Oregon Department of Fish and Wildlife
Technical Report

2013 Middle Deschutes Fisheries Monitoring Report: Redband Trout Movement in the Middle Deschutes River

Carrasco, Ryan
Moberly, Erik

Oregon Department of Fish & Wildlife
Bend, Oregon
June 2014

Acknowledgments

Appreciation is extended to the employees of ODFW's Bend Regional Office and the many volunteers that assisted with the monitoring project. Further thanks is issued to Bruce Lilleston for access to his property, members of the Mitigation &Enhancement Board, Oregon Watershed Enhancement Board (Grant #211-4020), Upper Deschutes Watershed Council, and Restoration & Enhancement Board for their funding and/or assistance; Shivonne Nesbit for her training on proper surgical procedures and trout care.

Abstract

Water management for irrigation has resulted in dramatically altered flow and temperature regimes in the middle Deschutes River downstream of Bend, Oregon. Temperatures are known to exceed state standards for trout rearing and migration, but it is unknown how high temperatures affect native trout abundance, movement, and habitat selection. ODFW staff radio tagged thirty redband trout (*Oncorhynchus mykiss*) in May of 2013 and monitored their movements until December 31st. Lotek MST-930 radio tags were surgically implanted in trout from Sawyer Park downstream to Lower Bridge on the middle Deschutes River. Thirty-one percent (n = 9) of trout migrated over 2.15 miles during the study. Seventeen percent (n = 5) of trout were discovered to stay within 0.6 miles of their release sites after tagging. Twenty four percent (n= 7) did not move further than 0.1 mile from the release site after tagging. Fourteen percent (n = 4) were assumed to have moved out of the immediate study area and were not able to be relocated. Fourteen percent (n = 4) of the tagged trout were assumed to have been mortalities or discharged tags. One radio tagged trout was never located after release and was assumed to have had a faulty tag. Our results provide preliminary information about trout movement in the Deschutes River in relation to known locations of cold water inputs and high temperature zones.

Introduction

The Deschutes River, a tributary of the Columbia River, historically was recognized for its extremely stable interannual flows. However, since the early 1900's it has been subjected to significant streamflow modification and is currently one of the most manipulated rivers in Oregon. From mid-April to mid-October, water is diverted at a series of irrigation canals upstream of the North Canal Dam in Bend (Figure 1). These diversions can remove over 90% of the flow from the Deschutes River in the reach between the City of Bend and Lake Billy Chinook. Downstream of these diversions, the remaining flow warms quickly during the hot summer months. As a result, the middle Deschutes River within the project area routinely exceeds the state of Oregon's Department of Environmental Quality (ODEQ) 18ºC temperature standard for redband trout (Houston and Jones 2010). In addition, water management and fish passage barriers resulting from numerous dams are likely to have disconnected populations of redband trout and limited suitable habitat in the middle Deschutes River.

Temperature and flow conditions resulting from water management, as well as inter-specific competition and social hierarchy, can influence fish abundance and distribution in river systems, specifically trout movement, habitat selection, and migration (Budy et al. 2008, Freeman et al. 2001, McHugh and Budy 2006, Pert and Erman 1994, Starcevick et al. 2006). Life history characteristics and movement patterns of redband trout in the middle Deschutes River were not well-documented prior to construction of dams in the Deschutes Basin and recent information on resident fish populations is limited; it remains unclear how elevated stream temperatures in the summer months may impact redband trout in the middle Deschutes River. The Middle Deschutes Fisheries Monitoring Project was initiated to investigate baseline fish assemblages and responses of trout to both restored stream flows and water management. A key aspect of the project is identifying cold water refugia for redband trout and movement patterns that may be influenced by current water management and resulting water quality variability.

In September, 2012, the Deschutes District of the Oregon Department of Fish and Wildlife, in collaboration with the Upper Deschutes Watershed Council, began monitoring stream temperature and fish populations in the middle Deschutes River from North Canal Dam (RM 164.74) to Foley Waters (RM 128) to meet the following objectives: 1) to establish baseline populations and relative abundance information for fish species; 2) to document fish use of Tumalo Creek; 3) to describe the effect of flow, temperature, and habitat conditions on fish assemblages and quantify fish response to instream flow

restoration; 4) to evaluate changes in fish communities relative to changes in temperature along the longitudinal gradient and lastly; 5) to develop a proven protocol to monitor these populations so that future monitoring can extend into other reaches of the Deschutes River. To evaluate fish movement and habitat selection in relation to stream temperature and flow, ODFW used radio telemetry to track 30 redband trout from May to October, 2013. The resulting data will provide critical information to support fisheries management and strategic restoration planning in the Middle Deschutes. Results of 2013 fish population surveys are presented in a separate report.

Methods

Study Area

The middle Deschutes River is defined as extending from the North Canal Dam in the City of Bend (RM 165) to Lake Billy Chinook (RM 120) (Figure 3). This section of river is characterized by steep canyons with occasional reaches sweeping open to form narrow valleys. The mean gradient from North Canal Dam (RM 164.75) to Foley Waters (RM 128.75) is 6.4% and mean width is 17.4 meters. Habitat in this section is comprised of 35.7% riffles, 27.6% scour pools, 22.3 % glides, 6.7% rapids, and 1.7% cascades, and 1 % backwater pools (Loerts & Lorz 1994).

The study area extends from North Canal Dam in Bend (RM 164.75) downstream to the area of Lower Bridge (RM 133.5) (Figure 1). North Canal Dam is a barrier to upstream passage; however, there are no restrictions to downstream passage on the middle Deschutes. There are several natural waterfalls that may restrict upstream fish movement, depending on flows, which include: Awbrey Falls (152.75), Cline Falls (144.6), Big Falls (RM 132.25) and Steelhead Falls (127.8). Odin Falls is located at RM 139.8, however, it is believed this feature could be passable at low or high flows. Big Falls, historically the natural barrier to upstream fish passage, has a fish ladder which is not believed to be adequate for trout passage (Table 1).

