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Photograph of a pool in the spring brook at Foskett Spring.

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INTRODUCTION

Speckled Dace (*Rhinichthys osculus*) are geographically widespread throughout the western United States and occur in many isolated subbasins and interior drainages in south-central Oregon. The Foskett Speckled Dace (*R. osculus* ssp.) is an evolutionary significant unit of Speckled Dace that is represented by a naturally-occurring population that inhabits Foskett Spring and an introduced population that inhabits Dace Spring, both are located on the west side of Coleman Lake in Lake County, Oregon (Figure 1). The Foskett Speckled Dace became isolated in Foskett Spring at the end of the Pluvial Period (9,000-10,000 years ago). Foskett Speckled Dace was listed as threatened under the federal Endangered Species Act in 1985 (U.S. Fish and Wildlife Service 1985). Foskett Spring is a natural spring that rises from a springhead pool, flows through a narrow spring brook into a series of shallow marshes, and then disappears into the soil of the normally dry Coleman Lake (Figure 1). Dace Spring consists of two pools excavated in a shallow spring brook.

The primary recovery objective for this species is long-term persistence through preservation of its native ecosystem (U.S. Fish and Wildlife Service 1997). The recovery plan further states that the conservation and long term sustainability of this species will be met when: 1) long-term protection of its habitat, including spring source aquifers, spring pools and outflow channels, and surrounding lands is assured; 2) long-term habitat management guidelines are developed and implemented to ensure the continued persistence of important habitat features and guidelines will include monitoring of current habitat and investigation for and evaluation of new spring habitats; and 3) research into life-history, genetics, population trends, habitat use and preference, and other important parameters is conducted to assist in further developing or refining criteria 1) and 2), above. Actions needed to meet these criteria include protecting the fish population and its habitat, conserving genetic diversity of the fish population, ensuring adequate water supplies are available, monitoring of the dace population and habitat conditions, and evaluating long-term effects of climatic trends on the health of this fish population.

Substantial progress has been made towards the conservation and long term sustainability of this species. In 1987, the Bureau of Land Management (BLM) acquired the 65 hectare parcel of land containing Foskett and Dace Springs and fenced 28 hectares to exclude cattle from the springs. Currently, the BLM manages the lands surrounding the springs consistent with the Lakeview Resource Management Plan (Bureau of Land Management 2003), which identifies Foskett Speckled Dace as a Special Status Species to be managed in accordance with the Recovery Plan.

In 2012, BLM conducted a controlled burn in the tule and cattail marshes to reduce the vegetative biomass and in 2013-2014, they hand excavated 11 pools, substantially increasing the amount of open water habitat suitable for Foskett Speckled Dace (Scheerer et al. 2013; 2014).

In 2009, the BLM and the U.S. Fish and Wildlife Service (USFWS) completed a habitat enhancement project creating two spring-fed pools at Dace Spring. The population in Dace Spring was initially established from an introduction of 100 fish from Foskett Spring in 1979-1980 (Williams et al. 1990); however this population failed due to habitat loss (vegetative succession) and lack of successful recruitment. In 2010-2011, Oregon Department of Fish and Wildlife (ODFW) introduced 124 dace from Foskett Springs into these ponds; however survival of these fish was low, due to frequent

prolonged algal blooms and resultant anoxic conditions (Scheerer et al. 2012; 2013). In September 2013, BLM excavated flow-through channels to improve water circulation in the Dace Spring ponds and saw immediate improvement in water clarity (algal bloom subsided) and water quality (dissolved oxygen increased from 0.1 ppm to over 4.0 ppm) (Scheerer et al. 2013). In October 2013, ODFW transferred an additional 200 Speckled Dace from Foskett Spring into the Dace Spring ponds (100 fish ea.).

ODFW monitored the dace population and habitat at Foskett Spring in 1997, 2005, 2007, 2009, and in both springs from 2011-2015 and described a declining trend in open water habitat and dace abundance at Foskett Spring from 1997 through 2012 (Dambacher et al. 1997; Scheerer and Jacobs 2005; 2007; 2009; Scheerer 2011; Scheerer et al. 2012; 2013; 2014). Following BLM's recent habitat restoration activities, the dace population responded, increasing in abundance from approximately 1,800 individuals in 2011 to more than 24,000 individuals in 2014 (Scheerer et al. 2014). Also during these surveys, ODFW gained knowledge of several key demographic parameters. We documented annual recruitment (presence of young-of-the-year dace) and a broad size (presumptive age) structure. In 2013, we noted that dace spawning occurs, as evidenced by presence of larval dace, beginning in early spring (March-April) and extending into July and that young-of-the-year dace were more common in the shallow marsh habitats (unpublished data). At Dace Springs, we documented individuals/recruits that grew to adult size and matured in a single year and gained insight into species longevity by noting individuals from 2010-2011 translocations that were present and alive in 2014 (4-5 years old).

