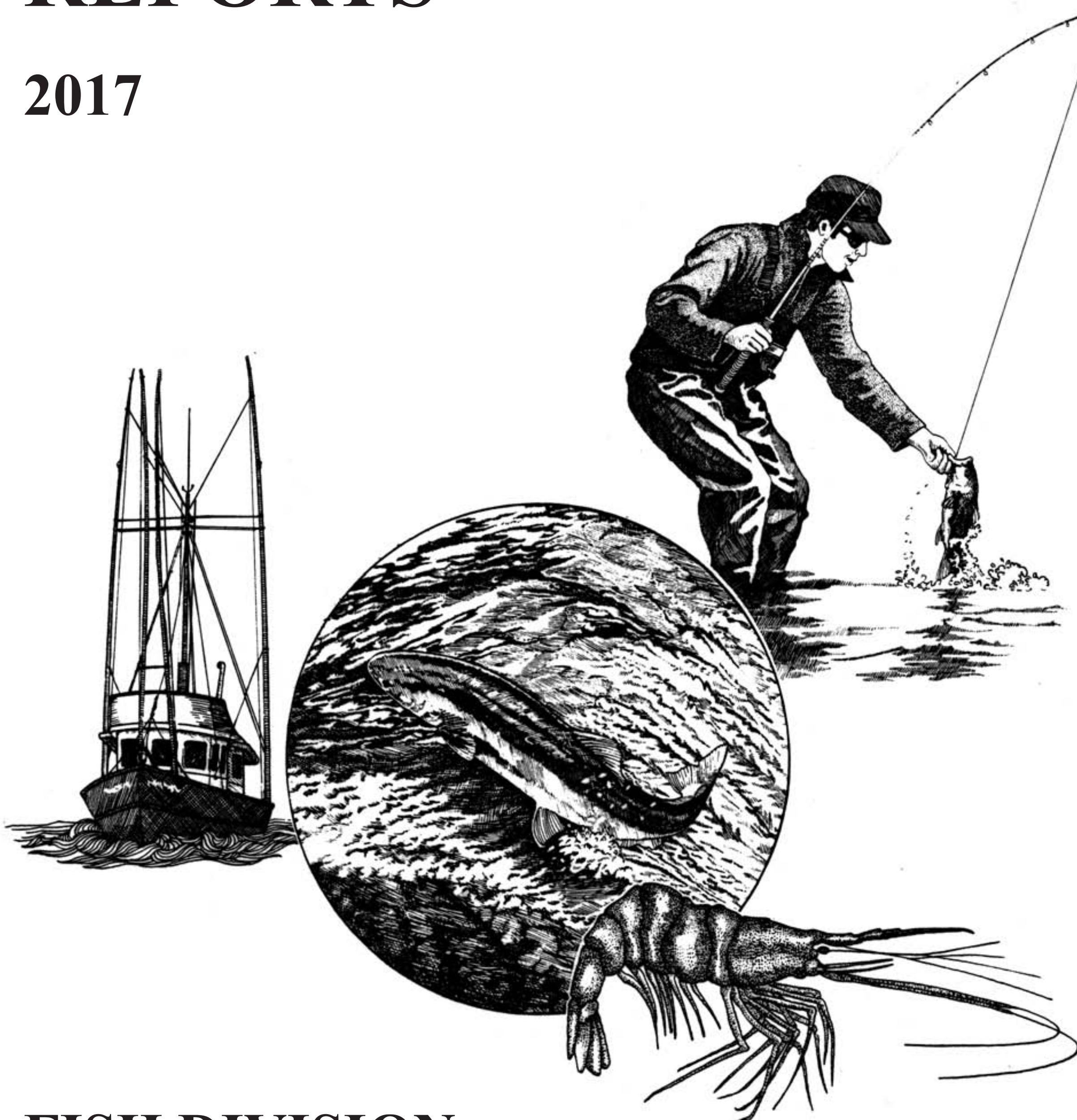
PROGRESS REPORTS

2017



FISH DIVISION

Oregon Department of Fish and Wildlife

2016 Warner Sucker Investigations (Lower Twentymile Creek)

ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: **2016 Warner Sucker Investigations (Lower Twentymile Creek)**

CONTRACT NUMBERS: BLM L12AC20619

Photograph of Twentymile Creek downstream of the culverts at the MC Diversion.

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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 due to habitat fragmentation and threats from introduced nonnative fish. Recent recovery efforts have focused on providing passage at irrigation diversion dams that limit Warner Sucker movement within the Warner Basin. Our 2016 objectives were to: 1) evaluate Warner Sucker passage success at the Dyke Diversion and describe Warner Sucker movement at the MC and Cahill diversions, 2) describe Warner Sucker distribution and estimate abundance and demographic rates (apparent survival and immigration) in the stream segment between the MC and Cahill diversions, and 3) describe nonnative fish use in this stream segment. We documented the successful upstream passage of Warner Suckers at the Dyke Diversion fishway at a range of stream discharges (0.93-2.63 m^3/s), movement of Warner Suckers downstream past the MC Diversion, and movement within the study reach. We estimated that there were 963 Warner Suckers (95% CI: 860-999) in the study area, most of which were juveniles. We estimated apparent weekly survival of 95.4% to 98.7% (survival increased with fish size) and a 21% immigration rate.

INTRODUCTION

Warner Suckers *Catostomus warnerensis* are endemic to the Warner Basin, an endorheic subbasin of the Great Basin in southeastern Oregon and northwestern Nevada. Historically, the species was abundant and its range included three permanent lakes (Hart, Crump, and Pelican), several ephemeral lakes, 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 nonnative game fishes (U.S. Fish and Wildlife Service 1985).

Warner Suckers inhabit the lakes and low gradient stream reaches of the Warner Basin. The Warner Sucker metapopulation is comprised of both stream-dwelling and lake-dwelling fish. The stream-dwelling Warner Suckers inhabit and spawn in Honey, Deep, and Twentymile creeks. The lake-dwelling Warner Suckers typically exhibit a lacustrine-adfluvial life history; however, upstream migration may be blocked by low stream flows during low water years or by irrigation diversion dams. When this happens, spawning and rearing may occur in nearshore areas of the lakes (White et al. 1990) where large populations of lake-dwelling nonnative fishes likely reduce recruitment by preying on young Warner Suckers (U.S. Fish and Wildlife Service 1998).