Table 1. Barriers and passage status on the Middle Deschutes between North Canal Dam and Lower Bridge. Data Source: Oregon Department of Fish and Wildlife.

Barrier	River Mile	Passage Status
Steelhead Falls	127.8	Partial passage via ladder*
Big Falls	132.2	Partial passage via ladder*
Cline Falls	145.0	Partial passage via ladder*
North Canal Dam	164.8	No passage
		* May be passable at certain flows

Distributions of radio tags (Table 2) in the middle Deschutes River were based on reaches where responses to seasonal temperature fluctuations may impact habitat utilization by redband trout (*Oncorhynchus mykiss*). Areas include Sawyer Park (RM 164), Gopher Gulch (RM 161.5), Tumalo State Park downstream to Twin Bridges (RM 159-154.5), and Odin Falls downstream to Lower Bridge (139.5-133.5).

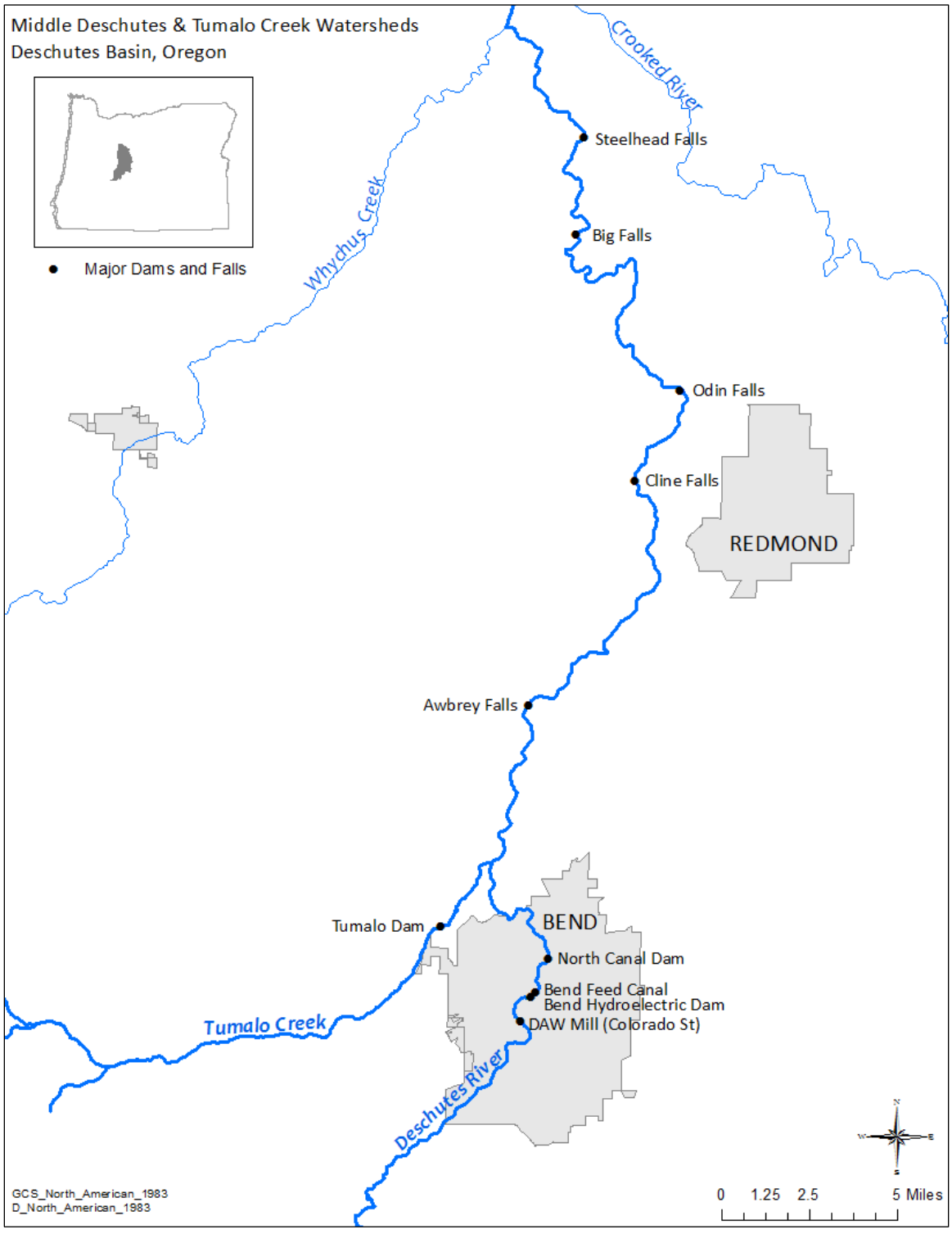

Figure 1. Middle Deschutes and Tumalo Creek fish population study area with major dams and waterfalls shown. The North Canal Dam in Bend and Big Falls downstream are trout passage barriers.

Table 2. Species, length (mm), weight (g), ID #, temperature (C), site, data and release location of 30 redband trout captured on the middle Deschutes River.