In addition, two genetics studies were recently completed. Ardren et al.'s (2010) genetic analysis called into question the taxonomic status of the subspecies. Speckled Dace from the Warner Basin, including those from Foskett Spring, were found to be closely related, but showed signs of recent isolation from each other. Levels of genetic divergence observed between dace from Foskett Spring, compared to other dace from the Warner Basin, were in the range typically observed between populations belonging to the same species. This study was followed up by a more extensive geographic, taxonomic, and phylogenetic analysis of Speckled Dace from Foskett Spring and adjacent basins (Hoekzema and Sidlauskas 2012). Their findings confirmed the conclusion of Ardren et al. (2010) that Foskett Spring dace were isolated relatively recently (10,000 years vs. millions of years) and suggest that Foskett Spring dace do not constitute a distinct subspecies under a phylogenetic species concept. Using microsatellites, which evolve more quickly than mitochondrial genes, they found evidence for no recent gene flow, that Foskett Spring is a genetically distinct population, and suggest, with support from their morphological analysis, that Foskett Spring dace constitute a distinct ESU under the Endangered Species Act (ESA) (Hoekzema and Sidlauskis 2014).

In 2015, the BLM, ODFW, and the USFWS completed a Cooperative Management Plan for Foskett Speckled Dace to ensure the continued persistence of important habitat features in these spring areas including actions to: 1) protect and manage these habitats, 2) enhance the habitat, when appropriate, 3) monitor the dace populations and habitats, 4) develop a regular maintenance schedule to increase and maintain suitable open-water habitat and 5) develop an emergency contingency plan to address potential threats from pollutants or the introduction of nonnative species (USFWS 2015a).

The status of ESA listed species is reviewed every 5 years. This process reviews available data gathered and activities undertaken since the time of listing to determine if recovery actions have progressed, and reviews any new information regarding the status of the threats to the species and Recovery Plan criteria to make recommendations regarding potential changes to the species' listing status. The Foskett Speckled Dace 5-Year Review was initiated in 2014 and completed in 2015, with a recommendation to delist the species (USFWS 2015b).

This report updates monitoring initiated by ODFW in 2005 (Scheerer and Jacobs 2005; 2007; 2009; Scheerer 2011; Scheerer et al. 2012; 2013) by providing results of monitoring conducted in 2015. Our objectives were to: 1) estimate the abundance of the federally listed Foskett Speckled Dace, and 2) document the habitat conditions at Foskett and Dace Springs to assess the effectiveness of the restoration efforts.