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 Warner Suckers. 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 has been a focused effort to provide fish passage at migration barriers throughout the basin (criterion two). Until recently, Twentymile Creek had at least four barriers that limited fish movement including the dam at Greaser Reservoir, the MC

Diversion, the Cahill Diversion, and the Dyke Diversion. To partially address passage issues in this basin, the Lake County Watershed Council, the Bureau of Land Management (BLM), and River Design Group (RDG) worked with contractors to modify the Dyke Diversion in the winter of 2014-2015, replacing an aging Denil-type fish ladder with a fishway designed to pass both Warner Suckers and Redband Trout *Oncorhynchus mykiss*. The new fishway is 17 m long with 10 pools (cells), has 0.3 m square orifices on the fishway floor for Warner Sucker passage, 0.15 m weir drops for Redband Trout passage, and a simulated streambed floor (cobble). It was designed for a passage period of April-June, maximum orifice velocities of 1.2 m/s, stream discharges ranging from 0.99-4.19 m^3/s (see Appendix A for a m^3/s to cfs conversion table), a minimum pool depth of 0.3 m, a slope $\leq$4%, and a jump height of 0 m (Troy Brandt, RDG, personal communication). In 2015, we documented successful Warner Sucker passage at the Dyke Diversion fishway, despite low stream discharges (0.03-0.42 m^3/s) (Scheerer et al. 2015).

Our 2016 objectives were to: 1) evaluate Warner Sucker passage success at the Dyke Diversion and describe Warner Sucker movement at the MC and Cahill diversions, 2) describe Warner Sucker distribution and estimate abundance and demographic rates (survival and immigration) in the stream segment between the MC and Cahill diversions, and 3) describe nonnative fish use in this stream segment.

METHODS

In the spring of 2016, we conducted fish sampling on the 1.1 km segment of lower Twentymile Creek, bounded on the upstream end by the MC Diversion and on the downstream end by the Cahill Diversion, and evaluated passage success at the Dyke Diversion fishway, which is located 1.7 km upstream from the MC Diversion (Figure 1). Lower Twentymile Creek has low channel gradient (<1%) and flows through private agricultural hay fields and pasture lands. This stream segment has been channelized, discharge varies depending on irrigation demand, and is limited to ~2.27 m^3/s channel capacity.

Fish Sampling

We captured fish in the study area using six-panel hoop nets (0.92 m diameter, 13 mm mesh) with a single 15.2 m lead or dual 7.6 m wings (13 mm mesh). We surveyed the study area every two weeks from 11 April through 23 June 2016. We set 11 hoop nets per day and soaked the nets overnight Monday through Thursday (three net sets per week). We combined the weekly catch from all 11 hoop nets (33 net sets) and considered this as one sampling occasion. All captured Warner Suckers were placed in a bucket filled with aerated stream water until processing. We anesthetized the fish using methyl sulfonate (20 g/L) buffered with sodium bicarbonate (20 g/L), measured fork length (FL) to the nearest 1 mm, scanned each Warner Sucker for previously implanted passive integrated transponder (PIT) tags using a hand-held PIT-tag reader, and recorded detections of PIT tags when observed. We tagged all un-tagged Warner Suckers ≥100 mm FL with 23-mm half-duplex PIT tags in the anterior ventral side of the body cavity and added secondary marks (partial upper caudal fin clips) to estimate tag loss. We marked all 60-99 mm Warner Suckers with partial fin clips. We used an upper caudal clip for the first capture of any Warner Sucker

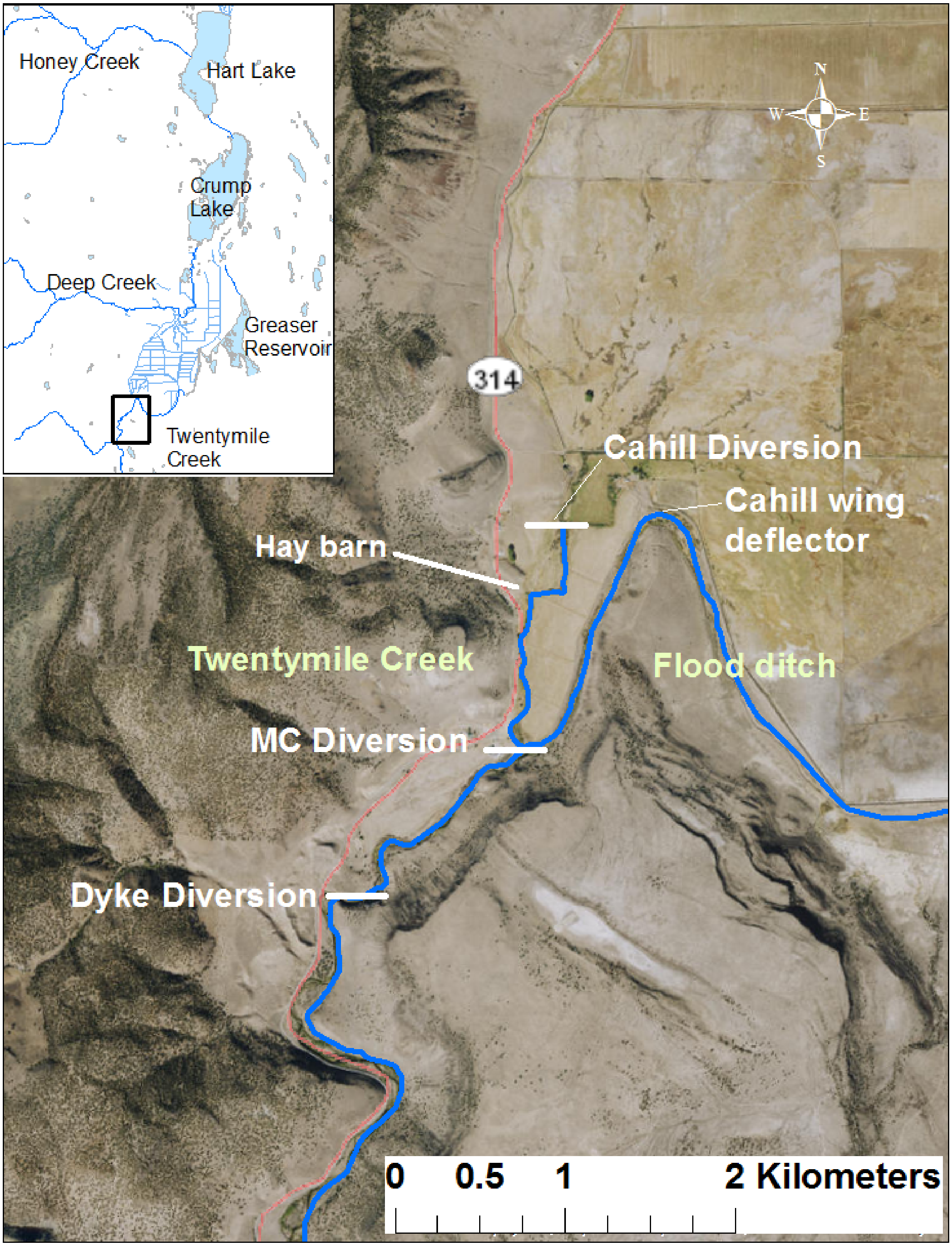

Figure 1. Map of lower Twentymile Creek. The stream flows from the Dyke Diversion towards the Cahill Diversion. The inset map shows the study area (rectangle) relative to irrigation canals, Greaser Reservoir, Deep Creek, and Crump Lake.