Species	Length (mm)	Weight (g)	Radio Tag	Temp(C)	Site	Date	Release Latitude	Release Longitiude
RB	235	137	24	15	Gopher Gulch	5/13/2013	44.09776	121.33722
RB	270	180	25	15.6	Gopher Gulch	5/13/2013	44.09776	121.33722
RB	290	250	26	16.7	Gopher Gulch	5/13/2013	44.09776	121.33722
RB	230	123	27	13.1	Gopher Gulch	5/14/2013	44.09776	121.33722
RB	274	213	28	14.5	Gopher Gulch	5/14/2013	44.09776	121.33722
RB	240	125	29	16	Gopher Gulch	5/14/2013	44.09776	121.33722
RB	230	182.5	14	15.6	Odin	5/10/2013	44.34546	121.26440
RB	269	181.5	15	15.6	Odin	5/10/2013	44.34537	121.26439
RB	233	127	16	15.6	Odin	5/10/2013	44.34537	121.26439
RB	235	111	17	15.6	Odin	5/10/2013	44.34537	121.26439
RB	223	131.5	18	18	Odin	5/10/2013	44.36043	121.28568
RB	222	110	19	18	Odin	5/10/2013	44.36043	121.28568
RB	230	108	20	18	Odin	5/10/2013	44.36043	121.28568
RB	253	176	21	18	Odin	5/10/2013	44.36043	121.28568
RB	235	143	22	18	Odin	5/10/2013	44.36043	121.28568
RB	236	136	23	18	Odin	5/10/2013	44.36043	121.28568
RB	220	105	30	12.6	Odin	5/15/2013	44.35066	121.26060
RB	245	120	31	13.8	Odin	5/15/2013	44.35066	121.26060
RB	238	116	33	13.7	Odin	5/15/2013	44.35066	121.26060
RB	255	130	37	13.6	Sawyer Park	5/16/2013	44.08321	121.30777
RB	228	108	38	13.6	Sawyer Park	5/16/2013	44.08321	121.30777
RB	248	102	39	13.6	Sawyer Park	5/16/2013	44.08321	121.30777
RB	210	109	40	13.6	Sawyer Park	5/16/2013	44.08321	121.30777
RB	240	168	11	10.7	Tumalo Road Bridge	5/8/2013	44.15454	121.32678
RB	225	133	12	10.7	Tumalo Road Bridge	5/8/2013	44.15454	121.32677
RB	230	135	13	10.7	Tumalo Road Bridge	5/8/2013	44.15464	121.32680
RB	270	190	32	10	Tumalo State Park	5/16/2013	44.15090	121.32961
RB	300	230	34	10	Tumalo State Park	5/16/2013	44.15090	121.32961
RB	242	130	35	10	Tumalo State Park	5/16/2013	44.15090	121.32961
RB	235	104	36	10	Tumalo State Park	5/16/2013	44.15090	121.32961

Temperature and Flow Monitoring

Six temperature loggers located throughout the middle Deschutes River and two on Tumalo Creek have been recording temperature hourly since the fall of 2012. Vemco Minilog II-T temperature loggers were used to be consistent with partners and the Oregon Department of Environmental Quality (UDWC 2008). Before deployment in 2012 we calibrated all temperature loggers by placing them in two separate baths, the first at 8.1 °C and the second at 23.0 °C for ten minutes each (UDWC 2008). A National Institute of Standards and Technology (NIST) certified thermometer was used to manually record temperature every minute. (ODEQ calibrated NIST #52096 Inspected 4.12.12). Data from each logger were then downloaded and readings were compared to the manual recording from the NIST certified thermometer. Loggers within a difference 0.5°C from the NIST received an A and loggers within 1.0°C received a B. All eight temperature loggers received either an A or a B, none exceeded a difference greater than 0.6°C. ODFW temperature loggers were set to record temperature every hour and were placed in the Deschutes River on September 24th, 2012 (RM 129.0, 139.0, 144.5, 155.0 & 165.9) and on September 25th (RM 141). Temperature loggers with the same settings were placed in Tumalo Creek on October 10th (RM 0 & 6.0). Each logger was secured to the bank with a cable extending 8-12 feet into the water to accommodate for high and low flows. Loggers were audited every other month and data offloaded onto a Vemco field reader. At the time of audit, the NIST was used to take a manual temperature, recording river temperature to compare with the logger for accuracy. All uploaded data were entered into a database along with the NIST thermometer reading.

We used data from three UDWC Vemco temperature loggers located downstream of Tumalo Creek (RM 160), upstream of Tumalo Creek (RM 160.25) and at RM 164.75 downstream from the North Canal Dam. UDWC temperature loggers recorded temperatures in 2013 from March 30th to November 26th. Temperature data obtained just below North Canal Dam was collected from the BOR stream gauge.

Instantaneous flow readings were recorded from the U.S. Bureau of Reclamation Hydromet system. The middle Deschutes River stream gauge is located below the North Canal Dam in Bend (DEBO RM 164.25) and records flows on 15 minute intervals. Tumalo Creek flows were recorded directly below the Tumalo Feed Canal (TUMO RM 2.05).

Redband Trout Collection

Collection of redband trout to be implanted with a radio tag began on May 8th and continued until May 16th, 2013. Criteria used for tagging redband trout was a minimum weight of 100 grams. Once three or more redband trout were collected, a suitable spot on the river bank was located to conduct surgeries and implant the radio tags. The majority of fish were captured using a cataraft equipped with a Smith Root electrofishing unit. Hook and line was also used to collect redband trout at Gopher Gulch due to inability to navigate the river with the cataraft.

Surgical Procedure

Fish were held in two separate live wells containing aerators; one live well was used prior to surgery and one to hold fish for post-surgery recovery. The surgical procedure occurred on the river bank in a custom-made two-gallon tank with a V-shaped tray at the top of the tank to hold fish in place. Fish were anesthetized with MS-222 (tricane methanesulfonate). Once fish were sedated, they were removed from the tank and placed in the tray for surgery. An incision approximately 19mm was made just posterior to the left pectoral fin and an exit was made for the antenna just above the anal fin. Monocryl absorbable violet monofilament with a 26mm tapered needle was used for suture material. MS-222 solution was flushed over the gills until the first suture was completed. River water was used after the first suture was completed to expedite the recovery process. Two to three sutures were tied per incision using a 1X1X1X1 interrupted knot, which has been shown to minimize tissue trauma and reduce exposure to MS-222 due to ease of tying (Deter et al 2012). The tagging procedure took less than five minutes; once completed, fish were placed in the recovery live well until recovery was achieved, and then released at the tagging site.

