ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: **2013 Borax Lake Chub Investigations**

PROJECT NUMBERS: Bureau of Land Management Cooperative Agreement L10AC20301

PROJECT PERIOD: 28 July 2010 – 25 July 2015

Paul D. Scheerer
Brian L. Bangs
Shaun Clements

Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, Oregon 97333

This project was financed with funds administered by the U.S. Fish and Wildlife Service and the U.S. Bureau of Land Management.

CONTENTS

Page

INTRODUCTION....................1

METHODS....................2

RESULTS....................3

Water Temperatures....................3

Shoreline Pedestrian Surveys....................6

Seasonal Water Level Fluctuations....................6

Fish Sampling....................9

DISCUSSION....................9

ACKNOWLEDGEMENTS....................11

REFERENCES....................11

INTRODUCTION

The Borax Lake chub (*Gila boraxobius*) is a small minnow endemic to Borax Lake and adjacent wetlands in the Alvord Basin in Harney County, Oregon (Williams and Bond 1980). Borax Lake is a natural, 4.1 hectare, geothermally-heated alkaline lake which is perched 10 meters above the desert floor on borosilicate deposits. The Borax Lake chub was listed as endangered under the federal Endangered Species Act in 1982 (U.S. Fish and Wildlife Service 1982). At the time of the listing, Borax Lake was threatened by habitat alteration from proposed geothermal energy development and alteration of the lake shore crust to provide irrigation to surrounding pasture lands. The Borax Lake chub federal recovery plan, completed in 1987, advocated protection of the lake ecosystem through the acquisition of key private lands, protection of groundwater and surface waters, controls on access, and the removal of livestock grazing (U.S. Fish and Wildlife Service 1987).

The basis for the Borax Lake chub's listed status was not population size, but the vulnerability of a very limited, unique, and isolated, habitat (U.S. Fish and Wildlife Service 1982). Population abundance estimates obtained since 1991 have fluctuated from approximately 4,100 to 37,000 fish (Salzer 1997; Scheerer and Bangs 2011; Scheerer et al. 2012). In 2013, a decision was made by the U.S. Fish and Wildlife Service and the Desert Nongame Fishes Working Group to monitor population abundance less frequently (every two to three years) rather than annually. 2013 marks the first year since 2005 that population estimates were not obtained.

Recovery measures implemented since listing have improved the conservation status of Borax Lake chub, primarily by protecting the habitat (Williams and Macdonald 2003). When the species was listed, critical habitat was designated on 259 hectares of land surrounding the lake, including 129 hectares of public lands and two 65-hectare parcels of private land. In 1983, the U.S. Bureau of Land Management (BLM) designated the public land as an Area of Critical Environmental Concern. The Nature Conservancy (TNC) began leasing the private lands in 1983 and purchased them in 1993, bringing the entire critical habitat into public or conservation ownership. TNC ended water diversion from the lake for irrigation and livestock grazing within the critical habitat. Passage of the Steens Mountain Cooperative Management and Protection Act of 2000 removed the public BLM lands from mineral and geothermal development within a large portion of the basin. In addition, detailed studies of the chub and their habitat have added substantially to our knowledge of basic Borax chub biology and the Borax Lake ecosystem (Scoppettone et al. 1995, Salzer 1992, Perkins et al. 1996).

In a 2003 conservation review, Williams and Macdonald (2003) listed three primary threats, which remain, for Borax Lake chub: 1) the threat to the fragile lake shoreline, wetlands, and soils from a recent increase in recreational use around the lake (particularly off-road vehicle usage), 2) the threat of introduction of nonnative species, and 3) potential negative impacts to the aquifer from geothermal groundwater withdrawal if groundwater pumping were to occur on private lands outside the protected areas. Because Borax Lake is shallow (average depth $\underset{\sim}{}$1 m) and situated above salt deposits on the desert floor, alteration of the salt crust shoreline could reduce lake levels and have a dramatic effect on the quantity and quality of habitat available to Borax Lake chub. The third threat resurfaced in 2009, when Pueblo Valley Geothermal proposed a geothermal energy project on 2,000 acres of private property within 5 km of Borax Lake.

The second threat surfaced in 2013, when we observed a large fish with paired dorsal fins (presumably a largemouth bass) in Borax Lake during our shoreline surveys.

In 2012, the U.S. Fish and Wildlife Service completed a draft, multi-agency "Borax Lake Chub (*Gila boraxobius*) Cooperative Management Plan" to manage and protect the Borax Lake area for the conservation and recovery of the Borax Lake chub. The Cooperative Management Plan (CMP) was developed to establish a strategy and framework to identify responsibilities for collaboration to complete conservation related tasks to delist the species. Under the CMP, the cooperators (Bureau of Land Management, The Nature Conservancy, U.S. Fish and Wildlife Service, and Oregon Department of Fish and Wildlife) will work together to achieve the delisting criteria, stated in the recovery plan (U.S. Fish and Wildlife Service 1987) as follows: "The Borax Lake chub will be recovered when complete control exists over management of surface and subsurface waters by The Nature Conservancy or a public resource agency within the 640 acres of critical habitat; and when a self-sustaining population of Borax Lake chubs has been maintained free of threats for five consecutive years". To reach recovery, Borax Lake 1) must be protected from disturbance, 2) historic wetlands must be restored, 3) disturbance to the fragile salt-crust shoreline must be prevented, 4) the geothermal aquifer must be maintained in its natural condition, and 5) Borax Lake chub must exist throughout its native ecosystem without threats (U.S. Fish and Wildlife Service 1987). In 2012, the U.S. Fish and Wildlife Service also completed a Five-Year Review of Borax Lake chub and recommended downlisting of the species from endangered to threatened status (U.S. Fish and Wildlife Service 2012).

