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Distribution and abundance of Alvord chub in the Alvord basin of southeastern Oregon and northwestern Nevada

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Photograph of Jana's Pond in the Alvord desert of southeastern Oregon.

Paul D. Scheerer[1], **James T. Peterson**[2], **Brad Bauman**[3], 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

[3]Nevada Department of Wildlife, 815 East 4th Street, Winnemucca, NV 89445

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CONTENTS

Page

INTRODUCTION 1
- Surveys in 1948-1982 1
- Surveys in 1994-1996 1
- Surveys in 2010-2012 3
- Unknown Current Status 3

METHODS 5

RESULTS 6
- Thousand Creek Drainage 9
- Virgin Creek Drainage 9
- Bog Hot Creek Drainage 10
- Craine Creek Drainage 10
- Pueblo Slough 10
- Trout Creek Drainage 12
- Ponds Near Alvord Lake 12
- Squaw Creek Drainage 12
- Length-Frequency Distributions 13

DISCUSSION & MANAGEMENT RECOMMENDATIONS 14

ACKNOWLEDGEMENTS 15

REFERENCES 16

INTRODUCTION

The Alvord chub, *Siphateles alvordensis,* is endemic to the Alvord Basin, an endorheic basin located in southeastern Oregon and northwestern Nevada. During the late Pleistocene, most of the Alvord valley was covered by a large lake, measuring approximately 1,200 km^2 (Snyder et al. 1964). The Alvord basin receives an average of 18 cm of annual precipitation (Western Regional Climate Center 2013). Aquatic habitats are rare and occur primarily in the Trout Creek drainage in Oregon, the Virgin-Thousand Creek drainage in Nevada, and in several small streams, ponds, and springs. Historically, Alvord chub were widely distributed across southeastern Oregon and northwestern Nevada (Williams and Bond 1983). Based on recent sampling, there was concern that the range of this species may have contracted, thereby warranting a more robust assessment to determine the current species status and whether management action is required. Alvord chub is a strategy species under the Oregon Conservation Strategy (ODFW 2005) with specific conservation actions focusing on maintaining water availability and reducing localized impacts that could fragment populations.

Surveys in 1948-1982

Historical data on the Alvord Basin chubs is limited. Hubbs and Miller (1948) provided a brief description of the uniqueness of the native Alvord Basin fishes and their isolation, which included documentation of Alvord chub in several unnamed locations in the Alvord Desert region in Oregon and in the Thousand Creek system in Nevada. Williams et al. (1980) and Williams and Bond (1980; 1983) described the distribution and relative abundance of Alvord chub at locations throughout the Alvord basin in Oregon and Nevada based on sampling conducted in 1978, 1979, and 1982. In Oregon, Alvord chub locations included Serrano Pond and Spring (abundant), Trout Creek (common), and Pueblo Slough (Red Point School Springs and Tum Tum Lake; abundant). In Nevada, locations included Bog Hot Reservoir (abundant), Bog Hot Creek (rare to common), Thousand Creek Spring (rare), an unnamed spring near Thousand Creek (common), Thousand Creek (abundant), Continental Lake (winter only; intermittent), Virgin Creek (abundant), Dufurrena Ponds 13, 19, and 22 (common to abundant), Warm Creek (a tributary to Virgin Creek; abundant), Gridley Springs (common), West Spring (common), and West Creek (common). This species was also collected in 1974 from Juniper Lake in Oregon (Bond 1974), with additional museum records from 1960. Unfortunately, these reports do not list which locations were sampled and did not contain Alvord chub. It is reasonable to assume that Alvord chub historically inhabited other suitable low-gradient habitats in the basin, from which there is no documentation. Figure 1 illustrates all locations where Alvord chub were historically collected (through 2012).

Surveys in 1994-1996

In Oregon, the Oregon Department of Fish and Wildlife (ODFW) conducted fish surveys in 1996 at five historical Alvord chub locations (unpublished data). Alvord chub were collected from Serrano Pond (n=224), Serrano Spring (n=54), Pueblo Slough (n=430), and Tum Lake