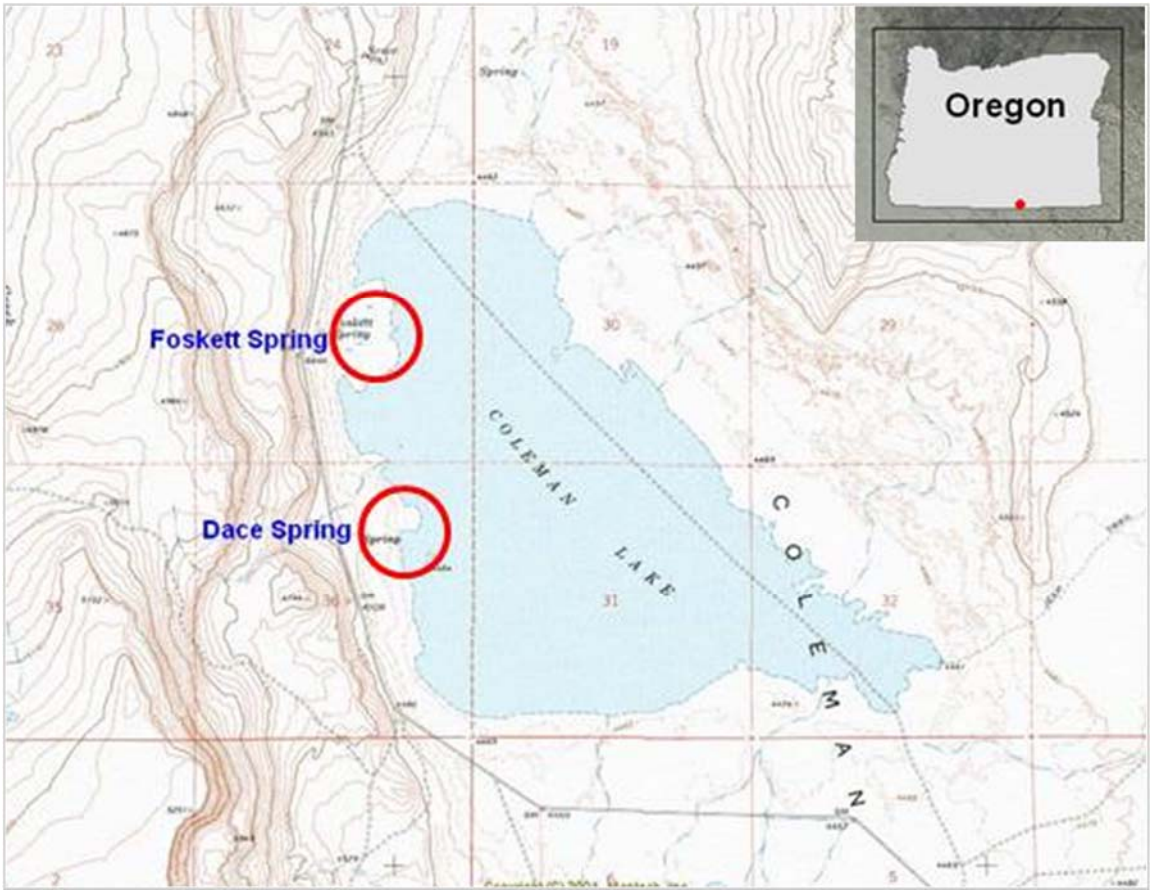

Figure 1. Map showing the locations of Foskett and Dace Springs in the Warner Valley of southeastern Oregon.

METHODS

We used baited minnow traps (1/16" mesh) to obtain mark-recapture population estimates of Foskett Speckled Dace at Foskett and Dace Springs from 22-23 June 2015. We distributed the traps haphazardly throughout the spring pool (n=6), spring brook (n=11), tule marsh (n=11), and cattail marsh (n=4) at Foskett Spring and in the two pools (9 traps ea.) and spring brook (3 traps) at Dace Spring and left them in place for 3-4 h. We placed the traps in the same density and approximate locations as we did for our 2012-2014 estimates.

We counted and recorded the number of fish in each of three size categories (small <35 mm TL, medium 35-59 mm TL, and large ≥60 mm TL). After we measured the fish, we returned them to the water near the location of capture. The following morning (day 2), we set the traps at approximately the same locations, left them in place for 3-4 h to capture fish, recovered the traps, recorded the number of marked and unmarked fish in each size category, and released them near the location of capture.

We estimated the abundance of dace using a state space model (Bolker 2008), which allows us to vary capture probabilities for different sized fish and habitats. Here the capture of fish was assumed to follow a binomial distribution:

$$c_{i,j,k} \sim bin(\hat{p}_{i,j,k}, \widehat{N}_{i,j}),$$

where *c* is the number of fish captured, *p* is the estimated capture probability, and N is the estimated abundance for size class *i* in habitat *j* on sampling occasion *k*. Capture probabilities were estimated using the best approximating Huggins capture-recapture models from Scheerer et al. (2012; 2013; 2014), which allowed us to reduce fish handling in 2015, compared to 2012-2014 (two sampling occasions rather than three or four sampling occasions), and required no additional marking of the fish. Variability in the estimated capture probabilities was incorporated using a beta distribution with parameters that corresponded to the mean estimated capture probability and associated standard errors. The state space model was fit using Markov Chain Monte Carlo (MCMC) as implemented in WinBUGS software, version 1.4 (Lunn et al., 2000) with 10,000 iterations, 20,000 burn in and diffuse priors. These values were determined by fitting the model with 10,000 iterations and evaluating the output with the Raftery and Lewis (1995) diagnostic as implemented in the R package Coda (Plummer et al. 2006). We estimated abundance separately for the Foskett spring pool, spring brook, tule marsh, cattail marsh and for the Dace Spring ponds. We calculated 95 percent confidence intervals for the estimates according to Chao (1987).

We assessed the effects of BLM's habitat restoration at Foskett spring by mapping the aquatic vegetation in 2015 and comparing these results to similar mapping done in 2012-2014.

RESULTS

We estimated the 2015 Foskett Speckled Dace abundance at 16,340 fish (95% CI: 10,980-21,577) fish, which was less than but not significantly different from the 2014 estimate of 24,888 fish (95% CI: 19,250-31,510), similar to the 2013 estimate of 13,142

fish (10,665-16,616), and significantly larger than the 2012 estimate of 1,848 fish (1,489-2,503) (Figure 1). We noted significant declines in dace abundance in the spring pool, tule marsh, and cattail marsh in 2015 (Table 1). This was likely the result of the loss of 11 and 38 % of open water habitat (vegetative succession to emergent wetland) in the spring brook and marsh habitats, respectively (**APPENDIX A**).

