# Oregon Department of Fish and Wildlife

# SCIENCE BULLETIN

## Number 2021-12

## NATIVE FISH INVESTIGATIONS PROGRAM

*Warner Sucker Population Characteristics and Passage Success in Deep Creek*

*Contract Numbers: F17AC00449, F20AC10347, L20AC00145*

## 2021

This report should be cited as:

Monzyk, F. R., Miles J. P. and A. S. Harrison. 2021. Warner Sucker Population Characteristics and Passage Success in Deep Creek. 2021-12. Oregon Department of Fish and Wildlife, Native Fish Investigations Program, Corvallis. 23 p.

ODFW SCIENCE BULLETIN
FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Warner Sucker Population Characteristics and Passage Success in Deep Creek

CONTRACT NUMBERS: F17AC00449 (USFWS), F20AC10347 (USFWS), L20AC00145 (BLM)

PROJECT PERIOD: March 2020–November 2021

Prepared by: Fred R. Monzyk, Justin P. Miles, and Alexis S. Harrison


The forebay pool upstream of Starveout Diversion with hoop net set. photo credit Troy Brandt-RDG

Oregon Department of Fish and Wildlife
4034 Fairview Industrial Drive SE
Salem, OR 97302

*This project was funded in part by the Native Fish Investigations Program - Oregon Department of Fish and Wildlife.*

TABLE OF CONTENTS

LIST OF TABLES



LIST OF FIGURES

## 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 from numerous irrigation diversion dams in the tributaries and threats from introduced nonnative fish in the lakes. Little is known about the population status of Warner Sucker in Deep Creek. Recent recovery efforts have focused on providing passage at three irrigation diversion dams on Lower Deep Creek (Relic, Starveout, and Town diversions) that currently restrict Warner Sucker movement of any extant stream-resident population and upstream spawning migrations of lake-resident suckers. Our objectives in in this study were to: 1) assess Warner Sucker population status in lower Deep Creek downstream of the Deep Creek Falls, including abundance, age and growth; 2) assess upstream passage effectiveness of the newly constructed rock ramps at the three diversions. A secondary objective was to assess water quality, specifically dissolved oxygen (DO) and temperature in lower Deep Creek associated with thick mats of pondweed *Elodea canadensi*s.

We used hoop nets and backpack electrofishing to assess distribution and abundance in lower Deep Creek. We installed Passive Integrated Transponder (PIT) antennas at the head of each ramp and in irrigation ditches to monitor movements of tagged fish.

We estimated 2,572 (95%CI: 1,567-4,351) Warner Suckers resided in Deep Creek in 2020. Warner Suckers were found in the reaches downstream of the Town Diversion, including the Town irrigation ditch with most (92%) located between the Town and Starveout diversions. No suckers were found in the creek upstream of the Town diversion. Based on fin-ray aging, the suckers were all age-1 and age-2. It's unclear why no older aged suckers were collected. Growth of suckers appeared normal, averaging 34mm from July to September (51-57 days). The abundant pondweed in lower Deep Creek did not adversely impact DO levels.

Passage monitoring at the rock ramps was hampered by a very low water year in 2021 that resulted in infrequent flows over the ramps. However, we documented successful upstream passage at all ramps: 3 of 8 suckers passed the Relic diversion; 2 of 23 suckers passed at Starveout; and 3 of 15 passed at Town. The fish used in this study were relatively small (91-179 mm FL) compared to previous passage studies in the basin, but their success suggest larger fish should be able to pass successfully. We detected a couple instances of suckers entering the irrigation ditches. Suckers that enter the Town irrigation ditch may not be able to pass back upstream through the diversion headgates at high flows.

# INTRODUCTION

Warner Suckers *Catostomus warnerensis* are endemic to the Warner Basin, a semi-arid endorheic subbasin of the Great Basin in southeastern Oregon, northwestern Nevada, and extreme northeastern California. The presumed historical range of the Warner Sucker consists of the low- to moderate-gradient reaches of Twentymile, Honey, and Deep creeks, the three relatively permanent lakes (Hart, Crump, and Pelican lakes), and several ephemeral lakes during periods of abundant precipitation (U.S. Fish and Wildlife Service 1985; Williams et al. 1990; Figure 1). Stream-dwelling suckers exhibit a fluvial life-history and spawn in the tributary drainages. Lake-dwelling suckers typically exhibit an adfluvial life history. However, when upstream spawning migration may be blocked by low stream flows during low water years or by irrigation diversion dams, spawning can occur in nearshore areas of the lakes (White et al. 1990) with unknown success. Furthermore, it is believed that stream-dwelling populations recolonize the lakes following drought-induced desiccation events that periodically decimate lake-dwelling sucker abundance.

Warner Sucker abundance and distribution has declined over the past century and the species was federally listed as threatened in 1985 due to habitat fragmentation from numerous irrigation diversion dams and threats posed by the proliferation of piscivorous nonnative game fishes in the lakes (U.S. Fish and Wildlife Service 1985). Recovery criteria for Warner Sucker includes, in part, providing passage and screening improvements at the diversion dams in the basin (U.S. Fish and Wildlife Service 1998).

The Warner Basin Aquatic Habitat Partnership (WBAHP), a collaboration of local, state, and federal partners, is committed to the recovery of the Warner Sucker through the completion of passage, screening, and habitat enhancement projects with participating landowners. The most recently completed passage projects include the Town, Starveout, and Relic diversion dams on lower Deep Creek – all three concrete dams have been modified with rock ramps (roughened channels) to allow upstream passage. The Town and Starveout diversions were complete barriers to upstream movement, while the Relic diversion was a partial barrier (Monzyk 2019). Construction of the Town rock ramp was completed in late 2019 and the Relic and Starveout ramps were completed in early 2021. Combined, these fishways provided Warner Sucker access to 12 of the 15 km of occupiable habitat in Deep Creek below Deep Creek Falls (Figure 1).

Although the historic distribution of Warner Sucker in Deep Creek was purportedly throughout the stream system below Deep Creek Falls (Figure 1), the present status of Warner Sucker in Deep Creek is unknown. The stream and associated irrigation network downstream of the O'Keeffe diversion (Figure 1) is privately owned and landowners have generally denied access in the past. On the public land upstream of the diversions, no suckers have been reported in recent surveys (White et al. 1990; Allen et al. 1994; Scheerer et al. 2007), however there is anecdotal evidence of suckers in a large pool about 1 km downstream of the falls in 2005 (Paul Scheerer – ODFW retired, personal communication).