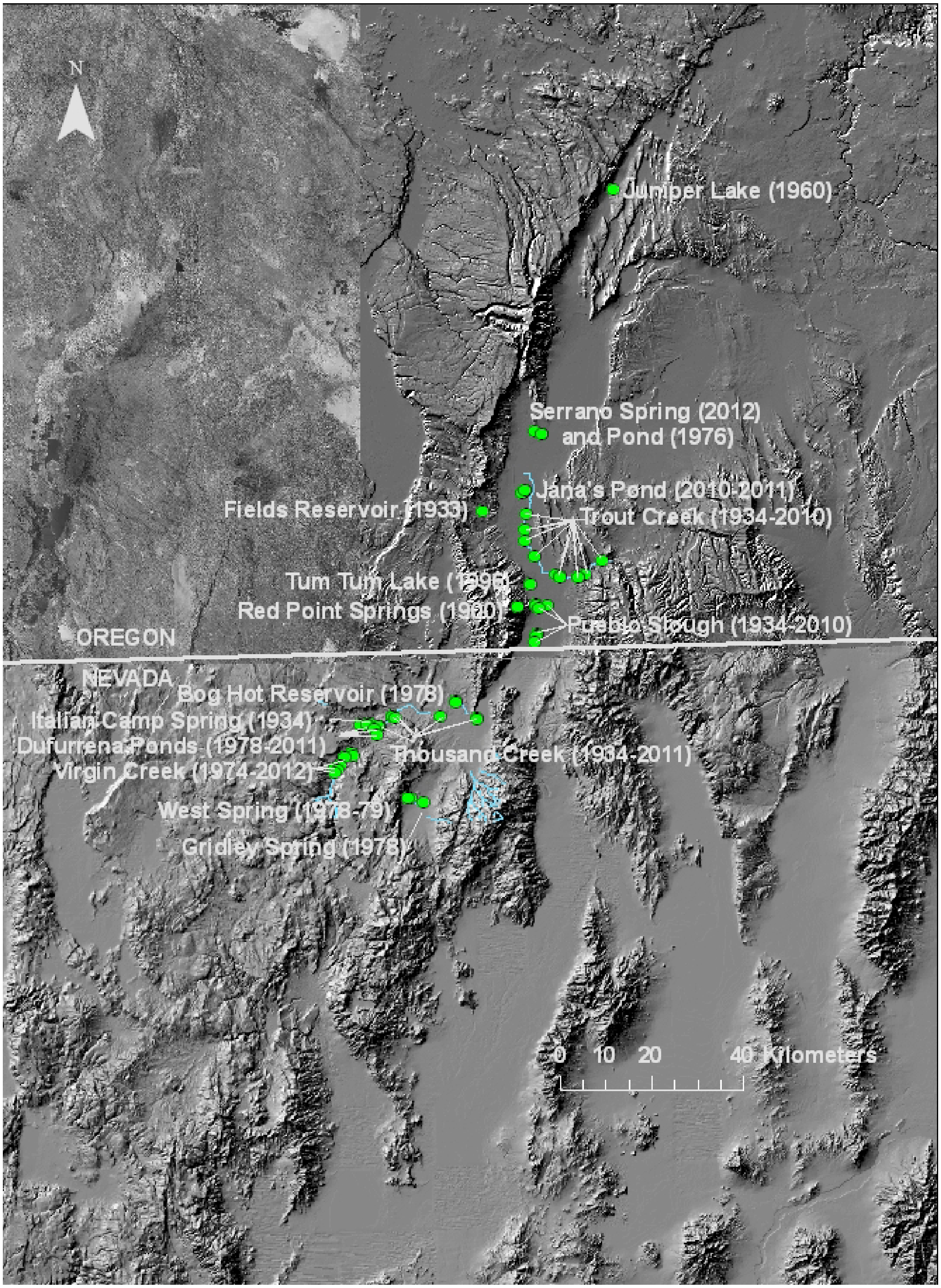

Figure 1. Historical distribution (green dots) of Alvord chub, based on reports from the literature and from museum specimens (Oregon State University, University of Michigan Museum of Zoology, California Academy of Science, and University of Washington).

(n=42); no chub were collected from Trout Creek, Squaw Creek, or Denio Creek (the latter two are suitable, but undocumented/unoccupied Alvord chub habitats).

In 1994, the Nevada Department of Wildlife (NDOW) conducted fish surveys at three historical locations and reported finding Alvord chub in Lower Thousand Creek (n=2) and above McKenney Camp on Big Spring Creek upstream of Dufurrena Ponds(few); none were collected from Bog Hot Spring (unpublished data).

Surveys in 2010-2012

In Oregon, the Bureau of Land Management (BLM) conducted limited surveys in 2010 and 2012. They collected Alvord chub from Trout Creek in 2010 (n=7 from one location) and 2012 (n=16, from one of seven locations sampled), but did not capture chub from Tum Tum Lake or Juniper Lake (both desiccate regularly). They also reported that large portions of lower Trout Creek and Pueblo Slough were desiccated. In 2010, BLM discovered an undocumented (abundant) population in Jana's Pond, which is located ~0.5 km northeast of Borax Lake. ODFW estimated there were 1,760 (95% CI: 1,093-2,794) chub at Jana's Pond in 2010 (Scheerer and Jacobs 2010). In addition, BLM sampled for chub at several locations for which there was no historical record of sampling. These sites were deemed suitable to have historically supported Alvord chub in Oregon and included Van Horn Creek (supplies water to Pueblo Slough), Bone Creek, Little Cottonwood Creek, Little Trout Creek, Oliver Creek (dry), Willow Creek, Williams Creek, Squaw Creek, Alvord Creek, Tule Springs, Mann Lake, and Salt Bog Waterhole; no Alvord chub were collected from these locations. In 2011 and 2012, ODFW collected Alvord chub (n=2 and n=20, respectively) from Serrano Springs. Serrano Pond was desiccated and the water control structure that feeds water to the pond was non-functional.

In Nevada, the Nevada Division of Wildlife (NDOW) with assistance from Dr. Douglas Markle, Oregon State University, collected chub in 2011 from Thousand Springs (abundant) and Virgin Creek (Dufurrena Pond 13; abundant). No Alvord chub were collected from Virgin Creek, Dufurrena Ponds 19 and 20 (nonnatives were abundant in both ponds), or Big Springs Creek. They also noted that Virgin Creek through Virgin Valley desiccated in 2011, except for Dufurrena Pond 13 where chub were abundant.

Unknown Current Status

Recent data suggests that Alvord chub distribution may have contracted and chub abundance may have declined, compared to historic data (Table 1). Alvord chub have not been collected from several historically occupied locations in decades. During recent surveys, the numbers of chub collected at several locations were substantially lower than those collected during earlier surveys. In addition, no surveys have been conducted in 30 years in many of the historical habitats, thus the status of Alvord chub is unknown at these locations. Currently identified threats included competition and predation by nonnative fishes and impacts to chub habitat quality and quantity from grazing and water withdrawals.

Table 1. Results from Alvord chub sampling conducted during three sampling periods since 1974. Sites not surveyed are denoted with "NS". Note, two sites were only sampled in 1934 and are documented in the Oregon State University fish collection database.

	Relative abundance			
Location	1974-1982 Surveys	1994-1996 Surveys	2010-2012 Surveys	Source/reference
Oregon				
Juniper Lake	present	0	0	Bond (1974); ODFW unpublished data (1996); BLM unpublished data (2012)
Serrano Spring	abundant	54	2-20	Williams and Bond (1983); ODFW unpublished data (1996; 2011; 2012)
Serrano Pond	abundant	224	dry	Williams and Bond (1983); ODFW unpublished data (1996; 2011; 2012)
Fields Reservoir	present in 1934	NS	NS	OSU museum record
Jana's Pond	NS	NS	1,760	Scheerer and Jacobs 2010
Trout Creek	common	0	7-19	Williams and Bond (1983); ODFW unpublished data (1996); BLM unpublished data (2010; 2012)
Pueblo Slough	abundant	430	3-22	Williams and Bond (1983); ODFW unpublished data (1996); BLM unpublished data (2010; 2012)
Red Point School Springs	abundant	abundant	NS	Williams and Bond (1983); ODFW unpublished data (1996)
Tum Tum Lake	abundant	42	0	Williams and Bond (1983); ODFW unpublished data (1996); BLM unpublished data (2012)
Nevada				
Thousand Creek Spring	rare	NS	NS	Williams and Bond (1983); NDOW unpublished data (2011)
Thousand Creek	common	2	abundant	Williams et al. 1980; Williams and Bond (1983); NDOW unpublished data (1994)
Unnamed spring near Thousand Creek	common	NS	NS	Williams and Bond (1983)
Italian Camp Spring	present in 1934	NS	NS	OSU museum record
Dufurrena Pond 19	common	NS	0	Williams et al. 1980; Williams and Bond (1983); NDOW unpublished data (2011)
Dufurrena Pond 22	abundant	NS	NS	Williams et al. 1980; Williams and Bond (1983)
Virgin Creek	abundant	NS	18	Williams et al. 1980; Williams and Bond (1983); Lohr et al. (2012)
Dufurrena Pond 13	common	NS	abundant	Williams et al. 1980; Williams and Bond (1983); NDOW unpublished data (2011)
Bog Hot Reservoir	abundant	NS	NS	Williams et al. 1980; Williams and Bond (1983)
Bog Hot Creek	rare	0	NS	Williams and Bond (1983); NDOW unpublished data (1994)
Continental Lake	intermittent	NS	NS	Williams and Bond (1983)
Warm Creek	abundant	NS	NS	Williams et al. 1980; Williams and Bond (1983)
Gridley Springs	common	NS	NS	Williams et al. 1980; Williams and Bond (1983)
West Spring	common	NS	NS	Williams et al. 1980; Williams and Bond (1983)
West Creek	common	NS	NS	Williams and Bond (1983)