(all unmarked Warner Suckers on any sampling occasion), a lower caudal clip for the second capture of any Warner Sucker (first recapture of an upper caudal clipped fish on any sampling occasion), and an anal clip for the third capture (first recapture of a fish with both upper and lower caudal clips). No 60-99 mm Warner Suckers were captured more than three times during the period of the study. We recorded the presence and categorized relative abundance (few- <10 fish; many- ≥10 fish) of other native and nonnative fish species that we collected. After processing, we released the fish back into the stream near the capture location. During subsequent surveys, we scanned Warner Suckers for existing PIT tags, looked for fin clips, recorded the number of tagged or clipped and un-tagged or un-clipped Warner Suckers, and recorded the PIT-tag number when one was detected

We surveyed the study area between the MC and Cahill diversions with a mobile PIT-tag antenna (two consecutive passes) in late-June to determine the location and evaluate the status (live or dead) of PIT-tagged Warner Suckers. We recorded the tag number and stream location of all PIT-tagged fish that we detected. We used a hand-held Global Positioning System (GPS) unit to describe the stream location (Universal Transverse Mercator (UTM) coordinates) of detected fish. These detection data were included in our abundance model (see subsequent section) and were also used to identify any dead fish or shed tags. We estimated the mobile PIT-tag antenna's read range at approximately 0.75 m using a test tag.

Habitat Characterization

We collected habitat data at each location where we set a hoop net including: habitat type (glide or backwater pool), habitat length (m), wetted width (m), average depth (m), maximum depth (m), aquatic vegetation area as a percentage of total surface area (ocular estimate), and dominant substrate type. We calculated average depth 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 recorded the single deepest water depth (maximum depth) in each habitat unit using a graduated depth staff. We recorded whether the majority of the stream substrate in each habitat unit was fines (<0.063 mm), sand (0.063-2 mm), gravel (3-64 mm), cobble (65-256 mm), boulder (>256 mm), or bedrock. We recorded UTM coordinates for each hoop net location using a hand-held GPS unit. We recorded stream temperatures (°C) each time we checked a hoop net and at the beginning of the mobile PIT-tag antenna sampling pass using a handheld thermometer, and continuously during the study period at the Dyke Diversion fishway and Cahill Diversion using HOBO® recording thermographs set to record at 1-h intervals. We downloaded stream discharge data from the Oregon Water Resources Department stream gage, which is located ~1.7 km upstream of the MC Diversion on Twentymile Creek and ~200 m upstream of the Dyke Diversion (Oregon Water Resources Department 2016).

Movement and Passage Assessment

We installed and operated fixed PIT-tag antennas at the Dyke Diversion fishway to evaluate Warner Sucker passage success. We installed these antennas at: 1) the tail crest of the pool immediately downstream of the fishway, 2) the downstream-most fishway orifice, and 3) the upstream-most fishway orifice. We also installed fixed flat-plate PIT-tag antennas across the creek channel ~20 m downstream of the MC Diversion and ~10 m upstream of the Cahill Diversion to describe Warner Sucker movement in lower Twentymile Creek. We tested antenna performance and downloaded data every two weeks at all antennas and installed a continuous detection beacon on the antenna located on the downstream-most orifice of the Dyke Diversion fishway. We monitored movement of Warner Suckers that we PIT-tagged downstream of the fishway in 2014 and 2015 and movement of Warner Suckers (*n*=8) that we translocated in 2016 from a backwater pool located upstream of the Dyke Diversion into the pool downstream of the fishway. We examined the relationship between passage interval (the amount of time it took for a Warner Sucker to move through the fishway) and fish fork length and the relationship between passage interval and stream discharge using linear regression.

Warner Sucker Abundance and Demographic Rates

We used a Bayesian Jolly-Seber open-population model (Kéry and Schaub 2011) to estimate Warner Sucker population abundance, apparent survival, and immigration (i.e., probability of entry). The model estimates apparent survival, as opposed to true survival, because it cannot distinguish mortality from emigration. In the model, we included fish which were captured and recaptured using trap nets, and fish tagged with PIT tags which we detected with PIT-tag antennas (fixed and mobile). We included habitat covariates (site dimensions, dominant substrate, percent vegetation), fish fork length, the year when the fish were PIT tagged, and sampling method (categorical variable: hoop net, fixed PIT-tag antenna, or mobile PIT-tag antenna) in our modelling of demographic rates and capture probabilities. During previous analyses (Scheerer et al. 2014; 2015), we found substantial heterogeneity in Warner Sucker capture probabilities based on fish length and sampling gear. We incorporated additional variation (heterogeneity) in model parameters using random effects corresponding to sampling occasion. The random effects in our model represented unique effects associated with each sampling 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 methods in WinBUGS version 1.4 (Lunn et al. 2000) with 225,000 iterations and 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 a global model for each of these three model parameters. To accommodate the large number of parameters and avoid problems with the lack of parameter identifiability, we conducted model selection for each parameter individually. 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), which are similar to Akaike Information Criteria (AIC; Burnham and Anderson 2002). We then combined the best approximating models for each parameter into a single model and evaluated all subsets of the combined model to determine the best approximating Jolly-Seber model. We reported the parameter estimates and random effects (expressed as variance components) from the best approximating models (ΔDIC<2) and expressed precision of the estimates using 95% credible intervals, which are analogous to 95% confidence intervals.