This report describes results from monitoring conducted by Oregon Department of Fish and Wildlife's Native Fish Investigations Program (NFIP) in 2013. In 2013, our objectives were to evaluate habitat conditions at Borax Lake, including a description of annual fluctuations in water levels and the condition of the fragile lake shoreline and outflows. During these surveys, we noted a large, nonnative fish in the lake and conducted limited sampling to confirm the continued existence and relative abundance of Borax Lake chub and to attempt to capture the nonnative fish or fishes.

METHODS

We monitored water temperatures (ºC) at five locations with Hobo® recording thermographs deployed from 28 September 2012 to 2 October 2013. The thermographs recorded temperature at 1 h intervals.

We assessed the condition of the lake's shoreline, the wetland, and the outflow channels from pedestrian surveys and photo points that we established in 2005 (Scheerer and Jacobs 2005). We downloaded data (water elevations and temperatures) from the piezometers we installed in 2011 (Scheerer and Bangs 2011), to describe the changes in wetted area and water volume that occur due to seasonal fluctuations in water elevation. We used ArcGIS® (version 9.3.1) to generate a Triangulated Irregular Network file from the previously surveyed geographic coordinates and measured depths. We used this file to generate bathymetric contour maps using ArcGIS®.

While conducting habitat assessments, we observed a large non-native fish (likely bass) in the lake. To determine whether there was an immediate risk to the chub population, we assessed their relative abundance using baited minnow traps (N=6, 1/16" mesh). We distributed the traps approximately every 25 m along the northern shore of the lake (Figure 1) and left them in place overnight (~16 h). We conducted the trapping on the night of 2 October 2013. We set three experimental gill nets (30.5 m long) of varying mesh size (12–48 mm), overnight on 2 October and 7-8 October 2013, in an attempt to capture the large, unknown fish we observed during our shoreline surveys.

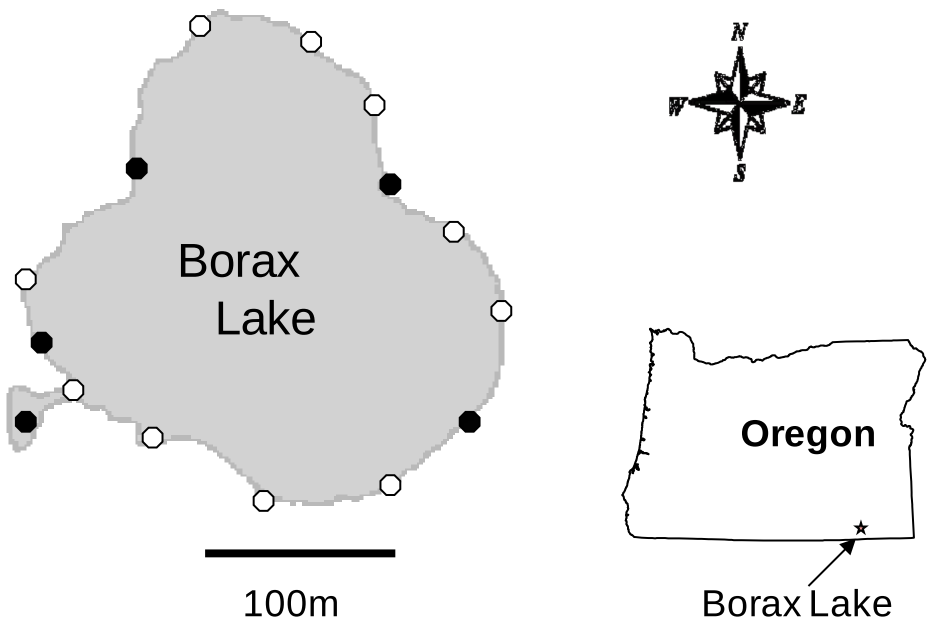

Figure 1. Map of Borax Lake showing the locations of shoreline photo points (all circles) and thermographs (black circles).

RESULTS

Water Temperatures

The pattern of seasonal fluctuations in Borax Lake water temperature was similar at all monitoring sites from September 2012 to September 2013 and similar to results from previous sampling (Scheerer and Jacobs 2009, 2010; Scheerer and Bangs 2011; Scheerer et al. 2012). Daily temperature fluctuations were typically less than 5°C. Peak water temperatures (27.2-39.4°C) were observed in July and August (Figure 2). Average water temperatures in the main portion of the lake ranged from 25.9–27.2°C, whereas the average water temperature (15.9°C) and range of temperatures (3.9–27.2 °C) in the wetland were substantially lower. We observed intra-annual differences in the 7-day running average maximum daily temperatures recorded on the northwestern shoreline of Borax Lake. Water temperatures were cooler in the summers of 2008, 2010, and 2011 compared to those recorded in 2005, 2006, 2007, 2009, 2012, and 2013 (Figure 3). We also observed intra-annual changes in temperature in different regions of the lake in recent years (Table 1). Average temperatures in the wetland have declined by 7°C in the past

