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Distribution and Abundance of Pit Sculpin in Drews and Camp Creeks, Oregon

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Drews Creek

Pit Sculpin

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Abstract— Pit Sculpin *Cottus pitensis* are endemic to Goose Lake basin, south-central Oregon. The species was listed as sensitive by the U.S. Forest Service Region 6 and Bureau of Land Management and by the State of Oregon. Recent surveys suggested Pit Sculpin have a restricted range in Oregon. The objectives of our surveys were to: 1) describe the current distribution and estimate the abundance of Pit Sculpin in Drews and Camp creeks, 2) describe the fish assemblages in Drews and Camp creeks, and 3) describe stream habitat conditions and collect habitat covariate data at each sampling location for modelling capture probabilities and abundance. We found Pit Sculpin distribution was limited to approximately 5.2 km of Drews Creek and 0.8 km of Camp Creek. Pit Sculpin primarily occupied riffles with gravel substrate. We estimated 12,331 and 1,518 Pit Sculpin in Drews and Camp creeks, respectively.

INTRODUCTION

There are nine fishes native to the Goose Lake Basin: Goose Lake Redband Trout *Oncorhynchus mykiss* ssp. *(*undescribed), Goose Lake Lamprey *Entosphenus* sp. *(*undescribed), Goose Lake Sucker *Catostomus occidentalis lacusanserinus*, Goose Lake Tui Chub *Siphateles bicolor oregonensis*, Modoc Sucker *Catostomus microps*, Pit-Klamath Brook Lamprey *Entosphenus lethophagus*, Speckled Dace *Rhinichthys osculus*, California Roach *Lavinia symmetricus*, and Pit Sculpin *Cottus pitensis*. The Goose Lake Redband Trout, Goose Lake Lamprey, Goose Lake Sucker, and Goose Lake Tui Chub are endemic to the Goose Lake Basin. California Roach, Goose Lake Sucker, Goose Lake Lamprey, and Goose Lake Redband Trout are listed as 'Species of Concern' by the U.S. Fish and Wildlife Service (USFWS); a designation that implies there is concern about the species viability, but that not enough information is available to initiate a listing review for threatened or endangered status.

In response to severe drought and habitat degradation, the Goose Lake Fishes Working Group drafted a conservation plan (Goose Lake Fishes Working Group 1996) for 'pre-listing' recovery of all native fish in the Goose Lake Basin. The Oregon Department of Fish and Wildlife (ODFW) conducted habitat and fish distribution surveys (1991 – 1994) to obtain baseline information for Redband Trout recovery (Dambacher 1995). Prior to 2007, field work to monitor distribution and abundance of Goose Lake fishes was limited and sporadic, targeting only Goose Lake Redband Trout and Modoc Sucker (Dambacher 1995; Stewart Reid, personal communication). In 2007, ODFW conducted a field study to assess the distribution and relative abundance of Goose Lake fishes and found that two species, Pit Sculpin and Modoc Sucker, had very limited distributions in Oregon. Oregon Department of Fish and Wildlife also found that nonnative fishes were common in the downstream, agricultural reaches and had apparently increased in both abundance and distribution when compared to prior surveys (Scheerer et al. 2010).

The objectives of our 2016 surveys were to: 1) describe the current distribution and estimate the abundance of Pit Sculpin in Drews and Camp creeks, 2) describe the fish assemblages in Drews and Camp creeks, and 3) describe stream habitat conditions and collect habitat covariate data for modelling capture probabilities and abundance. We also noted the presence of native Western Pearlshell Mussel *Margaritifera falcata*, Floater Mussel *Anadonta* sp., and Signal Crayfish *Pacifastacus leniusculus* due to interest and concern by local biologists regarding their current distribution. The present study was not intended to infer status of the species (i.e., stable, declining, or increasing abundance trend) because no prior abundance estimates exist for Pit Sculpin in these streams. However we provide rigorous distribution and abundance data for Pit Sculpin that may be used as comparative data for future population status assessments.