RESULTS

Movement and Passage Assessment

In 2015 and 2016, Twentymile Creek experienced below average stream discharge (Figure 2) (Oregon Water Resources Department 2016). We detected 12 Warner Suckers

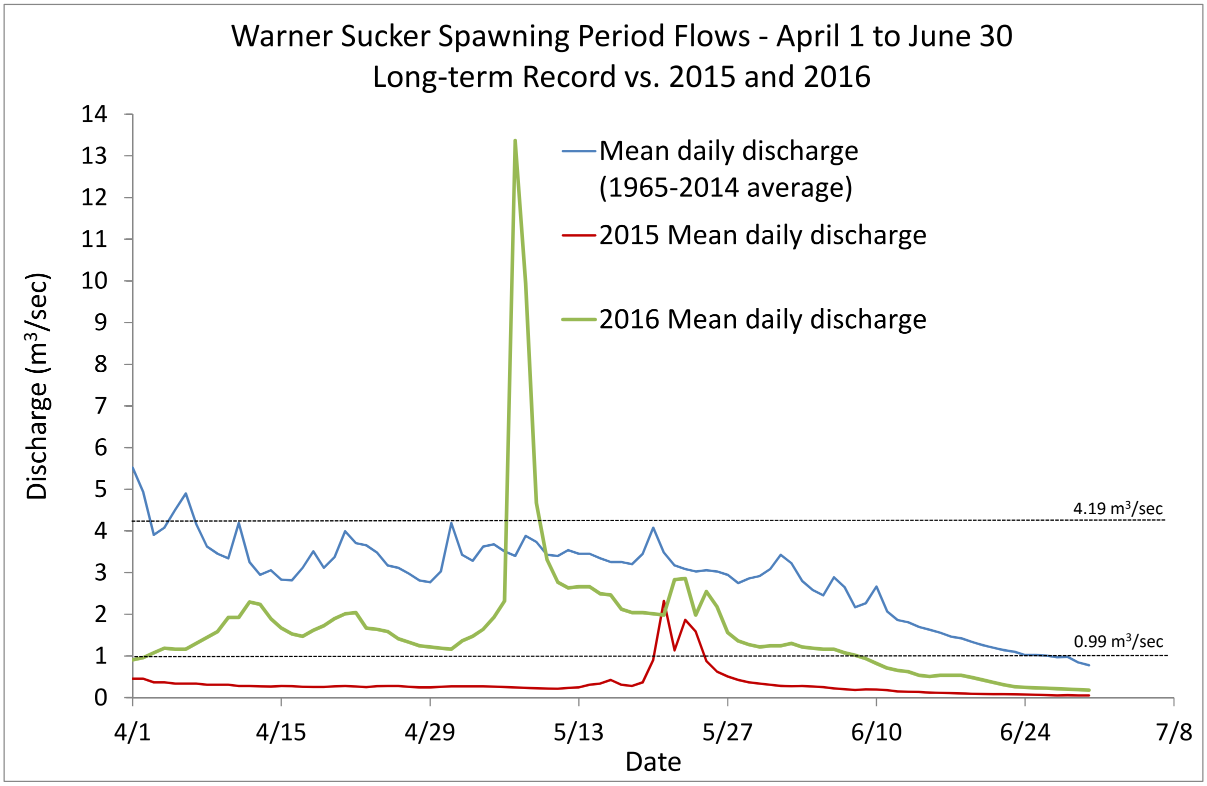

Figure 2. Comparison of 2015-2016 Twentymile Creek mean daily discharges and the 50-year average of mean daily discharges from 1965-2014. Dotted lines represent the fishway design criteria for stream discharge.

passing successfully upstream through the fishway at the Dyke Diversion in 2016. Five Warner Suckers that we captured, PIT-tagged, and released into the creek downstream of the fishway in 2014-2015 successfully passed through the fishway (140-201 mm FL when originally captured). One Warner Sucker that we PIT-tagged in 2015 (132 mm FL) was detected entering the pool and at the lower fishway orifice, but was never detected again. This fish may have moved downstream during the spring freshet when the lower antenna was inoperable (see last paragraph in this section). Seven of the eight Warner Suckers that we translocated in 2016 from a backwater pool located upstream of the Dyke Diversion passed successfully upstream through the fishway (174-240 mm FL). One translocated fish (153 mm FL) did not pass through the fishway, but rather moved downstream and was later detected at the PIT-tag antenna located downstream of the MC Diversion.

The average time that it took for Warner Suckers to move from the pool below the fishway through the fishway was 20.1 h (range 1.5-74.2 h; n=12); movement occurred at stream discharges ranging from 0.93-2.63 m^3/s. There was a significant (p=0.006) inverse relationship between fish length and passage interval (as fish length increased passage interval decreased) and no relationship between stream discharge and passage interval (p=0.356) (Figure 3). Most Warner Suckers (9 of 12) passed through the fishway between May 9 and June 8, which coincided with warming stream temperature and declining stream discharge (Figure 4).

