# Spring 2018 Monitoring of Humpback Chub (*Gila cypha*) and other Fishes above Lower Atomizer Falls in the Little Colorado River, Arizona

Trip Report for May 15-24, 2018

Prepared for: U.S. Geological Survey Grand Canyon Monitoring and Research Center Flagstaff, Arizona

by

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#### INTRODUCTION

In 2018, the U.S. Geological Survey's Grand Canyon Monitoring and Research Center (GCMRC) contracted the U.S. Fish and Wildlife Service (USFWS) to monitor Humpback Chub (Gila cypha) above Lower Atomizer Falls (river kilometer [RKM] 13.58) to RKM 17.67 in the Little Colorado River (LCR; Fig. 1). This section of the LCR became of interest after juvenile Humpback Chub were translocated above Chute Falls (RKM 14.11) and released at RKM 16.20 in 2003. To date 3,423 juvenile chub (median= 87 mm TL; range = 50-146 mm TL) have been translocated above Chute Falls. The reach above Chute Falls has been annually sampled for fishes since the 2003 translocation, and the reach between Lower Atomizer Falls and Chute Falls (hereafter, Atomizer reach) has been annually sampled since 2006. From 2006 to 2009 the monitoring protocol included using two-pass mark recapture methods to estimate Humpback Chub population sizes, but since 2010 capture probability data have been used to estimate their abundances. This trip report summarizes information on Humpback Chub and other fishes that were captured, LCR physical parameters, and sampling efforts during the May 2018 monitoring trip. Humpback Chub population estimates resulting from this trip will be presented in an annual report.

### STUDY AREA

Cooley (1976) reported that the perennial discharge in the lower 21 km of the LCR essentially begins at Blue Spring (RKM 20.74; ~90 ft<sup>3</sup>/s) and is supplemented downriver by numerous other springs resulting in a final discharge between 217 and 232 ft<sup>3</sup>/s near the confluence (Fig. 1). Springs located between RKM 16.10–20.74 account for about nine-tenths of the perennial flow. The springs release waters supersaturated with dissolved CO<sub>2</sub>, which gradually diffuse from the river as it flows downstream and allows carbonates to precipitate in the form of travertine and unconsolidated marl.

During the May 2018 monitoring trip above Lower Atomizer Falls, all fish sampling was conducted between RKM 13.58–17.67. This stretch of river was separated into the "Atomizer reach" from above Lower Atomizer Falls to just below Chute Falls (RKM 13.58–14.11), and the "Chute Falls reach" from above Chute Falls (RKM 14.20) to RKM 17.67 (Fig. 1). The short 0.54 km Atomizer reach also encompasses a waterfall known as Upper Atomizer Falls. Each of these three travertine dams (Lower and Upper Atomizer Falls, and Chute Falls) give rise to over a two meter drop in river elevation, and are collectively known as the Atomizer Falls Complex. The Atomizer reach contains a myriad of travertine formations (dams, terraces and cascades), hydrologic configurations (deep plunge pools, shallow pockets, falls, rapids, runs, and eddies) and diverse bottoms (boulders and rocks, gravel, sand, and unconsolidated marl). In contrast, the ~3.5 km reach above Chute Falls consists of proportionally fewer and much

smaller travertine structures, shallower depths, and more homogenous bottoms blanketed with sand and unconsolidated marl.

Historically, Chute Falls was considered to be an impassible chemical and/or physical barrier to all upriver migrations of Humpback Chub (Kaeding and Zimmerman 1983; Mattes 1993; Robinson et al. 1996), but this assumption was proven incorrect by USFWS monitoring efforts in 2007, 2009, 2014, and 2017. Although Chute Falls likely impedes the upriver migrations of many chub, USFWS has thus far detected eight adult chub that migrated above this falls and into the uppermost, perennial corridor of the LCR (Stone et al. 2018).

#### METHODS

During the May 15-24, 2018 monitoring trip, the two reaches above and below Chute Falls were sampled by biologists Dennis Stone (USFWS), Tricia Parker (USFWS), and Cory Nelson (AZGFD). Hoop nets (50-60 cm in diameter, 100 cm long, a single 10 cm throat, 6 mm nylon mesh netting) were the sole fishing gear used, and were baited near their cod ends by attaching nylon mesh bags (30 x 30 cm, 6 mm mesh) filled with ~160 g AquaMax<sup>TM</sup> Grower 600 for Carnivorous Species (Purina Mills Inc., Brentwood, MO) to maximize fish captures (Stone 2005). During this trip, the crew sampled the reach above Chute Falls with 33 nets deployed for three consecutive ~24 h hauls, and the Atomizer reach with 17 nets deployed for three ~24 h hauls. Many nets were re-deployed to new locations between hauls to increase capture probability.