METHODS

We sampled 32 sites in Drews and Camp creeks (Figures 1 and 2) over a three-week period from September 19 – 29 and October 10 – 13, 2016. Sites were equally spaced (1.05 km apart) within the sampling frames for each tributary (20.9 km for Drews Creek and 10.5 km for Camp Creek, based on prior surveys). However, we modified the location of sampling sites on Camp Creek after sampling was initiated by: 1) eliminating five upstream-most sites after no Pit Sculpin were detected in the two sites immediately downstream, 2) adding five additional downstream sites (spaced ~0.3 km apart), and 3) adding two sites on East Fork Camp Creek. At each site, we used single-pass backpack electrofishing to sample a stream segment that was about 50 m long and that included both pool and riffle habitat. Site boundaries were occasionally modified to avoid splitting channel units (e.g., so that a site boundary was not located in the middle of a pool). We resampled 8 of the 32 sites the day after the initial sampling occasion and we resampled one site twice; we exerted similar electrofishing effort during each sampling occasion. Resampling occurred at all of the sites where Pit Sculpin were detected during the initial sampling event plus two sites where Pit Sculpin were not detected during the initial sampling event.

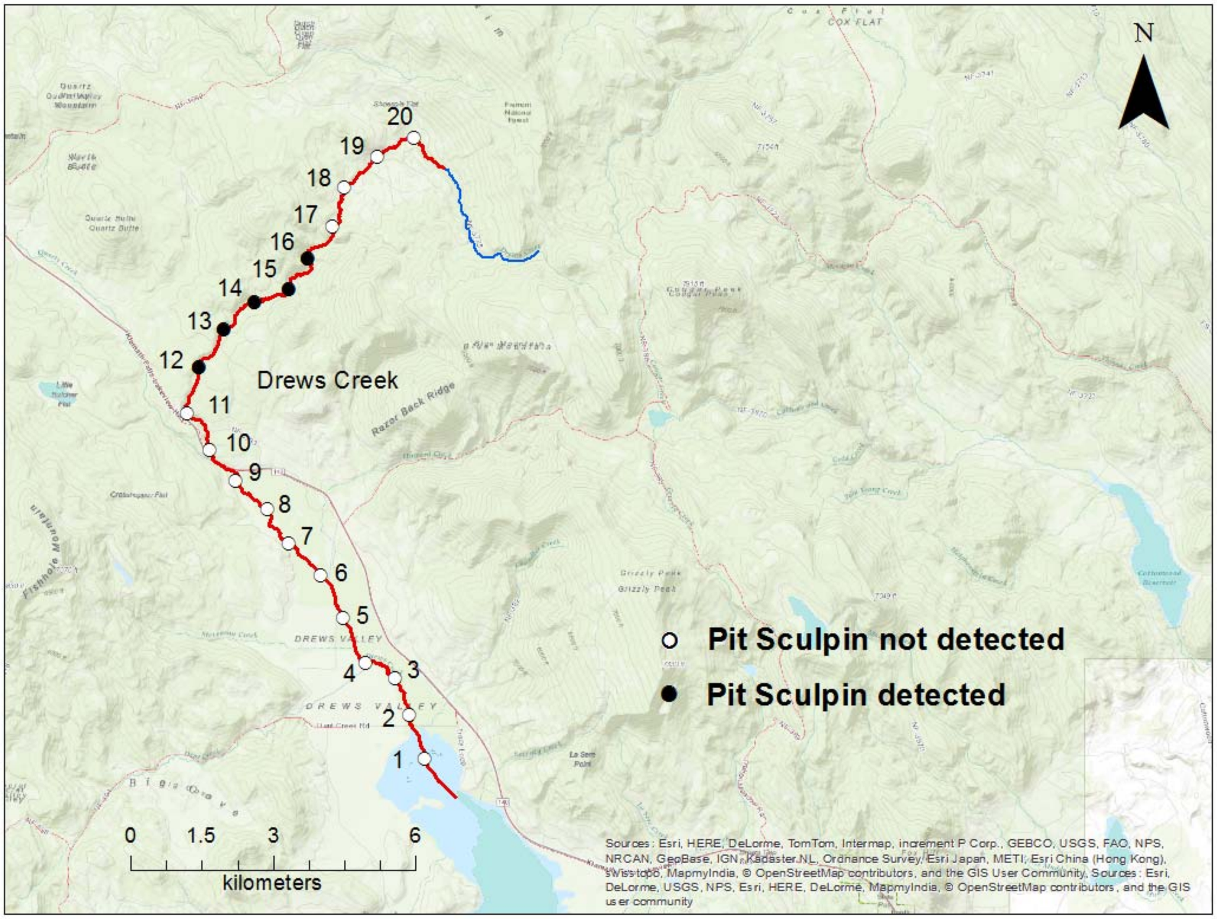

Figure 1. Sampling locations (circles) for Pit Sculpin on Drews Creek. The sites where Pit Sculpin were detected are shown as black circles, sites where they were not detected are shown as white circles, and the sampling frame is highlighted in red. Sampling sites are numbered and refer to those on Drews Creek listed in Tables 1 and 2.

We placed captured Pit Sculpin in an aerated five-gallon bucket filled with stream water until the entire site was sampled. After sampling was completed, we counted and recorded the number of Pit Sculpin in each of three size-groups (<60 mm total length