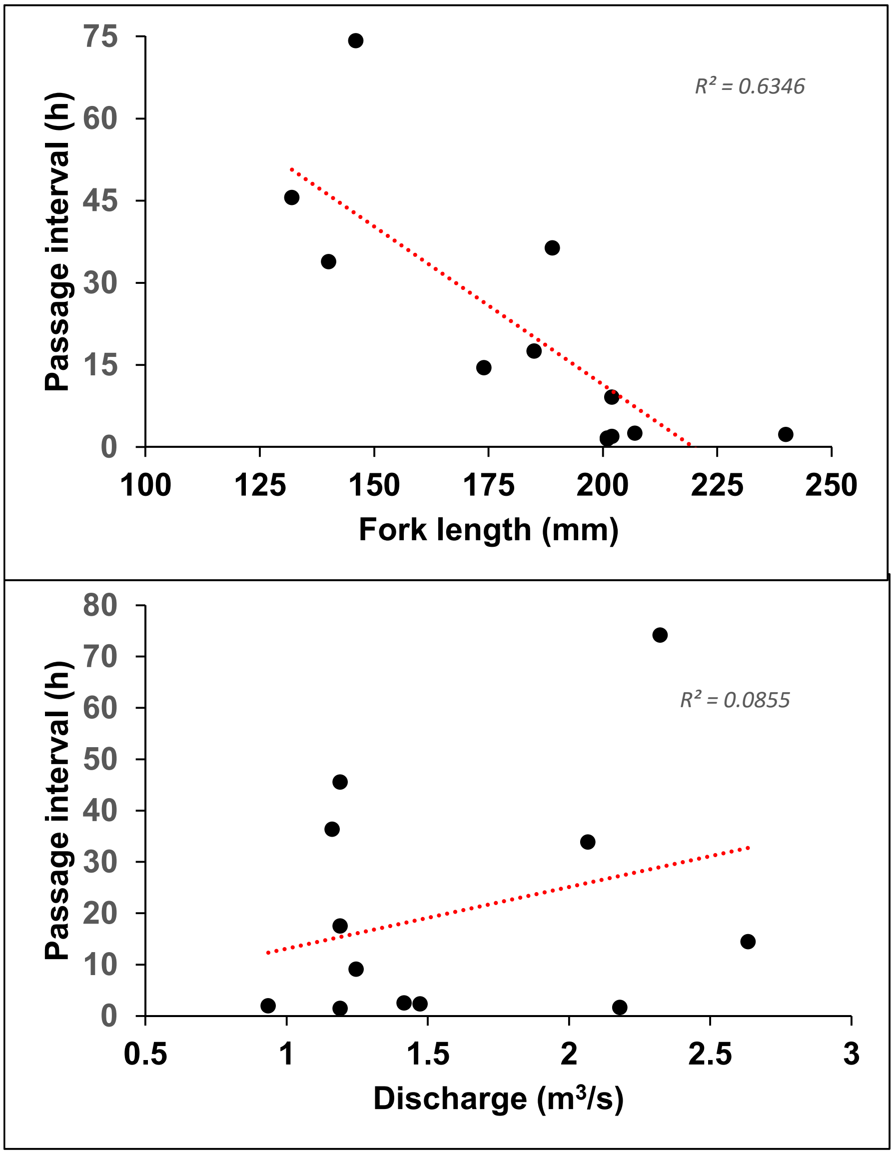

Figure 3. Passage interval through the Dyke Diversion fishway as a function of Warner Sucker fork length (upper panel) and stream discharge (lower panel).

We detected 11 Warner Suckers at the PIT-tag antenna near the MC Diversion; eight of these were detected on multiple occasions (28 total detections). Nine of the 11 detected fish were tagged upstream of the MC Diversion in 2014 or 2015, seven of these nine fish moved downstream into the study area prior to our 2016 sampling period (i.e. they were not detected moving downstream past the MC Diversion's PIT-antenna in the spring of 2015 or 2016), and two of these nine fish moved downstream through the culvert at the MC Diversion in June 2016. The other two (of the 11) fish detected at the MC Diversion were tagged in 2016 in the study area. Of the nine Warner Suckers that moved upstream across the MC Diversion's PIT-antenna, the timing of their movement occurred throughout the study period, with a peak in late-April (Figure 4). All of these fish eventually moved back downstream; the MC Diversion's culvert is impassable. We only detected two Warner Suckers (one on three occasions) at the antenna near the Cahill Diversion (Figure 4). The Cahill Diversion may be impassable for Warner Suckers as outflow occurs only at the water surface over weir boards.

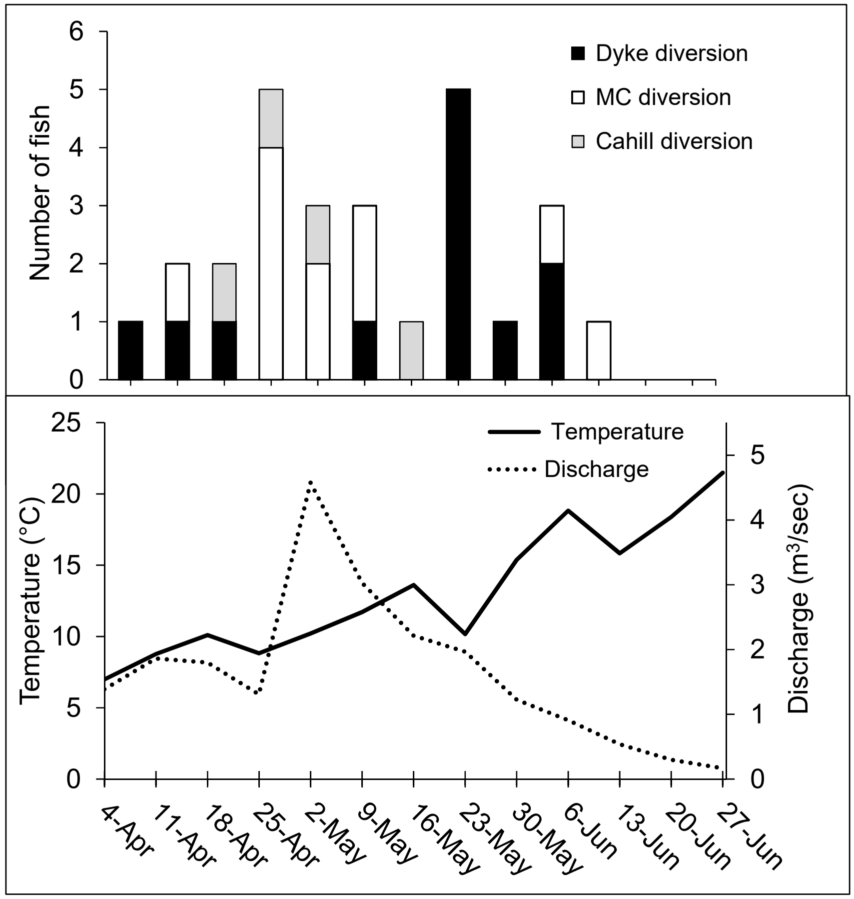

Figure 4. Relationship between Warner Sucker passage timing at the Dyke Diversion (upper panel), PIT-tag detections at the MC and Cahill diversions (upper panel), mean daily stream temperatures (lower panel), and mean daily stream discharge (lower panel) in Twentymile Creek, from 4 April through 29 June 2016. Discharge downstream of the MC Diversion is based on irrigation demand, does not necessarily track with discharge at the stream gage, and is limited to ~2.3 m^3/sec channel capacity. The numbers of fish at the MC and Cahill diversions are first detections of unique fish (i.e., numbers do not include fish that subsequently crossed the antennas on later dates), whereas all fish at Dyke Diversion were only detected once as they passed through the fishway.

The PIT-tag detection beacon that we installed on the fishway's lower orifice antenna 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, MC Diversion, and Cahill Diversion were operational when tested every two weeks. The antenna at the pool downstream of the Dyke Diversion fishway was inoperable (dislodged) for four days during a spring freshet (7-10 May; Figure 2).

Warner Sucker Abundance and Demographic Rates

We captured and PIT tagged nine unique large Warner Suckers (128-249 mm FL) in the hoop nets, captured and fin clipped 100 unique juvenile Warner Suckers (52-96 mm FL) in the hoop nets, detected seven unique large Warner Suckers (103-240 mm FL when tagged) at the fixed PIT-tag antennas (*n*=13 total detections, including fish previously

Table 1. Weekly Warner Sucker hoop net catch and mobile PIT-tag antenna detections.