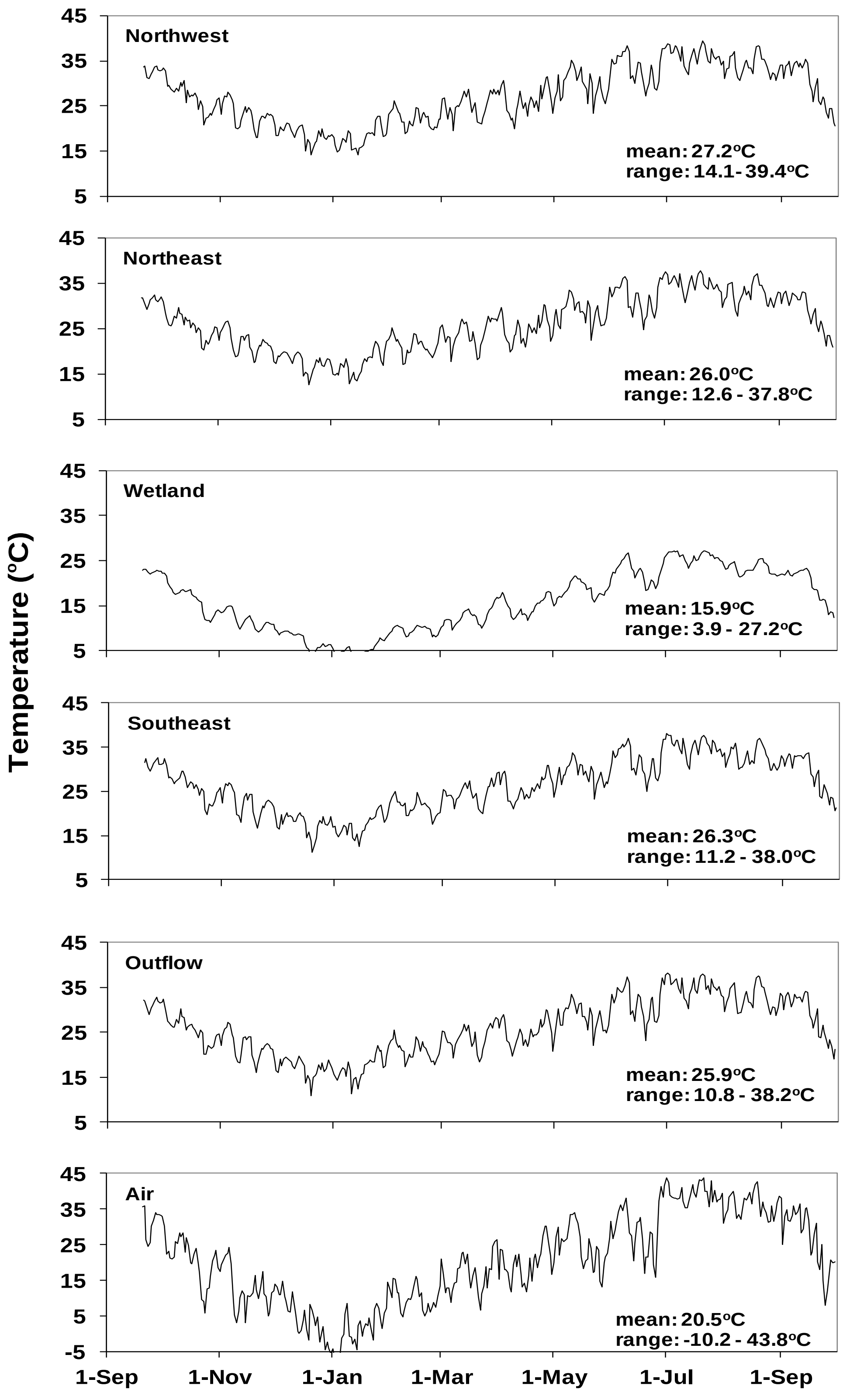

Figure 2. Water temperatures recorded at five locations in Borax Lake from September 2012 through September 2013. Also included are air temperatures for that time period.