The objectives of ODFW's 2013 Alvord chub surveys were to: 1) describe the current distribution in the Alvord basin, 2) estimate their abundance at occupied sites, and 3) describe current habitat conditions and threats. Note, these surveys were conducted following two years of below average precipitation in the Alvord basin (Western Regional Climate Center 2013).

METHODS

We sampled fish at locations known to have supported Alvord chub historically, including sites on private land (access dependent), using a combination of baited minnow traps, seines, and hoop nets. We also sampled several suitable locations at which chub have not previously been documented. We estimated Alvord chub population size at each location using a Huggins closed capture model (Huggins 1991), implemented in program MARK (White and Burnham 1999), using only used catch data from minnow traps in this model. The Huggins model requires a minimum of three capture occasions to model the variability in capture probabilities among trapping occasions. We included covariates, such as body size and habitat characteristics, in the Huggins model to account for variability in capture probabilities. This variability, if unaccounted for, can result in population estimates that are biased low (Peterson and Paukert 2009). Prior to model fitting, we combined the capture-recapture data from all sites into a single data set, treating each site as a group. We sampled eight of the eleven sites on three occasions and sampled the other three sites on two occasions. To account for the missing third sample at the three sites, we fixed the capture and recapture probabilities at zero for the third capture occasion at these three locations.

We began modeling capture probability by fitting a global model with all covariates including: body size (small: <35 mm, medium: [baseline size group] 35-59 mm, and large fish: >59 mm); average water temperature (average of all sampling occasions); percent of the site's surface area covered with aquatic vegetation; average and maximum site depth; number of traps used; area and volume of the site; area per trap, which was area divided by the number of traps used; volume per trap, which was site volume divided by the number of traps used; and a parameter representing recapture of marked fish (recapture effect). After fitting the global model, we found overdispersion (c-hat) was 2.51, indicating lack of model fit due to overdispersion (i.e., variance was in excess of that assumed by the model). A potential source of overdispersion is dependence among samples collected at individual sites (spatial autocorrelation). To account for the extra variability, we modeled capture and recapture probabilities using a hierarchical (Huggins) model. The model included random effects associated with the intercept (fish capture probability) and recapture effect that varied among sites. The random effects represented unique effects associated with each site on the capture probabilities and recapture probabilities, respectively, which were unexplained by the site-specific covariates. We fit all models using Markov Chain Monte Carlo (MCMC) methods in program MARK with 360,000 iterations and 10,000 burn-in samples (Raftery and Lewis 1996).

We were primarily interested in obtaining the best predicting model of capture probability and population size. Therefore, we fit all subsets of the global model and determined the best approximating model using Deviance Information Criteria (DIC; Spiegelhalter et al. 2002). We report the parameter estimates and random effects, expressed as variance components, for the best approximating model and express precision of the estimates using 95% credible intervals, which are equivalent to 95% confidence intervals.

The Huggins model does not directly estimate abundance, but rather abundance (N) is derived using the following formula:

$$N = M_t / (1 – [(1-p_1)(1-p_2)(1-p_3)]),$$

where M_t is the total number of marks in the populations, p_t is the probability of capture for occasions (t) one to three. We estimated the capture probabilities using the best approximating model and estimated population size for each site and body size group (which we summed). We also calculated 95% confidence intervals for each population estimate according to Chao (1987).

We described the current habitat conditions (model covariates) at each location including site dimensions, site depth (maximum, average, and range), substrate composition, aquatic vegetation (type and percent cover), and water temperature. We measured site dimensions using a laser rangefinder or a graduated depth staff. We measured site depths with a graduated depth staff at a minimum of five locations per site. We characterized substrate as the proportion of the wetted area composed of fines (<1/16th mm), sand (1/16th-2 mm), gravel (3-64 mm), cobble (65-256 mm), boulder (>256 mm), and bedrock (native consolidated rock). We described current conditions which affect water quality (grazing), water availability (withdrawals), and/or may be causing fragmentation of habitats (barriers). We recorded Universal Transverse Mercator (UTM) coordinates of each site using a hand-held Global Positioning System (GPS) and took photographs at each site. We also collected fin clips and voucher specimens for future genetic and morphometric analyses (up to 10 fish per population and not exceeding 10% of the estimated population abundance, whichever was less).

RESULTS

We sampled 46 unique locations for Alvord chub in Oregon (n=25) and Nevada (n=21), including 38 historically occupied locations. We found Alvord chub at 15 locations (33%), all of which were historically occupied. Another 15 sites (33%) were dry or puddled. We found Alvord chub at six locations in Nevada (29%) and nine locations in Oregon (36%). We estimated chub abundance at 11 locations. The parameter estimates and random effects, expressed as variance components, from the best approximating model of population size are shown in Table 2.

Table 2. Parameter estimates and random effects, expressed as variance components, from the best approximating model of Alvord chub population size.

Parameter[1]	Mean	SD	95% Credible intervals Lower	95% Credible intervals Upper
Fixed effects				
Intercept (fish capture probability)	-1.7768	0.3479	-2.5420	-1.1611
Small fish (< 50 mm)	-0.2282	0.0332	-0.2939	-0.1636
Average depth (m)	-0.8411	0.3417	-1.4758	-0.1062
Number of traps used	0.3996	0.1391	0.0900	0.6543
Site area	-0.3971	0.2139	-0.8077	0.0209
Area-number of traps interaction	-0.1830	0.1039	-0.3806	0.0242
Recapture probability	-0.0073	0.4851	-0.9270	1.0101
Random effects[2]				
Intercept (fish capture probability)	0.8135	0.3967	0.3145	1.8259
Recapture probability	1.4345	0.4350	0.8260	2.4975

[1]Models were fit using standardized (normalized) data where a 1 unit change corresponds to a 1 SD change in the variable.