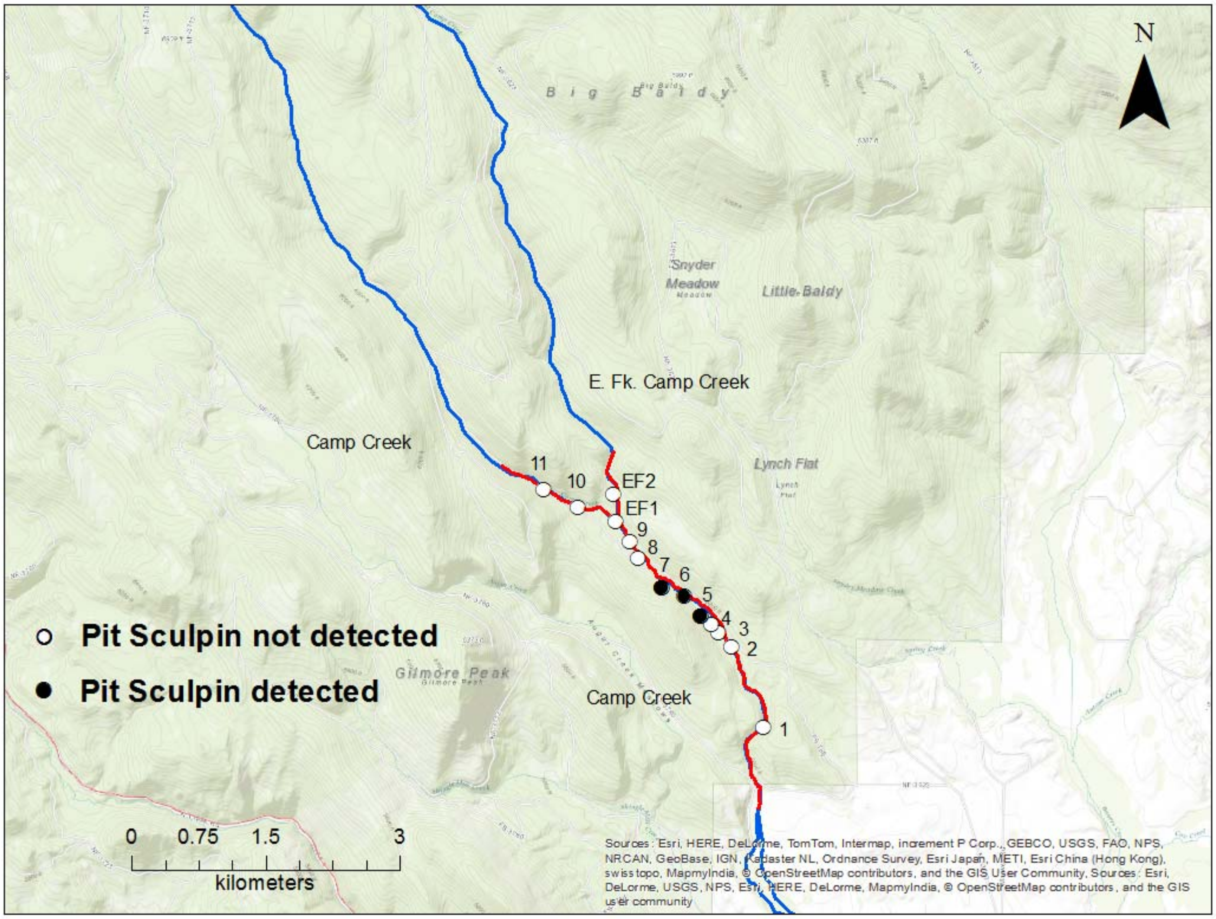

Figure 2. Sampling locations (circles) for Pit Sculpin on Camp Creek. The sites where Pit Sculpin were detected are shown as black circles, sites where they were not detected are shown as white circles, and the final sampling frame is highlighted in red (see Methods for modifications to the original sampling frame). Sampling sites are numbered and refer to those on Camp Creek listed in Tables 1 and 2.

(TL), 60 – 79 mm TL, and ≥80 mm TL), which were based on presumptive age-categories from length-frequency analysis for Pit Sculpin collected during prior sampling (unpublished data). We marked the Pit Sculpin with a partial caudal fin clip during the initial sampling occasion and a partial right pectoral fin clip on the first resampling occasion. On subsequent sampling occasions, we counted and recorded the number of Pit Sculpin in each of the three size-groups by mark type (none, caudal, right pectoral, both). We recorded the presence of all other fish species at each site and the presence of native mussels and crayfish. Additionally, we collected a sample of fin clips from 50 Pit Sculpins from each creek for potential future genetic analysis.

We collected habitat data after electrofishing was completed at each site. We measured the total site length (m) using a graduated tape measure. We recorded the single deepest water depth (maximum depth; m) at each site using a graduated depth staff. We measured wetted channel width (m), water depth (m), and dominant substrate type at three equally spaced transects located 12.5 m, 