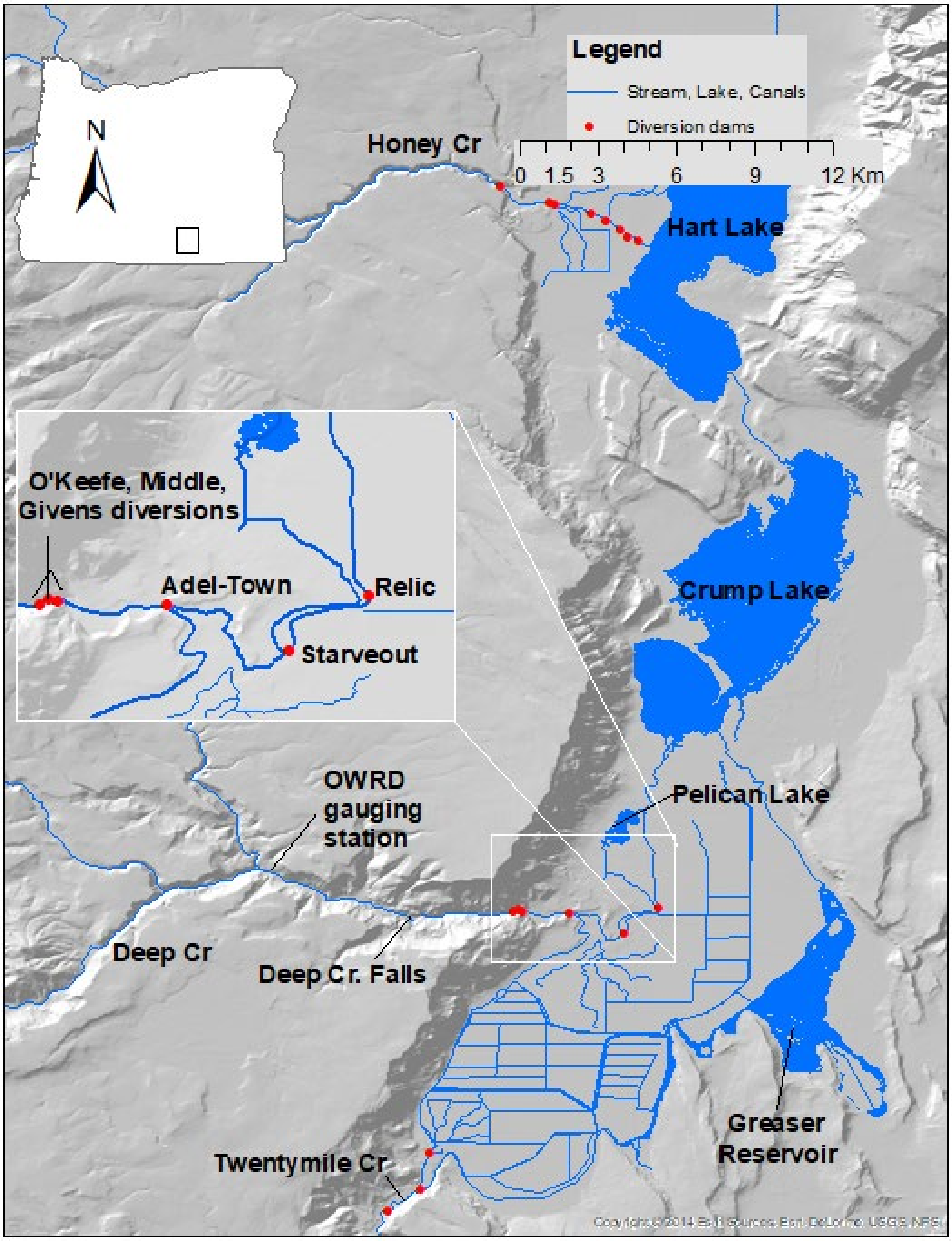



Figure 1. Map of the Warner Basin showing lakes, canals, streams, and irrigation diversion dams**.** Inset shows the location of diversion dams on lower Deep Creek.

Almost all Warner Suckers collected in Deep Creek occurred in the reach below Starveout diversion (White et al. 1990; Scheerer et al 2007). Because Relic diversion (the downstream-most diversion) is considered only a partial barrier to upstream movement, the suckers collected downstream of Starveout may be progeny of lake-resident spawners. Only one sucker was collected upstream of Starveout diversion in recent surveys: a 116mm FL individual from the forebay pool (Scheerer et al. 2007). Beginning in 2019, landowners granted access to the stream system downstream of O'Keeffe Diversion, allowing for the first thorough status assessment of Warner Suckers in Deep Creek. Sampling upstream of the Town Diversion in 2019 did not reveal any Warner Sucker (Monzyk et al. 2019).

Our main objectives for this study were to: 1) assess Warner Sucker population status in lower Deep Creek downstream of the falls, including abundance, age and growth; 2) assess passage effectiveness at the newly constructed rock ramps at Relic, Starveout, and Town diversions. A secondary objective was to assess water quality, specifically dissolved oxygen (DO) and temperature in lower Deep Creek associated with thick mats of pondweed *Elodea canadensi*s. Oxygen depletion at depth in vegetation mats has been known to occur due to plant respiration (Buscemi 1958; Frodge et al. 1990).

## SITE DESCRIPTION

Lower Deep Creek has been extensively altered by irrigation development from its historic condition. Prior to irrigation development, Deep Creek fanned out in a large alluvial plain to the southeast of the town of Adel, inundating low-lying marshland. Remnants of the distributary channels are still evident on the valley floor (Figure 1; Appendix Figure 1). During spring high-flow periods, Deep Creek water would merge with water from Twentymile Creek to follow the gradual slope of the valley floor north through the marshland to the lakes with no well-defined channels (Whistler and Lewis 1916; Stricklin and Perry 1923; Hunt 1964). The construction of the Reclamation Ditch in the early 1920's carried water ~2.9 km from the main distributary channel SE of Adel, across a low ridge, to the marshland the NE of Adel (Appendix Figure 1). Erosive forces soon enlarged the ditch so that it resembled a natural stream and carried most of the flow during high flow periods (Stricklin and Perry 1923). Subsequent dredging of another canal connected the ditch directly to Crump Lake. Six irrigation diversion dams were constructed in lower Deep Creek (Figure 1) to improve the land for cattle production.

Lower Deep Creek is a low gradient stream as it flows through the alluvial plain on the valley floor. The reach between O'Keeffe and Town diversions (1.9 km) is typified by pool-riffle sequences with sparse aquatic vegetation and cobble-dominant substrate. Downstream of the Town Diversion the stream can become intermittent during summer low-flow periods when all surface stream flow is diverted into the Town irrigation ditch. During these periods, the water in the creek channel downstream of Town diversion is from subsurface return flow. The reach between Town and Starveout diversions (2.6 km) consist of a series of deep pools connected by shallow reaches with little or no gradient change. Beds of submergent pondweed are prevalent throughout the reach and substrate is predominately cobble in the upstream half of the reach but transitions to hardpan and silt in the lower half. Between Starveout and Relic diversions (1.7 km), a series of long narrow pools (1-2 m deep) typify the stream. Downstream of Relic Diversion to Crump Lake (6.2 km), the stream is relatively shallow with few pools and substrate of hardpan and silt.

Diversion Dams. – Warner Sucker upstream passage was provided at the Relic, Starveout, and Town diversions by replacing the vertical concrete weirs with rock ramps (roughened channels) with a slope <4%. The Starveout diversion consisted of two weirs and a split channel, with the west channel set at higher in elevation and only flowing during high water periods (Figure 2).

Figure 2. Before and after aerial photos of the Starveout diversion showing rock ramps on east and west channel. The PIT antenna was installed only on east channel that receives most of the streamflow.

## METHODS

<u>Population Status (2020)</u>

*Abundance.-* Sampling was conducted from 6-16 July, 2020 in lower Deep Creek between O'Keeffe and Relic diversions (Figure 1). The sampling frame was divided into four reaches: Reach 1 (Relic to Starveout diversion); Reach 2 (Starveout to Town); Reach 3 (Town to O'Keeffe); and Reach 4 (the upper 1.5 km of the Town irrigation ditch). Backpack electrofishing and hoop nets were used to collect and mark Warner Suckers over 3-4 days in each reach (Figure 3). All fish were measured for fork length (FL) and checked for marks. If not previously marked, fish were given a caudal fin clip and, if > 70 mm FL, implanted with a passive integrated transponder (PIT) tag. The Schnabel method was used on the mark-recapture data to estimate abundance (Ricker 1975).

Supplemental sampling was conducted outside the sampling frame used for abundance estimation and included sites downstream of Relic Diversion (2020), Crump Lake (2020) upstream of O'Keeffe diversion (2020 and 2021) and in the Town irrigation ditch network downstream of Reach 4 (2021). Stream sampling was limited to single overnight hoop net sets or backpack electrofishing and was conducted opportunistically when landowner permission was granted. Sampling upstream of O'Keeffe diversion included the pool below the falls where anecdotal information suggested the presence of suckers. In Crump Lake, we used lake nets and hoop nets in overnight sets in the southern half of the lake in September 2020.