[2]Random effects are variance components representing among site variability of the parameter

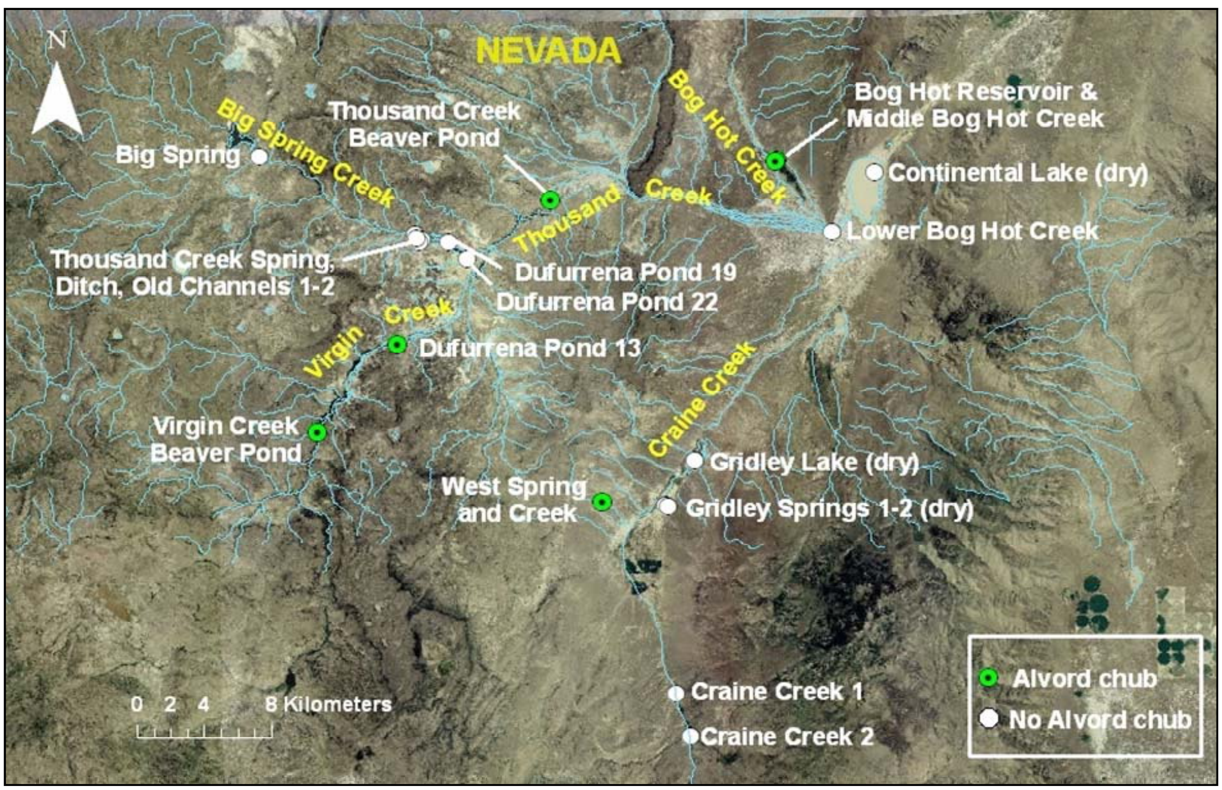

Figure 2. Map showing the 2013 sampling locations for Alvord chub in Nevada. Green circles with center dots indicate locations where Alvord chub were collected. White circles indicate locations where no Alvord chub were collected.

Table 3. 2013 Alvord chub abundance estimates, 95% confidence limits, and current threats at 46 locations in the Alvord basin of Nevada and Oregon. Historically occupied sites are distinguished by italics.

			Confidence limits		Threats				
Site	State	Abundance	lower	upper	Grazing	H2O withdrawals	Desiccates	Fragmentation	Nonnatives
Big Spring	Nevada	**0**	-	-					
Thousand Creek Spring	Nevada	**0**	-	-				yes	yes
Thousand Creek ditch	Nevada	**0**	-	-					yes
Old Thousand Creek channel #1	Nevada	**0**	-	-		yes		yes	
Old Thousand Creek channel #2	Nevada	**0**	-	-		yes		yes	
Thousand Creek beaver pond	Nevada	**2,850**	2,139	3,835					yes
Dufurrena Pond 19	Nevada	**0**	-	-				yes	yes
Dufurrena Pond 22	Nevada	**0**	-	-			yes	yes	
Dufurrena Pond 13- small pool[1]	Nevada	**4,825**	3,898	6,329				yes	
Dufurrena Pond 13- large pool	Nevada	**1,722**	1,583	1,905				yes	
Virgin Creek beaver pond	Nevada	**13,948**	10,003	19,690					
Bog Hot Reservoir	Nevada	**151,594**	126,667	181,817				yes	
Middle Bog Hot Creek	Nevada	**565**	483	759	yes	yes	yes		
Lower Bog Hot Creek	Nevada	**0**	-	-			yes		
Continental Lake	Nevada	**0**	-	-			yes		
West Spring	Nevada	**0**	-	-	yes				
West Creek	Nevada	**458**	394	608	yes				
Gridley Lake	Nevada	**0**	-	-	yes		yes		
Gridley Spring 1	Nevada	**0**	-	-	yes	yes?			
Gridley Spring 2	Nevada	**0**	-	-	yes	yes?			
Craine Creek 1	Nevada	**0**	-	-	yes				
Craine Creek 2	Nevada	**0**	-	-	yes				
Juniper Lake	Oregon	**0**	-	-			yes	yes	
Squaw Creek	Oregon	**0**	-	-		yes			
Serrano Spring and Springbrook	Oregon	**2**	-	-	yes				
Serrano Pond	Oregon	**0**			yes				
Trout Creek 1- USGS gage	Oregon	**1**	-	-					
Trout Creek 2- Beaver Pond/Backwater	Oregon	**1**	-	-					
Trout Creek 3	Oregon	**5**	-	-					
Trout Creek 4-Riggs	Oregon	**0**	-	-	yes		yes		
Trout Creek 5- Smith/Gilbert	Oregon	**0**	-	-	yes		yes		
Jana's Pond	Oregon	**5,205**	4,459	6,221					
Salt Spring	Oregon	**0**	-	-					
Tule Spring 1- eastern (OR)	Oregon	**0**	-	-					
Tule Spring 2- middle (OR)	Oregon	**0**	-	-					
Tule Spring 3- western (OR)	Oregon	**0**	-	-					
Pueblo Slough Pool 6A	Oregon	**1,353**	1,007	1993	yes				
Pueblo Slough Pool 6C	Oregon	**930**	794	1097	yes				
Pueblo Slough Pool 6B	Oregon	**740**	568	1018	yes				
Pueblo Slough Pool 6D	Oregon	**234**	197	293	yes				
Pueblo Slough Well 1	Oregon	**0**	-	-	yes				
Pueblo Slough Well 3	Oregon	**0**	-	-	yes				
Pueblo Slough Well 1920-1	Oregon	**0**	-	-	yes				
Pueblo Slough Well 1920-2	Oregon	**0**	-	-	yes				
Pueblo Slough Well 1920-3	Oregon	**0**	-	-	yes				
Pueblo Slough Well 8	Oregon	**0**	-	-	yes				
Tum Tum Lake	Oregon	**0**	-	-			yes		