In Dace Spring, we estimated the dace abundance at 876 fish (95% CI: 692-1637), which was larger but not significantly different from the 2014 estimate of 552 fish (95% CI: 527-694). We also noted substantial recruitment at Dace Spring in 2015, as evidenced by large numbers of young-of-the-year dace observed, but not captured in minnow traps.

Table 1. Estimates of Foskett Speckled Dace abundance by habitat type, obtained using the Lincoln-Petersen model (1997-2012), the Huggins closed-capture model (2011-2014), and a state-space model (2015). Abundance estimates were not calculated by habitat type using the Huggins model in 2011, because length-frequency data was not available for each habitat location.

	Lincoln-Petersen model				Huggins model				State-space model
Location	1997	2005	2007	2009	2011	2012	2013	2014	2015
Spring pool	204	1,627	1,418	247	-	633	2,579	2,843	698
	(90 - 317)	(1,157 - 2,281)	(1,003 - 1,997)	(122 - 463)	-	(509-912)	(1,985-3,340)	(2,010-3,243)	(520-954)
Spring brook	702	755	719	1,111	-	589	638	7,514	11,941
	(321 - 1,082	(514 - 1,102)	(486 - 1,057)	(774 - 1,587)	-	(498-1024)	(566-747)	(2,422-13,892)	(5,465-15,632)
Tule marsh	not sampled	425	273	1,062	-	625	6,891	11,594	3,662
		(283- 636)	(146 - 488)	(649 - 1,707)	-	(442-933)	(5,845-8,302)	(7,891-12,682)	(2,158-6,565)
Cattail marsh	26,881	353	422	158	0	0	3,033	2,935	38
	(13,158 - 40,605)	(156-695)	(275 - 641)	(57 - 310)			(2,500-3,777)	(1,175-7,002)	(8-111)
Entire site	27,787	3,147	2,984	2,830	1,728	1,848	13,142	24,888	16,340
	(14,057 - 41,516)	(2,535 - 3,905)	(2,403 - 3,702)	(2,202-3,633)	(1.269-2,475)	(1,489-2,503)	(10,665-16,616)	(19,250-31,510)	(10,980-21,577)

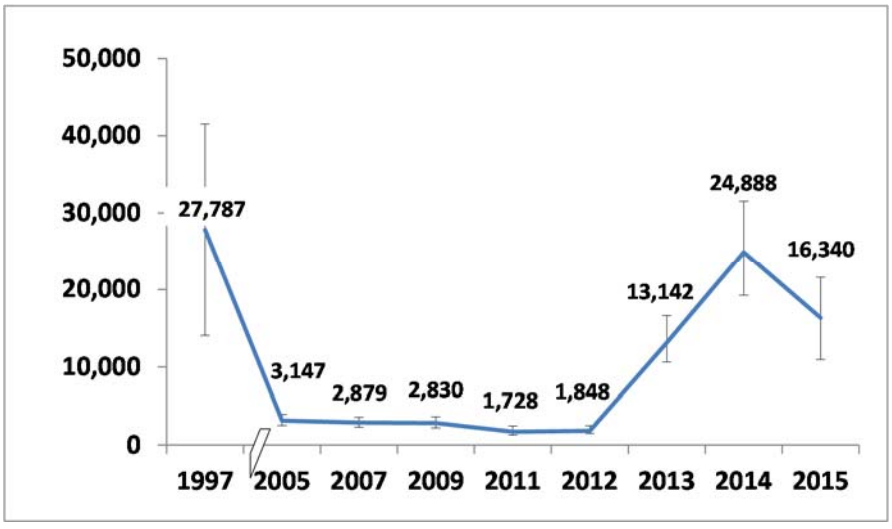

Figure 2. Population estimates for Foskett Speckled Dace, 1997-2015. Vertical bars represent 95% confidence limits for each estimate.

DISCUSSION

The ODFW's Native Fish Investigations Program has been monitoring the status of the federally listed Foskett Speckled Dace and its habitat since 2005. We found the abundance of Foskett Speckled Dace declined substantially from 1997 through 2012 (Dambacher et al. 1997; Scheerer and Jacobs 2005, 2007, 2009; Scheerer et al. 2011, 2012). Encroachment by aquatic macrophytes since the habitat was fenced by BLM in 1987 substantially reduced the open-water habitat, with a subsequent decline in the dace population. This is not uncommon in desert spring ecosystems, when springs are fenced and livestock removed, these ecosystems often experience increases in aquatic vegetation, reduction of open-water habitat, and reduction of fish populations (Kodric-Brown and Brown 2007).

