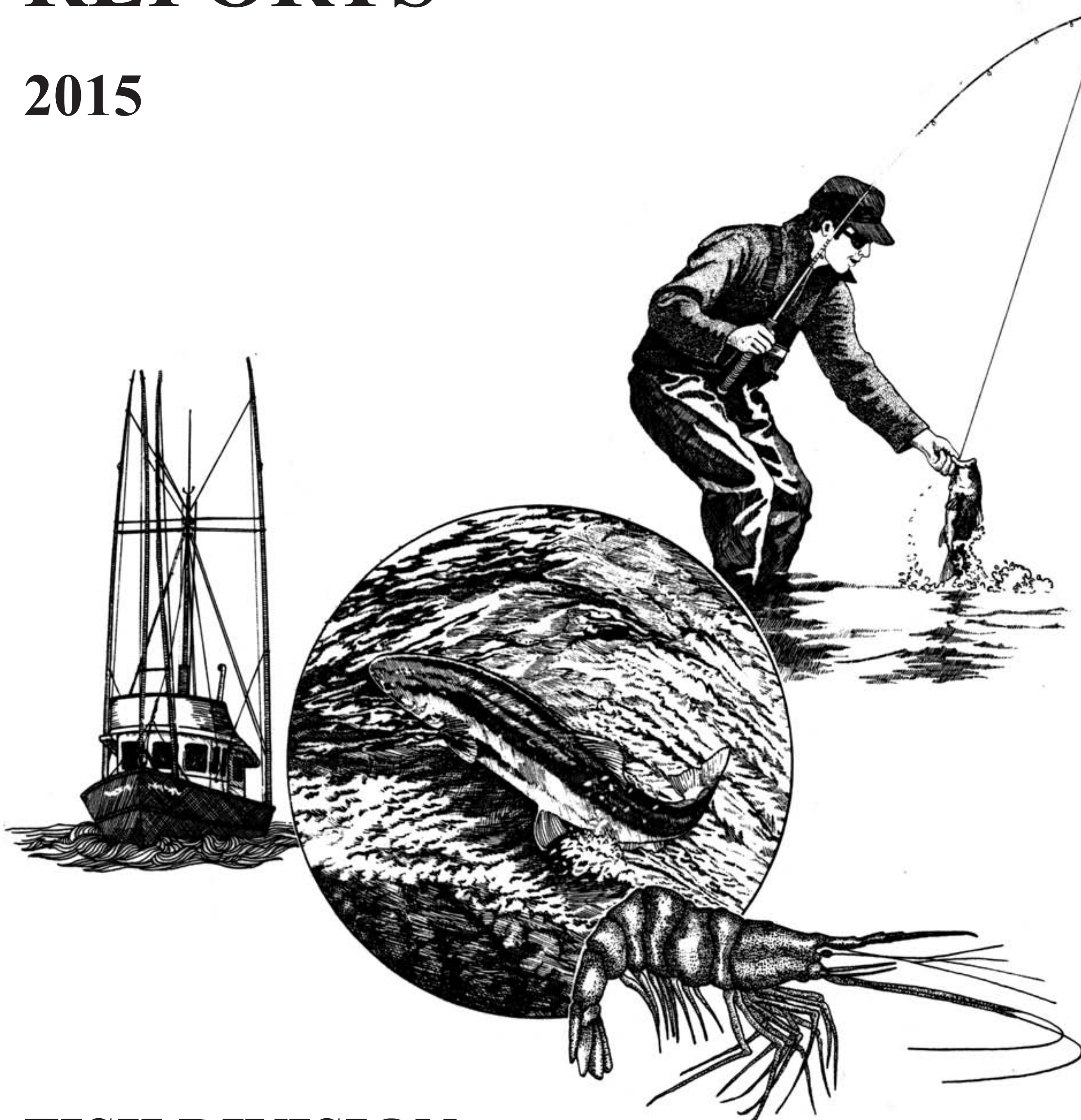
PROGRESS REPORTS

2015



FISH DIVISION

Oregon Department of Fish and Wildlife

2015 Warner Sucker Investigations (Lower Twentymile Creek Passage)

ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: **2015 Warner Sucker Investigations (Lower Twentymile Creek Passage)**

CONTRACT NUMBERS: BLM L10AC20356

Photograph of the Dike Diversion and fishway on lower Twentymile Creek during a May 2015 freshet.

Paul D. Scheerer[1], James T. Peterson[2], and **Shaun Clements[1]**

[1]Oregon Department of Fish and Wildlife, 28655 Highway 34, Corvallis, Oregon 97333

[2]USGS Oregon Cooperative Fish and Wildlife Research Unit, 104 Nash Hall, Oregon State University, Corvallis, OR 97331

This project was financed with funds administered by the U.S. Bureau of Land Management.

CONTENTS

Abstract— Warner suckers (*Catostomus warnerensis*) are endemic to the lakes and tributaries of the Warner basin, southeastern Oregon. The species was listed as threatened by the U.S. Fish and Wildlife Service in 1985 because of habitat fragmentation and the threats from introduced non-native fish. Recent recovery efforts have focused on providing passage at irrigation diversion dams that limit sucker movement within the Warner basin. To assess the effectiveness of passage restoration activities in lower Twentymile Creek we: 1) used a Bayesian Jolly-Seber open population estimator to estimate sucker population size, apparent survival, and immigration in the lower Twentymile Creek drainage, 2) tagged suckers with a passive integrated transponders (PIT), and 3) installed fixed, flat-plate PIT-tag antennas to evaluate passage at the Dike diversion and the timing and numbers of suckers moving downstream through the MC diversion and out of the study area. We captured/detected fish using two gear combinations (hoop nets and mobile PIT antenna). We estimated there were 813 suckers (95% CI: 761-861) in lower Twentymile Creek. We estimated apparent survival of 69% to 79% (survival increased with fish size) over the duration of the study and a 7% immigration rate. We found no evidence that hoop net capture probabilities differed from the probability of detection with the mobile PIT antenna. We documented the successful passage of suckers at the Dike diversion and emigration of suckers downstream into the MC diversion channel.

INTRODUCTION

The Warner sucker is endemic to the Warner Valley, an endorheic subbasin of the Great Basin in southeastern Oregon and northwestern Nevada. Historically, this species was abundant and its range included three permanent lakes (Hart, Crump, and Pelican), several ephemeral lakes, a network of sloughs and diversion canals, and three major tributary drainages (Honey, Deep, and Twentymile Creeks) (U.S. Fish and Wildlife Service 1985). Warner sucker abundance and distribution has declined over the past century and it was federally listed as threatened in 1985 due to habitat fragmentation and threats posed by the proliferation of piscivorous non-native game fishes (U.S. Fish and Wildlife Service 1985).

