

CALIFORNIA GOLDEN TROUT AND CLIMATE CHANGE: IS THEIR STREAM HABITAT VULNERABLE TO CLIMATE WARMING?

Kathleen R. Matthews

Research Scientist USDA Pacific Southwest Research Station PO Box 245 Berkeley, CA 94701. 510-559-6454; 510-559-6440; kmatthews@fs.fed.us

ABSTRACT — The California golden trout (CGT) *Oncorhynchus mykiss aguabonita* is one of the few native high-elevation fish in the Sierra Nevada. They are already in trouble because of exotic trout, genetic introgression, and degraded habitat, and now face further stress from climate warming. Their native habitat on the Kern Plateau meadows mostly in the Golden Trout Wilderness (GTW) currently includes stream areas impacted by cattle grazing. As a result, some areas have reduced streamside vegetation (willows or sedge) and widened channels with shallow stream depths that often lead to warmer water temperatures. Climate change will further compromise CGT and their habitat in stream areas still being grazed, because the warmer water temperatures predicted under most warming scenarios could increase water temperatures to lethal levels. One important management response to climate warming will be to ensure that habitats are more resilient to predicted changes in water temperature, flow, and snow pack. I have initiated a study to determine the climate change resiliency of golden trout habitat by conducting a spatially explicit analysis of stream temperatures in restored and degraded sections of meadows in the GTW. Preliminary data from 2008 to 2010 indicate that stream temperatures are already 24°C in degraded areas. The detailed temperature profiles will also be used to estimate what proportion of the habitat will be resilient to climate change and what proportion should undergo increased restoration. Because water temperatures are already approaching stressful limits, management action to restore CGT habitat is imperative.

INTRODUCTION

The California golden trout *Oncorhynchus mykiss aguabonita* (Figure 1) is native to the South Fork Kern River and Golden Trout Creek (Behnke 1992), and most of its native range lies within the GTW (Figure 2). Stream populations in the GTW are long lived, slow growing, and exist at high densities because of increased spawning habitat due to cattle grazing (Knapp and Dudley 1990; Knapp and Matthews 1996; Knapp et al. 1998). The California golden trout (CGT) has been the subject of management interest because of its status as California's state fish, its limited natural distribution, and several perceived threats to its viability, including introduction of nonnative brown trout *Salmo trutta*

and habitat degradation caused by livestock grazing. Because of these threats, the California golden trout is being considered for federal listing as a threatened species. The CGT was the focus of a major restoration effort in the 1970s-1980s (Pister 2008) to remove exotic trout throughout its native range. Several studies have described golden trout habitat preferences (Matthews 1996a, 1996b) and concluded that adult trout prefer habitats (vegetated and undercut banks) typically reduced by cattle grazing. One emerging threat that has not been evaluated is the impact of climate warming that could further stress CGT streams already near their temperature maximums due to cattle grazing.

METHODS

To determine the water temperature vulnerability of the CGT within its stream habitat in the GTW, I deployed temperature probes (Onset HOBO Water Temp Pro v2) throughout the stream to include a typical range of stream areas: areas degraded by cattle grazing (collapsed banks, little vegetation, shallow depth) and those in recovering areas with more vegetation and greater depth. Potentially

harmful water temperatures will be reported to managers so that actions can be taken. The analysis is being conducted in Mulkey, Ramshaw, and Big Whitney meadows in the GTW (Figure 2). The detailed temperature and dissolved oxygen (DO) profiles will be used to estimate what proportion of the habitat will be resilient to climate change and what proportion should undergo increased restoration.



Figure 1. California golden trout. Photo by Kathleen Matthews.