When the USFWS completed the initial Foskett Speckled Dace Five-Year Review in 2009 (U.S. Fish and Wildlife Service 2009), they specifically recommended: 1) assessing encroachment by aquatic vegetation at Foskett Spring, 2) developing a restoration plan and regular maintenance schedule to increase and maintain suitable open-water habitat, 3) assessing the restoration potential at Dace Spring, and 4) evaluating the feasibility of a Foskett Speckled Dace transplant effort (U.S. Fish and Wildlife Service 2009).

To address the encroachment by aquatic vegetation at Foskett Spring, the BLM implemented a controlled burn in 2013 in the tule and cattail marshes at Foskett Spring to reduce the biomass of aquatic vegetation. Controlled burns can be an effective management tool to reduce vegetative biomass, restore open water, and increase plant diversity in desert spring habitats (Kodric-Brown et al. 2007). In 2013 and 2014, the BLM hand excavated 11 pools and increased the open water habitat by 164 m^2 (>150%) (Scheerer et al. 2014). The response of Speckled Dace to this habitat restoration was remarkable. In 2014, we estimated there were nearly 25,000 dace at Foskett Spring, with the majority of these (>19,000) in the restored tule and cattail marshes. We also found the marsh habitats were dominated by native aquatic plants, as they were prior to the burn. However, it should be noted that we observed a reduction of open water habitat in the tule and cattail marshes in 2015. This illustrates the need for frequent maintenance to maintain open water habitat at Foskett Spring. In the winter of 2015, BLM proposes to enhance the open water pools by excavating them to a greater depth (>1 m) using an excavator and lining a portion of them with pond liners and/or stock tanks.

To address the need for a restoration plan and maintenance schedule, the cooperators completed a Cooperative Management Plan for Foskett Speckled Dace in 2015 (USFWS 2015b). This plan proposes the following actions to increase and maintain suitable open-water habitat: 1) protect and manage the habitat, 2) enhance the habitat when needed, 3) monitor the fish population and habitat, and 4) implement the emergency contingency plan as needed to address potential threats from introduction of non-native species, pollutants, or other unforeseen threats.

To address the restoration potential at Dace Spring and feasibility of a dace transplant effort, the BLM and USFWS created two spring-fed pools at Dace Spring in 2009. In 2010-2011, ODFW introduced 124 dace from Foskett Springs into these ponds. In 2011-2013, we documented evidence of recent recruitment at Dace Springs,

but also documented substantial algal blooms, periods of low dissolved oxygen, trapping related mortalities, and low survival. In 2013, BLM modified the fresh water delivery from the spring source so that it passes through the ponds; previously, only a single channel existed. We noted an immediate response with improved water clarity and quality in the ponds. In October 2013, we introduced 200 dace from Foskett Spring into the ponds (100 ea.). In 2014 and 2015, we documented successful recruitment and an associated increase in abundance (2015 estimate = 876 fish) at Dace Spring. We plan to transfer 10% of the Foskett Springs population of Speckled Dace into Dace Springs per year until a total of 500 have been transferred, to minimize impacts to the donor population and potential genetic consequences resulting from drift or founders effect in the recipient population. To date, 324 dace have been translocated from Foskett to Dace Spring.

In 2015, the USFWS completed a 5-Year Review of Foskett Speckled Dace, determined that all recovery criteria had been met, and recommended delisting the species (USFWS 2015a).

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APPENDIX A. Habitat dimensions, by location, at Foskett Spring in 2014. Also included are measurements from 2012 (pre-restoration) and the changes in open water habitat from 2013 to 2015. We defined open water habitat as habitat which is suitable for Speckled Dace. Wetted water habitat includes both the open water habitat and emergent wetland habitat, which is typically unsuitable for Foskett Speckled Dace.

Habitat type	Length (m)	Wetted width (m)	Open water width (m)	Average depth (m)	Wetted area (m^2)	2015 open water area (m^2)	2014 open water area (m2)	2013 open water area (m2)	2012 open water area (m^2)	Change in open water area from 2014 to 2015
Spring pool	4.7	12.2	4.0	0.08	57	19	21	4	4	-11%
Spring brook	71.0	2.8	1.0	0.19	200	71	68	31	25	4%
Tule marsh	98.3	20.6	0.6	0.15	2022	55	88	86	43	-38%
Cattail marsh	96.0	21.0	0.8	0.17	2013	74	93	181	35	-20%
total	270.0				4292	219	271	301	107	-19%

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