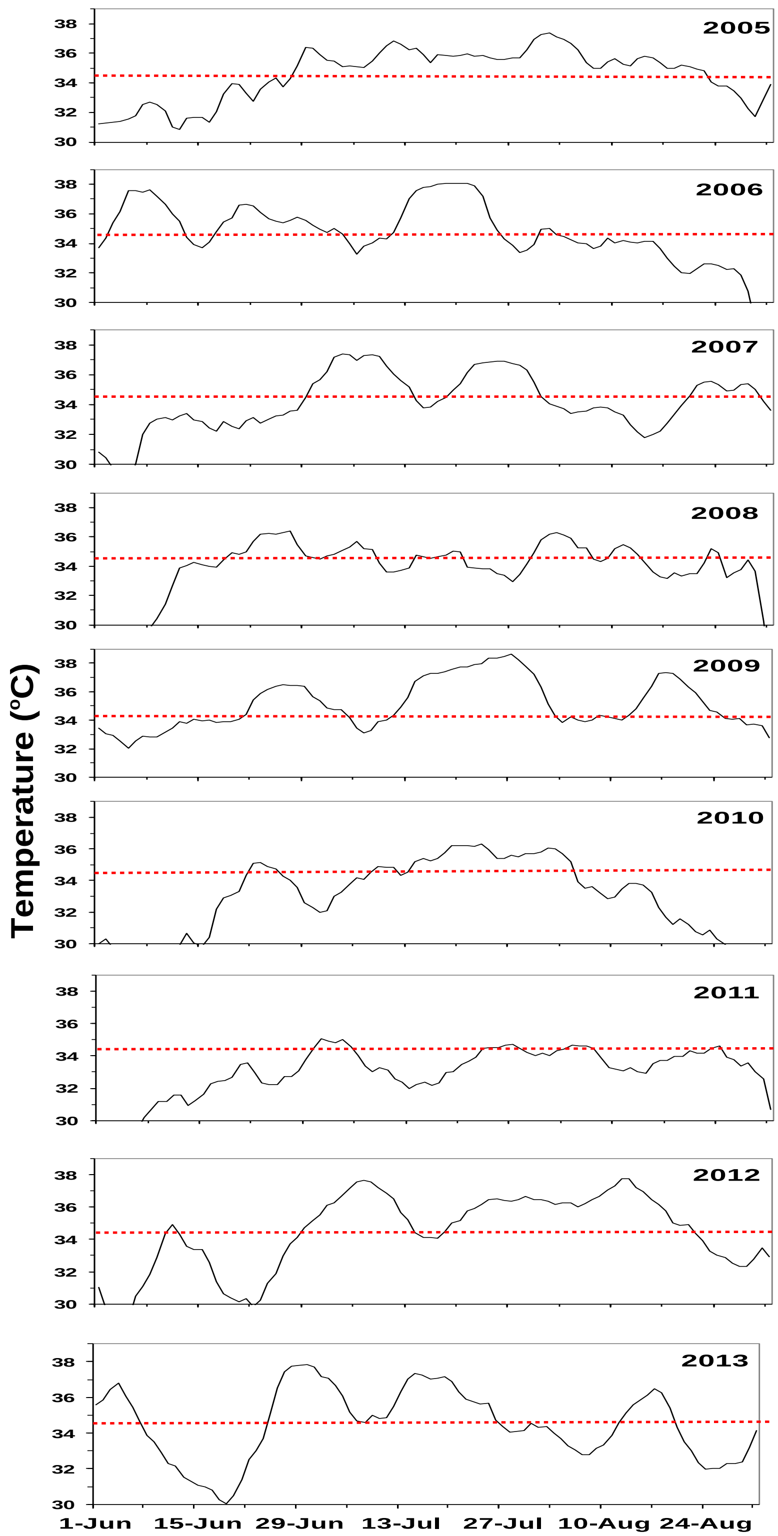

Figure 3. Seven-day running average of the maximum daily temperature recorded on the northwestern shoreline of Borax Lake, 2005-2013. Red lines denote the critical thermal maximum temperature of 34.5°C for Borax chub. Note: temperatures in early-June 2007, 2008, 2010, 2011, and 2012 were less than 30°C.

Table 1. Mean water temperatures recorded in different areas of Borax Lake, 2009-2013. The numbers in parentheses represent the 95% confidence limits. Mean temperatures were significantly different ($p < 0.05$) between years at any given location when superscripted letters were different.

	Location				
Year	Wetland	NE	Outflow	SE	NW
2009	**23.0**[a]	**27.9**[a]	**24.6**[a]	**22.9**[a]	**27.3**[a]
	(22.4-23.6)	(27.2-28.5)	(24.0-25.3)	(22.2-23.5)	(26.7-28.0)
2010	**20.0**[a]	**25.6**[b]	**24.3**[a]	**25.9**[b]	**26.0**[b]
	(19.5-20.5)	(25.1-26.1)	(23.8-24.9)	(25.3-26.4)	(25.4-26.5)
2011	**18.4**[b]	**26.3**[b]	**24.1**[b]	**25.3**[b]	**25.6**[b]
	(17.9-18.9)	(25.6-26.9)	(23.4-24.7)	(24.6-25.9)	(25.0-26.2)
2012	**17.2**[b]	**25.7**[b]	**25.5**[c]	**26.1**[b]	**27.1**[a]
	(16.7-17.9)	(25.0-26.3)	(24.8-26.1)	(25.4-26.8)	(26.8-27.7)
2013	**15.9**[c]	**26.0**[b]	**25.9**[c]	**26.3**[b]	**27.2**[a]
	(15.2-16.5)	(25.3-26.6)	(25.2-26.5)	(25.7-26.9)	(26.5-27.8)

five years, whereas average temperatures along the southeastern shoreline have increased by more than 4°C. These temperature shifts are likely a result of natural variability in geothermal flow paths to the various vents in the lake. Average temperatures in the outflow have remained relatively constant. The 7-day average maximum temperatures in 2013 represent some of the most extreme conditions that exist in the lake, and exceeded the species critical thermal maximum of 34.5ºC (Williams and Bond 1983) during a large portion of the summer. However, fish can seek refuge from the warmest temperatures by moving to cooler areas of the lake, including the wetland. This behavioral thermoregulation was noted in July 1987 by Williams et al. (1989), when presumed high temperature induced mortality was observed and chub congregated in cooler portions of the lake.

Shoreline Pedestrian Surveys

The Borax Lake shoreline was in good condition. We have not documented any substantial changes in the shoreline habitat conditions at Borax Lake in recent years (Scoppettone et al. 1995; Scheerer and Jacobs 2005; 2006; 2007; 2008; 2009; 2010; Scheerer and Bangs 2011; Scheerer et al. 2012). No unauthorized vehicular traffic around the locked gates or through the perimeter fence was apparent.