All captured fishes were identified to species, and examined for the presence and number of external anchorworms (*Lernaea cyprinacea*) and other visible parasites. Speckled Dace (*Rhinichthys osculus*) were often just tallied per net set to reduce handling, but all other fishes were measured to total length (TL mm); hereafter, all references to fish lengths infer TL. All Humpback Chub were scanned for previously implanted Passive Integrated Transponder (PIT) tags (Biomark, Inc.), whereby untagged individuals were implanted with a 134.2 KHz PIT tag. In addition, adult chub were inspected for sex, spawning condition (e.g., ripe, spent) and spawning characteristics (e.g., tuberculation and coloration). For additional fish handling protocols see Persons et al. (2015).

This report focuses on "unique" Humpback Chub, which refers to individuals counted only once during the trip, regardless of how many times they were recaptured. PIT tags of previously tagged chub captured during this study were queried in other data bases to distinguish known translocated chub from other chub. Ultimately, all Humpback Chub captured in the study reaches were classified as being (1) translocated, (2) local chub, which were unmarked when first captured in the study reaches, or (3) upriver migrants, which were initially captured and PIT-tagged in downriver locations. Likewise, all descriptions of Fathead Minnow (*Pimephales promelas*) and Black Bullhead (*Ameriurus melas*)

refer to unique individuals because of their low captures. Because Speckled Dace were commonly captured and these fishes were not marked, their tallies may include some recaptured individuals.

At Translocation Camp (RKM 16.20) measurements of water temperatures (°C) and turbidity (nephelometric turbidity unit [NTU]; Hach Model 2100Q Turbidimeter, Loveland, CO) were taken each day. Provisional mean daily discharge data from the U.S. Geological Survey gage 09402300 located ~1.05 km above the LCR confluence were downloaded (http://nwis.waterdata.usgs.gov) to provide discharge information during the sampling trip.

Dissolved  $CO_2$  of the LCR was measured with a digital titrator (Model 16900): Hach Co., Loveland, CO) at Translocation Camp (RKM 16.20) on May 24, 2018. This measurement was preceded by the greatest number of days of baseflow discharge since at least 2003. Prior to this measurement a total of 231 and 279 days, respectively, elapsed since mean daily flood discharges exceeded 50 ft<sup>3</sup>/s (October 5, 2017) and 100 ft<sup>3</sup>/s (August 18, 2017) in the intermittent corridor near Cameron, AZ (USGS gage 09402000). Stone et al. (2018) described a significant positive correlation ( $r_s = 0.59$ ; P = 0.006) between mean CO<sub>2</sub> levels taken among 20 trips at Translocation Camp (RKM 16.2) and the number of preceding days since mean daily flood waters exceeded 100 ft<sup>3</sup>/s at USGS gage 09402000. Hypothetically, the number of preceding days of baseflow discharges and high CO<sub>2</sub> levels could affect the distributions and growth rates of Humpback Chub in these study reaches. Therefore, Spearman's rank correlation (2-tailed) tests were used to examine the relationships of the uppermost RKMs where 75% of unique Humpback Chub captures occurred among trips above Chute Falls against (1) mean CO<sub>2</sub> levels of these trips and (2) the number of days before these trips since the mean daily flood waters exceeded 100 ft<sup>3</sup>/s at USGS gage 09402000. Only those monitoring trips from spring 2006 onward and contained over 100 captures of unique Humpback Chub were examined. A Spearman's (2-tailed) test was also used to examine the relationship between winter-spring growth rates among six annual batches of chub translocated in October-November and recaptured during the ensuing spring trips against the intervening number of intervening days of baseflow discharges ( $\leq 232$  ft<sup>3</sup>/s).

Summary statistics were calculated for physical parameters, sampling efforts, fishes captured, spawning conditions, and external parasites. Length frequency and capture location histograms, and growth rate comparisons were constructed for all unique Humpback Chub captured in the study reaches. Statistics and figures were computed using SPSS statistical software (version 25; IBM Corp.).

### **RESULTS and DISCUSSION**

#### Physical parameters and sampling efforts:

The entire May 2018 trip occurred under baseflow discharges and extremely low turbidities (range of mean daily discharges = 217-218 ft<sup>3</sup>/s; turbidity range = 0.95-1.91 NTU), which were ideal abiotic conditions for high hoop-net catch rates of native fishes (Stone 2010a). Cumulatively, we deployed 51 net sets for a total of 1,145 fishing hours in the Atomizer reach (RKM 13.58-14.11) and 99 net sets for a total of 2,391 fishing hours above Chute Falls (RKM 14.20-17.67). The LCR maintained relatively warm water temperatures throughout the trip (range= 20.2-22.6 °C). Mean dissolved CO<sub>2</sub> measured at RKM 16.20 on May 24, 2018 was 223 mg/L (N = 12 titrations; range = 220-228 mg/L), which is the fourth highest of 22 mean measurements among different trips at this site since 2003 (grand mean of trips = 209 mg/L; range of trip means = 184-230 mg/L).