Lotek MST-930 radio tags were programmed on a 12-hour on/off cycle with pulse rates set at 3, 3.5 and 4 seconds. Transmitter batteries were warrantied for 150 days with a typical life of 200 days. Allotted frequencies were 150.380 and 151.890 and were coded from 11-40. All tags were tested prior to surgery to confirm functionality.

Distribution of tags

Allocation of tags was distributed in the middle Deschutes River in a manner that would provide information regarding fish movement relative to fluctuations in temperatures and available habitat. Tumalo Creek contributes variable amounts of cold water seasonally and may serve as a cold water refuge for trout during non-drought years. Therefore, a group of redband trout were tagged both upstream and downstream of the confluence of Tumalo Creek to determine seasonal movement. The Odin Falls reach experiences abnormally high water temperatures during July and August and gaining information on how fish responded to the water quality during this time of year was also considered a high priority.

Tags were assigned as follows: four at the Sawyer Park reach; six at Gopher Gulch; four from Tumalo State Park down to Tumalo Road; three from Tumalo Road down to Twin Bridges. Thirteen tags were assigned to the Odin Falls reach. Six days were required for District staff to distribute all the tags. (Figure 2).

Tracking Fish Movements

Tracking fish movements on the middle Deschutes River was conducted by foot, kayak, and from aircraft from May to December using a Lotek SRX-600 reciever. All fish were monitored on a weekly basis with the exception of September. Once trout were located and the strongest signal identified, a position was marked using a Garmin *e*trex 20 GPS unit. All GPS points were entered into a Microsoft Excel spreadsheet. Tracking fish movements on foot was the most reliable way to pinpoint trout locations but was time consuming. Kayaking proved to be the most efficient way to locate redband trout. Aerial surveys were the least effective with a location rate of about 25-35%. Speed of the plane, interference with other radio towers, and cover trout were residing in made for aerial surveys less effective. However, aerial surveys were necessary due to time constraints; without the aerial surveys several fish would have been overlooked, due to their relocation.

Results

Flow and Temperature

Temperatures in the middle Deschutes River routinely exceeded 20ºC and in the area of Lower Bridge exceeded 25ºC in 2013 (Figure 2). Flows in the middle Deschutes River fluctuated throughout the year (Figure 3). In 2013, average daily discharge ranged from 82 cfs to 1280 cfs (BOR, 2013). Fluctuations can vary by 100 cfs in a 24 hour period, with a difference of 410 cfs recorded from December 10th to December 11th, 2013 (BOR, 2013). Extreme fluctuations in flow such as those observed are known to directly influence habitat available to redband trout and their ability to find and utilize optimal habitats (Pert and Erman 1994).

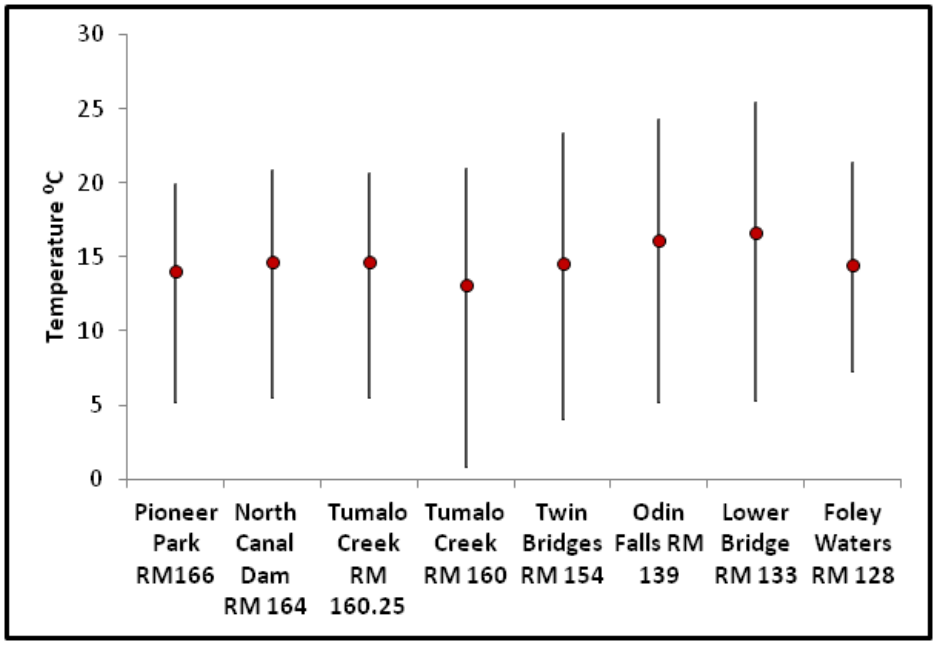

Figure 2. Temperature (ºC) data from April 15th to October 15th, 2013 at eight Middle Deschutes monitoring sites. Lines represent maximum/minimum temperatures and red dots represent annual average. Cline Falls temperature data are not shown because the datalogger could not be retrieved.