Seasonal Water Level Fluctuations

In 2011, we mapped the bathymetry of Borax Lake, including the wetland, and created maps showing the spatial distribution of lake depths and temperatures (Figures 4-5). The wetted surface area and volume of the lake were 39,117 m^2 and 15,460 m^3, respectively. We identified the water elevation when the wetland would disconnect from the lake (0.25 m drop). We also calculated the effects of reduced water elevations on habitat area and volume. For example, if lake elevations were reduced by 0.5 m, then wetted area and volume would decrease 36% and 14%, respectively. If lake elevations were reduced by 1.0 m, then wetted area and volume would decrease by 71 and 61%, respectively (Figure 6). Only the vent and wetland would be wetted if water elevations were reduced by 1.5 m. In the past year, we observed minimal fluctuation (0.08 m; 3 in) in lake water elevations (Figure 7). This represents a 2% fluctuation in surface area and a 5% fluctuation in water volume.

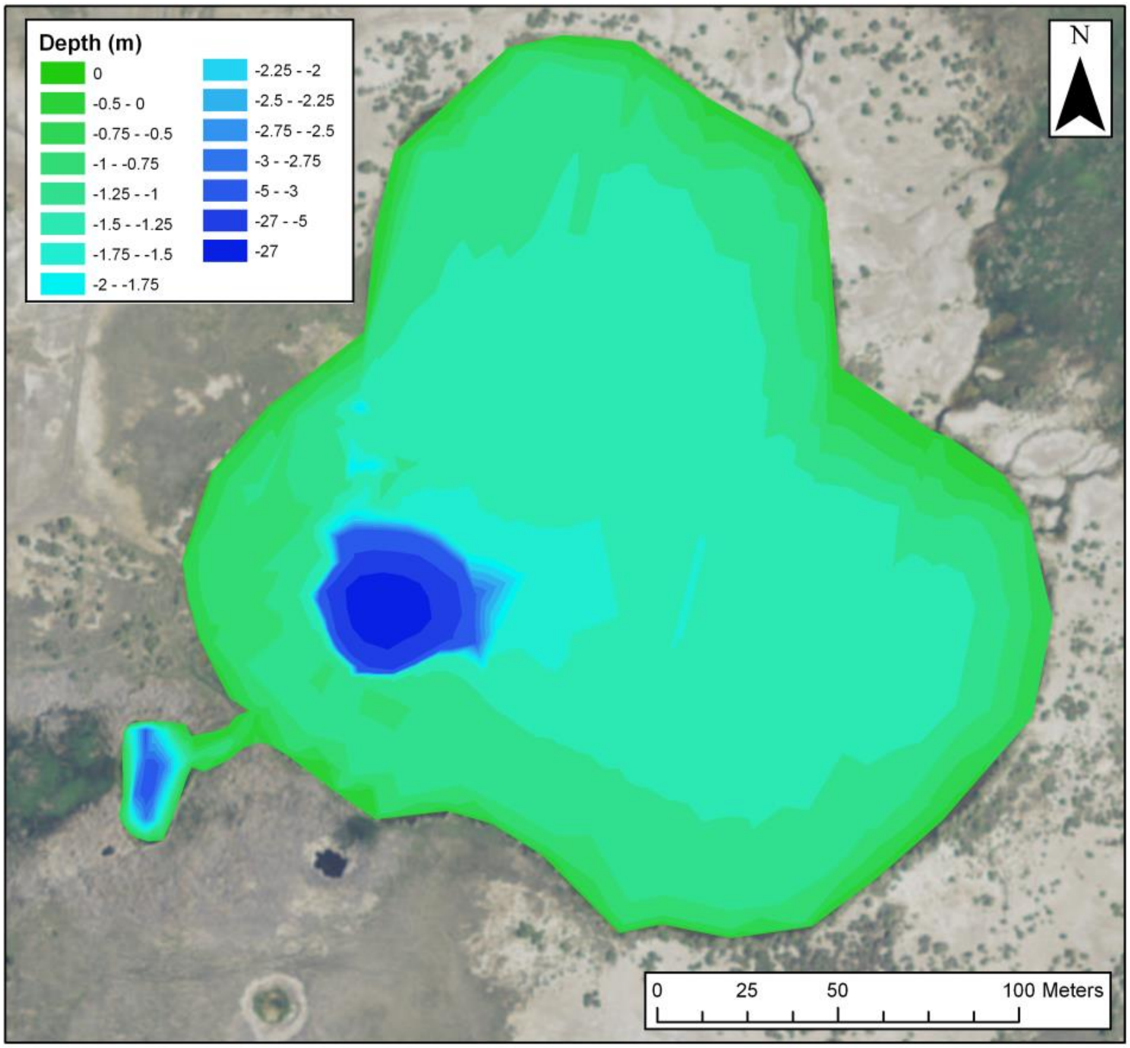

Figure 4. Map of the bathymetry of Borax Lake.