[1]The mark-recapture estimate for Dufurrena Pond 13 small pool was calculated using the Lincoln-Peterson model (different gear type=seine).

Thousand Creek Drainage

In the Thousand Creek drainage in Nevada, we estimated there were 2,850 (95% CI: 2,139-3,835) Alvord chub in the beaver ponds located downstream of Thousand Creek gorge (Table 3; Figure 2). We also collected nonnative redear sunfish *Lepomis microlophus* from this site, the only location where we found chub and nonnatives coexisting. The habitat in these ponds was in good condition (deep, cool, and densely vegetated). We did not collect chub from six sites we sampled upstream of the Thousand Creek gorge. No chub were collected from Thousand Creek spring or Thousand Creek ditch, which supply water into Dufurrena Ponds 19-22. Nonnative guppies *Poecilia reticulate* were very abundant at these locations. No fish were found in the unnamed spring near Thousand Creek, or from two former stream channels that historically flowed through Dufurrena Ponds 19-22. We collected redear sunfish and white crappie *Pomoxis annularis* from Dufurrena Pond 19, but no chub. This pond is managed for warmwater fishing. We did not sample Dufurrena Pond 22, a site historically occupied by chub which reportedly desiccated earlier in 2013. The pond had a small amount of water (<0.1 m deep) which originated from heavy rains that occurred the week prior to our sampling. This shallow puddle also had a dense algal bloom. We sampled Big Spring, which during high flows drains into Big Creek and eventually into Thousand Creek. This site had high quality habitat (deep, densely vegetated) but no fish were collected. The water temperature was very cold (4^{o}C), which likely precluded successful chub recruitment. We were unable to locate Italian Camp Springs, an historically occupied chub location last sampled by Hubbs in 1934 (OSU museum record; unpublished data). Nevada Natural Heritage Program records suggest Italian Camp Springs and Thousand Creek Spring may be one in the same (E. Miskow, personal communication). The Thousand Creek subbasin was fragmented by the construction of the Dufurrena Ponds, which restrict upstream fish movements. The stream channel downstream of the ponds currently desiccates on an annual basis. It is uncertain whether this desiccation occurred regularly, prior to the construction of the ponds.

Virgin Creek Drainage

In the Virgin Creek drainage in Nevada, chub were abundant in the beaver ponds located immediately downstream of the Virgin Creek gorge (estimate- 13,948; 95% CI: 10,003-19,690) (Table 2; Figure 3). The habitat in these ponds was in good condition (deep, cool, and densely vegetated). Chub were also abundant in Dufurrena Pond 13. We obtained abundance estimates in two isolated pools at this site. The chub estimate in the larger pool was 1,722 fish (95% CI: 1,583-1,905) and in the smaller pool was 4,825 fish (95% CI: 3,898- 6,329). The habitat quality in Dufurrena Pond 13 was marginal. The pools were shallow, warm, and turbid with no aquatic vegetation. Apparently, the dissolved oxygen content was also low in these pools, as we noted fish gulping air at the surface, and had some trap mortalities, where fish died with their mouths open and gills flared. The combined Virgin Creek estimate of over 20,000 chub is likely a minimum estimate for the subbasin, as we were unable to secure private landowner access to sample other suitable habitats in the subbasin, like Warm Spring. The Virgin Creek drainage is seasonally fragmented by desiccation; the impoundments (Dufurrena Pond 13 and others on private land) restrict upstream movement during most flow levels.

Bog Hot Creek Drainage

In the Bog Hot drainage in Nevada, chub were very abundant in Bog Hot Reservoir (estimate- 151,594; 95% CI: 126,667-181,817) and common in middle Bog Hot Creek immediately downstream of the reservoir (estimate- 565; 95% CI: 483-759). The reservoir habitat was in good condition, except that the spillway was highly eroded (exposed tires and metal t-posts) and the water levels varied substantially (~0.5 m) when water was diverted for irrigation. The habitat in middle Bog Hot Creek was heavily impacted by cattle grazing. Immediately downstream from where we sampled the creek, Bog Hot Creek was diverted into a pasture (sheet flow). No fish were collected from lower Bog Hot Creek. This section of the creek desiccated earlier during the summer of 2013 (cracked clay substrate and submerged terrestrial vegetation were noted) and the cloudy brown water we saw was likely a result of the heavy rains that occurred the week prior to our sampling. Continental Lake, which receives water from both Bog Hot Creek and Virgin-Thousand Creeks, was dry. The Bog Hot Creek drainage is negatively affected by habitat fragmentation. The dike and two water control structures on Bog Hot Reservoir restrict upstream fish passage. The irrigation diversion that irrigates the pasture seasonally desiccates the downstream stream channel.

Craine Creek Drainage

We sampled (visited) seven locations in the Craine Creek drainage in Nevada. We collected chub from West Creek (estimate- 458; 95% CI: 394-608), but not from West Spring. West Creek was a narrow, shallow spring brook that flowed ~400 m, before terminating in a small marsh. The spring was shallow (~0.1 m deep) with gravel substrate, and was trampled by cattle. We visited Gridley Springs and Gridley Lake. Historical records noted 17 springs at Gridley Springs; we only found remnants of two springs, which amounted to damp soil with emergent vegetation. Gridley Lake had a small amount of water, which originated from a thermal spring (41^{o}C) and recent rains. The Gridley habitats were negatively affected by heavy cattle grazing. The local landowner reportedly drilled additional irrigation well(s) in recent years, which may have lowered the water table and affected the springs. We did not collect any fish from two locations we sampled in Craine Creek, despite presence of suitable habitat (adequate flow, depth, and aquatic vegetation). Alvord chub were not historically reported from Craine Creek.