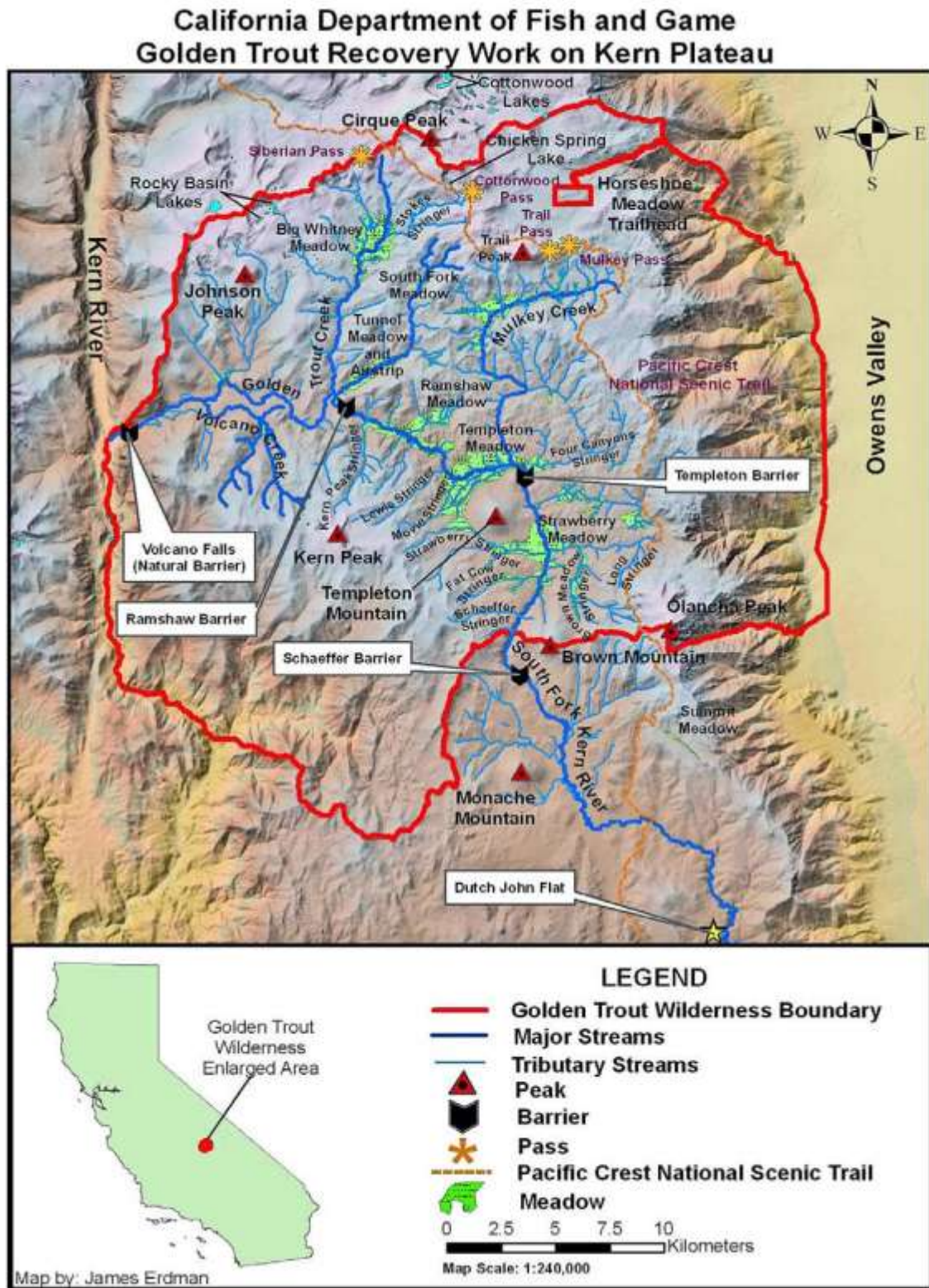


Figure 2. Map of Kern plateau from Pister 2008.

RESULTS

Preliminary temperature data from 2009 show that water temperature reaches 24°C in late July (Figure 3a) in degraded portions of Mulkey Creek (Figures 3a-b). A 24-hour breakdown of tempera-

tures also indicates a 15°C diel change in water temperature (Figure 3 b). In contrast, in recovering sections of Mulkey and Ramshaw meadows (Figure 3c), water temperature did not exceed 22°C and diel changes were 11°C or less.