	Hoop nets					
	Trap	Large fish >128 mm		Juvenile fish <100 mm		Mobile PIT
Week of	nights	Unmarked	Marked	Unmarked	Marked	antenna
April 11	33	0		1		
April 18	33	3	0	7	0	
May 2	33	1	0	21	1	
May 23	33	3	0	44	7	
June 20	33	2	2	27	11	6
	165	9	2	100	19	6

captured in the hoop nets) (Table 1, Appendices B and C), and detected two unique Warner Suckers with the mobile PIT-tag antenna (*n*=6 total detections, including four fish previously captured in the hoop nets). Captured Warner Suckers ranged in size from 52-249 mm FL, indicating the presence of several age-classes (Figure 5). The majority (92%) of the Warner Suckers that we captured were <150 mm FL. We did not observe any loss of PIT tags in fish with secondary marks, nor did we detect any dead Warner Suckers or shed tags with the mobile PIT-tag antenna. We captured the majority (97%) of the Warner Suckers (and other fishes) from the hoop nets set in the stream segment between the MC Diversion and the hay barn (see Figure 1 for locations). Stream habitat downstream of the hay barn was ~35% narrower, had shallower maximum depths (~33%) (Table 2), and higher water velocities. We also captured many Speckled Dace *Rhinichthys osculus and* Tui Chub *Siphateles bicolor*, and a few Redband Trout in the hoop nets. No nonnative fishes were captured or observed.

The best approximating Jolly-Seber model contained constant immigration rates, apparent survival modeled as a function of fish fork length, capture probability modeled as a function of sampling method (hoop net or mobile PIT-tag antenna) and a hoop net by fork length interaction, and a random effect corresponding to sampling occasion (Table 3). Warner Sucker abundance was estimated at 963 fish (95% CI: 860-999) (Table 3). Apparent survival during the 11 week period was positively related to body size (Figure 6); survival increased 1.54 times with each 50 mm increase in fish fork length. The immigration rate into the study reach was estimated at 21%. Estimated capture (detection) probabilities averaged 0.39 and 0.22 for the mobile and fixed PIT-tag antennas, respectively. The parameter estimates indicated that larger fish were more difficult to capture with hoop nets than smaller fish (Figure 7).

The second best approximating Jolly-Seber model contained constant immigration rates, apparent survival modeled as a function of whether the fish was PIT-tagged in 2015 or 2016, capture probability modeled as a function of sampling method and hoop net by fork length interaction, and a random effect corresponding to sampling occasion (Table 3). Warner Sucker abundance was estimated at 936 fish (95% CI: 717-998) (Table 3). Apparent survival during the 11 week period was higher for fish PIT-tagged in 2015 than those tagged in 2014 or 2016; a Warner Sucker tagged in 2015 was 3.6 times more likely to survive than one tagged in 2014 or 2016. The immigration rate into the study reach was estimated at 19%. Estimated capture (detection) probabilities averaged 0.39 and 0.22 for the mobile and fixed PIT-tag antennas, respectively. The parameter estimates indicated that larger fish were more difficult to capture with hoop nets than smaller fish.

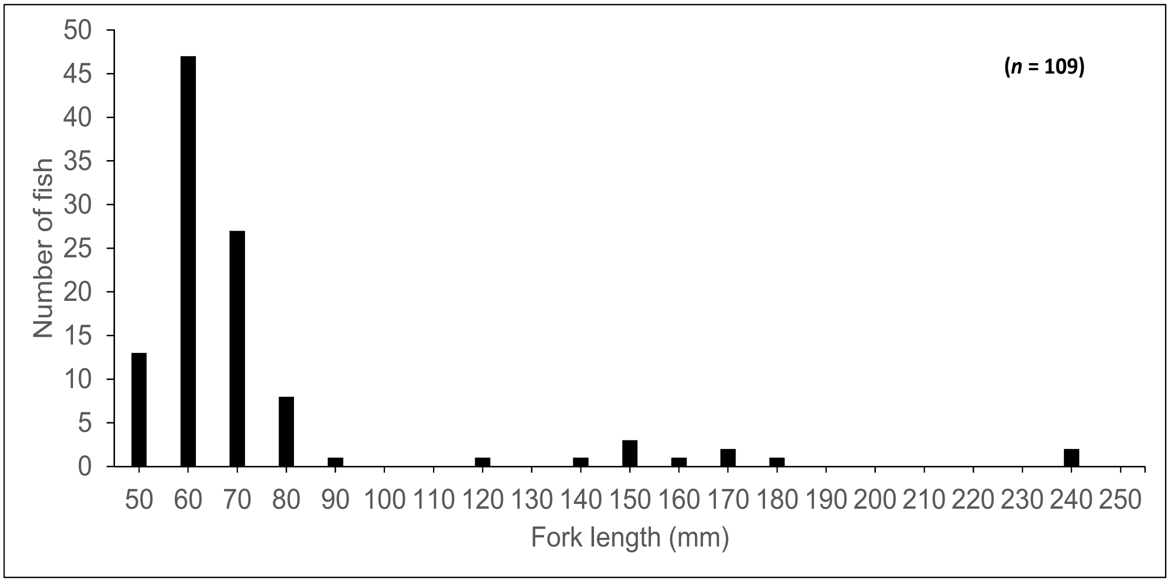

Figure 5. Length-frequency histogram for Warner Suckers captured in lower Twentymile Creek, 2016.

Table 2. Characteristics of the habitats sampled in lower Twentymile Creek, 2016.

Pool	Habitat type	Length (m)	Width (m)	Mean depth (m)	Maximum depth (m)	Dominant substrate	Percent vegetation
1	Glide	25.5	6.6	0.44	0.60	fines	20
2	Backwater pool	28.7	8.7	0.41	0.61	fines	70
3	Glide	21.6	6.0	0.44	0.83	gravel	5
4	Glide	22.0	9.0	0.50	1.29	fines	80
5	Backwater pool	38.5	9.2	0.52	1.30	fines	50
6	Glide	26.5	5.2	0.71	1.30	gravel	40
7	Backwater pool	26.6	8.8	0.40	0.61	fines	30
8	Glide	29.8	4.8	0.46	0.60	gravel	30
9	Backwater pool	30.4	6.1	0.36	0.50	gravel	20
10	Glide	29.2	4.2	0.40	0.65	gravel	40
11	Glide	18.8	4.6	0.50	0.75	gravel	20

Table 3. Model parameters for the two best approximating Jolly-Seber models for Warner Suckers, 2016.