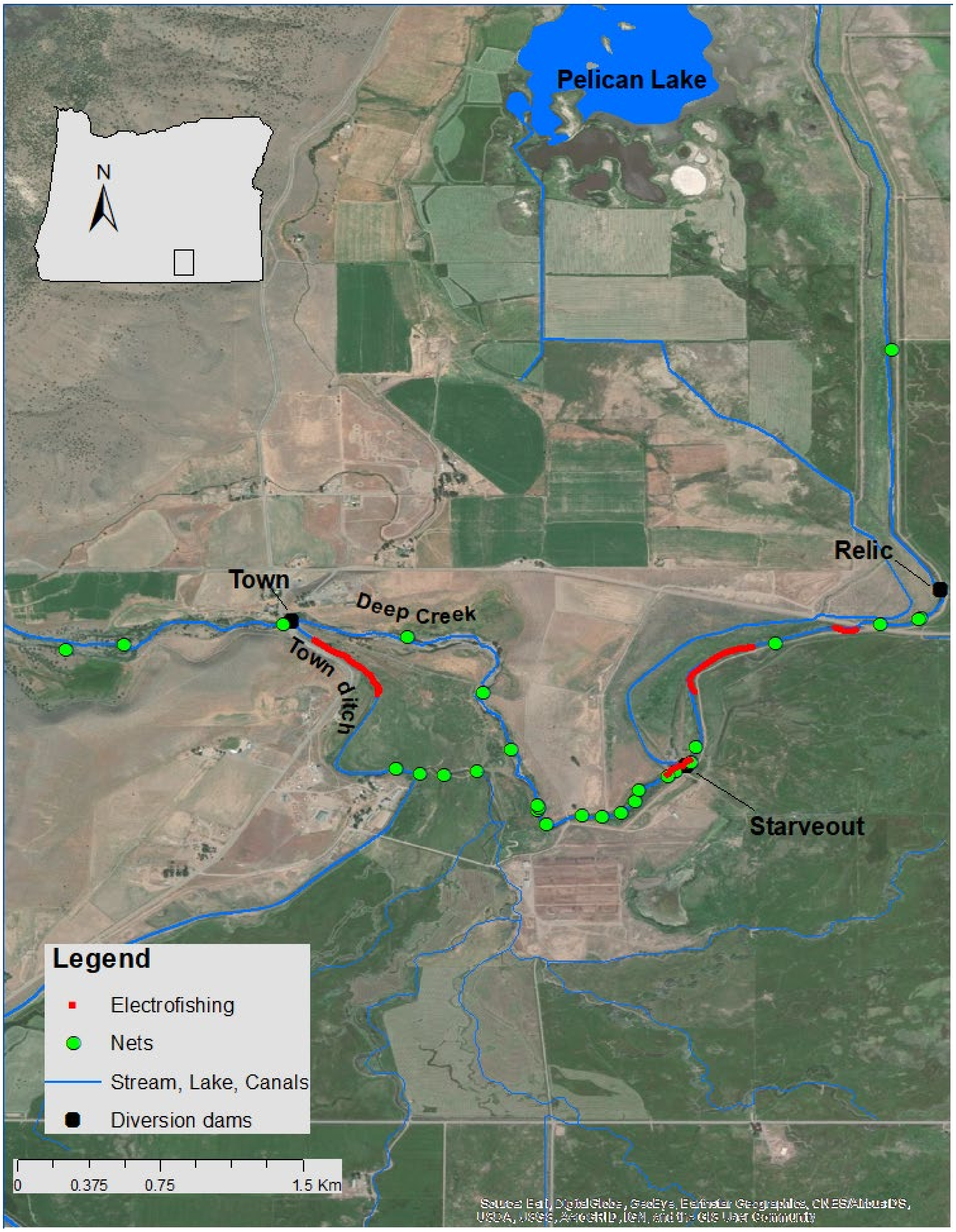



Figure 3. Location of hoop nets and electrofishing in lower Deep Creek, 2020.

*Age and Growth*.- We collected pectoral fin rays from suckers in Deep Creek in September 2020. We removed the two anterior-most fin rays from the right side of each fish by cutting the rays near the articulation point with cutting pliers. We inserted the distal end of the fin ray into putty and allowed them to air dry. Samples were sent to the Klamath Falls National Fish Hatchery where ODFW and U.S. Geological Survey employees completed processing and aging the fin rays. Cross-sectional slices of the fin rays (0.5 mm thick) were made using a low-speed saw with a diamond-tipped wafering blade. Three serial sections (0.5 mm thick) from the base of each ray towards the distal tip were made to assess annuli loss with distance away from the body. The first section was made at the point where the proximal end of the fin ray curved away from the body toward the distal tip. We set the slices onto a microscope slide and used a microscope, MiniVID USB Microscope Camera and ToupView software to photograph each slice. The photographs were reviewed to determine growth increments.

*Water Quality*.- We measured dissolved oxygen (DO) and temperature in 2020 to determine if plant respiration in the thick beds of pondweed affected DO concentrations. Two sites in Reach 2 were evaluated. At each site, measurements were taken with a YSI D20 meter at two locations: within a thick bed of pondweed; and in an adjacent vegetation-free area. Sampling at each location was conducted mid-day on 01 September during peak photosynthetic oxygen production, and again just before sunrise on 02 September when plant respiration effect on DO would be maximal. Sampling entailed measuring DO and temperature at 10-cm intervals from 10 cm below the surface to the bottom of the water column. To assess seasonal changes in DO during plant die-off in the fall/winter, we installed a miniDOT ® logger (PME, Inc) in Reach 2 from 28 October 2020 through 31 March 2021. The logger was installed at a depth of 14.5 cm in a pool with abundant pondweed. The logger recorded DO and temperature measurements every hour.

## Passage Effectiveness Monitoring (2021)

We installed and operated pass-over PIT antennas at the upstream end of the rock ramps at Relic, Starveout and Town diversions to assess passage success of PIT-tagged fish released below the diversions (Figure 4). Antenna arrays were also installed in the irrigation ditches of the Town and Starveout diversions to assess movement into the irrigation system. Arrays in the Starveout irrigation ditches consisted of two pass-through antennas approximately 2-m apart to provide directional movement of fish. In the Town ditch, pass-over antennas were located just upstream and downstream a water control structure fitted with dam boards, approximately 190 m downstream of the diversion (Figure 4). Lastly, a pass-over antenna was located approximately 180 m downstream of Relic ramp to monitor tagged fish leaving the study area. Beacons were installed on each antenna to monitor the functional continuity of the antenna systems throughout the study period. Fish detection data from the antennas was uploaded approximately once a month to assess passage timing and success.

River Design Group (RDG) installed water level loggers (Onset HOHBO® U20L) in the forebay pools of each diversion to monitor water elevation above mean sea level (MSL) every 15 minutes. We used the water level data and the elevation of the ramp crests to determine periods when water was flowing over the ramps. The timestamp recorded with tag detections at the ramps were compared to water elevation data to evaluate water depth on the ramps during successful upstream passage events.

In early spring of 2021, we captured fish using hoop nets in Reach 2 of Deep Creek. All Warner Sucker were measured for fork length and interrogated for previously implanted PIT tags. If not previously tagged, we implanted into the body cavity a 23-mm half-duplex PIT tag for fish ≥120 mm FL and a 12-mm tag for fish <120 mm FL. Tagged fish were released below each diversion dam (Figure 4). To increase the likelihood that fish would attempt to pass over the ramps, we skewed PIT-tagging to larger suckers, with the assumption that they would be more likely to migrate upstream to spawn. In addition to suckers, Redband Trout *Oncorhynchus mykiss* were PIT-tagged and released just upstream of the Relic ramp.