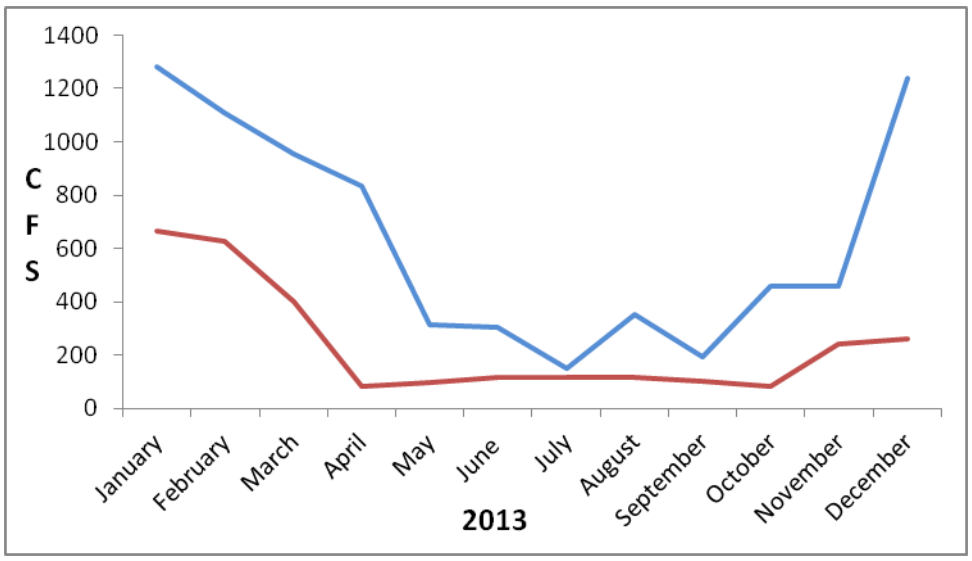

Figure 3. Middle Deschutes River maximum and minimum average monthly flow values for 2013 as recorded by Bureau of Reclamation.

Trout Movement

Thirty redband trout were implanted with Lotek MST-930 radio tags. Total lengths of tagged fish ranged from 210 mm to 300 mm while weights ranged from 102g to 250 g. Fish tracking began May 21st, 2013 and was conducted manually via foot, kayak, and fixed wing aircraft. Fish identifications from aircraft were coarse in scale and identifications of fish located on foot or by kayak were believed to have accuracy within 30 meters (Roberts and Rahel 2005). Toward the end of the tag life, fish were monitored at close range to confirm that they were alive by tracking from the river bank to within 20 m or less.

From May 21st to December 16th, 221 locations were documented for 29 redband trout (Figure 4). All fish were located at least twice with the exception of Trout #21, which was assumed to have a failed tag as it was never located after tagging. All radio tags expired by December 31st.

Without exception, trout released in the Tumalo Road bridge reach moved substantial distances from and in the vicinity of the release location. Three trout were tagged in the Tumalo Road bridge reach on May 8th between RM 156.5-157 and released at RM 156.25 (Figures 4 & 5). Trout #11 was first detected on June 6th, 1.65 miles upstream from the release location. It went undetected until October 17th at which time it had moved as far as 2.15 miles upstream; #11 was generally detected below and above the release site for the duration of the study. Trout #12 was first detected on May 31st, 2.65 miles upstream of the release location, where it remained for the rest of the study. On the release date, combined flows from the Deschutes River and Tumalo Creek were at 198 cfs. Flows increased until May 21st when they peaked at 364 cfs (14.3°C) and steadily declined thereafter. Temperature at this time was approximately 16°C and is not believed to have been responsible for the observed fish movements. Trout #13 was first detected downstream 3.85 miles from the release site on June 6th. Increasing stream flow that peaked on May 21st (364 cfs), two weeks prior to the June 6th detection, may have influenced this relocation. Trout #13 remained at this new location for the remainder of the study, with the exception of some minor movement 0.1-0.25 miles in the vicinity.

Ten trout were captured and tagged on May 10th at two locations along the Odin Falls reach (RM 133.5-139.5). Maximum flow and temperature on May 10th were recorded at 252 cfs and 17.9°C. Four trout (14-17) captured between RM 139.5-138 and released at RM 137.8 (Figure4) moved short (<1 mi.) distances from the release site. Trout #15 initially relocated 0.6 miles downstream but remained in close proximity to the release site. Trout #17 moved downstream 0.55 miles then returned 0.2 miles upstream of the release site and did not move during the next several relocations. Lack of subsequent movement suggests #17 likely became a mortality or discharged its tag. Numbers 14 and 16 were believed to have been mortalities or to have discharged their tags, as they did not move during the study. Six additional trout tagged between RM 137.5-134 (Odin Falls reach) and released at RM 134 (Figure 4) varied widely in the distances they moved during the study: two moved substantial distances (>1 mi.), and at least one moved only 0.3 mi. from the release site, while the movement and fate of three trout tagged at this location remains unknown. Trout #18 was located on June 10th and July 18th just upstream of the release location, and was not relocated again until November 25th when it was found six miles upstream, just below Odin Falls (Figure 5). This trout remained below Odin Falls for the remainder of the study. Trout #19 was believed to have relocated out of the study area, as it was only located twice during the study, with a final detection on July 5th. Trout #20 first moved upstream 0.4 miles and then moved just over 2 miles downstream and stayed above Big Falls (RM 132.25). Trout #22 was detected only once, 0.5 miles downstream of the release site, on October 12th, and was believed to have moved out of study area or had a faulty tag. Trout #23 was only detected three times; all detections were in very close proximity (0.3 mile) to the release site. Trout #21 was believed to have had a faulty tag as it was never relocated after release.

Due to low captures on the first visit, an additional visit was required to capture trout to tag on the Odin Falls reach. Trout numbers 30, 31, and 33 were captured, tagged, and released on May 15th at river mile 137.25 on the Odin Falls reach (Figure 4). Two of these trout moved substantial distances, all downstream of the release site. Trout #31 was located four times; the furthest downstream location documented was 3.75 miles on July 6th, when maximum flows were 116 cfs and the maximum temperature was 16.3°C. This fish was never located above the release site (Figure 5) and was last detected on August 28th, 3.15 miles below the release site. Trout #33 was first detected on June 10th, 3.25 miles downstream of the release site. Between detections on October 18th and November 14th, it relocated upstream 2.2 miles and remained there for the rest of the study (Figure 5). Flows on these dates were 490 cfs and 471 cfs respectively and temperatures were within 0.4°C. Trout #30 was only relocated three times and the furthest downstream location at which it was documented was 0.35 miles from the release site; it remained downstream of the release site for the duration of the project.