The Warner sucker inhabits the lakes and low gradient stream reaches of the Warner Valley. The Warner sucker metapopulation is comprised of both lake and stream life history morphs. The lake suckers are lacustrine adfluvial fish that normally spawn in the streams. However, upstream migration may be blocked by low stream flows during low water years or by irrigation diversion dams. When this happens, spawning may occur in nearshore areas of the lakes (White et al. 1990). Large lake-dwelling populations of introduced fishes likely reduce recruitment by preying on young suckers (U.S. Fish and Wildlife Service 1998). The stream suckers inhabit and spawn in Honey, Deep, and Twentymile Creeks.

The Recovery Plan for the Threatened and Rare Native Fishes of the Warner Basin and Alkali Subbasin (U.S. Fish and Wildlife Service 1998) sets recovery criteria for delisting the species. These criteria require that: 1) a self-sustaining metapopulation is distributed throughout the Twentymile, Honey, and Deep Creek (below the falls) drainages, and in Pelican, Crump, and Hart Lakes, 2) passage is restored within and among the Twentymile, Honey, and Deep Creek (below the falls) drainages so that the individual populations of Warner suckers can function as a metapopulation, and 3) no threats exist that would likely threaten the survival of the species over a significant portion of its range.

Recently, there have been several efforts to provide fish passage at barriers throughout the basin to address criterion two. Twentymile Creek has at least three barriers to fish passage including Greaser Reservoir, the MC Diversion, and the Dike Diversion. To partially address passage issues in this basin, the Lake County Watershed Council, the BLM, and River Design Group worked with contractors to modify the Dike Diversion in the winter of 2014-2015, replacing an ageing Denil fishway with a sucker-friendly fishway. The new fishway is 57 ft long with ten pools/cells, has 0.5 ft weir drops for redband trout (*Oncorhynchus mykiss*) passage, 1 ft square orifices for sucker passage, and a simulated streambed floor (cobble). It was designed for a passage window of April-July, maximum orifice velocity of 4 ft/s, range of flows between 35-148 cfs, minimum pool depth of 1 ft, slope ≤4%, and a jump height of 0 ft (Troy Brandt, River Design Group, personal communication). To inform progress towards criteria two, and to assess the effectiveness of modifications to the Dike Diversion, our objectives in 2015 were to: 1) assess Warner sucker passage success at the Dike Diversion structure, 2) estimate sucker vital rates (abundance, survival, and emigration) in the stream segment between the MC and Dike Diversions.

METHODS

In the spring of 2015, we surveyed the sucker population and aquatic habitat in a 1.7 km section of lower Twentymile Creek. The study area was bound on the upstream end by the Dike irrigation diversion dam and on the downstream end by the unscreened MC irrigation diversion dam (Figure 1). Precipitation was sparse from 2013-2015 and stream flows during the spring of 2015 resembled typical late summer flows (Oregon Water Resources Department 2015).

We captured fish in deep pools in the study section using six-panel hoop nets (0.92 m diameter, 13 mm mesh) with single 15.2 m lead or dual 7.6 m wings (13 mm mesh). We surveyed the entire sample frame biweekly (downstream to upstream) from 20 April through 18 June 2015. We set eight hoop nets per day and fished the nets overnight (three net sets per week). We combined the weekly catch from all hoop nets and counted this as one hoop net sampling occasion. All captured suckers were placed in an aerated bucket until processing. We anesthetized the suckers using methyl sulfonate (20 g/L) buffered with sodium bicarbonate (20 g/L), measured fork length (FL) to the nearest 1 mm, scanned each sucker for previously-implanted PIT tags using a hand-held PIT tag reader, and recorded detections of PIT tags when observed. We marked all un-tagged suckers ≥100 mm FL with 23 mm half-duplex PIT tags in the anterior ventral side of the body cavity and double marked these suckers with partial upper caudal fin clips to quantify tag loss. We marked all suckers 60-99 mm with partial fin clips. We used an upper caudal for the first capture, lower caudal clip for the second capture (first recapture), anal clip for the third capture (second recapture), and dorsal clip for the fourth capture (third recapture). After processing, we released the suckers back to the stream near the capture location. During subsequent surveys, we scanned each fish for an existing PIT tag, looked for fin clips, recorded the number of tagged/clipped and un-tagged/un-clipped suckers, and recorded the PIT-tag number when one was detected. If no PIT tag was detected, we implanted one as described above.

We surveyed the entire study section with a mobile PIT antenna bi-weekly after pulling the hoop nets for the week, (two consecutive passes in a day) to detect and determine the location of PIT-tagged suckers. We recorded any detected PIT tagged fish and its stream location (UTM coordinates) using a hand held Global Positioning System (GPS) unit. The typical tag read range using this mobile PIT antenna was approximately 0.75 m, which was estimated using test tags.