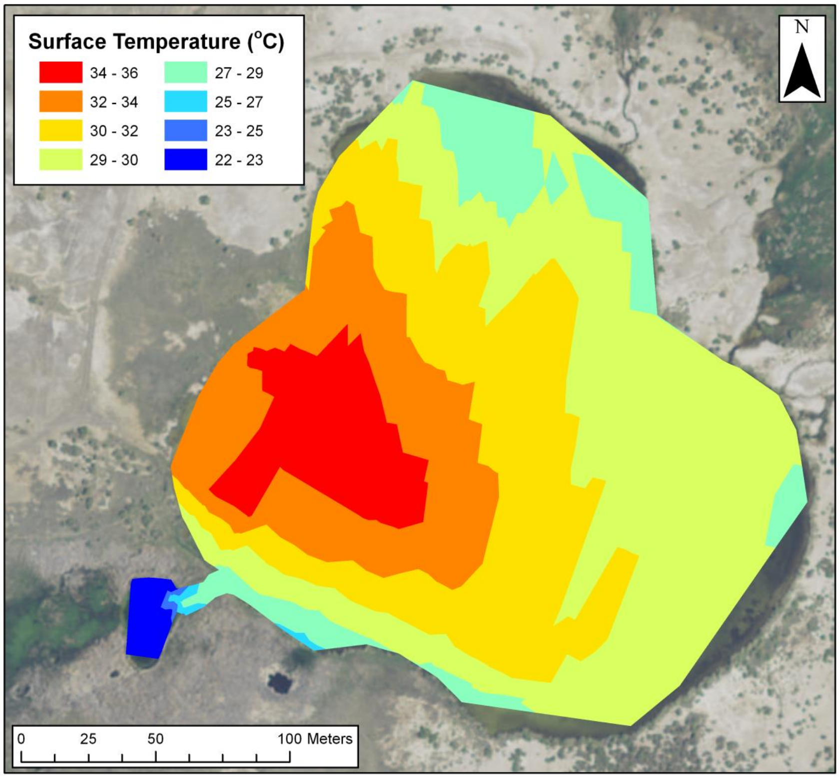

Figure 5. Map showing the surface temperature profile at Borax Lake in October 2011.

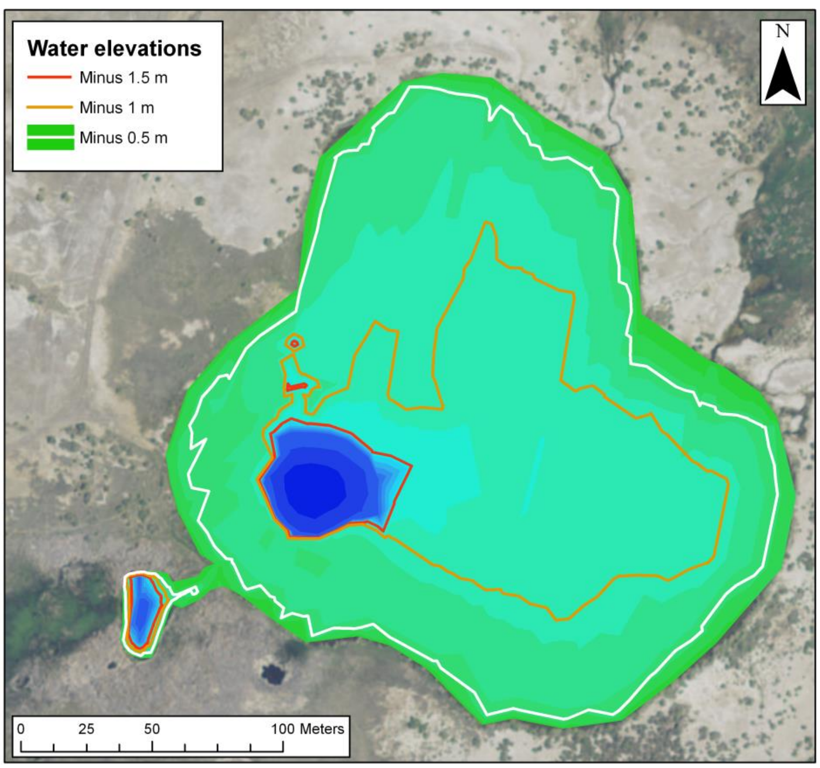

Figure 6. Map showing the limits of wetted surface area if water elevations were reduced by 0.5 m, 1.0 m, and 1.5 m from maximum levels observed in October 2011.