	Best approximating model			
Parameter	Estimate	SD	Lower 95% CI	Upper 95% CI
Abundance	963	38.4	860	999
Immigration	0.212	0.059	0.114	0.343
Survival[1]				
Intercept	2.604	0.772	0.958	4.176
Fork length	0.009	0.005	-0.003	0.020
Capture/detection probability[2]				
Intercept	-1.280	0.378	-2.002	-0.516
Hoop net	1.036	0.657	-0.300	2.505
Hoop net*fork length	-0.031	0.004	-0.040	-0.024
Mobile PIT-tag antenna	0.813	0.923	-0.954	2.663
Random effect				
Sampling occasion	0.831	0.315	0.341	1.550

	Second best approximating model			
Parameter	Estimate	SD	Lower 95% CI	Upper 95% CI
Abundance	936	72.7	717	998
Immigration	0.186	0.060	0.075	0.311
Survival[1]				
Intercept	2.129	0.510	1.120	2.936
Fish PIT-tagged in 2015[3]	1.281	0.573	0.260	2.199
Capture/detection probability[4]				
Intercept	0.061	0.300	-0.492	0.660
Hoop net	0.123	0.425	-0.869	0.975
Hoop net*fork length	-0.032	0.005	-0.043	-0.024
Fixed PIT-tag antenna	-1.253	0.288	-1.690	-0.264
Random effect				
Sampling occasion	0.849	0.209	0.515	1.339

[1] Survival was estimated on a weekly (7 day) interval.

[2] Baseline method was the fixed PIT-tag antenna. Parameters correspond to the logit linear model.

[3] This parameter is an indicator variable. The value of the parameter was one when the fish was tagged in 2015, otherwise it is zero. Fish tagged in 2015 were 3.6 times more likely to survive than those tagged in 2014 or 2016.

[4] Baseline method was the mobile PIT-tag antenna. Parameters correspond to the logit linear model.

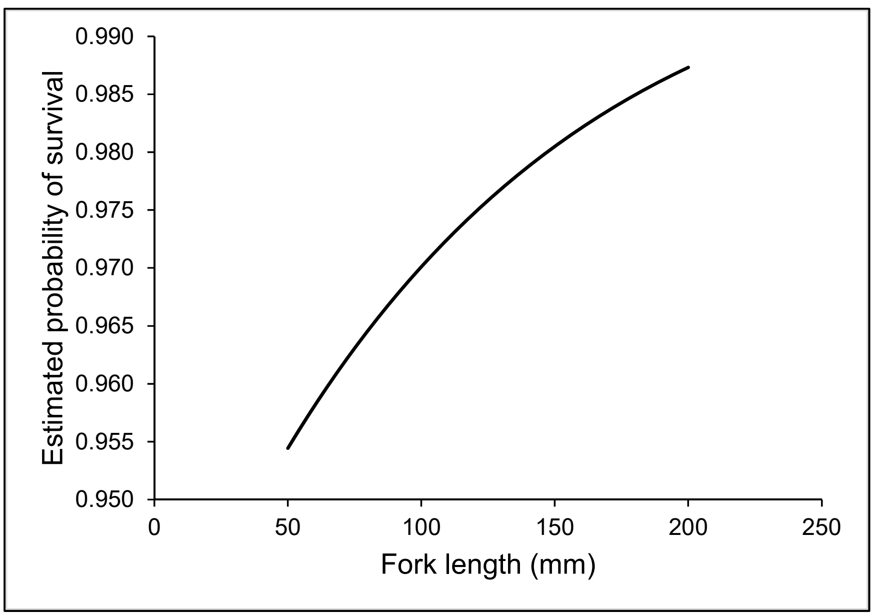

Figure 6. Relationship between weekly apparent survival and Warner Sucker fork length, estimated from the best approximating model.

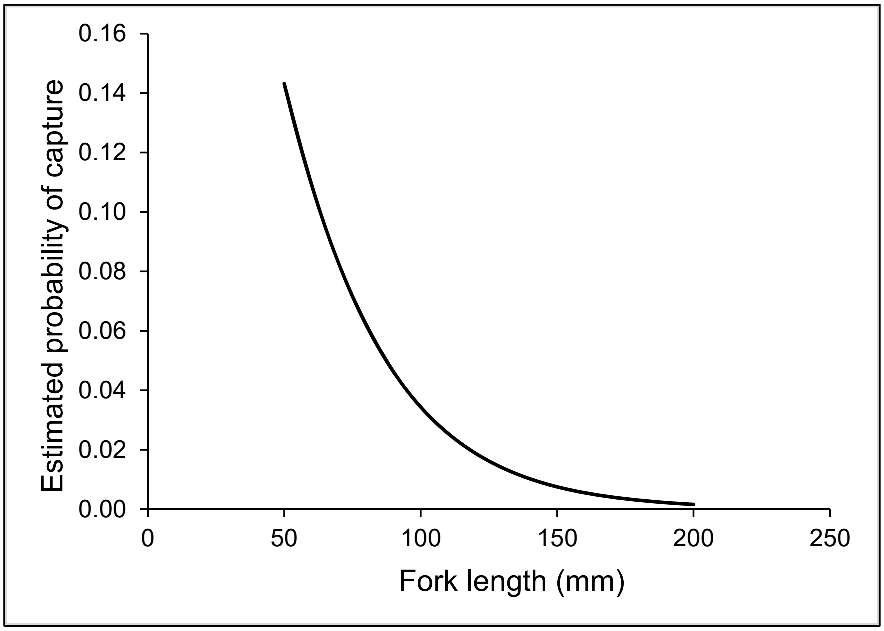

Figure 7. Relationship between estimated hoop net probability of capture and Warner Sucker fork length, estimated from the best approximating model.

DISCUSSION

Irrigation diversions restrict movement and genetic exchange of Warner Suckers within tributaries, between tributaries, and between lakes and tributaries in the Warner Basin. Recent recovery actions have focused on improving fish passage by replacing or reconstructing aging irrigation diversion structures, most of which were constructed decades ago without fishways or screening. In 2014-2015, the Denil-type fish ladder on the Dyke Diversion was replaced with a fishway designed with orifices on a cobble substrate to facilitate passage of Warner Suckers. In 2015 and 2016, we documented successful upstream passage of Warner Suckers (113-240 mm) at the fishway at a wide range of stream discharges (0.14-2.6 m^3/s). Thus, stream connectivity has been restored for Warner Suckers in Twentymile Creek upstream of the MC Diversion (~19.7 km).