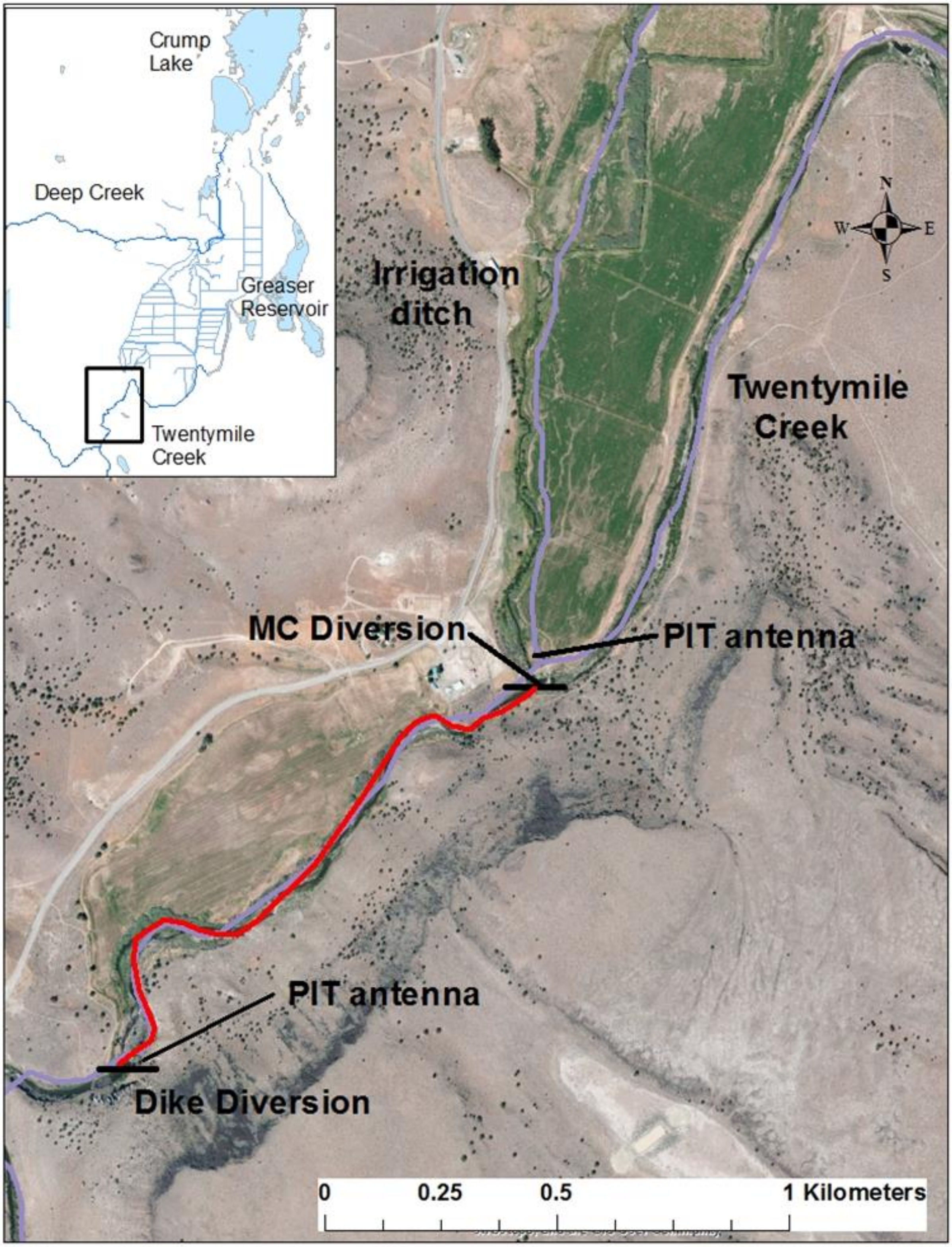


Figure 1. Study area sampled in lower Twentymile Creek in 2015 (red line). The stream flows from the Dike diversion towards the MC diversion. The inset map shows the study area (rectangle) relative to irrigation ditches, Greaser Reservoir, Deep Creek, and Crump Lake.

We installed and operated four fixed, flat-plate Passive Integrated Transponder (PIT) antennas to evaluate the timing and number of suckers moving upstream and passing (or attempting to pass) the Dike Diversion fishway. These were located: 1) below the pool immediately downstream of fishway, 2) downstream fishway orifice, 3) upstream fishway orifice, and 4) riffle upstream of the pool impounded by the irrigation dam. We installed a fifth PIT antenna in the irrigation ditch below the MC diversion to assess emigration of suckers into the MC diversion channel. We tested antenna performance and downloaded data biweekly at all antennas and installed a continuous detection beacon on the downstream orifice antenna at the Dike Diversion fishway. We tested water velocity at various locations in the passage structure at various flow levels to assess whether passage success was related to orifice velocity.

We divided the creek into 500 m reaches (same reaches established in 2014 surveys; Scheerer et al. 2014) and collected the following habitat data in each reach: wetted width (m), average depth (m), maximum depth (m), aquatic vegetation area as a percentage of total surface area, dominant substrate type, pool area as a percentage of total surface area, and number of pools. We obtained width, depth, substrate, and aquatic vegetation measurements at transects located 50, 150, 250, 350, and 450 m from the downstream boundary of each reach. We calculated average depth at each transect by summing depth measurements collected at 25, 50, and 75% of the wetted width and dividing by four, to account for zero depth at the stream margins. We waded through each 100 m stream section and recorded the single deepest water depth (maximum depth). We determined the dominant substrate from seven equally-spaced points along each transect. At each point (100 mm circle), we recorded whether the majority of the substrate was fines (<0.063 mm), sand (0.063-2 mm), gravel (3-64 mm), cobble (65-256 mm), boulder (>256 mm), bedrock (native consolidated rock), or embedded. We recorded stream temperature at the beginning and end of the 500 m reach, recorded UTM coordinates, and took photographs. We also recorded stream temperatures when checking each trap net, at the beginning of each mobile PIT sampling pass, and continuously during the study period at the Dike diversion fishway using a HOBO® thermograph set to record at 1 h intervals.

Data analysis

The fish sampling activities took place biweekly over 9 weeks (5 week-long periods of hoop netting and mobile PIT scanning). Thus, the closure assumptions required by closed capture population estimators (i.e., no immigration, emigration, births or deaths) may have been violated. Previous analyses (Scheerer et al. 2014) also found substantial heterogeneity in fish capture probabilities. Fish were captured and recaptured using multiple gears, and fish marked with PIT tags were detected using antennas. The latter meant that the probability of detection for unmarked fish and marked fish (juveniles) without PIT tags was zero. To analyze the data, we used a Bayesian Jolly-Seber open population estimator (Kéry and Schaub 2011) to estimate sucker population size, apparent survival, and immigration, also termed probability of entry. The model estimates apparent survival, as opposed to true survival, because it cannot distinguish mortality from emigration (i.e., a fish leaving the study area during the sample period). This approach also can be used to model the demographic rates and capture probabilities using covariates and can incorporate additional variation (heterogeneity) in model parameters using random effects corresponding to sample occasion. The random effects in our model represented unique effects associated with each capture occasion that were unexplained by the covariates. Abundance was estimated during model fitting using data augmentation (Kéry and Schaub 2011). All models were fit with Markov Chain Monte Carlo (MCMC) methods in WinBUGS version 1.4 (Lunn et al. 2000) with 225,000 iterations with 30,000 burn in samples as determined by a Gibbsit analysis (Raftery and Lewis 1996).

We were primarily interested in obtaining the best predicting model of demographic rates, capture probability, and population size. Therefore, we constructed global models for each model parameter. The global capture probability model contained: sampling method, fish total length, and a random effect corresponding to sample occasion. The global apparent survival and immigration models contained: fish total length, whether a fish was captured and marked (N=147) in 2014, and a random effect corresponding to each interval between sample occasions. To accommodate the large number of parameters and avoid problems with the lack of parameter identifiability, we conducted model selection for each parameter individually. Here we modeled two parameters as constant and fit all subsets of the global model for the remaining parameter. The best approximating model for each parameter was determined using Deviance Information Criteria (DIC; Spiegelhalter et al. 2002). We then combined the best approximating models for each parameter in a single model and evaluated all subsets of the combined model to determine the best approximating Jolly-Seber model. We report the parameter estimates and random effects (expressed as variance components) from the best approximating model and express precision of the estimates using 95% credible intervals, which are equivalent to 95% confidence intervals.

RESULTS

Lower Twentymile Creek is low gradient (<1%) and flows through private agricultural hay fields and pasture lands. From the spring of 2013 through the fall of 2015, the Warner basin experienced below average precipitation (Figure 2), snow pack, and stream flows (Oregon Climate Service 2014, 2015; Oregon Water Resources Department 2014, 2015).

