Centennial Valley Arctic Grayling Adaptive Management Project 2017 Spring Update

- The Centennial Valley Arctic Grayling Adaptive Management Plan (AMP) is being implemented to identify limiting factor(s) for Arctic grayling in the upper Centennial Valley (CV) of southwestern Montana. Non-native hybrid Yellowstone cutthroat trout, spawning habitat, and overwinter habitat have been identified as the three most likely factors that could limit long-term viability of grayling in the upper CV. Long-term viability is expected to be maintained by 1) conserving genetic diversity, 2) establishing spawning and/or refugia in at least two tributaries, and 3) maintaining a spawning population of $\geq$ 1,000 fish. The latter is based on the Species Status Assessment Workshop for Arctic grayling conducted in 2014.
- The AMP focus is on identifying factors that cause the spawning population to decline below 1,000 fish and, if that occurs, management actions that will most effectively return the population to objective. An emphasis on learning through 'management as experiment' during the first phase of the AMP is being accomplished via two experiments that 1) reduced non-native hybrid Yellowstone cutthroat trout population (2013–2016) and 2) will maximize availability of spawning habitat. No experiments have been planned for altering winter habitat; natural variability has been sufficient to explore the hypothesized relationship between grayling spawning population and area of suitable winter habitat in Upper Red Rock Lake (Upper Lake).
- The estimated number of Arctic grayling in the 2017 Red Rock Creek spawning population was **176 (95% CI = 159–213**), nearly unchanged from the previous year ($\hat{N}$ = 214, 95% CI = 161–321; Figure 1).
- The estimated number of Yellowstone cutthroat trout in the Red Rock Creek spawning population was **387**, an approximate reduction of **88%** from the highest estimated population in 2014 ($\hat{N}$ = 3282; Figure 1). Estimated angler harvest was 176 trout.

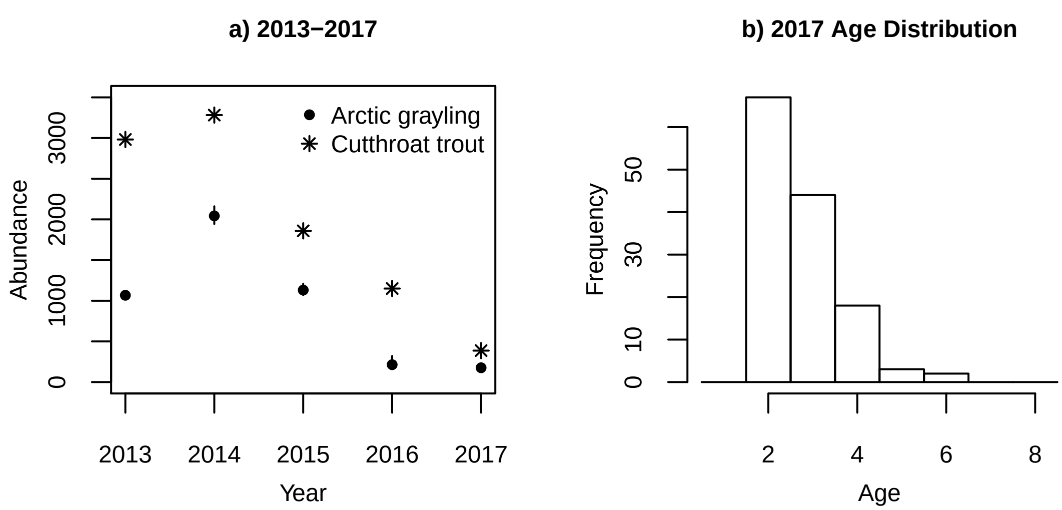

Figure 1. a) Arctic grayling and non-native hybrid Yellowstone cutthroat trout abundance estimates and 95% confidence intervals (grayling only) from Red Rock Creek, 2013–2017, and b) age distribution of the 2017 grayling spawning population.

- Two grayling (1% of the spawning population) were reported as caught and released by anglers during angler access surveys conducted mid-April–mid-May; no grayling were reported as caught based on angler self-reporting catch cards. Fourteen of 698 grayling (2%) were observed with hook scars at the fish weir in 2015, the only year these data were available.

- We will continue to learn how grayling respond to trout population reductions, the first management experiment undertaken as part of the AMP, as 1) grayling cohorts spawned during low trout abundances recruit, and 2) trout spawning population recovers.

- Suitable winter habitat within Upper Lake (i.e., water depth below the ice $\geq$ 1 m and dissolved oxygen $\geq$ 4 ppm) reached a minimum during February sampling at an estimated 10 ha. Grayling spawning population was reduced to $\leq$ 214 fish in all years when <10 ha of suitable winter habitat was available in Upper Lake (Figure 2).

- Suitable spawning habitat was most recently quantified in 2014–2015, with an estimated total area of suitable spawning habitat (A_{ts}) of 6.5 ha, and weighted area of suitable habitat (A_{tw}) of 11.9 ha, in Red Rock and Elk Springs creeks. Surveys to estimate area of suitable spawning habitat will be completed again in 2017.