Pueblo Slough

In the Pueblo Slough drainage in Oregon, we collected chub from four pools in a previously modified wetland associated with Well 6. Compared to photographs from 1996 surveys, open water habitat in this wetland has declined substantially, as emergent wetland plants, primarily cattails *Typha latifolia,* have expanded their distribution. Despite this loss of suitable open water habitat, chub were abundant, ranging from 234-1,353 individuals per pool (Table 3; Figure 3). In addition to the pools associated with the Well 6 wetland, we sampled six small pools associated with Wells 1, 3, 8, 1920-1, 1920-2, and 1920-3. These sites were small, shallow puddles (0.10-0.20 m deep) and were fishless. Impacts from cattle grazing were

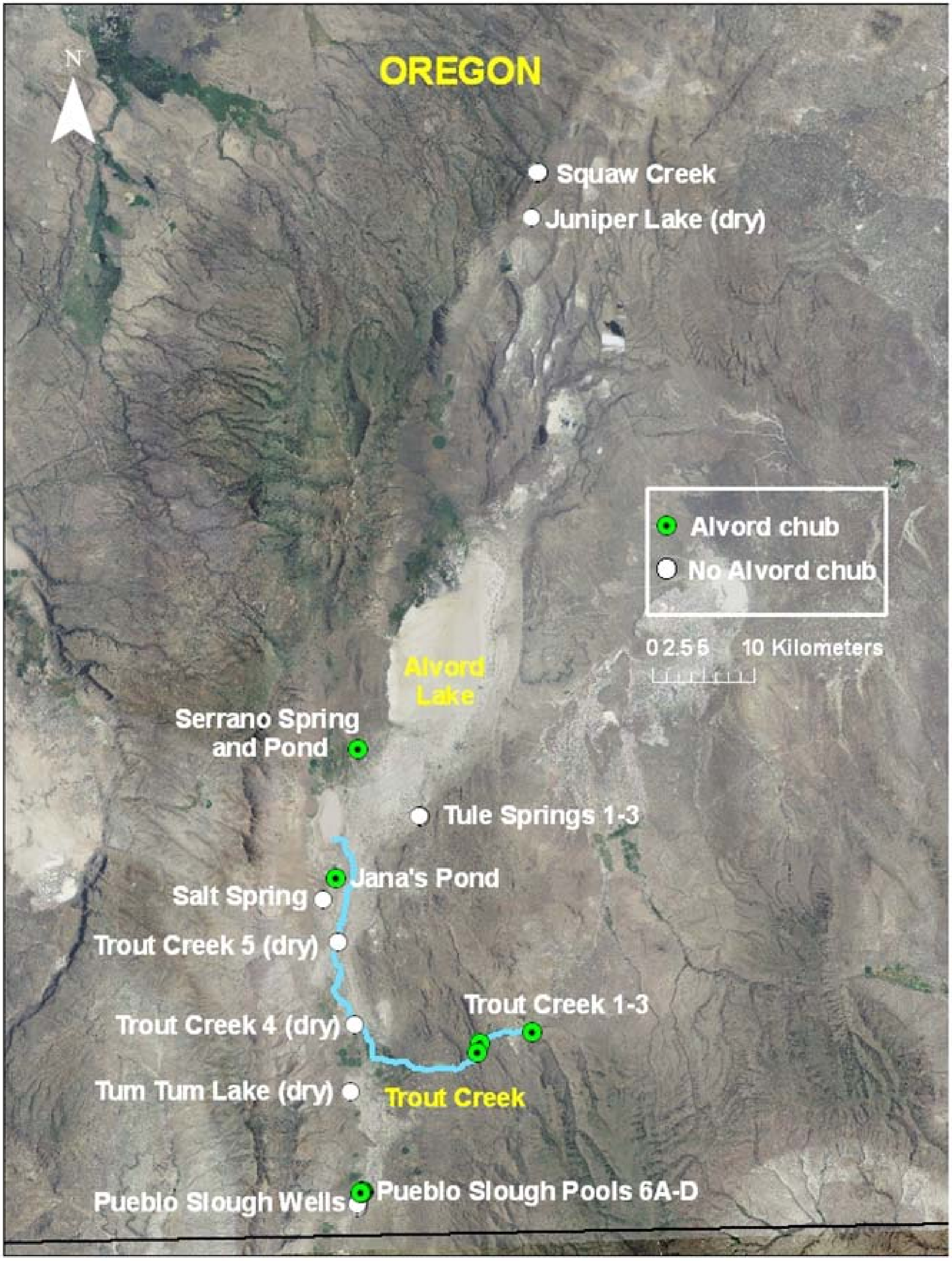

Figure 3. Map showing the 2013 sampling locations for Alvord chub in Oregon. Green circles with center dots indicate locations where Alvord chub were collected. White circles indicate locations where no Alvord chub were collected.

widespread in the slough, despite fences that could have excluded the livestock if the gates had been closed. When the wetlands were modified in the 1970's, dikes were constructed to create impoundments. These dikes fragment the slough habitat and seasonally restrict fish movement. During most years, Tum Tum Lake and a small pond, which is located approximately 5 km south of the lake, desiccate, as they did in 2013. We did not receive landowner permission to sample Red Point School Springs.

Trout Creek Drainage

In Trout Creek in Oregon, we collected only a handful of chub (n=7 total) from three sites in the lower end of the canyon. We also collected redband trout *Oncorhynchus mykiss* from these sites. We visited four sites in the lower, valley portion of the drainage; all were desiccated. We were unable to obtain landowner permission to sample on private land encompassing most of the low gradient sites in the drainage. All of the Trout Creek sites, with the exception of the beaver ponds on BLM property (Trout Creek site 2), were negatively affected by cattle grazing. The beaver ponds at Trout Creek site 2 had good quality stream habitat (deep, cool, and heavily vegetated), but chub were rare.