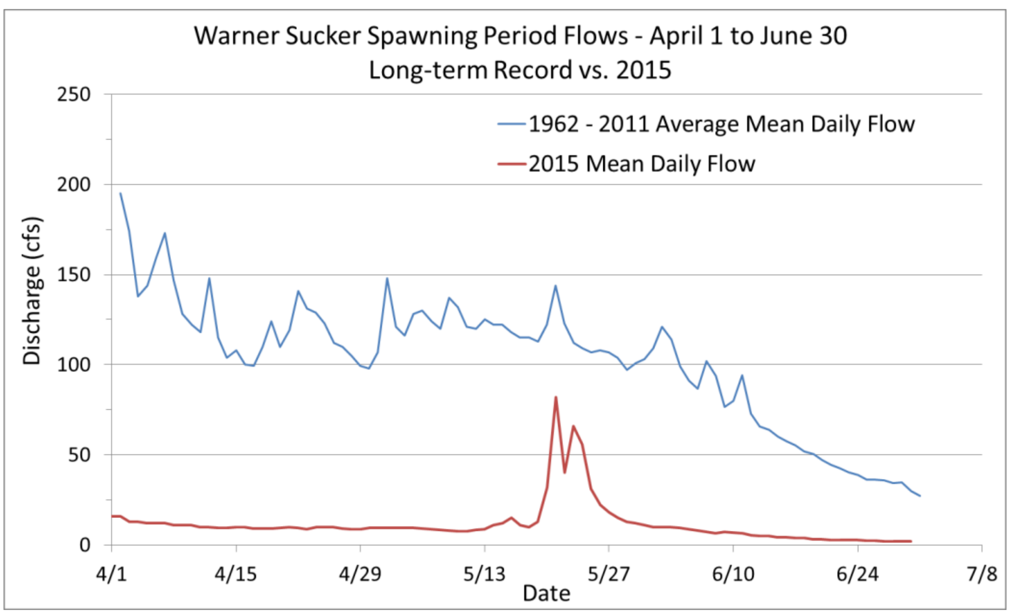


Figure 2. Comparison of 2015 Twentymile Creek mean daily flows and the long term mean of average of mean daily flows from 1962-2011.

Population Abundance and Survival

In 2015, we captured and PIT tagged 93 adult suckers and captured and fin clipped 293 juvenile suckers (Table 1). The 2015 total hoop net catch of suckers (N=386) was >2.5 times the 2014 catch (N=147), despite substantially lower effort in 2015 (40 trap nights vs. 170 trap nights). We recaptured a total of 96 adult suckers, 41 that we tagged in 2014 and 55 that we tagged in 2015, and 52 juvenile suckers, all of which we marked in 2015. We also detected 54 unique suckers using the mobile PIT antenna. Suckers ranged in size from 51-270 mm FL, with at least three apparent age-classes (Figure 3).

We estimated there were 813 suckers (95% CI: 761-861) in lower Twentymile Creek, which was significantly higher than our 2014 estimate of 482 suckers (95% CI: 368-638) (Scheerer et al. 2014) and similar to our 2009 estimate of 677 suckers (299-1,334) (Richardson et al. 2009). Note, the 2009 and 2014 estimates included a small number of suckers residing downstream of the MC diversion. The best approximating Jolly Seber model contained constant immigration rates, apparent survival modeled as a function of fish length, capture probability modeled as function of fixed antenna receiver methods, and a random effect corresponding to capture occasion (Table 2). Apparent survival during the nine week period was positively related to body size (Figure 4) and the parameters suggest that survival was 1.11 times greater for each 50 mm increase in fish body size. Surprisingly, model selection also indicated no evidence that capture probabilities differed between mobile antenna and hoop nets. However, fixed receiver antennas were much less efficient at detecting suckers than mobile antennas and hoop nets, with estimated probabilities of detection averaging 0.22 and 0.45 for the latter two gear types, respectively.

We did not observe any PIT tag loss in double tagged fish. Habitat characteristics for the study reaches are shown in Table 3.

Table 1. Weekly Warner sucker catch from hoop nets and detections using the mobile PIT antenna.

	Hoop nets			
Week of	Trap nights	Number of adults	Number of juveniles	Mobile PIT antenna
April 20	8	16	16	7
May 4	8	29	42	13
May 18	8	12	33	12
June 1	8	16	89	13
June 15	8	25	165	9
	40	98	345	54

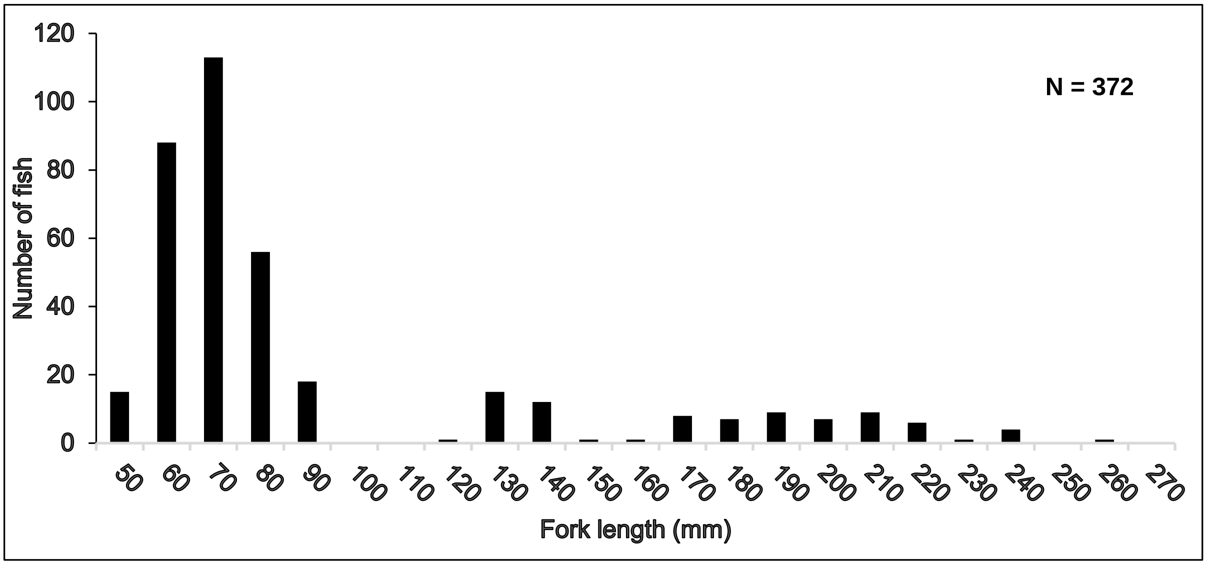


Figure 3. Length-frequency histogram for suckers captured in lower Twentymile Creek, 2015.

Table 2. Model parameters and estimated capture probabilities for Warner suckers in lower Twentymile Creek, 2015.