Twentymile Creek supports the most abundant Warner Sucker population in the basin. In 2009, we estimated 4,612 Suckers in the Twentymile Creek subbasin upstream of the Cahill wing deflector, with the majority (*n*=3,786; 82%) residing in the 7.6 km stream segment between the Dyke Diversion and the mouth of the Twentymile Creek canyon (Richardson et al. 2009). In 2015 and 2016, we estimated 813 and 963 Warner Suckers in the lower Twentymile Creek stream segments between the MC and Dyke diversions and between the Cahill and MC diversions, respectively (Scheerer et al. 2015; this study). Downstream of the Cahill Diversion, Warner Suckers have a patchy distribution and are in low abundance in the irrigation canals (Scheerer et al. 2007). In this lower stream segment, all of the water in the creek is diverted for irrigation into irrigation canals. Genetic analysis of the origin of lake-dwelling Warner Suckers found no evidence of Warner Suckers from the Twentymile Creek subbasin recruiting into the lakes in the past decade (DeHaan et al. 2017), suggesting that they are unable to navigate these irrigation canals to gain access to Crump Lake and currently exist as a resident stream population.

Nonnative fishes have not been found upstream of the MC or Cahill diversions (Richardson et al. 2009; Scheerer et al. 2014; 2015; this study), but are present downstream of these diversions (Scheerer et al. 2007; 2014). Warner Suckers are rare downstream of these diversions (Scheerer et al. 2007) and many, if not all of the stream channels (canals) downstream of these diversions seasonally desiccate (F. Cahill, landowner, personal communication). For these reasons, major stakeholders in the Warner Basin (BLM, U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, Lake County Umbrella Watershed Council, and private landowners) have been discussing the possibility of isolating this resident population of Warner Suckers in Twentymile Creek to reduce the risks of nonnative fishes invading this stream segment and from Warner Suckers take occurring under the Endangered Species Act, if or when the irrigation canals desiccate.

If the proposed isolation of resident Warner Suckers in Twentymile Creek moves forward, it will be necessary to decide on the location for an upstream fish barrier. Considerations for barrier placement include topography, access to electrical power to operate fish screens, and accessibility for maintenance (Troy Brandt, River Design Group, personal communication). We suggest that one potential location for a fish barrier is near the hay barn (Figure 1). Few fish were found downstream of the hay barn, the site is easily accessible, and there is electrical power nearby to operate fish screens.

To restore connectivity among Warner Suckers inhabiting the Twentymile Creek stream segment between the Cahill Diversion and the MC Diversion and those inhabiting the stream segment upstream of the MC Diversion, the Lake County Watershed Council and the BLM contracted RDG to develop a passage design for the MC Diversion. The proposed design includes a series of rock weirs to facilitate fish movement above the MC Diversion's impassable culvert. Irrigation water has two potential flow patterns downstream of the MC Diversion. Twentymile Creek generally flows though the culvert(s) at the MC Diversion into the stream segment that leads to the Cahill Diversion. However, during high stream discharges and when irrigation demands have been met downstream of the Cahill Diversion, water flows over the MC Diversion dam into the flood ditch, which flows into Greaser Reservoir (Figure 1). Additionally, there are three culverts at the MC Diversion, but only one is typically used and the other two have closed gates.

In 2017, we plan to continue to monitor Warner Sucker passage effectiveness in the Warner Basin. Abundant precipitation and snowpack during the winter of 2016-2017 and spring of 2017 (Oregon Climate Service 2017; Natural Resources Conservation Service 2017), resulting in Warner Basin tributary flows in the spring of 2017 that are greater than those of the past two years, may allow us to more easily track Warner Suckers migrating in the tributaries. We plan to focus our efforts at the Honey Creek Rookery Diversion fishway. This fishway has a slightly different design (smaller orifices, no cobble floor, and artificial boulders connected to concrete fishway floor in the downstream half of the fishway). We will assess whether this design permits passage, whether modifications in the design of this fishway are warranted, or both.

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Appendix A. Chart to convert cubic meters per second (m^3/sec) to cubic feet per second (cfs). Formula: multiply m^3/sec by 35.31 to obtain cfs.

m^3/sec	cfs
0.125	4.4
0.25	8.8
0.5	17.7
1	35.3
2	70.6
3	105.9
4	141.2
5	176.6
6	211.9
7	247.2
8	282.5
9	317.8
10	353.1
11	388.4
12	423.7
13	459.0
14	494.3
15	529.7
16	565.0
17	600.3
18	635.6
19	670.9
20	706.2

Appendix B. Capture histories for PIT-tagged Warner Suckers, 2016. Fish lengths with a "+" sign are fish that were tagged in 2014-2015, but not recaptured and measured in 2016. Gear types: HN= hoop net catch, PIT= fixed PIT-tag antenna detections, Mobile 1= mobile PIT-tag antenna detections, and the number following each gear type refers to the sampling occasion (summarized by week and gear type).

		Gear type and sampling occasion															
		HN1	PIT1	HN2	PIT2	PIT3	HN3	PIT4	PIT5	PIT6	HN4	PIT7	PIT8	PIT9	PIT10	HN5	Mobile 1
PIT tag	Length	11-Apr	11-Apr	18-Apr	18-Apr	25-Apr	2-May	2-May	9-May	16-May	23-May	23-May	30-May	6-Jun	13-Jun	20-Jun	23-Jun
361656947	128	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
361656971	141	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
361678997	154	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
356977807	183	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1
361656983	171	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
356977772	244	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
356977805	249	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0
177050742	208+	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0
360936849	69+	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
360936840	103+	0	0	0	1	0	0	1	1	0	0	1	1	1	1	0	0
152505372	117+	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
356977609	240+	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
356977608	237+	0	0	0	1	0	0	1	0	1	0	1	0	0	0	1	1
356977742	180+	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
361656989	168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
361678997	154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
356977735	177	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
361656884	103+	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
361656981	153	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Appendix C. Juvenile Warner Sucker capture histories, 2016. Fin clips: UC= partial upper caudal, LC= partial lower caudal, and UC/LC= both clips.

		Week of				
Fin clip	11-Apr	18-Apr	2-May	23-May	20-Jun	Total
No clip	1	7	21	44	27	100
UC	0	0	1	7	9	17
UC/LC	0	0	0	0	2	2
	1	7	22	51	38	119

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