25.0 m, and 37.5 m from the downstream boundary of the site. We multiplied the average wetted channel width by the site length to calculate the wetted cross-sectional stream area (m^2) for each site. We measured water depth (m) at three equally spaced points across the stream channel at each transect (25, 50, and 75% of the wetted width) using a graduated depth staff. We calculated the average site depth from these nine measurements (three transects; three depth measurements per transect) divided by twelve, to account for zero depth at the stream margins of each transect. We visually estimated the dominant substrate type within a 15 cm diameter circle at seven equally spaced points across each transect. Substrate was classified as fines (<0.063 mm), sand (0.063 – 2 mm), gravel (3 – 64 mm), cobble (65 – 256 mm), boulder (>256 mm), or bedrock. We calculated the proportion of the stream substrate in each substrate category from the 21 dominant substrate estimates. We measured the length of riffle habitat and divided this by total site length to estimate the proportion of each site comprised of riffle habitat. We recorded the water temperature (°C) at the beginning of each sampling occasion using a hand held thermometer, the Universal Transverse Mercator (UTM) coordinates in North American Datum 1927 (NAD27) at the downstream starting point for each site using a handheld Global Positioning System, and took photographs of each sample site. We estimated stream gradient for a 200 m stream segment encompassing each sampling site from an ArcGIS stream elevation coverage.