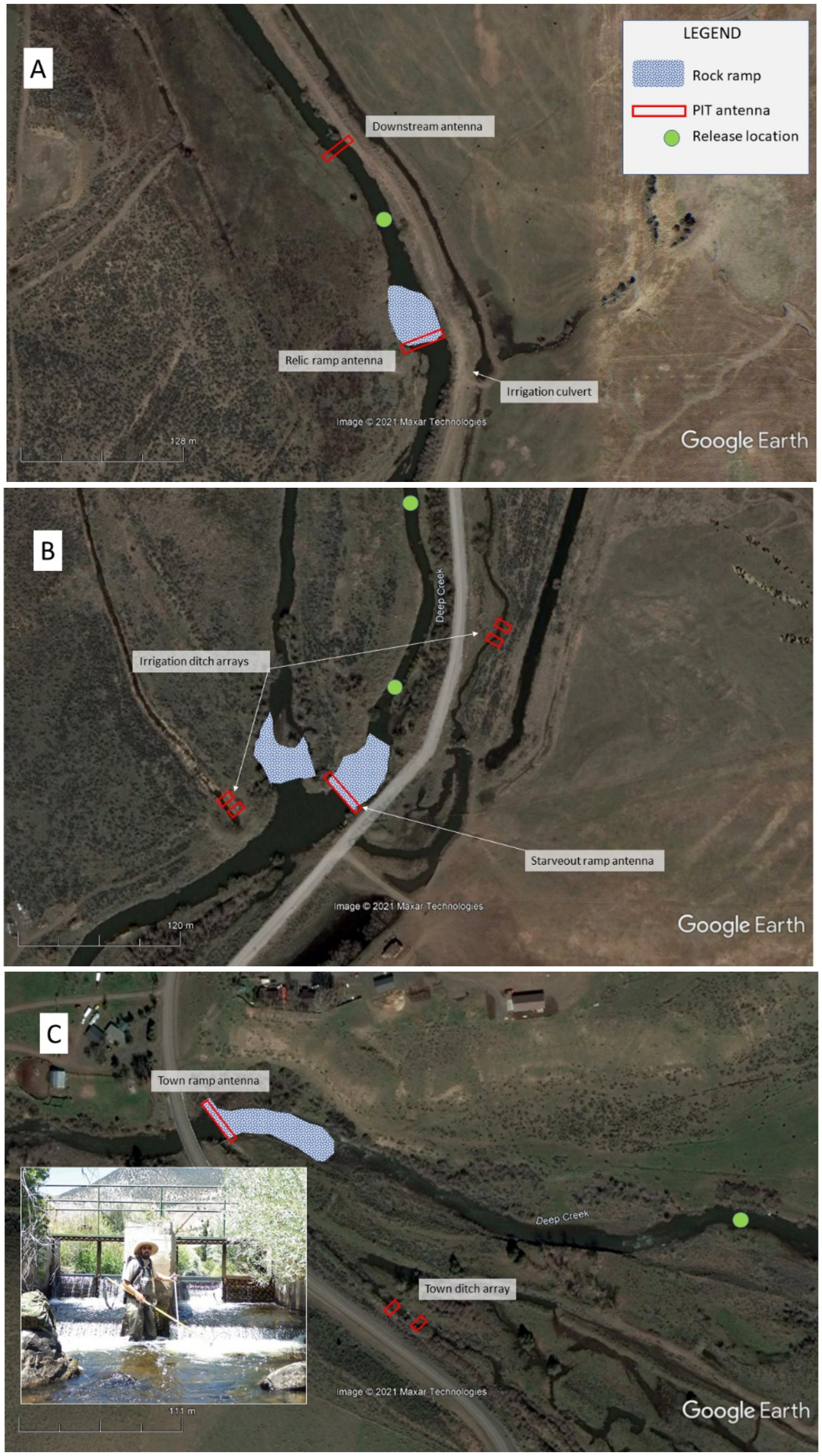



Figure 4. Aerial photos of Relic (A), Starveout (B), and Town (C) diversions showing location of rock ramps, PIT antennas, and Warner Sucker release locations. Inset photo shows water control structure located between the two PIT antennas in the Town irrigation ditch.

## RESULTS AND DISCUSSION

Population Status (2020)

At the time of sampling in the summer of 2020, all streamflow (9.5-14 cfs; measured at OWRD station 10371500) was entering the Town irrigation ditch. The stream channel downstream of the Town Diversion, including the rock ramp fishway, was dry for approximately 150 m until subsurface return flow provided a small amount of streamflow (<1 cfs).

We conducted 39 overnight hoop net sets and 95 minutes of backpack electrofishing in lower Deep Creek in July 2020, capturing 325 Warner Suckers (mean size=89 mm FL; range 53-133 mm) and 12 Redband Trout (mean size=237mm; range 52-385 mm). Electrofishing proved ineffective at capturing sucker (n=4). In Crump Lake, we set 7 lake nets and 9 hoop nets and caught one Warner Sucker (373 mm FL male).

Incidental catch from Deep Creek sampling (including supplemental sampling in 2020 and 2021) included Tui Chub *Siphateles thalassinus*[1], Speckled Dace *Rhinichthys osculus*, Brown Bullhead *Ameiurus nebulosus*, and Largemouth Bass *Micropterus salmoides*. Tui Chub and Speckled Dace were captured in all reaches. Brown Bullhead were captured in Reach 1 (Relic to Starveout) and Reach 2 (Starveout to Town) and downstream of Reach 4 (Town irrigation ditch). A single largemouth bass was captured in the Town irrigation ditch downstream of Reach 4. Incidental catch in Crump Lake included Tui Chub, Brown Bullhead, White Crappie *Pomoxis annularis*, and Black Crappie *Pomoxis nigromaculatus*.

*Population Estimate.-* We estimated 2,572 (95%CI: 1,567-4,351) Warner Suckers resided in Deep Creek. Most suckers and trout were in Reach 2 (Table 1) with an estimated 2,374 (95%CI: 1,447-4,016) suckers in this reach. Most of the suckers occurred in the 0.4 km forebay pool of Starveout dam (Figure 5).

No suckers were captured in Reach 3 (Table 1) or in the limited sampling upstream of O'Keeffe diversion. The two suckers captured in Reach 4 could be recent migrants originating from Reach 2 that passed upstream over the Town rock ramp after completion in 2019 and then fell back into the ditch. This type of occurrence was observed with one sucker in 2021 (see Passage Effectiveness Monitoring section). No suckers were captured in the supplemental sampling in the ditch network downstream of Reach 4. The sizes of the two suckers in Reach 4 (105 and 111 mm) were larger than the mean size of all sucker captured in July 2020.

[1] Using taxonomic nomenclature recommended by Harris (2000) and Chen et al. (2009) for Tui Chub in the Warner Basin.

Table 1. Catch of Warner Sucker and Redband Trout in hoop nets in Deep Creek, 2020.

| Reach | Description | Suckers | Sucker CPUE | Redband |
|---|---|---|---|---|
| 1 | Relic to Starveout | 5[a] | 0.7 | 1 |
| 2 | Starveout to Town | 314 | 14.3 | 9 |
| 3 | Town to O'Keeffe | 0 | 0 | 0 |
| 4 | Town irrigation ditch | 2 | 0.3 | 2 |

[a] The four suckers caught via electrofishing were in Reach 1 as well.

*Age and Growth*.- We collected 24 fin rays from Warner Suckers in Deep Creek in early September, 2020 and based on fin-ray aging, only age-1 and age-2 were present in our sample. Absence of age-0 suckers was likely an artifact of our gear selecting for larger fish. Older cohorts were not evident from either fin-rays or plots of length-frequency distributions of fish collected in July or September in Deep Creek (Figure 6). A similar lack of older cohorts was evident in the length frequency distribution of suckers collected in April 2021.

