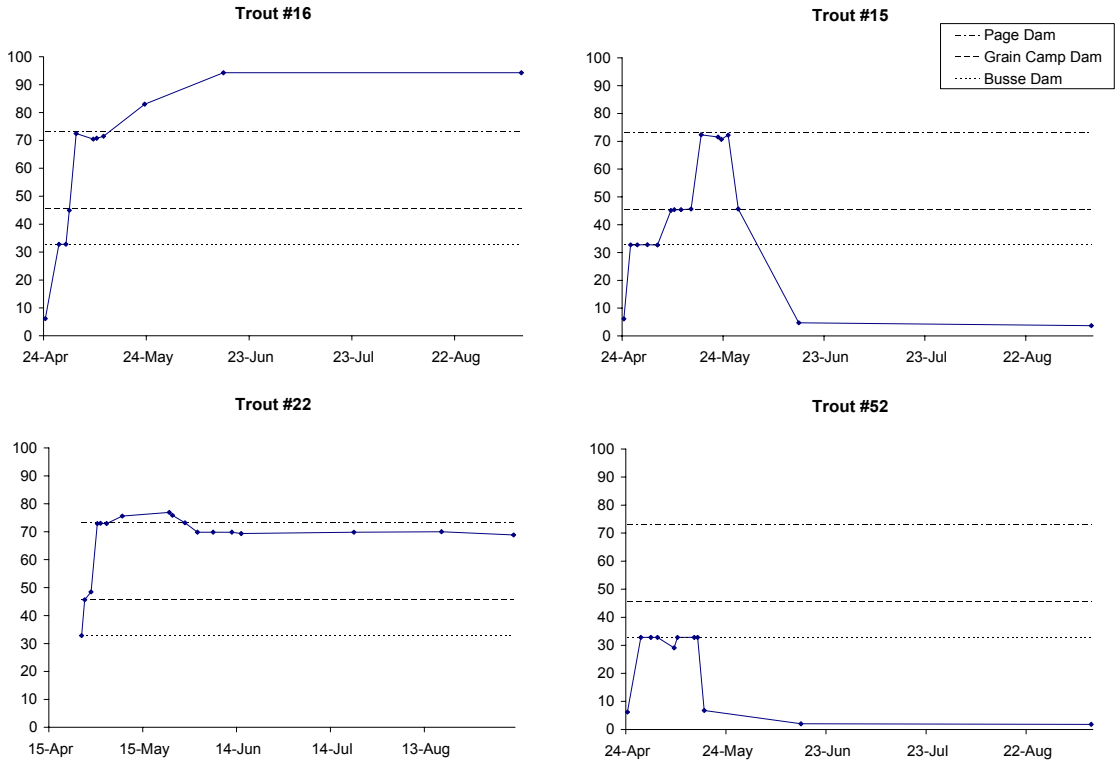

Figure 9. Four examples of radio tagged redband trout movement in the Blitzen River relative to the location of Busse, Grain Camp, and Page diversion dams. The vertical axis is river distance from the river mouth (km) and the horizontal axis is date.

Radio telemetry detections were used to evaluate fish passage at Busse and Grain Camp Dams. Upstream migrating redband trout that were detected above a dam or less than one km downstream of the dam were considered to have encountered that dam. After a fish was located in the one km reach below the dam, subsequent relocations below the dam were attributed to be fish passage delays. If a fish that encountered the dam was never detected above the dam, it was considered to have failed passage. Fish that did pass the dam were assumed to have passed the same day as the last detection below the dam, so the delay times were calculated conservatively. The results of this analysis for fish that encountered Busse Dam and fish that encountered Grain Camp Dam are shown in Figure 10. Of the 16 radio tagged fish that encountered Busse Dam, 7 never passed the dam and 5 were notably delayed. Fish passage problems at Grain Camp Dam were less severe, but still evident. During this period, Grain Camp Dam only had one functioning gate, which may have contributed to fish passage problems.