Mulkey Meadow water temperature

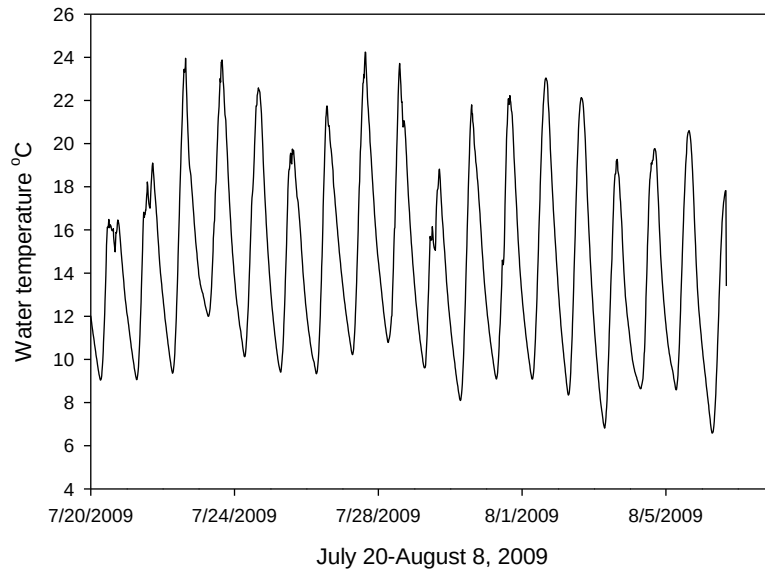


Figure 3a. Water temperatures in Mulkey Creek, Golden Trout Wilderness from July 19-August 8, 2009.

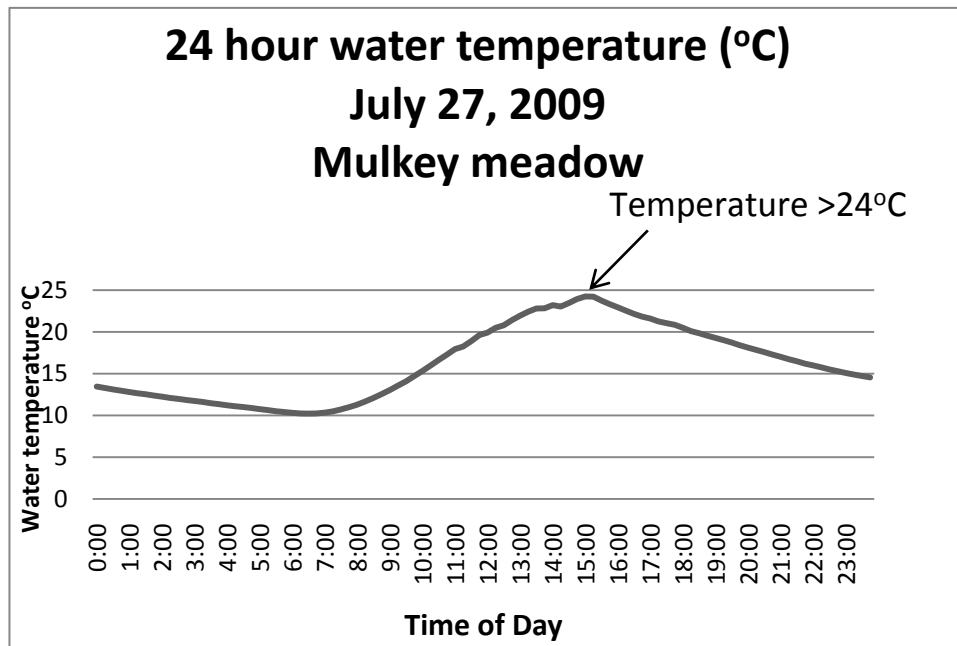


Figure 3b. Diel change in water temperature on July 27, 2009.