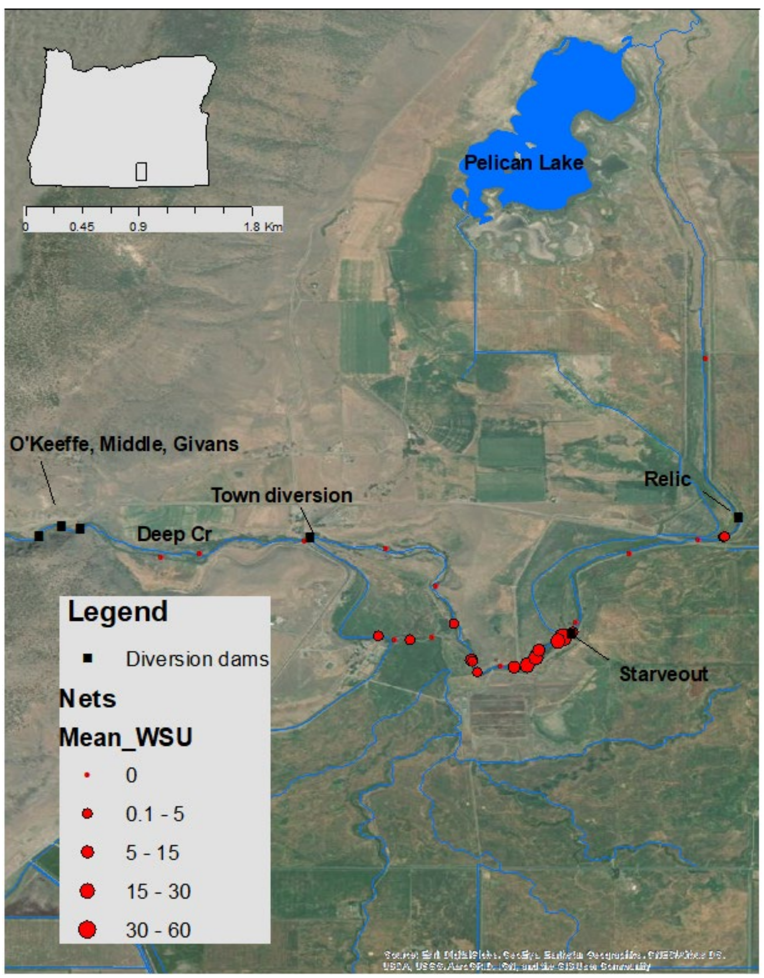



Figure 5. Map showing Warner Sucker relative abundance in hoop net sets in lower Deep Creek.

Growth of Warner Sucker in Deep Creek was normal relative to estimates from other populations. The size of age-2 suckers collected in September ranged from 99-148 mm FL, which is within the expected size at age for Warner Sucker reported by Coombs et al.(1979; Appendix Figure 2). The mean growth rate was 0.61 mm/d (range: 0.42-0.65) for fish tagged in early July and recaptured 51-57 d later in September (n=4), which corresponds to a mean size increase of 34 mm during that period. Fish growth is expected to be greatest in summer and the mean size increase observed is within the 30-50 mm of annual growth reported for subadult suckers (Coombs et al. 1979).

The lack of older suckers in Deep Creek in 2020 was unexpected and atypical for Warner Sucker populations; we do not currently have an explanation for this observation. Warner Suckers do not reach maturity until at least age-3 and can live up to 20 years (Monzyk 2019); fish older than age-3 were expected since age-1 and age-2 fish indicate the presence of spawning adults within the past two years. More investigation may reveal answers to the age-class structure observed. It’s worth noting that the age-2 fish in 2020 were age-3 when collected in spring of 2021 and some showed signs of sexual maturity (i.e., spawning tubercles and coloration).

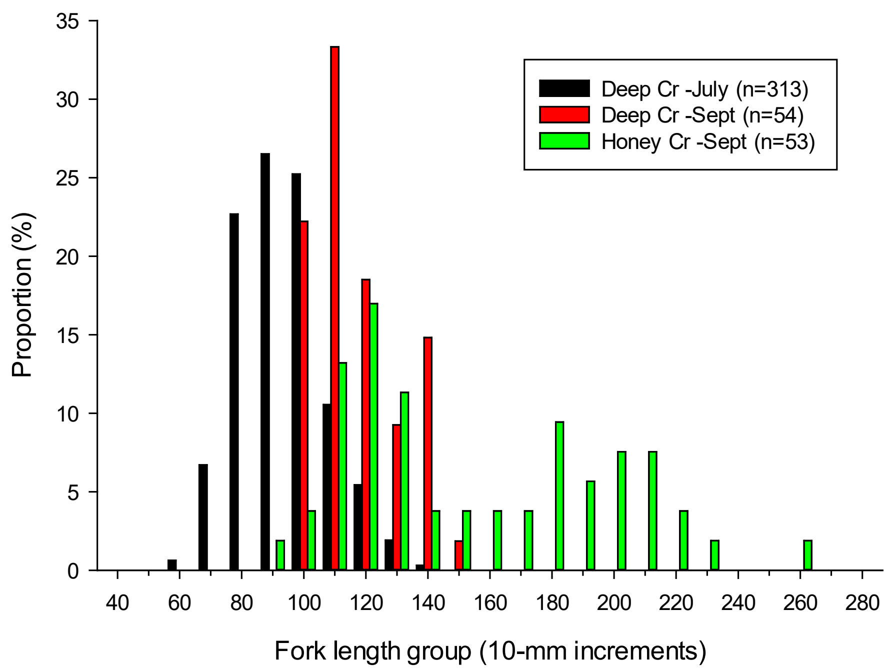



Figure 6. Length distributions of Warner Suckers sampled in Deep and Honey creeks in 2020. The bimodal distribution of Honey Creek fish suggests the presence of at least one older cohort. All fish captured with same hoop net gear.

*Water Quality.-* We did not observe any instances of low DO in Deep Creek associated with vegetation beds. Generally, the highest DO levels were found in Elodea beds during midday and the lowest DO levels were observed in the beds at sunrise (Table 2). Monitoring of DO over the fall and winter did not reveal any periods of hypoxia that would harm fish (Figure 7).

Table 2. Mean dissolved oxygen and temperature measured in Elodea vegetation beds and in open-water locations of lower Deep Creek. Measurements were taken 1-2 September, 2020.

| | | DO (mg/l) | | Mean Temperature (C) | |
|---|---|---|---|---|---|
| Location | Depth | Midday | Sunrise | Midday | Sunrise |
| Elodea | surface | 17.1 | 7.4 | 19.9 | 16.8 |
| | bottom | 9.2 | 7.1 | 16.2 | 16.8 |
| Open water | surface | 10.8 | 8.5 | 18.0 | 16.8 |
| | bottom | 9.6 | 7.5 | 16.3 | 16.8 |

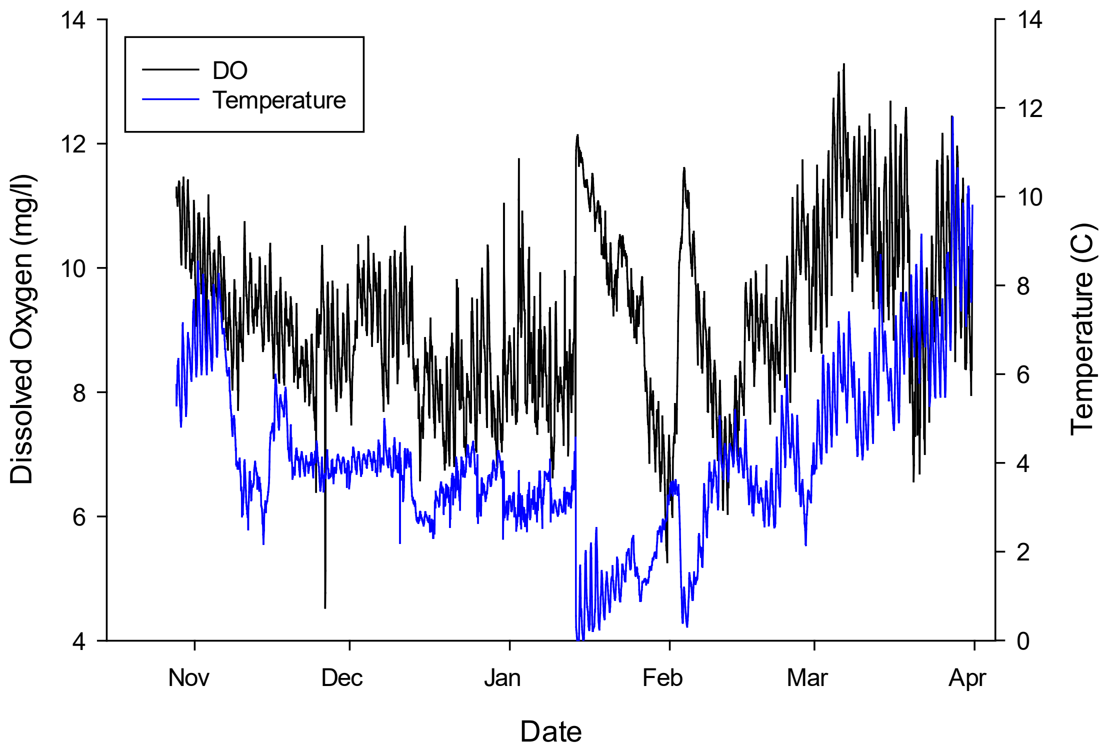



Figure 7. Plot of DO, temperature recorded from miniDOT logger in lower Deep Creek (42.16566, -119.88499) from 28 October 2020 to 31 March 2021. Logger recorded data hourly. .