Parameter	Mean	SD	Lower 95% CI	Upper 95% CI
Abundance	813	24.74	761	861
Immigration	0.070	0.005	0.061	0.081
Survival[1]				
Intercept	0.717	0.212	0.273	0.955
Fish length	0.002	0.001	0.001	0.005
Capture/detection probability[1]				
Intercept	-0.189	0.224	-0.622	0.251
Fixed reciever	-1.056	0.380	-1.604	-0.301
Random effects				
Sample occasion	0.920	0.193	0.619	1.384

[1]Parameters correspond to logit linear model

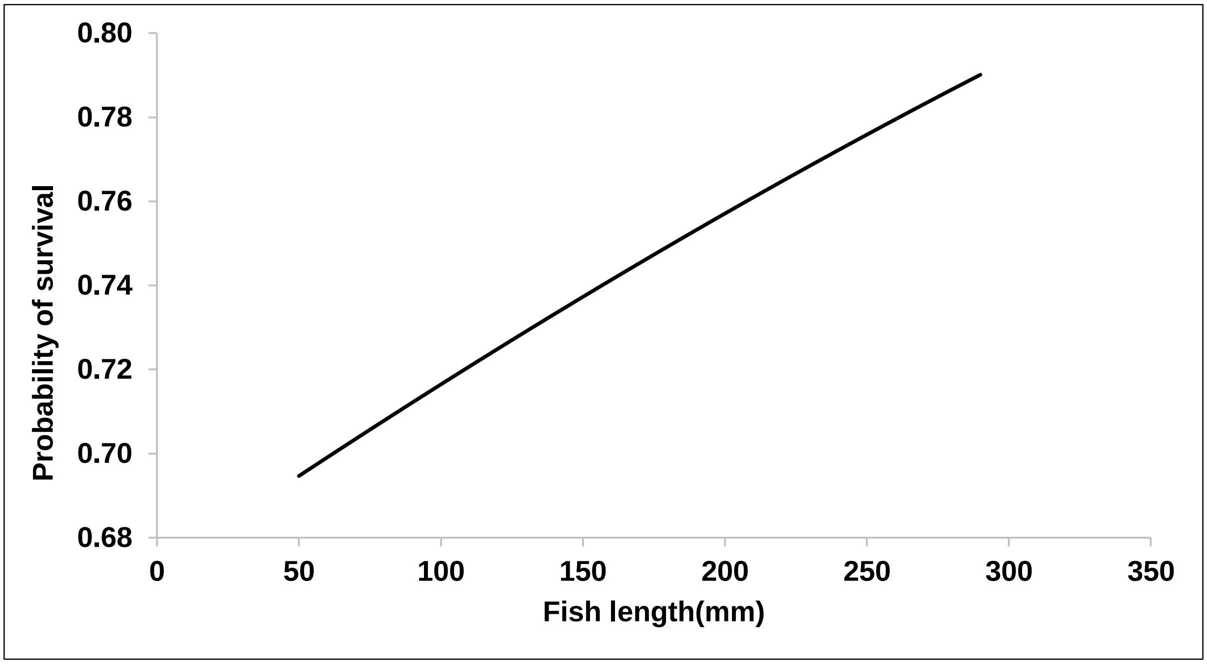


Figure 4. Relationship between apparent survival, estimated from the best approximating model, and fish length for Warner suckers, 2015.

Table 3. Habitat characteristics of the reaches sampled in lower Twentymile Creek in 2015. Stream flows were low, defined as surface water flowing across 1-75% of the active channel width (Oregon Department of Fish and Wildlife 2013). Reach 3 includes ~200 m of secondary channel.

Reach	Length	Average width	Average depth	Maximum depth	Dominant substrate	Number of pools	Percent pools	Percent aquatic vegetation
1	500	10.3	0.43	2.00	boulders	7	76.0	18.0
2	500	11.5	0.28	2.70	gravel	6	52.0	20.0
3	700	13.9	0.43	2.00	bedrock	6	34.0	16.0
	1700	12.1	0.38					

Sucker Movement and Passage at the Irrigation Diversions

We detected 20 suckers passing the fishway at the Dike Diversion; most movement was nocturnal. Fourteen of these 20 suckers were ones that we translocated from an upstream stream segment into or just downstream of the fishway. Of the eight suckers we released into the fishway, all passed the structure successfully. Of the 12 suckers we released into the pool immediately downstream of the fishway, six passed the structure successfully and two moved (were captured or detected) downstream. The mean length of the suckers that we released into the pool and passed upstream successfully (162.6 mm; range 133-214 mm; 95% CI: 127-199 mm) was not significantly larger than that of the suckers that we released in the pool and did not pass upstream (144.3 mm; range 131-177 mm; 95% CI: 126-162 mm). Additionally, six suckers (of 98) that we captured, tagged, and released into the creek downstream of the fishway successfully passed through the fishway (mean length- 171 mm; range 128-215 mm; 95% CI: 143-200 mm).

Note, the PIT tag detection beacon that we installed on the fishway's lower orifice antenna (A2) was detected continuously throughout the study period indicating that there was no break in detection at this antenna. The antennas at the upper fishway orifice (A3), the upstream riffle (A4), and the MC diversion were operational when tested biweekly. The antenna at the pool downstream of the fishway was inoperable (blown out) for 10 days during the spring freshet (May 22-31).

The average time that it took for a suckers to move from the pool below the fishway into the fishway, through the fishway (antenna A2-A3), or from the fishway through the pool impounded by the diversion dam (~100 m long) was 41.3 h (range 0.5-78.7 h; n=10), 77.5 h (range 0.6-578.3 h; n=20), or 133.1 h (range 3.0-655.0 h; n=20), respectively (Table 4). Sucker passage occurred primarily during two time periods, the weeks of May 4 and May 25 (Figure 5). The former period coincided with the release of most translocated fish into the fishway and pool below the fishway and the later time period coincided with the declining limb of the hydrograph and warming stream temperatures. Note, suckers that were not translocated, i.e. those 98 fish captured and released in the creek downstream of the diversion, typically moved through the fishway more quickly (mean 1.9 h; range 0.6-3.2 h) than those released into the fishway (mean 97.9 h; range 0.9-376.2 h) or into the pool below the fishway (mean 126.5 h; range 0.6-578.3 h).

We found a statistically significant positive relationship between fish length and time spent moving through the fishway (linear regression: t=2.14; 19 df; P=0.046), but not between fish size and time spent moving through the pool impounded by the diversion dam (linear regression: t=1.06; 19 df; P=0.302). The former finding is consistent with results from our swimming performance trials where larger suckers were able to achieve higher critical swimming speeds (Scheerer et al. 2013). Note that water velocities measured in the fishway frequently exceeded those predicted by the engineers who designed the fishway (APPENDIX A) and the critical swimming speeds for Warner suckers that we observed in laboratory swimming performance trials (critical speed 0.8-2.0 ft/s; burst speed 0.9-2.6 ft/s) (Scheerer et al. 2013). Nonetheless, we did not detect any suckers that moved upstream (excluding six of the 12 suckers we translocated into the pool below the ladder), entered the pool below the fishway, and did not ascend the fishway.