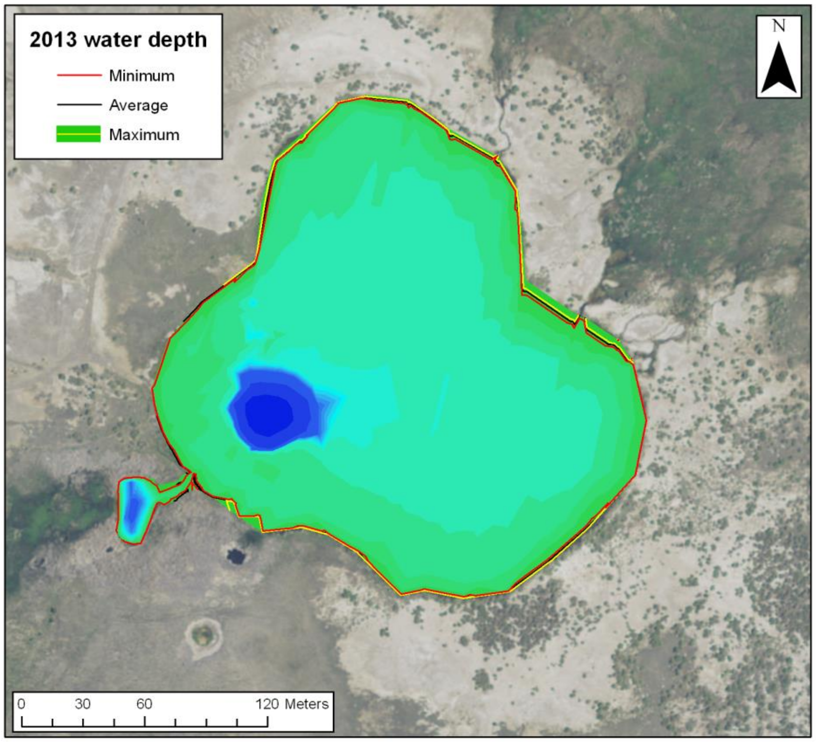

Figure 7. Map showing the minimum (red line), maximum (yellow line) and average (black line) water elevations recorded in 2013.

<u>Fish Sampling</u>

We captured between 50 and 500 Borax chub (~1,200 total) in the six traps that we set at the north end of the lake. This catch rate was similar to that from previous years sampling, suggesting there was no immediate decline in chub abundance. We were unable to capture or re-sight the non-native fish (bass?) we sighted during our shoreline surveys.

DISCUSSION

There has been substantial progress made towards recovery of Borax Lake chub since listing. In 2012, the U.S. Fish and Wildlife Service completed a five-year review and recommended downlisting the species from endangered to threatened status (U.S. Fish and Wildlife Service 2012). Three main threats to the species and its habitat remain. These threats include habitat degradation of the lake shoreline resulting from recreation use in the area, introduction of nonnative fishes, and impacts to the aquifer from geothermal groundwater pumping on private lands outside the protected areas (Williams and Macdonald 2003; Williams et al. 2005).

To address protection of the fragile lakeshore, BLM's Resource Management Plan included implementation actions to restrict vehicle access, recreational boat use, and vehicle parking to protect Borax Lake and its fragile shoreline. In 2011, BLM and TNC completed a perimeter fence to exclude vehicles from the lake. In 2013, locks were installed on the roads entering the lake from the south and the north. For years, there have been plans to install educational interpretive signs near the lake (biological, geological, and historical/archaeological). We encourage the BLM and TNC to complete the design and install these signs at the north and south gates in the near future. Hopefully, installation of these signs describing the unique biological characteristics of the lake and explaining why access is restricted, in combination with maintenance of the secure perimeter fence, will greatly reduce the damage and threats from unauthorized vehicles accessing the restricted areas near the lake and from illegal introduction of nonnative fishes.

Nonnative fish continue to be a threat to Borax Lake chub. In October, while conducting shoreline surveys, we noted a large fish with paired dorsal fins (presumably a largemouth bass). We set experimental gill nets overnight on three occasions, but were unsuccessful in capturing any fish. We also walked the perimeter of the lake and boated across the lake, but did not observe the fish again. TNC and ODFW Burns District also attempted to capture the fish. It is unclear if one or more fish were illegally introduced into the lake and whether the fish died or still inhabit/s the lake.

Regarding potential geothermal development on private lands, in 2009 Pueblo Valley Geothermal proposed to develop a geothermal energy project on 2,000 acres of private land within 5 km of Borax Lake. The development of geothermal energy has the potential to have adverse effects on Borax Lake and the Borax Lake chub. If drilling disrupts the hot water aquifer that supplies the lake, it could decrease the lake's water elevation through changes in lake inflow. In response to this proposed geothermal development and to address concerns outlined in the recovery plan (U.S. Fish and Wildlife Service 1987), a multi-agency recovery team, consisting of representatives from BLM, USFWS, TNC, and ODFW, was assembled in 2010 to identify the information and research needed to assess the potential short and long-term effects of geothermal development on private lands on Borax Lake and the Borax Lake chub.

To monitor the potential effects of future geothermal development that could occur within the aquifer that supplies water to Borax Lake, we mapped the lake bathymetry and installed a water level monitor in 2011. We acquired data from 2011-2013, and will acquire additional data in the upcoming years, which we will use to describe the natural, seasonal variability in: 1) lake elevations, 2) the quantity, quality, and availability of habitat, and 3) the connectivity between the lake and wetland. If needed, we can use this baseline information, in combination with nine years of temperature data, to assess the effects of future groundwater mining on Borax chub and their habitat. For example, if groundwater extraction is found to reduce lake inflows and if lake elevations decline, this would restrict the connectivity of the lake and the wetland (the channel connecting the two is very shallow). If connectivity is eliminated, then the chub would not have access to the cooler waters in the wetland during periods of thermal stress (high lake temperatures), which could negatively affect their survival. Also, reduction in water levels could affect recruitment. The sand, gravel, and stromatolite (bedrock) substrates where Perkins et al. (1996) captured the majority of chub protolarvae ($\leq$6 mm), exist only in the shallow, near-shore areas of the lake. These areas are presumably used for spawning and if water levels decline, a reduction in suitable spawning habitat could reduce chub recruitment.