We estimated population abundance for Pit Sculpin at each location using a Bayesian multinomial N-Mixture model (Royle and Link 2005) that used the Huggins capture-recapture estimator. The model estimates abundance and capture probabilities as a function of covariates. Abundance was estimated assuming a Poisson distribution with natural log link. We evaluated the fit of alternative capture probability models that included combinations of the following covariates: wetted cross-sectional stream area, proportion substrate composition (in each category), maximum depth, stream gradient, water temperature (averaged, if the site was visited on multiple occasions), fish size-group (small, medium, and large), and whether a fish was recaptured. Prior to analyses, we examined Pearson's product-moment correlations for all pairs of predictor variables and excluded variables with r^2 greater than 0.49 to avoid multicollinearity (Moore and McCabe 1993). Additionally, previous studies found that the variables we included in the model were related to capture efficiency and detection of stream fishes (Bayley and Dowling 1993; Bayley and Peterson 2001, Peterson et al. 2004; Peterson and Paukert 2009; Peterson and Shea 2014), including sculpins (Parsley et al. 1989; Keeler et al. 2007; Price and Peterson 2010; Hense et al. 2010.). We evaluated alternative abundance models that included combinations of the following covariates: wetted cross-sectional stream area, proportion substrate composition (in each category), maximum depth, stream gradient, water temperature (averaged, if the site was visited on multiple occasions), fish size-group, site length, average stream width, proportion of the site composed of riffle habitat, and a random effect that corresponded with sample site to account for overdispersion (i.e., variance greater than that assumed by the Poisson distribution). Prior to analyses, we examined Pearson's product-moment correlations for all pairs of predictor variables and excluded variables with r^2 greater than 0.49 to avoid multicollinearity (Moore and McCabe 1993). Additionally, previous studies found that these variables were related to sculpin abundance and distribution (Brusven and Rose 1981; Baltz et al. 1982; Brown et al. 1995; Yamati and Goto 2000; Edwards and Cunjak 2007; Meyer et al. 2008).

The best approximating capture probability model was determined using stepwise inclusion of covariates in a model that contained all of the abundance covariates. The best approximating model was determined using Watanabe Akaike Information Criterion (WAIC, Watanabe 2010); smaller WAIC values indicating better fitting models. Once the best approximating capture probability model was determined, we used that capture probability model to determine the best approximating abundance model. Here, individual covariates were included stepwise in the model and the best approximating model was considered the one with the lowest WAIC value. Precision of parameter estimates and abundance estimates were estimated with 95% credible intervals. All model fitting was conducted with WinBUGS software, version 1.4 (Spiegelhalter et al. 2006) with 250,000 iterations, 50,000 burn in, and diffuse priors.

RESULTS

Pit Sculpin were narrowly distributed in both Drews and Camp creeks (Figures 1 and 2). We collected Pit Sculpin at 5 of the 20 sites on Drews Creek and 3 of the 13 sites on Camp Creek (Table 1). On Drews Creek, Pit Sculpin were concentrated in a low-gradient forested meadow stream section (~5.2 km), located on U.S. Forest Service land. We did not collect Pit Sculpin in the lower, agricultural section of Drews Creek between Drews Reservoir and Highway 395 (sites Drews 1 – 9), or in the higher-gradient forested habitats (Drews 10 – 11 and Drews 18 – 20). On Camp Creek, Pit Sculpin were restricted to a very short (~0.8 km), moderate gradient (2.0 – 2.6%) stream section, located on private timberland. Other taxa collected from the sample sites where Pit Sculpin were detected (*n*=8) included Redband Trout (8 of 8 sites), Pit-Klamath Lamprey (6 of 8 sites), Speckled Dace (1 of 8 sites), and Western Pearlshell Mussel (5 of 8 sites). In the lower, agricultural section of Drews Creek, we also collected native Tui Chub, California Roach, Goose Lake Sucker, and Floater Mussels, and nonnative Brown Bullhead *Ameiurus nebulosus* and Yellow Perch *Perca flavescens*. On Camp Creek, native Signal Crayfish were frequently encountered.

Habitats where we detected Pit Sculpin were dominated by gravel substrates (38 – 86% of total), a moderate to high proportion of riffle habitat (27 – 79%), low to moderate stream gradient (0.3 – 2.6%), and stream temperatures ranging from 7.5 – 12.5°C (Appendix A). The section of stream on Drews Creek where Pit Sculpin were detected had several large beaver dam pools, although none of the sampling sites included a beaver pool.

Table 1. Presence of native fishes, nonnative fishes, native freshwater mussels, and native crayfish at sites sampled in Drews and Camp creeks, 2016. Note, no nonnative mussels or crayfish were observed. Site numbers correspond with those on Figures 1 and 2.