Trout captured and released at Gopher Gulch made no major upstream or downstream movements during the study. Six trout captured on May 13th by hook and line at Gopher Gulch (RM 161.5) were tagged and released in the same location (Figure 4). Trout #24, #25 and #29 never made any significant movements but were believed to have been alive as movements were detected from fine scale monitoring. Trout #26 demonstrated some minor movement and eventually moved 0.2 miles upstream then came back down 0.1 mile. Trout #27 stayed in the vicinity of the release site during the majority of the study but was first located 0.1 mile downstream of the release site and was relocated upstream 0.2 miles. Trout #28 was only located four times near the release site and was never again located after August 27th.

Of the trout released at Tumalo Road Bridge, some traveled substantial distances while others moved only short distances from the release site. Four trout were captured on May 16th in the Tumalo State Park reach (RM 159-157) and were released at RM 157 at Tumalo Road Bridge (Figure 4). Trout #32 moved 7.75 miles upstream between June 20th and July 2nd, until travel was stopped by the North Canal Dam (Figure 5). Flows ramped up on June 25th to 306 cfs during Trout #32's migration to North Canal Dam, although Trout #32 had not moved from the release location when flows reached 268 cfs on June 13th. Trout #32 remained just below the North Canal Dam for the remainder of the study. Trout #34 was not located for nearly five months. When it was located on October 17th, it was 4.7 miles downstream and had gone over Awbrey Falls (Figure 5). It remained in that area for the rest of the study as well. Trout #35 travelled 0.6 miles upstream and was last detected on October 31st. Trout #36 was located up to 0.4 miles downstream and 0.6 miles upstream of the release site.

Trout released at Sawyer Park also moved relatively short distances. Four trout were captured on May 16th in the Sawyer Park reach and released at the same location (RM 164.25-164.5) (Figure 4). Trout #37 moved no more than 0.25 miles downstream but the majority of detections were within 0.15 miles of the release site. Trout #38 relocated upstream 0.15 miles and remained there until October 31st after which it was never detected again. Trout #39 movements were all within 0.15 miles of the release site. Trout #40 is assumed to have been a mortality or discharged its tag as inferred from lack of movement.

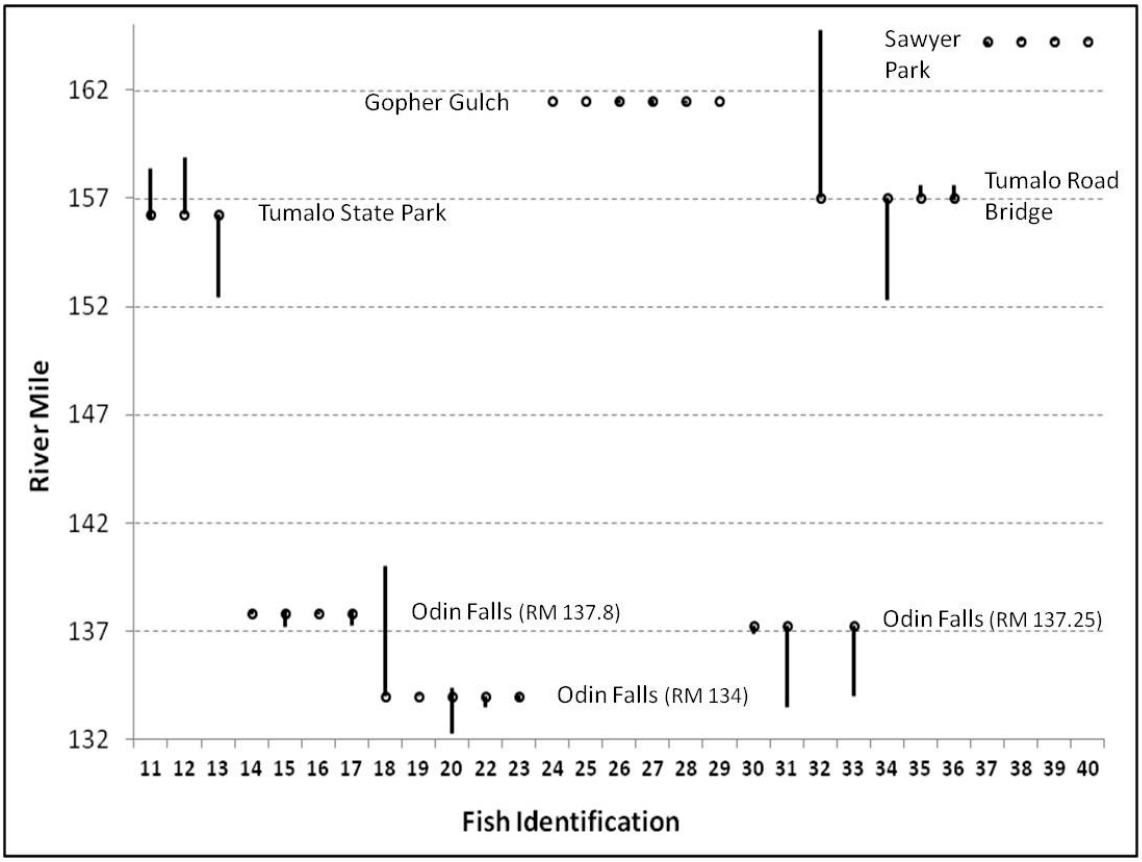

Figure 4. Fish movement on the middle Deschutes River from May 21st to December 21st 2013. Circles identify release locations after tagging and lines represent the furthest distance travelled both upstream and downstream. Trout #21 was omitted due to lack of data.