The Borax Lake chub population exhibited a stable abundance trend between 2005 and 2012, with estimates ranging from 8,246 and 26,571 individuals (Scheerer and Jacobs 2005, 2006, 2007, 2008, 2009, 2010; Scheerer and Bangs 2011; Scheerer et al. 2012). Because Borax Lake chub experience water temperatures that are at or near their thermal critical maximum (Williams and Bond 1983), chub survival and recruitment are likely higher during years when lake temperatures are cooler, which is supported by our data (Scheerer et al. 2012). We recommend continuing monitoring at Borax Lake, particularly to monitor trends in population chub abundance, to monitor habitat conditions, and to monitor for the presence of nonnative fishes. Because Borax Lake chub are short lived and presumed to be an annual species, i.e., most fish are <1 year old (Scoppettone et al. 1995), we feel that this sampling should be conducted at least every two to three years, so that serious declines in population abundance and/or unauthorized introductions of nonnative fish can be detected before the results are irreversible. To assess the condition of the fragile lake crust, we recommend continuing annual shoreline pedestrian surveys. To provide baseline data for monitoring the effects of proposed geothermal development on private lands near Borax Lake, we recommend continued monitoring of lake water temperatures and water elevations. We also recommend the initiation of a genetics study to describe the relationship between Borax Lake and Alvord chub (*Gila alvordensis*); the results of which could have implications on the conservation and listing status of both species.

ACKNOWLEDGEMENTS

ODFW is grateful to the Bureau of Land Management for use of the housing facilities in Fields. ODFW appreciates the support from The Nature Conservancy and gratefully acknowledges the funding provided for this study by the U.S. Bureau of Land Management.

REFERENCES

Perkins, D. L., C. E. Mace, G. G. Scoppettone, P. H. Rissler. 1996. Identification of spawning habitats used by endangered Borax Lake chub (*Gila boraxobius*). Final Report to: The Nature Conservancy, Portland, Oregon. Submitted by: U.S. Geological Survey, Biological Resources Division, Reno, Nevada. 37 p.

Salzer, D. 1992. Population estimates for the Borax Lake chub: 1991 results and a comparison of sampling procedures. A report to: Oregon Department of Fish and Wildlife, Portland, Oregon. Submitted by: The Nature Conservancy, Oregon Field Office, Portland, Oregon.

Salzer, D. 1997. Results of the 1997 Borax Lake chub population sampling. Memorandum from The Nature Conservancy, Oregon Field Office, Portland, Oregon.

Scheerer, P. D., and S. E. Jacobs. 2005. Borax Lake Chub Population Assessment and Monitoring Strategy. Fish Research Project E-2-40, Contract #134204M129, Annual Progress Report, Corvallis. 15 p.

Scheerer, P. D., and S. E. Jacobs. 2006. Borax Lake Chub Investigations. Fish Research Project E-2-40 and supplement, Annual Progress Report, Corvallis. 16 p.

Scheerer, P. D., and S. E. Jacobs. 2007. 2007 Borax Lake Chub Investigations. Fish Research Project E-2-41, USFWS contract 134206M085, and BLM Contract HAP074439, Annual Progress Report, Corvallis. 8 p.

Scheerer, P. D. and S. E. Jacobs. 2008. 2008 Borax Lake Chub Investigations. USFWS contract 13420-08-J814, Annual Progress Report, Corvallis. 9 p.

Scheerer, P. D. and S. E. Jacobs. 2009. 2009 Borax Lake Chub Investigations. USFWS contract 13420-08-J814 and BLM contract L07PX02726, Annual Progress Report, Corvallis. 14 p.

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.

Scheerer, P. D., and B. L. Bangs. 2011. 2011 Borax Lake chub investigations. USFWS contract 13420-08-J814 and BLM contract L10AC20301, Annual Progress Report, Corvallis. 14 p.

Scheerer, P. D., B. L. Bangs, S. Clements, and J. T. Peterson. 2012. 2012 Borax Lake chub investigations. USFWS contract 13420-08-J814 and BLM contract L10AC20301, Annual Progress Report, Corvallis. 19 p.

Scoppettone, G. G., P. H. Rissler, B. Nielsen, and M. Grader. 1995. Life history and habitat use of Borax Lake chub (*Gila boraxobius* Williams and Bond) with some information on the Borax Lake ecosystem. U.S. Geological Survey, Northwest Biological Science Center, Reno, Nevada.

U.S. Fish and Wildlife Service. 1982. Endangered and threatened wildlife and plants; endangered status and critical habitat for Borax Lake chub (*Gila boraxobius*). Federal Register 47(193):43957-43963.

U.S. Fish and Wildlife Service. 1987. (Williams, J. E.) Recovery plan for the Borax Lake chub, *Gila boraxobius*. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 2012. Borax Lake chub (*Gila boraxobius*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Portland, Oregon. http://www.fws.gov/pacific/ecoservices/endangered/recovery/documents/SignedBoraxLakeChub5-yrReview08-23-2012.pdf

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. Proceeding of the Biological Society of Washington. 93:291-298.

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.

Williams, J. E., C. A. Macdonald, and M. A. Stern. 1989. Population changes and seasonal abundance of the endangered Borax Lake chub, *Gila boraxobius*. Unpublished report. 24+ p.

Williams, J. E., and C. A. Macdonald. 2003. A review of the conservation status of the Borax Lake chub, an endangered species. A final report to: U.S. Fish and Wildlife Service, Portland Oregon. Submitted by: Southern Oregon University, Ashland, Oregon.

Williams, J. E., C. A. Macdonald, C. D. Williams, H. Weeks, G. Lampman, and D. W. Sada. 2005. Prospects for recovering endemic fishes pursuant to the U.S. Endangered Species Act. Fisheries 30:24-29.