		Native fishes							Nonnative fishes				
Stream	Site	Pit Sculpin	Redband Trout	Speckled Dace	Tui Chub	CA Roach	Goose Lake Sucker	Pit-Klamath Lamprey	Brown Bullhead	Yellow Perch	Western Pearlshell Mussel	Floater Mussel	Signal Crayfish
Drews Creek	1			X	X	X	X		X	X			
	2			X	X	X	X		X	X			
	3			X	X	X	X		X	X			
	4			X	X	X	X		X	X			
	5			X		X	X			X		X	
	6			X	X	X	X						
	7		X	X		X	X	X				X	
	8			X		X					X		
	9		X	X		X		X			X		
	10		X								X		
	11		X										
	12	X	X								X		
	13	X	X								X		
	14	X	X					X			X		
	15	X	X					X			X		
	16	X	X					X			X		
	17		X					X					
	18		X								X		
	19		X					X					
	20		X					X					
Camp Creek	1		X										X
	2		X										X
	3		X										X
	4		X					X					
	5	X	X					X					
	6	X	X					X					
	7	X	X	X				X					
	8		X										X
	9		X	X				X					X
	10		X	X									X
	11		X										X
	EF1		X										X
	EF2		X								X		X

Pit Sculpin were more abundant in Drews Creek (12,331; 95% CI: 10,890-14,010) than in Camp Creek (1,518; 95% CI: 1,292-1,789). Estimates at individual sampling sites varied from 0 – 229 fish (Table 2). The best approximating capture probability model contained the following covariates: whether a fish was recaptured, wetted cross-sectional stream area, proportion gravel substrate, and water temperature

(Table 3). The best approximating abundance model contained the following covariates: proportion gravel substrate, fish size-group, and a site-specific random effect (Table 3).

Table 2. Estimates of Pit Sculpin abundance at sites sampled in Drews and Camp creeks, Goose Lake Basin, 2016.

Stream	Site	Abundance estimate	Lower 95% CI	Upper 95% CI
Drews Creek	1	11	0	66
	2	2	0	5
	3	25	0	397
	4	28	0	59
	5	2	0	6
	6	1	0	3
	7	1	0	5
	8	0	0	2
	9	1	0	7
	10	1	0	4
	11	1	0	3
	12	16	7	29
	13	135	107	171
	14	229	184	284
	15	141	111	177
	16	98	72	130
	17	1	0	4
	18	1	0	4
	19	0	0	4
	20	0	0	3
Camp Creek	1	1	0	5
	2	1	0	5
	3	1	0	4
	4	1	0	4
	5	132	103	169
	6	43	35	55
	7	56	44	74
	8	1	0	4
	9	1	0	4
	10	0	0	3
	11	1	0	4
	EF1	1	0	4
	EF2	0	0	3

Table 3. Model parameters for the best approximating Huggins capture-recapture and multinomial N-mixture models.

Parameter	Estimate	Standard error	Lower 95% CI	Upper 95% CI
Capture probability model (logit scale)				
Intercept	-2.3733	0.7318	-3.8075	-0.9391
Recapture (yes/no)	-0.4704	0.2808	-1.0207	0.0799
Wetted cross-sectional area	-2.7012	1.1870	-5.0277	-0.3746
Proportion gravel substrate	2.6052	1.3426	-0.0264	5.2368
Water temperature	0.0632	0.0341	-0.0037	0.1300
Abundance model (log scale)				
Intercept	-9.496	4.511	-17.760	-1.186
Proportion gravel substrate	13.000	7.176	-1.195	25.400
Large fish size-group	-0.636	0.119	-0.871	-0.408
Sample site random effect	4.407	0.888	2.695	5.898

DISCUSSION

Pit Sculpin are rare in the Oregon portion of the Goose Lake Basin. Historical records in the Oregon State University Ichthyology Collection consist of seven collections from Drews, Thomas, and Cottonwood creeks from 1953 – 1979. A recent comprehensive survey conducted by ODFW in 2007 only detected Pit Sculpin in Camp Creek (a tributary to Thomas Creek) and Drews Creek (Scheerer et al. 2010). Prior to the current study, no estimates of abundance or limits of distribution in these tributaries had been obtained.