## Passage Effectiveness Monitoring (2021)

In 2021, Deep Creek experienced flows near historic lows (Figure 8), resulting in infrequent flows over the rock ramps during the spring. Of the three ramps, Starveout had the lowest and most infrequent observed flow. Despite infrequent ramp flows, we detected successful passage at all three ramps: three of the eight suckers released below the Relic ramp passed upstream; two of 23 suckers released below the Starveout ramp passed upstream (Figure 9); and three of the 15 suckers released below the Town ramp passed upstream.

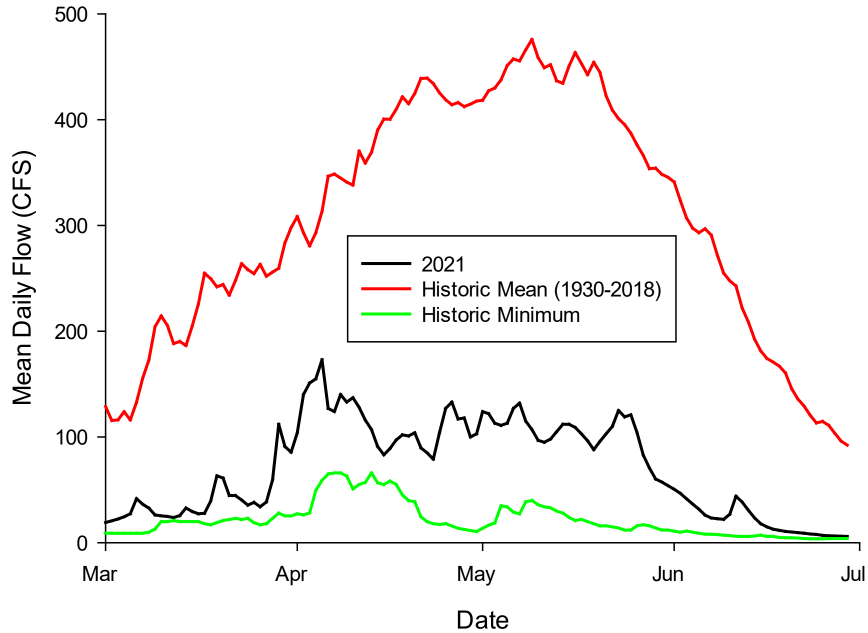



Figure 8**.** Comparison of 2021 Deep Creek mean daily discharges and the historic average and minimum of mean daily discharges from 1930-2018.

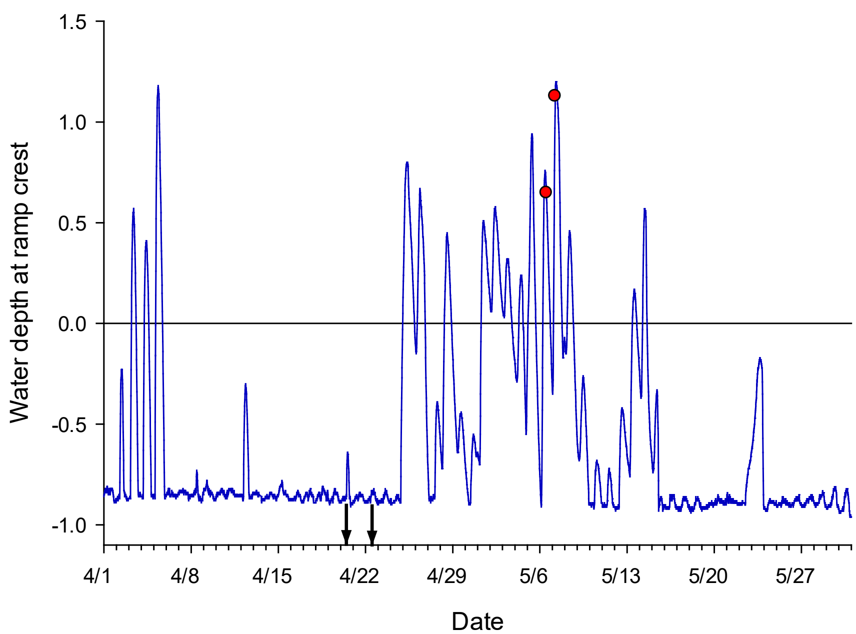



Figure 9. Water elevation of the Starveout ramp and Warner Sucker passage events (red dots) in 2021. Arrows on date axis indicate PIT-tagged sucker release dates downstream of the ramp.

Horizontal line marks the ramp crest at 4493.5 ft (MSL) so negative depths indicate the ramp was dry.

With previous passage effectiveness monitoring at sites in Twentymile and Honey creeks, 50-68% of adult suckers released below a project successfully pass upstream. Percentages were lower in this study primarily due to lack of adequate flows over the ramps. The size of suckers used in this study (91-179mm FL) were smaller than fish used in previous passage studies in the basin (Scheerer et al. 2017; Monzyk and Meeuwig 2018). Smaller suckers are weaker swimmers than larger fish (Scheerer and Clements 2013) so the successfully upstream passage over the rock ramps of the 100-179mm FL suckers in this study would suggest that larger, lake-resident suckers would be able to pass as well.

*Irrigation canals*. – No fish were detected in the west Starveout irrigation ditch, but it was not clear if this ditch was used for irrigation in 2021. Fish were detected in the east Starveout irrigation ditch. A Warner Sucker previously tagged in 2020 (93 mm FL at time of tagging) from Reach 2 was detected in the ditch. The fish was initially detected on the downstream antenna on 5 April, suggesting it was in the ditch prior to PIT array construction. It moved upstream over the array (first detected on the downstream antenna, then the upstream antenna) on 7 April and back downstream on 18 April. The reader malfunctioned soon after this date, so we are unable to determine if it successfully returned to the creek. A 385-mm Redband Trout released in the Relic forebay pool on 01 April was detected moving upstream over the Starveout irrigation ditch array on 11 April. This was the only detection event in the ditch array and the fish was never detected on the Starveout ramp antenna, so presumably it entered the irrigation ditch through a culvert at the Relic diversion and swam upstream through the 1.7-km canal and into Reach 2.

At the Town irrigation ditch, two Warner suckers were detected in 2021 on the array located at the water control structure. Dam boards were fitted to the structure for most of the spring, causing a vertical drop of about 0.5 m. At some point after 25 May, the dam boards were removed, likely in early June after the flows decreased. One sucker that was previously tagged in the ditch downstream of the structure in the summer of 2020 (105 mm FL at time of tagging) was detected on the downstream antenna on 30 March and never detected again. Flows over the dam boards was 102 cfs at time of detection. A 179-mm sucker that successfully passed upstream over the Town ramp on 01 May subsequently entered the ditch and was detected on 12 May. This fish was detected numerous times on both antennas from 12 May-12 June, making 16 separate back and forth movements over the structure during this period. At least five of the movements occurred when dam boards were in place and flows were 95 -115 cfs. The fish was last detected on the upstream antenna. This sucker was the largest fish tagged in this study and its behavior suggests that for some larger individuals, small vertical barriers can be successfully passed. After each successful upstream movement over the structure, the sucker would not be detected again on the upstream antenna for a period of a couple hours to a couple days. It’s unclear if it was attempting to return to Deep Creek through the diversion headgates located 190 m upstream, but if so, it was unsuccessful during high flows.