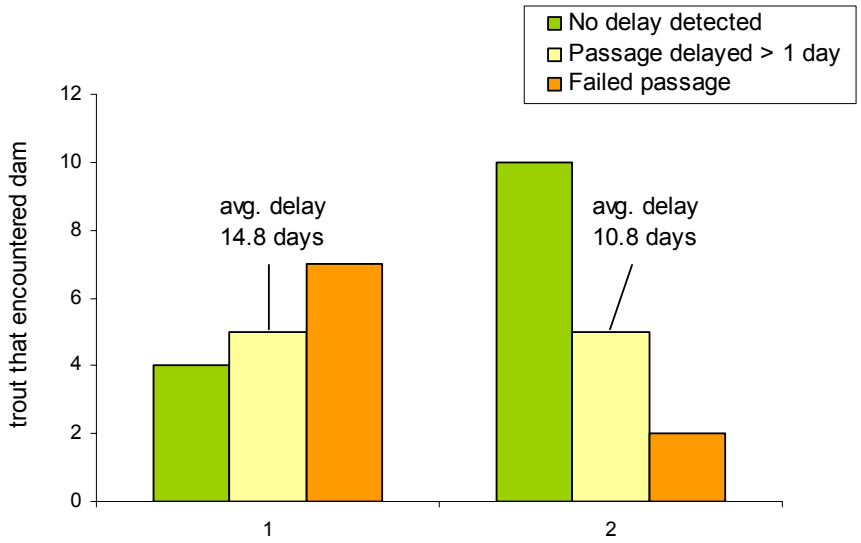

Figure 10. Fish passage fate of radio tagged redband trout that encountered Busse (1) and Grain Camp (2) Dams.

Preliminary Conclusions and Directions of Future Research

Based on one season of monitoring, it is apparent that there is a large, intact migratory population of redband trout in the Blitzen River. Upstream migrants ranged in size from 115 mm to 505 mm and the size of migrating redband had a bimodal distribution. Most fish movement occurred at the end of April and early May when flows were between 200 and 400 cfs. The peak migration period occurred after the peak discharge of the season. Redband trout appeared to move upstream during the time of day when the flows were the lowest. Radio tagged redband traveled an average of 35 km from their tagging location. Some tagged fish never migrated, while others traveled distances up to 90 km. Many fish were found to migrate to the area of the mainstem between river km 70 and km 81 during their spawning migration.

Movement of redband will be tracked through the rest of 2007 and through the summer of 2008 with both radio-telemetry and PIT tag detections. Fish movement tracking will continue during the summer and winter season. Movements between habitats will be compared with changes in stream temperature. An additional radio tagging and PIT tagging effort will be conducted during the spring of 2008. Information during the second season will be compared to first season migrations for differences in timing, distance and final location of spawning migration. Additional effort during the 2008 season will be spent pin-pointing spawning locations through visual surveys of spawning behavior and redd location.

Although many fish were able to successfully migrate through the river, there is some evidence of delays and failed migrations associated with passage at diversion dams. Numerous fish were delayed or blocked at Busse Dam and Grain Camp Dam. Grain Camp delays may have been related to temporary impaired function of the dam. Fish passage will be examined more explicitly during the spring of 2008 with the use of PIT

tag antenna arrays located at Busse, Grain Camp and Page Dams. The arrays will consist of two stream-spanning antennas below the dam, one antenna in the entrance of the fish ladder, and one antenna in the top of the fish ladder. The array will evaluate the rate of movement of a PIT tagged trout in an unobstructed section of channel and the rate of movement of that fish passed the dam. The PIT tag antenna array should also provide information about the time it takes a redband trout to enter the ladder and the time it takes to ascend the ladder after entering. Fish passage monitoring may provide useful information for passage improvement prioritization and effectiveness monitoring of recent upgrades at Page Dam.

Acknowledgements

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