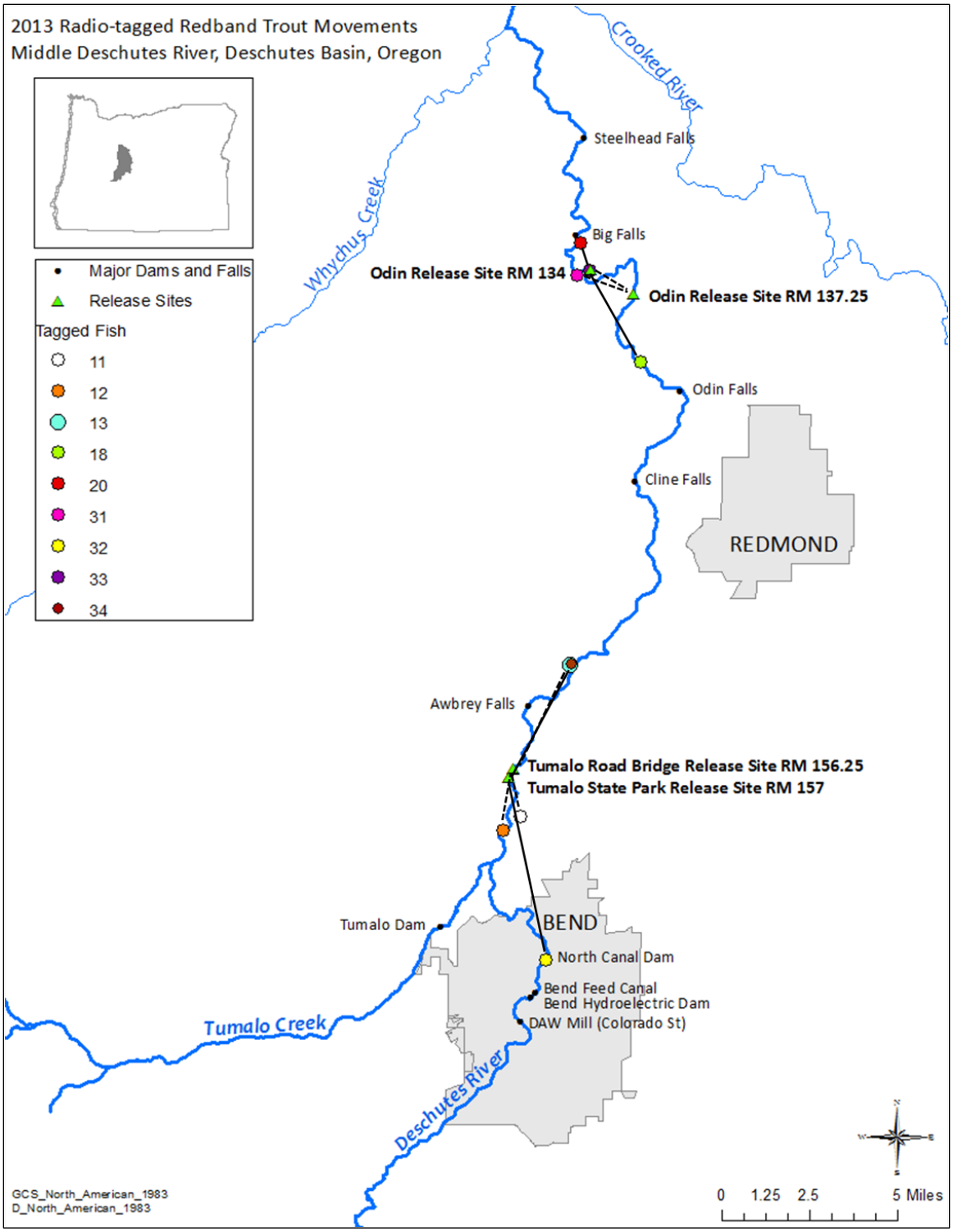

Figure 5. Redband trout release locations (green triangles) and furthest upstream/downstream movements of individual tagged fish. For clarity, only fish that moved ≥2.15 miles are shown.

Discussion

Of the thirty radio tagged redband trout, twenty five (86%) were successfully monitored for the life of the tags which was approximately seven months. Nine (31%) of the redband trout released at four sites, two within ¾ of a mile, migrated to new sites ≥2.15 miles away from the release sites. Five trout (17%) stayed relatively close to the release sites (<0.6 miles). Seven trout (24%) stayed within 0.1 miles of the release site and generally moved within 100 meters of the release site. Four trout (14%) were only located a handful of times and were believed to have moved out of the study area. Four others (14%) were believed to have been mortalities or discharged tags. One tag (#21) was never relocated and was assumed to have failed (Figure 4).

Of the nine radio tagged trout that relocated ≥2.15 miles, several could have moved in relation to flow and/or temperature. It is not certain these fish moved in response to increased flow, although flows did increase significantly between relocation dates. Of the trout that moved ≥ 2.15 miles, five relocated downstream and the other four relocated upstream. All of the trout that moved ≥ 2.15 miles moved from four release sites: Tumalo State Park, Tumalo Bridge Road, and the two downstream Odin Falls sites. Trout #32, which moved from the release site at Tumalo Bridge 6 miles upstream to North Canal Dam between June 20th and July 2nd, traveled *past* Tumalo Creek. Temperatures during that time were approximately 4°C colder in Tumalo Creek than in the Deschutes; Deschutes temperatures between the release site and North Canal Dam remained below 18°C until June 28th, and remained below 20°C altogether just downstream of North Canal Dam where Trout #32 remained for the duration of the study. Flows from Tumalo Creek during that period ranged from 17-91 cfs and in the middle Deschutes River ranged from 123-306 cfs. Trout at the three remaining sites moved < 0.6 mile, and at two of these sites, Sawyer Park and Gopher Gulch, no movement > 0.1 mile was observed.