In 2016, we described the distribution and estimated the abundance of Pit Sculpin in Camp and Drews creeks. We found that Pit Sculpin were narrowly distributed in both tributaries, but relatively abundant at the sites that they occupied. They occupied stream segments dominated by riffle habitats, typically with gravel substrates. Pit Sculpin occurred sympatrically with only native species, including Redband Trout, Speckled Dace, Pit-Klamath Lamprey, and Western Pearlshell Mussels. Pit Sculpin were not found stream segments dominated by silt or sand substrates or in stream segments with a low proportion of riffle habitats (<0.27) (Appendix A). Our modeling did not show that stream gradient had an effect on either capture probability or abundance of Pit Sculpin; however, Pit Sculpin were generally not observed in high gradient stream segments (i.e., >2.6%).

We detected nonnative Yellow Perch and Brown Bullheads, but no Pit Sculpin, in the lower agricultural reach of Drews Creek, a stream section that has been channelized, was dominated by silt and sand substrate, had little riffle habitat, and was heavily grazed. Pit Sculpin were also not detected in the forested reaches in middle and upper sections of Drews Creek and upper Camp Creek. No Pit Sculpin were detected in the downstream stream section sampled in Camp Creek, an area which had a high proportion of riffle habitats, and similar gradient, substrate composition, temperatures, and native fishes as those stream segments occupied by Pit Sculpin.

In 2017, we propose sampling for Pit Sculpin in Cottonwood Creek, upstream of Cottonwood reservoir. This is a stream segment where Pit Sculpin were collected in the past (Long and Bond 1979), but were not collected during our 2007 study. We may have missed them during our 2007 study due to their apparent highly restricted distribution in the streams that we sampled in 2016. We recommend resurveying Camp and Drews Creeks periodically in the future to assess the status and trends of this rare and unique fish.

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Appendix A. Habitat variables collected at each sample site in Drews and Camp creeks, autumn 2006.