## MANAGEMENT IMPLICATIONS

The discovery of ~2,500 Warner Suckers residing in Deep Creek substantially adds to the overall abundance of suckers in the basin. Previous studies estimated that approximately 4,500 suckers reside in Twentymile and Honey creeks combined (Scheerer et al. 2007, 2011; Richardson et al. 2009) and another 500 reside in the lakes (Allen et al 1996, Scheerer et al 2008), so the addition of the Deep Creek population increases the known abundance of Warner Suckers in the basin significantly.

Restoration of upstream passage in Deep Creek provides an opportunity for the Deep Creek population – the bulk of which is currently located in a relatively short (0.5 km) reach upstream of the Starveout diversion–to access much more habitat and increase its resilience and abundance. However, the length of stream habitat available in Deep Creek is only about half that of other basin streams. Improving the limited amount of habitat in Deep Creek would help this population persist. One way to improve habitat is the construction or expansion of pool habitat. Two candidate reaches for pool habitat improvements are downstream of the Relic diversion and the Town irrigation network (if this reach is not eventually screened). The habitat downstream of Relic consists of a shallow, straightened canal for 3 kilometers, and during dry periods only a few isolated pools exist. The canal is located between two levees approximately 100 m apart. Creating more sinuosity and pool habitat in this reach would provide holding/rearing habitat for suckers in the reach, especially during dryer years. The habitat in the Town irrigation ditch has several candidate areas for creating pool habitat where the ditch intersects with remnant distributary channels.

Warner Sucker were present in low numbers in the Town irrigation ditch, and we observed one of the three suckers that passed the Town diversion in 2021 entering the irrigation ditch. This suggest that suckers in the irrigation ditch entered since completion of the Town diversion rock ramp in 2019; if so, abundance in the ditch will increase over time. The WBAHP members and local landowners will need to decide to either screen the ditch or allow suckers to use the habitat in the irrigation network. Portions of the irrigation network are comprised of the remnant distributary channels and appear to provide good quality habitat (Appendix Figure 3). If the irrigation network is to serve as habitat, passage improvements will be necessary at a few irrigation control structures and at the headgates at the Town diversion so the entire system is connected during the spawning season. Information on the frequency of sucker entrapment through the side culverts that flood-irrigate fields would help inform this management decision.

## ACKNOWLEDGEMENTS

We would like to thank Barbara Martin and Rachael Paul-Wilson with the USGS Klamath Falls Field Station for processing and aging Warner Sucker pectoral fin rays. We would also like to thank Sandy Taylor, Joe Cahill, and Scott Hunsaker for graciously allowing us access on their property to conduct this study. Thanks to River Design Group, Inc. for providing information on water elevation and diversion designs. This work was funded by the U.S. Fish and Wildlife Service, the Bureau of Land Management and the Lake County Umbrella Watershed Council.

## REFERENCES

Allen, C. S., A. Atkins, and M. A. Stern. 1994. Status and recolonization rates of the Warner Sucker (*Catostomus warnerensis*) and other fishes in the Warner lakes in Southeast Oregon, 1994. Report to U.S. Bureau of Land Management and Oregon Department of Fish and Wildlife. 22 p.

Allen, C. S., K. E. Hartzell, and M. A. Stern. 1996. Warner Sucker Progress Report-1996 findings. Report to U.S. Bureau of Land Management. 55 p.

Buscemi, P. A. 1958. Littoral oxygen depletion produced by a cover of *Elodea canadensis*. Oikos 9: 239-245.

Chen, Y., S. Reid, and B. May. 2009. Genetic relationships of tui chub populations in the northwestern Great Basin and conservation implications for the Cow Head Slough Tui Chub. Conservation Genetics 10:101-114.

Coombs, C. I., C. E. Bond, and S. F. Drohan. 1979. Spawning and early life history of the Warner Sucker (*Catostomus warnerensis*). Report to U.S. Fish and Wildlife Service. 52 p.

Frodge, J. D., G. L Thomas, and G. B. Pauley. 1990. Effects of canopy formation by floating and submergent aquatic macrophytes on the water quality of two shallow Pacific Northwest lakes. Aquatic Botany 38: 231-248.

Harris, P. M. 2000. Systematic studies of the genus *Siphateles* (Ostrariophysi: Cyprinidae) from western North America. Ph.D. Dissertation, Oregon State University.

Hunt, J. H. 1964. The Warner Valley Stock Company-a geographic study. Master’s thesis. Oregon State University, Corvallis, Oregon.

Monzyk, F. R. and M. H. Meeuwig. 2018. Passage success of Warner Suckers at the MC Diversion on Twentymile Creek. Oregon Department of Fish and Wildlife, Progress Report, Salem. 16 p.

Monzyk, F. R. 2019. Warner Sucker life history: A review. Oregon Department of Fish and Wildlife, Information Report, Salem. 32 p.

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.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Scheerer, P. D., M. P. Heck, S. L. Gunckel, and S. E. Jacobs. 2007. Warner Sucker stream investigations. Oregon Department of Fish and Wildlife, Contracts HLP073006 (BLM) and 134206M086 (USFWS), Annual Progress Report, Salem. 15 p.

Scheerer, P. D., M. P. Heck, S. L. Gunckel, and S. E. Jacobs. 2008. Warner Sucker stream investigations- Warner Suckers. Oregon Department of Fish and Wildlife, Contracts HLP073006 (BLM) and 134206M086 (USFWS), Annual Progress Report, Salem. 15 p.

Scheerer, P. D., S. Clements, R. Jacobsen, and J. T. Peterson. 2011. 2011 Warner Sucker Investigations (Honey Creek). Annual Progress Report, Corvallis. 19 p.

Scheerer, P. D., and S. Clements. 2013. Evaluating Warner sucker swimming performance to inform passage design in the Warner Basin, Oregon. Oregon Department of Fish and Wildlife, Information Report, Salem. 12 p.

Scheerer, P. D., J. T. Peterson, and M. H. Meeuwig. 2017. 2016 Warner sucker investigations (lower Twentymile Creek). Oregon Department of Fish and Wildlife, Information Report, Salem. 18 p.

Stricklin, C.E., and A.C. F. Perry. 1923. Report of water supply, use and duty of water of Warner lakes and their tributaries. Made in connection with the adjudication of water rights under the direction of Percy A. Cupper, State engineer. Salem, Oregon