Fish that may have migrated out of the study area could have moved to Lake Billy Chinook, Whychus Creek or Tumalo Creek. For verification, flights were routinely flown over Lake Billy Chinook, twice up Tumalo Creek to Tumalo Falls and once briefly over Whychus Creek. Trout in any of these locations could have been overlooked due to cover obstructing the radio signal or interference which was a common occurrence during telemetry flights. Trout #32 clearly demonstrated that redband trout are capable of traveling significant distances in a relatively short period of time, and may have kept traveling upstream had it not encountered the North Canal Dam.

Trout in Gopher Gulch remained in the same location through a variety of flow regimes and movement at this site was nearly non-existent, while temperatures in the vicinity (RM 160) peaked just above 20°C and remained above 18°C for at least 29 and potentially up to 46 days in July and August. Trout #28 however did disappear after August 27th having remained in the area for three months prior. Radio tagged redband trout in Sawyer Park and several in the Odin Falls reach seem to have experienced higher than average mortalities or discharged tags. Fish in the Odin Falls reach may have experienced temperature-related stress which in turn may have caused a more dormant period during excessive temperatures.

It is uncertain why some redband trout relocated and why some remained near the release locations. Flow, temperature, and inter-specific competition have all been shown to affect trout habitat selection (Budy et al. 2008, McHugh and Budy 2006, Pert and Erman 1994, Starcevick et al. 2006). McHugh and Budy (2006) have shown that cutthroat trout in sympatry with brown trout display limited movement in river systems, as well as reduced growth rates. In addition, cutthroat trout were found in habitat with less forage. Pert and Erman (1994) demonstrated that lotic fishes are greatly affected by habitat availability and stability, and a manipulated flow regime may inhibit their ability to locate preferred habitat. However, not all fish respond to fluctuations in flows similarly.

Temperature data show that temperatures in the middle Deschutes routinely exceed ODEQ's standard for redband trout beginning in July and extending into mid-September in the lower reaches. Maximum temperatures exceeded 18ºC for 55 consecutive days at Twin Bridges, 60 days at Lower Bridge, 59 days at Odin Falls and 31 days at Foley Waters. The maximum recorded temperature was from Lower Bridge where it reached 25.4ºC on July 2nd and 3rd. Burnell et al. (2000) discovered that during stressful temperature conditions brown trout were less likely to move. The same study showed that brown trout did not seek thermal refugia when instream temperatures were above 19°C; it is unclear if redband trout respond to excessive temperatures by becoming dormant.

ODFW will continue to radio tag redband trout in the middle Deschutes in 2014, 2015, and 2016 to monitor habitat use and movement. Beginning in 2014 we will also tag redbands in Tumalo Creek in an attempt to document use of Tumalo Creek as spawning refugia for Deschutes River redband. Continued monitoring of redband trout over the next three years will contribute to a more robust dataset and a better understanding of redband trout habitat selection, movement, and spawning grounds that in turn will inform fisheries management and strategic restoration planning.

References

Budy P., G.P. Thiede, P. McHugh, E.D. Hansen, J. Wood. (2008). Exploring the relative influence of biotic interactions and environmental conditions on the abundance and distribution of exotic brown trout (*Salmo trutta*) in a high mountain stream. Ecology of Freshwater Fish 2008:17: 554-566

Bureau of Reclamation. Historical daily stream flow values for Deschutes River, Oregon. Available: http://www.usbr.gov/pn/hydromet/arcread.html. (January 2014).

Burnell, K.H., Isley, J.J., Bunnell, D.B., Van Lear, D.H., Dolloff, C.A. (2000) Seasonal Movement of Brown Trout in a Southern Appalachian River. American Fisheries Society 129:1373-1379

Deters, K. A., R S. Brown, J. W. Boyd, M. Brad Eppard & Adam G. Seaburg (2012). Optimal Suturing Technique and Number of Sutures for Surgical Implantation of Acoustic Transmitters in Juvenile Salmonids, Transactions of the American Fisheries Society, 141:1, 1-10

Freeman, M.C., Z.H. Bowen, K.D Boyee, E.R. Irwin. (2001). Flow and Habitat Effects on Juvenile Abundance in Natural and Altered Flow Regimes. Ecological Applications 11:179-190.

Gatz, A.J., M.J.Sale, L.J. Loar. (1987) Habitat Shifts in Rainbow Trout: Competitive Influences of Brown Trout. Oecologia Vol. 74, No. 1 p. 7-19

Houston, R. and L. Jones (2010). City of Bend Ambient Water Quality Monitoring:
Deschutes River and Tumalo Creek 2005-2008. Upper Deschutes Watershed Council.

Loerts, S., T. Lorz. ODFW Aquatic Inventory Project Stream Report. Oregon Department of Fish & Wildlife. 1994.

McHugh, P. & P. Budy (2006). Experimental Effects of Nonnative Brown
Trout on the Individual- and Population-Level Performance of Native Bonneville Cutthroat Trout, Transactions of the American Fisheries Society, 135:6, p. 1441-1455.

Pert, E.J. & D. C. Erman (1994). Habitat Use by Adult Rainbow
Trout under Moderate Artificial Fluctuations in Flow, Transactions of the American Fisheries Society, 123:6, p. 913-923

Roberts, J.J., and F.J. Rahel (2005). Accuracy of Radio Telemetry in Fisheries Studies. North American Journal of Fisheries Management 25; p. 660-666

Sloman, K.A. (2001).Plasma cortisol concentrations before and after social stress in rainbow trout and brown trout." *Physiological and Biochemical Zoology* 74.3 (2001): 383-389.

Starcevick, S., S. E. Jacobs, W. Tenniswood (2006). Effects of Dams on Life History of Redband Trout in the Upper Klamath River: A Summary and Synthesis of Past and Recent History. Oregon Department of Fish and Wildlife.