Ponds near Alvord Lake

We sampled seven spring fed ponds near Alvord Lake in Oregon (Jana's Pond, Tule Springs 1-3, Salt Spring, and Serrano Spring/Pond). Chub were abundant in Jana's Pond (estimate- 5,205; 95% CI- 4,459-6,221). This spring-fed pond is located northeast of Borax Lake and receives seepage runoff from the lake. The habitat is high quality (deep, cool, and vegetated) and is not affected by grazing. We collected two chub from the Serrano spring pool and upper springbrook. Serrano spring and springbrook are on private land and were negatively affected by cattle grazing. Serrano Pond, an impoundment east of the spring, was dry. Recent work to replace the water control structure on the Serrano spring pool was completed in 2013; however the gate supplying water to Serrano Pond was closed. No chub were collected from Tule Springs or Salt Spring. Salt Spring is fed by geothermal groundwater and is likely too hot (39.5^{o}C) to support Alvord chub. Tule Springs are excavated ponds that contain suitable chub habitat, but no fish. We could not locate Fields Reservoir, which was last sampled in 1934.

Squaw Creek Drainage

We visited two locations in the Squaw Creek drainage in Oregon. Juniper Lake was desiccated. Squaw Creek was puddled and contained only Lahontan cutthroat trout *Oncorhynchus clarkii henshawi*. An impoundment on lower Squaw Creek fragments this drainage and seasonally restricts fish movement.

Length-Frequency Distributions

The length-frequency distributions for Alvord chub populations sampled in 2013 are presented in Figure 4. Size distributions were broad and varied considerably among sites. We noted two apparent size (age) classes at Dufurrena Pond 13, West Creek, and Thousand Creek. Pueblo Slough and Bog Hot Reservoir were dominated by small fish (≤70 mm FL). Presumptive young-of-the-year chub (~40-50 mm FL) were captured at many sites, most notably in West Creek and Jana's Pond. These small fish, and the presence of broad size distributions at many locations, suggest that Alvord chub have had successful recruitment at most sites in recent years.

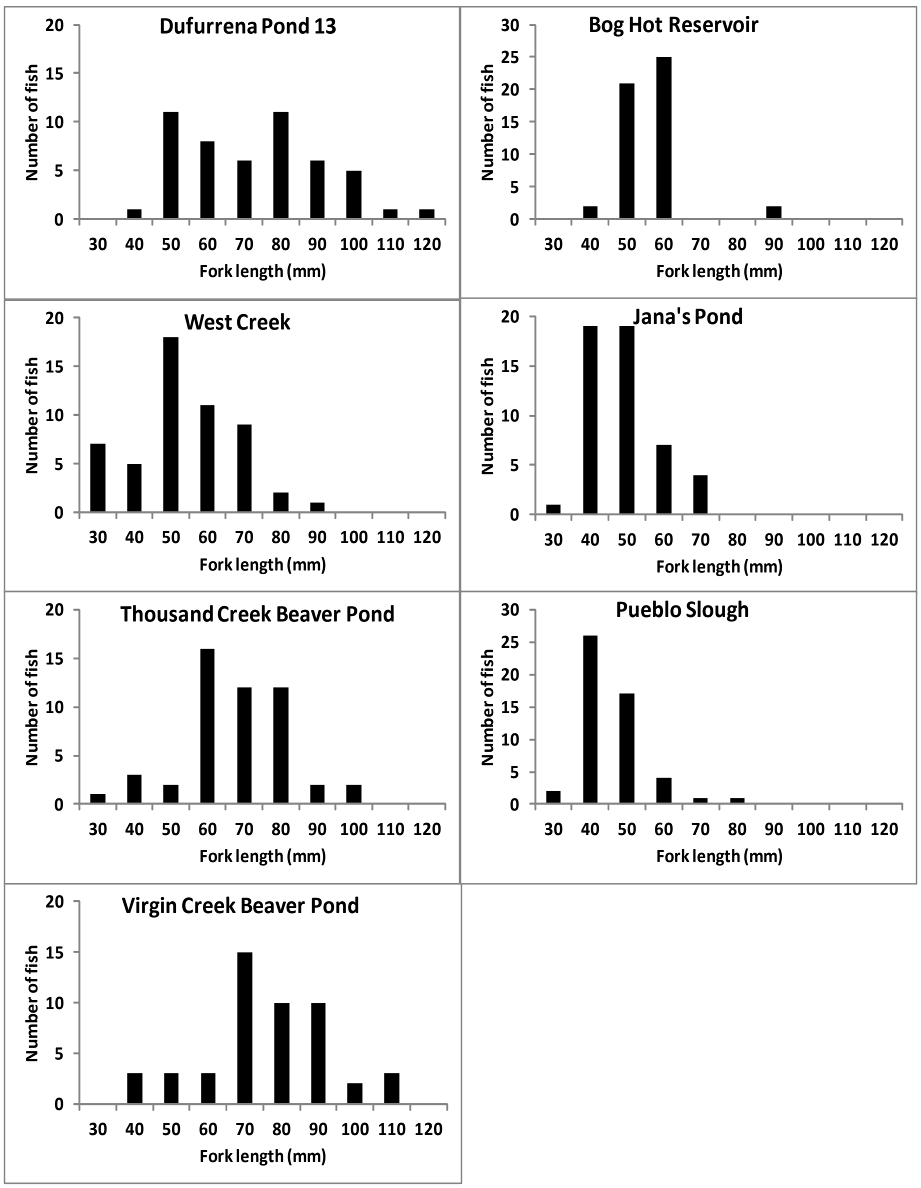

Figure 4. Length-frequency histograms for Alvord chub collected in September-October 2013 from locations in Oregon and Nevada.

DISCUSSION & MANAGEMENT RECOMMENDATIONS

In 2013, we completed the first comprehensive survey for Alvord chub in 30 years. Despite two years of below average precipitation, we found chub were abundant at many locations and present, albeit with restricted distribution, in most of the drainages. We noted numerous threats to the species, including the presence of nonnative fishes, habitat degradation from cattle grazing, habitat fragmentation resulting from the creation of impoundments, water withdrawals for irrigation, and seasonal desiccation.

We only collected nonnative fishes in the Thousand Creek drainage in Nevada. Guppies were very abundant in Thousand Creek Spring and in the ditch that diverts the creek into Dufurrena Ponds 19-22. Guppies were first noted in the spring, and sporadically in the diversion ditch, in the 1980's (Williams and Bond 1983). Immediately downstream in the drainage, the Dufurrena Ponds 19-22 are managed for warmwater sport fishing and contained predatory redear sunfish, crappies, and reportedly yellow perch *Perca flavescens* and largemouth bass *Micropterus salmoides*. No chub were collected from these habitats. Downstream of the ponds and upstream of the gorge, Thousand Creek was desiccated. Downstream of the Thousand Creek gorge, beaver ponds provided high quality chub habitat. This was the only location where we found coexistence of Alvord chub and nonnative fishes. We are concerned that if guppies expand their range downstream and/or if the redear sunfish abundance increases, we could lose this population. We recommend regular monitoring of chub and nonnative fish abundance (every 2-3 years) at this location, in the event that management action becomes necessary to save this subpopulation. We also recommend attempted removal of the guppies from spring and ditch and the reintroduction of chub from the Thousand Creek Beaver Ponds into these restored habitats. This could be done by first pumping the spring dry and/or applying rotenone to remove guppies from the spring, then diverting the spring flow into the historical channels and desiccating the ditch. Also, managers could consider the possible conversion of the Dufurrena sport fishing ponds into chub habitats.