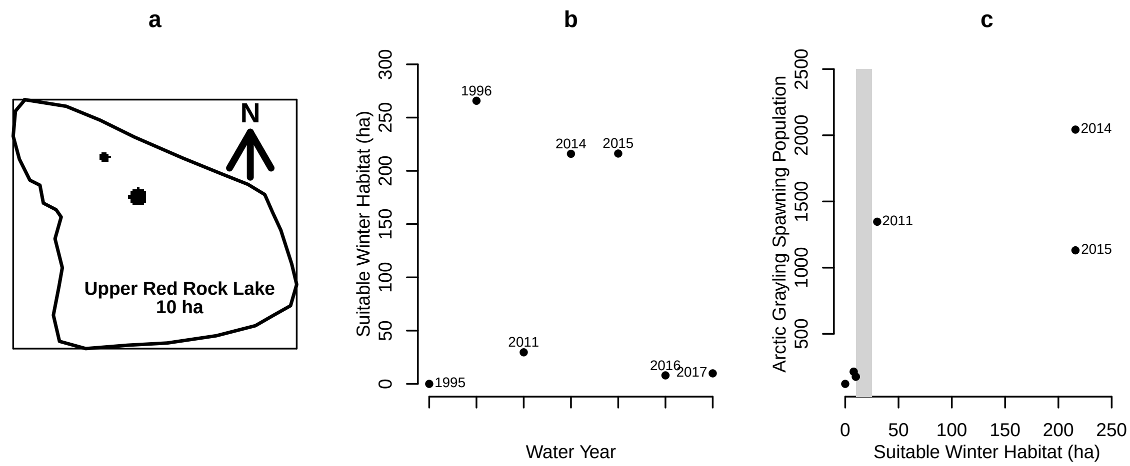

Figure 2. a) Extent of minimum area of suitable Arctic grayling winter habitat in Upper Red Rock Lake, 2017, b) annual estimate of minimum area of suitable habitat for water years 1995–2017, and c) grayling spawning population as a function of minimum area of suitable winter habitat for years when both were estimated (1995 [0 ha], 2016 [8 ha], and 2017 [9 ha] points are plotted but not labelled). The shaded polygon represents an hypothesized threshold (10–25 ha) of suitable winter habitat where 1) enough winter habitat is available to sustain grayling population at objective ($N \geq$ 1,000 fish, > 25 ha suitable habitat), and 2) winter habitat presumably reduces grayling survival, resulting in grayling population below objective ($\hat{N} \leq 214$, <10 ha suitable habitat).

- The *Winter Habitat*, *Spawning Habitat*, and *Non-native Fish* models predicted 60, 467, and 1057 grayling, respectively, in the 2017 Red Rock Creek spawning population. The *Winter Model* continued to predict grayling spawning population more precisely than the other models, resulting in an increased model weight again this year (Table 1). Thus, data collected to date provide support for overwinter habitat in Upper Lake being a primary driver of grayling abundance in the upper CV. Moreover, adult grayling annual survival ($\hat{S}$) estimates for 2014–2016 from the *Winter Habitat* model were comparable to apparent survival (ϕ) estimates based on capture-mark-recapture models ($\hat{S}$ = 0.273, 0.043, and 0.202; ϕ = 0.185 [95% CI = 0.115–0.357], 0.035 [0.009–0.087], and 0.198 [0.039–0.643]).

Table 1. Arctic grayling spawning abundance model predictions, observed abundance, and relative model weights for 2017. Model weights, which sum to 1, are a measure of relative support for a model given the data.

Model	2017 Prediction	Observed	Model Weights
Winter Habitat	60	176	0.578
Spawning Habitat	467	176	0.305
Non-native Fish	1057	176	0.117

- Management actions to assess the effect of spawning habitat on grayling abundance were initiated this spring. Spawning habitat was maximized by 1) restoring connectivity to, and habitat within, Elk Springs Creek, and 2) providing access to all spawning habitat in Red Rock Creek by breaching beaver dams ($n = 51$). However, the influence of trout abundance and spawning habitat on grayling recovery from the recent decline is currently confounded because the system has both low abundance of trout and high per-capita suitable spawning habitat. Therefore, strong grayling cohorts produced by the 2017 or 2018 spawning populations, as predicted by both the *Spawning Habitat* and *Non-native Fish* models, could be related to either, or both, low trout abundance or high per-capita spawning habitat. Disentangling the relative influence of these two factors requires maintaining one relatively constant while allowing the other to vary. This is currently being achieved by the second management experiment of the AMP, which maximizes the per-capita area of spawning habitat available to grayling until Yellowstone cutthroat trout return to relatively high abundances (i.e., as soon as 2020).

- No management actions to improve winter habitat are presently identified or planned. However, the recent restoration of Elk Springs Creek to improve spawning habitat may also improve winter habitat in Upper Lake by allowing the creek to largely circumvent Swan Lake, increasing the flow of highly-oxygenated water into Upper Lake. Assessing the potential for Elk Springs Creek restoration, or future management actions, to mitigate winter habitat is currently hampered by low grayling abundance. Based on three years where winter habitat and grayling spawning population were estimated, a threshold level of 10–25 ha of winter habitat appears necessary to overwinter grayling populations greater than the 1,000 fish objective (Figure 2). Based on winter habitat surveys conducted in 2017, the restoration may not have increased area of suitable habitat as currently defined, although during periods of low levels of dissolved oxygen in Upper Lake the mouth of Elk Springs Creek may still provide refugia with suitable dissolved oxygen in water depths less than currently considered suitable by the *Winter Habitat* model.

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