The number of suckers that we detected volitionally moving into the fishway (i.e., excluding translocated fish) was low (n=6), compared to the total number PIT-tagged in 2014 (n=147) and 2015 (n=93). This may be due, in part, to the low spring stream discharge in Twentymile Creek in 2015, which was approximately 10% of that recorded during typical (wetter) years. Additionally, there is a cascade over bedrock located ~250 m downstream from the fishway that likely limits upstream movement during low flow periods. However, almost all of the PIT tagged suckers that we recaptured in the hoop nets were collected from, or detected in, the same pool where they were tagged, suggesting few suckers moved very far upstream nor ascended the cascade in the spring of 2015.

We detected nine suckers moving downstream at the PIT antenna on the MC irrigation ditch; six (75%) were detected prior to 10 May (prior to the spring freshet). One sucker passed downstream across the antenna, returned upstream across the antenna three weeks later, and then was detected with the mobile PIT antenna further upstream three additional weeks later (after the spring freshet). These data indicate that suckers may be lost into the irrigation system, yet some proportion are able to move back upstream above the MC diversion. ODFW and BLM conducted a backpack electrofishing survey on 3 August 2015 and found suckers inhabiting the channel below the MC diversion (T. Watson, ODFW, unpublished data), the presence of high quality sucker habitat (deep vegetated pools), and no nonnative fishes. This channel extends approximately 1.5 km before water is diverted for irrigation, and future screening may be most appropriate at this lower diversion site.

Table 4. Passage timing of Warner suckers at the Dike Diversion fishway on Twentymile Creek, spring 2015. Dates and times are entered for the first detections and subsequent times are the time elapsed in hours since last detection. Year refers to the year in which the sucker was PIT tagged. Antenna A1 was installed downstream of the pool below the fishway, antennas A2 and A3 were installed on the lower and upper orifices of the fishway, and antenna A4 was installed in the riffle upstream of the pool impounded by the diversion. Antenna A1 was inoperable from May 22-31.

						Antenna			
Sucker	Length	Year	Release location	Pool	Ladder	A1	A2	A3	A4
1	180	2014	creek			4/30/15 5:26	**0.90**	**0.95**	**115.33**
2	193	2014	creek			inoperable	5/25/15 18:28	**3.15**	**15.37**
3	138	2014	creek			inoperable	5/25/15 12:23	**2.95**	**31.53**
4	185	2014	creek			6/14/15 15:01	**15.65**	**0.62**	**7.53**
5	215	2015	creek			5/22/15 16:12	**78.68**	**0.68**	**16.30**
6	128	2015	creek			5/7/2015 13:43	**0.48**	**2.87**	**4.13**
7	214	2015	pool below ladder	5/6/2015 15:10			**2.85**	**2.33**	**24.62**
8	133	2015	pool below ladder	5/7/2015 15:00			**24.82**	**1.75**	**3.03**
9	198	2015	pool below ladder	5/6/2015 15:10			**5.85**	**0.63**	**71.37**
10	138	2015	pool below ladder	5/6/2015 15:10			**1.08**	**83.40**	**6.38**
11	144	2015	pool below ladder	5/5/2015 15:15			**6.08**	**92.38**	**4.25**
12	149	2015	pool below ladder	5/5/2015 15:15			**0.25**	**578.32**	**24.73**
13	188	2015	fish ladder		4/22/15 15:30			**0.85**	**27.18**
14	194	2015	fish ladder		4/22/15 15:30			**10.55**	**264.97**
15	204	2015	fish ladder		5/6/15 15:10			**8.03**	**369.40**
16	135	2015	fish ladder		5/5/15 15:15			**376.21**	**4.92**
17	134	2015	fish ladder		5/6/15 15:10			**247.35**	**151.53**
18	138	2015	fish ladder		5/6/15 15:10			**104.08**	**358.22**
19	138	2015	fish ladder		5/6/15 15:10			**12.38**	**508.03**
20	142	2015	fish ladder		5/7/15 15:00			**23.93**	**655.00**
						average:	**41.33**	**77.48**	**133.05**
						range:	(0.48-78.68)	(0.62-578.32)	(3.03-655.00)