Ramshaw Meadow water temperature

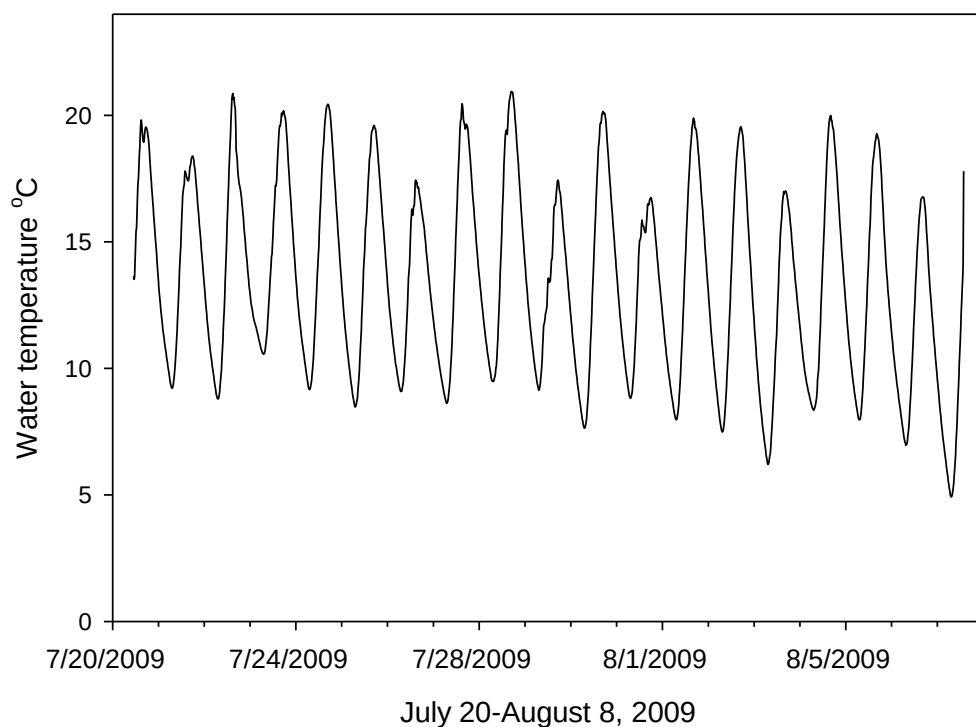


Figure 3c. Water temperatures in Ramshaw Meadow South Fork Kern River, Golden Trout Wilderness from July 20 to August 8, 2009.



Figures 4a and 4b. Sections of Mulkey Creek experiencing highest water temperatures.



Figure 5. Restored area within Ramshaw Meadow stream with maximum water temperatures never exceeding 22°C.

DISCUSSION

Preliminary water temperature data from 2009 shows some vulnerabilities: water temperatures in some degraded areas of the GTW are already experiencing stressful levels ($>24^{\circ}\text{C}$) (Bjorn and Reiser 1991), and these areas will not be resilient to future climate warming. Future climate warming could increase water temperatures to lethal levels stressing the importance of continued monitoring. Moreover, the diel range of temperatures ($\pm 15^{\circ}\text{C}$) experienced by CGT is extreme (Matthews and Berg 1997) and warrants further study because it may physiologically stress trout. Water temperatures will be monitored through 2011.

In the Sierra Nevada Mountains (California, USA), there is great opportunity to increase resiliency of high elevation aquatic habitats because most of it is within federally designated Wilderness set aside by U.S. Congress to “to preserve its natural conditions and which generally appears to have been affected primarily by forces of nature” (Kloepfer et al. 1994). Indeed, most of the CGT habitat is within the Golden Trout Wilderness; hence, there is the opportunity to reduce or eliminate activities that reduce the resiliency to increased climate warming. While Wilderness status typically prohibits logging,

roads, and mechanized equipment, it does allow cattle grazing, that often impacts stream habitat and increases water temperatures. To provide more resiliency of important habitat for aquatic species, Wilderness areas could be used as refuges, i.e., the freshwater version of marine preserves. In these preserves, managers could eliminate or minimize activities that are currently allowed, such as cattle grazing, but are lowering the resiliency of freshwater habitats to increased warming.

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