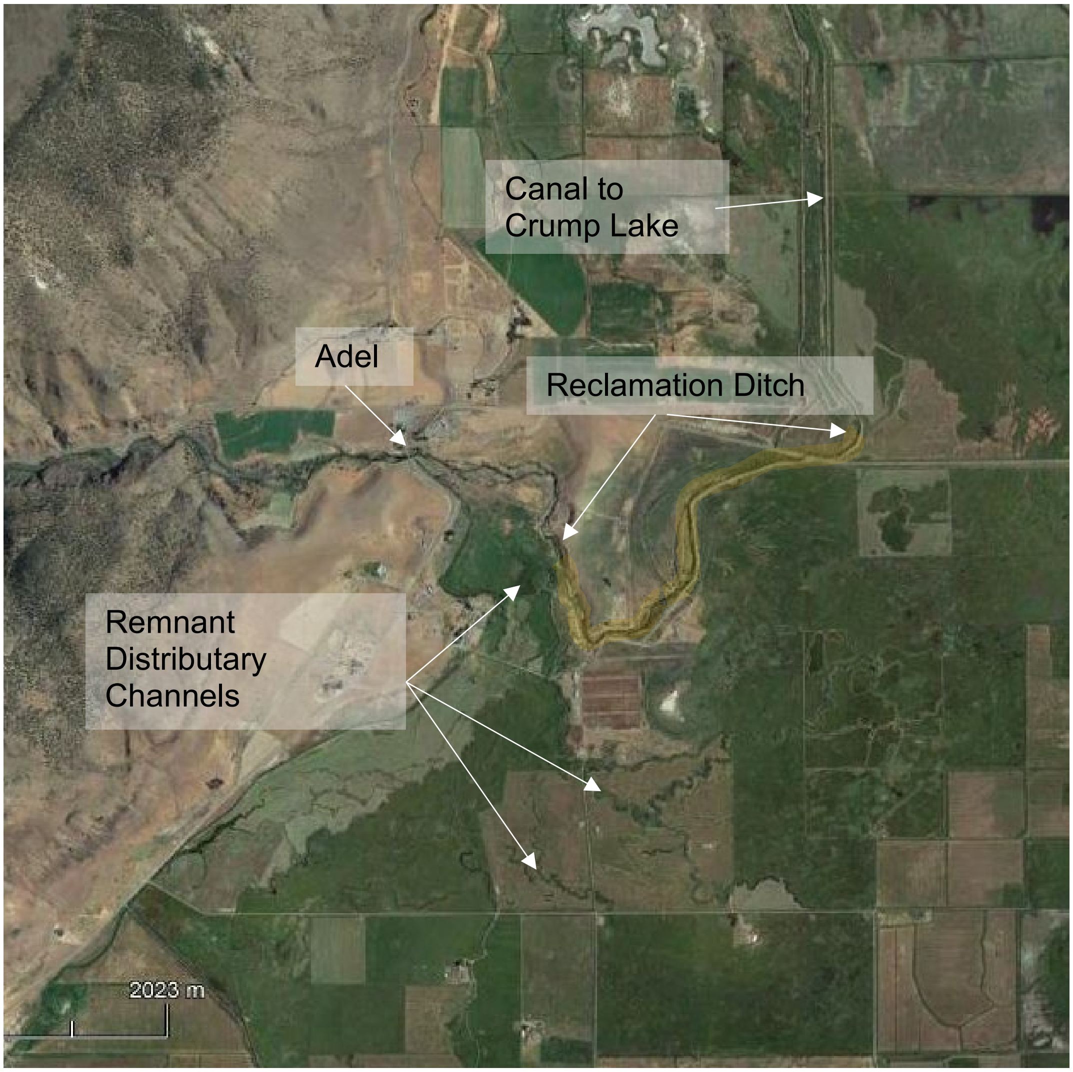
U.S. Fish and Wildlife Service. 1985. Endangered and threatened wildlife and plants; Determination that the Warner Sucker is a threatened species and designation of critical habitat. Federal Register 50(188):39117-39123.

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

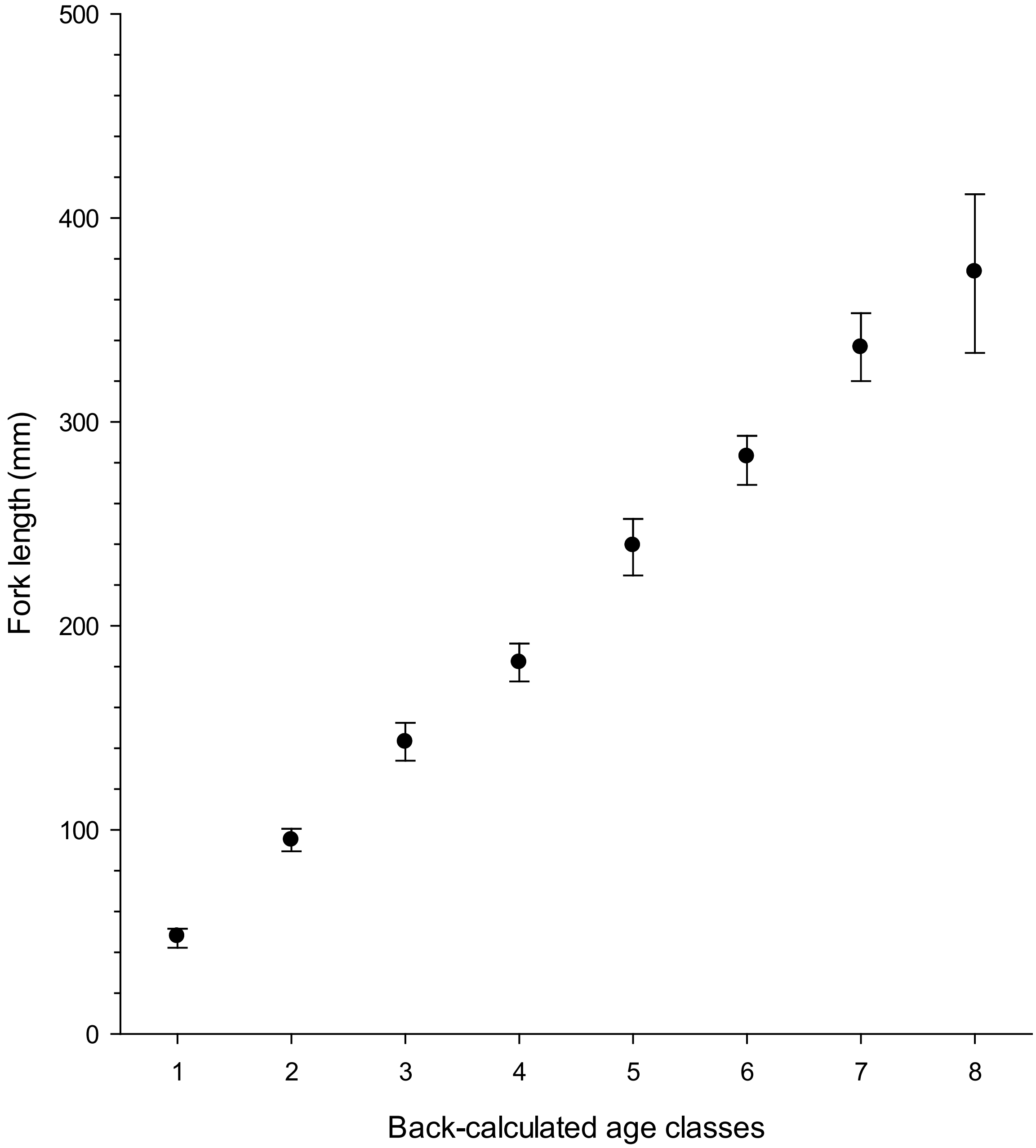
White, R. K., T. R. Hoitsma, M. A. Stern, and A. V. Munhall. 1990. Final report of investigations of the range and status of the Warner Sucker, *Catostomus warnerensis*, during spring and summer 1990. Report to U.S. Bureau of Land Management, Oregon Department of Fish and Wildlife, and U.S. Fish and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

Williams, J. E., M. A. Stern, A. V. Munhall, and G. A. Anderson. 1990. Conservation status of the threatened fishes in Warner Basin, Oregon. Great Basin Naturalist 50:243-248.

**APPENDIX**




Appendix Figure 1. Satellite imagery showing the remnant distributary channels and Reclamation Ditch (highlighted) terminating in the marshland on the valley floor of Deep Creek. Imagery from Google Earth.




Appendix Figure 2. The mean values and 95 percent confidence intervals for back-calculated fork length at the time of each annulus formation (age class) of *Catostomus warnerensis* based on scales (n=50). Figure adapted from Coombs et al. (1979) using the author's reported standard length to fork length conversion. Fish used for aging were captured throughout the Warner Basin with most captured in the spring, so size at age would be prior to expected annual growth.


Appendix Figure 3. Photo of a portion of the Town irrigation network comprised of a remnant distributary channel of Deep Creek.

OREGON
Fish & Wildlife

4034 Fairview Industrial Drive SE
Salem, OR 97302