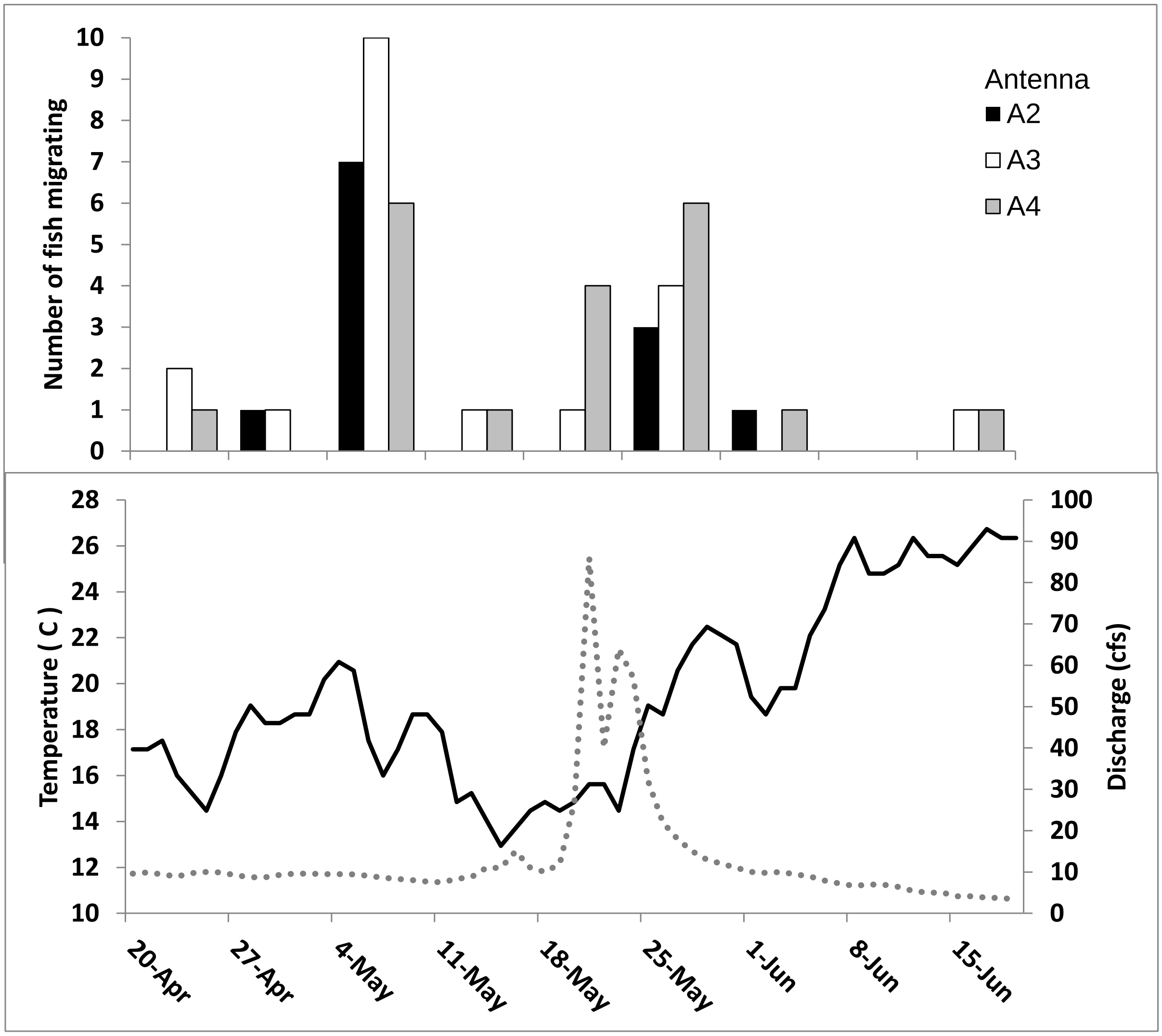


Figure 5. Relationship between sucker passage (upper), maximum daily stream temperatures (lower- solid line), and mean daily stream discharge (lower- dotted line) in Twentymile Creek, from late-April through late-June 2015. Antenna codes: A2- lower orifice of fishway, A3- upper orifice of fishway, and A4- riffle upstream of pool impounded by Dike diversion.

DISCUSSION

The Warner sucker was federally listed as threatened in 1985. Reasons for the listing included watershed degradation, irrigation diversion practices, and predation and competition from introduced fishes (U.S. Fish and Wildlife Service 1998). Irrigation dams and diversions limit movement and genetic exchange within tributaries, between tributaries, and between lake and stream suckers. Recent recovery actions have focused on improving passage by replacing or reconstructing aging irrigation withdrawal structures, most of which were constructed decades ago without fishways or screening.

In 2008, we operated a trap in the original Denil fishway at the Dike Diversion and found no evidence that it was passing fish (Scheerer et al. 2008) and was therefore acting to fragment this population. In 2009, we documented a mass upstream movement of PIT-tagged suckers during the late spring spawning period in the stream segment above the diversion, but did not detect suckers that were tagged downstream of the Dike diversion in this upper stream segment, so concluded that these upstream spawning areas were inaccessible to suckers residing below the Dike diversion (Richardson et al. 2009; Scheerer et al. 2011). These data prompted action to replace the existing fishway.

In the winter of 2014-2015, contractors replaced the aging Denil fish ladder at the Dike Diversion with a fishway that was designed to facilitate passage of suckers (APPENDIX B). In 2015, despite low spring flows, we documented successful movement of adult suckers through the fishway in 2015. Unfortunately, we also documented emigration of suckers downstream into the unscreened MC diversion channel, prompting discussion regarding future screening of this channel.

In 2015, we estimated there were 813 suckers in lower Twentymile Creek downstream of the Dike Diversion, which now have access to habitat above the diversion and the ability to mix with the suckers residing there. Our 2015 abundance estimate was significantly higher than our 2014 estimate of 482 suckers (Scheerer et al. 2014), thus despite recent drought conditions and low stream flows, this portion of the Warner sucker population showed an increase in abundance. Additionally, we noted a substantial increase in the number of juvenile (<150 mm) suckers captured (n=318; 40 trap nights), compared to 2014 (n=97; 170 trap nights), indicating recent successful recruitment. The deep pools in this subbasin are maintained by beavers. These data suggest that Warner suckers benefit from the presence/activity of beaver, which allow them to persist (thrive?) in stream habitats during drought cycles that are common to desert environment.

In 2016, we propose to continue to monitor Warner sucker passage effectiveness in the Warner subbasin. If December 2015's abundance of precipitation is any indication (Oregon Climate Service 2015), the 2016 Warner tributary flows should improve substantially over those of the past two years, allowing us to more easily track suckers migrating in the lower reaches of these tributaries. We would focus our efforts at the Honey Creek Rookery Diversion, which has been dry since the fishway was installed in 2013, and the Twentymile Creek Dike Diversion, where we would like to re-evaluate passage success during a wetter water year with flows that are within the range for which it was engineered (35-148 cfs). We will install PIT-tag antennas at the fishway entrances, exits, and a short distance downstream of the structures to monitor movement of PIT-tagged suckers at these fishways. We will use hoop nets to capture and PIT-tag suckers. If few suckers are captured in lower Honey Creek and Hart Lake, a distinct possibility since both were desiccated in 2013-2014, we will translocate suckers from the upper basin to assess movement through the Rookery Diversion fishway. These data will allow us to describe the timing and magnitude of sucker movement and to assess whether modifications in the design of these and future fishways is warranted.

ACKNOWLEDGEMENTS

We deeply appreciate cooperation of private landowners, Don and Diana Robinson, who generously allowed us access to their land. Thanks also to T. Watson, Lakeview ODFW and J. Leal, Lakeview BLM for their assistance and support. Thanks to River Design Group, Inc. for assistance with fishway hydraulics measurements. This work was funded by the BLM.

REFERENCES

Bailey, P. 2004. Fish Passageway design in the Upper Colorado River Basin. Wetlands Engineering and River Restoration 2001: 1-10.

Kéry. M. and M. Schaub 2011. Bayesian Population Analysis using WinBUGS: A hierarchical perspective. Academic Press, Boston, MA.

Lunn, D.J., Thomas, A., Best, N., and Spiegelhalter, D. 2000. WinBUGS -- a Bayesian modeling framework: concepts, structure, and extensibility. Statistics and Computing 10:325-337.

Oregon Climate Service. 2014. Oregon climate data. Retrieved on 8 January 2014. http://www.ocs.orst.edu/oregon-climate-data.

Oregon Climate Service. 2015. Oregon climate data. Retrieved on 28 December 2015. http://www.ocs.orst.edu/oregon-climate-data.

Oregon Department of Fish and Wildlife. 2013. Aquatic Inventories Project methods for stream habitat surveys. Conservation and Recovery Program, Corvallis, OR. 75 p.

Oregon Water Resources Department. 2014. Oregon Water Resources Department hydrographics database. Retrieved on 8 January 2014. http://apps.wrd.state.or.us/apps/sw/hydro_report/gage_data_request.aspx?station_nbr=10378500.

Oregon Water Resources Department. 2015. Oregon Water Resources Department hydrographics database. Retrieved on 28 December 2015. http://apps.wrd.state.or.us/apps/sw/hydro_report/gage_data_request.aspx?station_nbr=10378500.

Raftery, A. E., and S. M. Lewis. 1996. Implementing MCMC. Pages 115-130 *in* W. R. Gilks, S. Richardson, and D. J. Spiegelhalter, Eds. Markov Chain Monte Carlo in practice. Chapman and Hall/CRC, Boca Raton, Florida.

Richardson, S.E., P. D Scheerer, S. A. Miller, S. E. Jacobs, G. Swearingen, B. Berger, J. Deibner-Hanson, J. Winkowski, M. Terwilliger, and P. Hayden. 2009. Warner Sucker Investigations (2009). Oregon Department of Fish and Wildlife, Contracts: 13420-08-J814 (USFWS), LO9PX00618 (BLM), and W66QKZ90227848 (ACOE). Annual Progress Report, Salem. 33p.