We noted widespread impacts from cattle grazing in Alvord chub habitats. We recommend fencing the stream channels and ponds to restrict cattle (and burro) access and providing off-channel or limited instream watering for the cattle. Specifically, this would improve chub habitats in Bog Hot Creek, West Spring, Pueblo Slough, Trout Creek, Dufurrena Pond 13, and Gridley Springs.

Open water habitat has been reduced and is limiting at several chub sites, including, Gridley Springs, Serrano Pond, and Pueblo Slough. To create open water habitat for chub at Gridley Springs, we recommend habitat restoration to create pools at one or two locations. At Serrano Spring, we recommend diverting water from the spring pool through the new water control structure to restore habitat in the currently dry, diked pond. Likely, chub will naturally recolonize Serrano Pond from the spring pool after flow is restored. At Pueblo Slough, we also recommend habitat restoration to expand open water habitat. In the 1970's, the Bureau of Land Management (BLM) drilled nine artesian wells (in addition to eight wells privately drilled in the 1920's), constructed three dikes, and excavated four ponds at Pueblo Slough to enhance habitat for fish and wildlife, primarily migratory birds. Since then, decreasing water tables, sediment deposition, and dense aquatic vegetation growth has reduced the perennial wetted surface area from 86 acres to 2.3 acres (87% loss) (Daryl Bingham, BLM, personal communication). In 2013, the BLM developed a proposal and submitted NEPA documents to restore open water habitat at Pueblo Slough. This long-term, multiphase project proposes to restore open water habitat at the site by reducing pond surface areas and increasing pond depths to provide cooler, more reliable perennial habitats. During restoration at Pueblo Slough and Gridley Spring, we urge caution and recommend excavating pools adjacent to, but not at the spring sources, to minimize possible disruption of spring flows.

We recommend assessing the genetic structuring and diversity of all Alvord chub populations. These analyses can reveal patterns of historical connectivity, inform managers regarding which populations are suitable donor stocks for future introductions, and identify populations that have undergone bottlenecks and require genetic augmentation. For example, after restoration is completed at Gridley Springs (assuming it is initiated), the next step would be to reintroduce Alvord chub. While West Creek is a likely donor site, due to its close proximity to Gridley Spring, if this population is found to have undergone a recent genetic bottleneck and associated loss of diversity, then another choice of donor stock may be advisable. In addition, genetic analyses at Serrano Spring could determine whether this small population has undergone a genetic bottleneck and could assist managers in choosing a suitable donor population, if they desire to supplement this population in the future.

Finally, we recommend repeating this comprehensive survey every four to five years. Much has changed since the last comprehensive surveys were conducted 30 years ago. Williams and Bond reported that “more than 100 fish can be easily collected from Serrano Pond in a single seine haul” whereas we set four dozen traps overnight on successive days and capture only two fish. They also reported that Alvord chub occurred in Dufurrena Pond 19, Dufurrena Pond 22, and West Spring, where we found none. Had comprehensive surveys been conducted more frequently in the past three decades, perhaps these declines could have been noted and management actions could have been taken to prevent these substantial declines. We also recommend surveying additional spring habitats in the Alvord basin to potentially discover additional, previously undocumented Alvord chub populations. The largest Alvord chub population in Oregon, which is located at Jana’s Pond, was discovered in this way. The close proximity of this site to Borax Lake also raises the question of the relatedness of Alvord chub and Borax Lake chub *Siphateles boraxobius*. Morphological characters suggest these are distinct species. Genetic analyses and more detailed morphometric analyses could offer additional insight.

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LITERATURE CITED

Bond, C. E., 1974. Endangered plants and animals of Oregon I. Fishes. Agricultural experiment station, Oregon State University Special Report #205. 9 p.

Chao, A. 1987. Estimating the population size for capture-recapture data with unequal catchability. Biometrics 43(4):783-791.

Hubbs, C. L., and R. R. Miller. 1948. The Great Basin with emphasis on glacial and postglacial times. Bulletin of the University of Utah, Volume 38, Number 20, 191 p.

Huggins, R. M. 1991. Some practical aspects of a conditional likelihood approach to capture experiments. Biometrics 47:725-732.

Lohr, S., J. M. Hudson, M. Koski, and T. A. Whitesel. 2012. Fish and aquatic habitat surveys at Sheldon-Hart Mountain National Wildlife Refuge Complex. U.S. Fish and Wildlife Service Columbia River Fisheries Program Office, Vancouver, WA. 57 p.

Oregon Department of Fish and Wildlife. 2005. Oregon Conservation Strategy. Oregon Department of Fish and Wildlife, Salem, Oregon. 374+ p.

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.

Scheerer, P. D. and S. E. Jacobs. 2010. 2010 Borax Lake chub investigations. USFWS contract 13420-08-J814 and BLM contract L07PX02726, Annual Progress Report, Corvallis. 12 p.

Snyder, C. T., G. Hardman, and F. F. Zdenek. 1964. Pleistocene lakes in the Great Basin. USF Geological Survey, Miscellaneous Geologic Investigations, Map I=416.

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.

White, G.C. and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46 Supplement: 120-138.

Williams, J. E., and C. E. Bond. 1980. *Gila boraxobius*, a new species of cyprinid fish from southeastern Oregon with a comparison to *G. alvordensis* Hubbs and Miller. Proc. Biol. Soc. Wash. 93(2): 291-298.

Williams, J. E., Williams C. D., and C. E. Bond. 1980. Survey of fishes, amphibians, and reptiles on the Sheldon National Wildlife Refuge, Nevada. Report to U. S. Fish and Wildlife Service, contract 14-16-0001-78025. 53 p.

Williams, J. E., and C. E. Bond. 1983. Status and life history notes on the native fishes of the Alvord basin, Oregon and Nevada. Great Basin Naturalist 43:409-420.

Western Regional Climate Center. 2013. Fields, Oregon monthly climate summary. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?or2876. Accessed 14 November 2013.

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