	Site	Pit Sculpin detected	Length (m)	Average width (m)	Average depth (m)	Maximum depth (m)	Substrate (proportion by type)						Proportion riffle habitat	Water temperature (°C)	Stream gradient (%)	UTM coordinates		
							Silt	Sand	Gravel	Cobble	Boulders	Bedrock				Zone	Easting	Northing
Drews Creek	1	No	50.0	4.53	0.35	0.70	1.00	0.00	0.00	0.00	0.00	0.00	0.00	17.0	0.0	10T	689783	4676513
	2	No	50.0	4.28	0.26	0.65	0.43	0.57	0.00	0.00	0.00	0.00	0.00	14.0	0.1	10T	689423	4677419
	3	No	50.0	4.20	0.49	0.80	1.00	0.00	0.00	0.00	0.00	0.00	0.00	16.0	0.1	10T	689101	4678197
	4	No	50.0	4.83	0.45	0.93	0.43	0.43	0.14	0.00	0.00	0.00	0.00	17.0	0.1	10T	688464	4678485
	5	No	50.0	4.17	0.17	0.35	0.76	0.10	0.05	0.10	0.00	0.00	0.00	10.5	0.2	10T	687976	4679432
	6	No	50.0	3.13	0.13	0.28	0.24	0.29	0.00	0.33	0.00	0.10	0.00	14.5	0.3	10T	687465	4680307
	7	No	50.0	1.75	0.31	0.92	0.19	0.48	0.33	0.00	0.00	0.00	0.31	11.0	0.5	10T	686775	4680956
	8	No	50.0	2.10	0.09	0.20	0.48	0.00	0.52	0.00	0.00	0.00	0.05	18.0	0.4	10T	686297	4681669
	9	No	50.0	2.33	0.29	0.52	0.10	0.19	0.24	0.29	0.14	0.05	0.17	6.5	1.4	10T	685621	4682249
	10	No	53.9	1.87	0.16	0.50	0.00	0.00	0.67	0.33	0.00	0.00	0.48	7.0	4.8	10T	685051	4682874
	11	No	54.0	3.02	0.11	0.37	0.00	0.00	0.29	0.57	0.05	0.10	0.78	9.0	4.2	10T	684555	4683627
	12	Yes	53.0	3.33	0.25	0.60	0.00	0.05	0.76	0.10	0.10	0.00	0.34	10.0	1.5	10T	684768	4684621
	13	Yes	50.0	3.13	0.22	0.41	0.14	0.00	0.86	0.00	0.00	0.00	0.27	12.5	1.1	10T	685276	4685420
	14	Yes	51.4	2.45	0.17	0.55	0.19	0.00	0.62	0.19	0.00	0.00	0.48	8.0	0.3	10T	685911	4686017
	15	Yes	50.0	1.98	0.25	0.38	0.05	0.05	0.76	0.14	0.00	0.00	0.52	8.0	1.4	10T	686612	4686306
	16	Yes	50.0	2.58	0.12	0.42	0.05	0.05	0.38	0.33	0.19	0.00	0.64	8.0	1.9	10T	686993	4686973
	17	No	50.0	1.78	0.20	0.42	0.05	0.10	0.71	0.14	0.00	0.00	0.60	7.5	5.6	10T	687496	4687659
	18	No	50.0	2.67	0.14	0.36	0.05	0.00	0.48	0.43	0.05	0.00	0.71	11.0	1.6	10T	687736	4688494
	19	No	50.0	2.70	0.14	0.51	0.05	0.33	0.43	0.19	0.00	0.00	0.51	12.0	2.5	10T	688392	4689147
	20	No	50.0	1.98	0.17	0.55	0.10	0.10	0.67	0.14	0.00	0.00	0.51	11.5	2.5	10T	689157	4689571
Camp Creek	1	No	50.0	2.58	0.17	0.40	0.00	0.00	0.76	0.24	0.00	0.00	0.84	6.5	1.3	10T	710419	4686389
	2	No	50.0	3.27	0.18	0.42	0.05	0.14	0.19	0.43	0.19	0.00	0.66	6.5	2.0	10T	710031	4687274
	3	No	50.0	2.00	0.16	0.45	0.05	0.10	0.38	0.48	0.00	0.00	0.59	4.0	1.1	10T	709893	4687428
	4	No	50.0	1.40	0.24	0.51	0.00	0.00	0.33	0.00	0.00	0.67	0.54	5.0	1.0	10T	709809	4687520
	5	Yes	50.0	2.57	0.15	0.35	0.00	0.00	0.57	0.19	0.24	0.00	0.79	8.0	2.6	10T	709688	4687607
	6	Yes	50.0	2.37	0.11	0.25	0.00	0.00	0.62	0.38	0.00	0.00	0.77	10.0	2.3	10T	709352	4687958
	7	Yes	50.0	1.93	0.12	0.50	0.24	0.05	0.67	0.05	0.00	0.00	0.72	6.0	2.0	10T	709232	4687922
	8	No	50.0	2.22	0.15	0.30	0.00	0.00	0.24	0.67	0.10	0.00	0.87	9.0	3.3	10T	708967	4688234
	9	No	50.0	1.67	0.19	0.45	0.38	0.05	0.57	0.00	0.00	0.00	0.63	7.5	2.3	10T	708809	7688440
	10	No	50.0	1.60	0.11	0.25	0.00	0.00	0.57	0.43	0.00	0.00	0.98	10.0	8.7	10T	708700	4688637
	11	No	50.0	2.02	0.14	0.44	0.00	0.00	0.48	0.48	0.05	0.00	0.76	6.5	7.9	10T	707882	4688972
	EF1	No	50.0	2.02	0.10	0.40	0.00	0.05	0.43	0.52	0.00	0.00	0.61	4.5	4.1	10T	708863	4688423
	EF2	No	50.0	1.15	0.10	0.35	0.00	0.00	0.62	0.38	0.00	0.00	0.80	5.5	5.3	10T	708669	4688946

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