Scheerer, P. D., S. E. Jacobs, K. Bratcher, G. Swearingen, and S. Kramer. 2008. Warner Valley fish investigations- Warner suckers. Oregon Department of Fish and Wildlife, Contracts: HLP083003 (BLM), E-2-50 and 134207M085 (USFWS), W66QKZ-8094-612 (ACOE), and T-17-1 (Conservation Strategy), Annual Progress Report, Salem. 37p.

Scheerer, P. D., S. E. Jacobs, M. Terwilliger, S. A. Miller, S. Gunckel, S. E. Richardson, and M. Heck. 2011. Status, distribution, and life history investigations of Warner suckers, 2006-2010. Oregon Department of Fish and Wildlife, Information Report #2011-02, Salem. 78 p.

Scheerer, P.D., and S. Clements. 2013. Evaluation Warner sucker swimming performance to inform passage design in the Warner basin, Oregon. USFWS cooperative agreement F12AC01064. Oregon Department of Fish and Wildlife, Annual Progress Report, Corvallis. 12 p.

Scheerer, P. D., J. T. Peterson, and S. Clements. 2014. 2014 Warner sucker investigations (lower Twentymile Creek). BLM cooperative agreements L10AC20356 and L12AC20619. Oregon Department of Fish and Wildlife, Annual Progress Report, Corvallis. 14 p.

Spiegelhalter, D.J., N. G. Best, B. P. Carlin, and A. Van der Linde. 2002. Bayesian measures of model complexity and fit (with discussion). Journal of the Royal Statistical Society, Series B 64:583-616.

U.S. Fish and Wildlife Service. 1985. Endangered and threatened wildlife and plants; Determination that the Warner Sucker is a threatened species and designation of critical habitat. Federal Register 50(188):39117-39123.

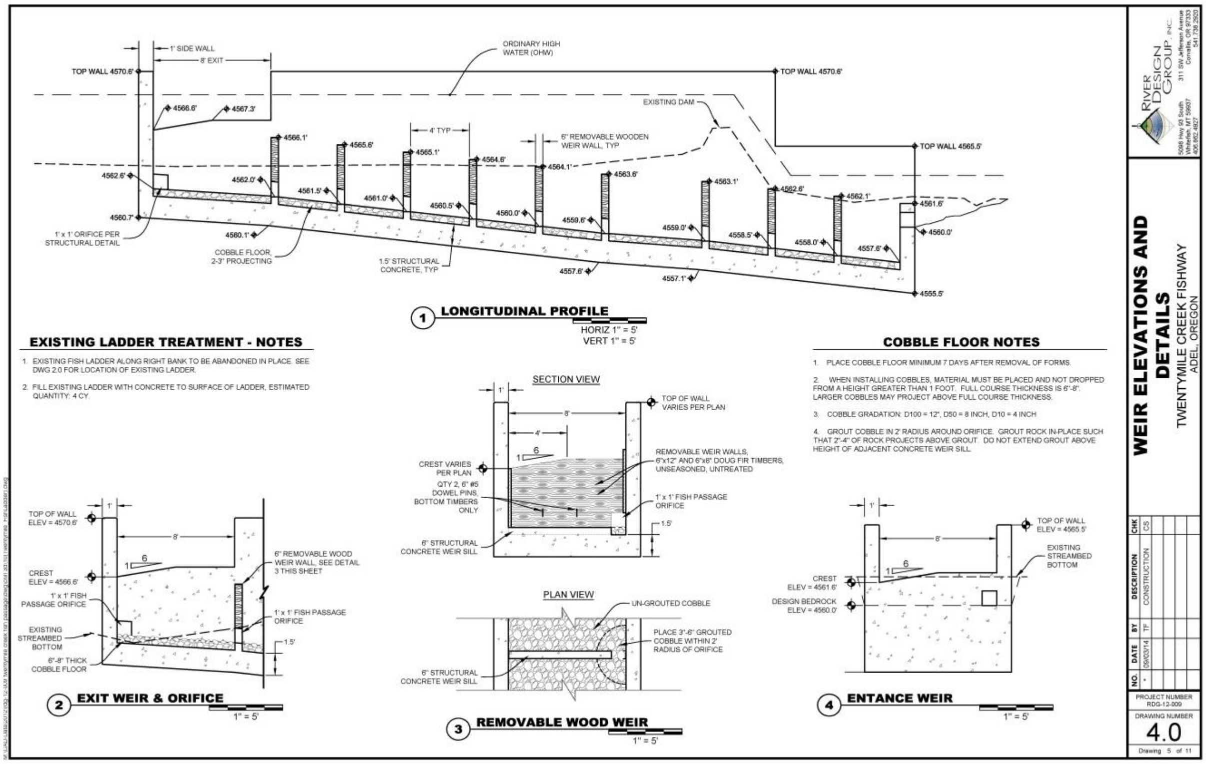
U.S. Fish and Wildlife Service. 1998. Recovery Plan for the Native Fishes of the Warner Basin and Alkali Subbasin. Portland, Oregon. 86 p.

White, R. K., T. R. Hoitsma, M. A. Stern, and A. V. Munhall. 1990. Final report of investigations of the range and status of the Warner Sucker, *Catostomus warnerensis*, during spring and summer 1990. Report to U.S. Bureau of Land Management, Oregon Department of Fish and Wildlife, and U.S. Fish and Wildlife Service. 66 p.

APPENDIX A. Predicted and measured orifice velocities at the Dike diversion fishway. Orifices are numbered starting at downstream end of fishway going upstream. Velocity measurements were taken on 6 May 2015 with a Marsh-McBirney meter at the centerline of each orifice. Stream discharge at the nearby upstream USFS gage was 6.8 cfs.

Feature	Orifice predicted velocity (ft/s)	Measured orifice velocities 0.2' off bottom (ft/s)	Measured orifice velocities 0.5' off bottom (ft/s)	Measured orifice velocities 0.8' off bottom (ft/s)
Orifice 1	2.67	0.90	4.00	3.68
Orifice 2	3.09	4.27	5.75	5.33
Orifice 3	1.40	5.00	5.35	6.62
Orifice 4	3.92	6.11	6.50	4.85
Orifice 5	2.71	7.27	7.57	6.80
Orifice 6	2.79	7.01	7.06	7.26
Orifice 7	2.51	6.77	7.19	6.57
Orifice 8	3.12	6.24	7.34	6.39
Orifice 9	2.67	7.03	5.73	5.36
Orifice 10	4.93	7.76	7.27	7.07
Orifice 11	3.29	3.13	4.43	5.78

APPENDIX B. Dike diversion fishway design (top) and photographs of fishway (bottom). Note the sandbags holding the fixed PIT antenna on the right photograph.



4034 Fairview Industrial Drive SE

Salem, Oregon 97302