#### Humpback Chub:

General overview .- Humpback Chub was second to Speckled Dace as the most commonly captured fish in both study reaches (Table 1). A total of 267 unique chub (median = 245 mm; range = 46-432 mm) were captured, which included 161 chub (225 mm; 121-362 mm) above Chute Falls and 106 chub (275 mm; 46-432 mm) in the Atomizer reach (Fig. 2). Most Humpback Chub caught above Chute Falls were slightly further downriver this spring following a prolonged period of baseflow and high CO<sub>2</sub> conditions, than they were during either the spring 2016 and 2017 monitoring trips, which were preceded by an intermingling of baseflow and flood discharges (Fig. 3). Two previously translocated chub captured at RKM 16.91 constituted the furthest upriver captures, which was 0.76 km downriver of the furthest upriver captures from 2016 and 2017. Spearman's correlation (2-tailed) tests on the uppermost RKMs where 75% of unique chub captures occurred among nine trips above Chute Falls detected (a) an almost significant negative relationship against mean CO<sub>2</sub> of these trips ( $r_s = -0.605$ ; P = 0.084), and (b) a highly significant negative relationship ( $r_{\rm s} = -0.817$ ; P = 0.007) against the number of preceding days since the mean daily flood waters exceeded 100 ft<sup>3</sup>/s. These tests suggest that many Humpback Chub avoid high CO<sub>2</sub> levels above Chute Falls by moving downriver to areas containing lower concentrations, and progressively more chub move downriver as the duration of baseflow high CO<sub>2</sub> levels becomes longer.

*Origin of Humpback Chub.-* One hundred and fifty-four of the 161 Humpback Chub (96%) captured above Chute Falls were previously translocated individuals, which included (a) 48 chub (121-175 mm) released in 2017 (b) 21 chub (175-242 mm) in 2016, (c) 50 chub (201-293 mm) in 2015, (d) 26 chub (232-330 mm) in 2014, (e) six chub (229-362 mm) in 2013, (f) two chub (305 & 361 mm) in 2011, one chub (287 mm) in 2010. We also recaptured five local chub (220-308 mm) above Chute Falls that were initially PIT-tagged in this reach

in 2015 and 2016, and captured two previously untagged local chub (144 & 199 mm) this year.

Only 36 of the 106 Humpback Chub (34%) caught in the Atomizer reach in 2018 were translocated individuals, which included (a) three chub (138-165 mm) released in 2017, (b) eight chub (200-267 mm) in 2016, (c) 11 chub (214-279 mm) in 2015, (d) six chub (257-316 mm) in 2014, (e) seven chub (285-352 mm) in 2013, and one chub (306 mm) in 2012. We also captured 23 previously unmarked local chub (range = 46-304 mm) in the Atomizer reach this year, and recaptured 45 other local chub (229-432 mm) that were initially captured and PIT-tagged in this reach during 2009-2017 trips. Only two upriver migrant chub were captured (277 & 285 mm), which were originally PIT-tagged below Lower Atomizer Falls.

Some Humpback Chub likely spawned in both reaches this spring. We captured 26 unique females displaying spawning coloration (range = 201-362 mm) and 48 ripe males above Chute Falls, and two ripe females (202 & 410 mm), 23 females displaying spawning coloration (249-432 mm), and 36 ripe males in the Atomizer reach. The previously untagged captures of two local chub (144 & 199 mm) above Chute Falls, and 23 local chub (a 46 mm YOY and 22 others 139-304 mm, median= 218 mm) in the Atomizer reach, coupled with their extremely high growth rates in these reaches (see below), suggest that some successful reproduction had likely occurred in these reaches during 2017 and early 2018.

**Retention of Humpback Chub.-** A mass exodus of Humpback Chub occurred in the two reaches above Lower Atomizer Falls between the summer 2009, when 890 unique Humpback Chub were captured, and the summer 2010, when only 13 unique chub were captured (Stone 2010b). However, juveniles (58-146 mm) translocated after this event have shown relatively good retention in the study reaches. Within the combined study reaches we recaptured one or more chub from every translocation since 2010 [1 from 2010 (1% of released); 2 from 2011 (2%); 1 from 2012 (0.5%); 13 from 2013 (4%), 32 from 2014 (10%); 61 from 2015 (20%); 29 from 2016 (21%); and 51 of 315 chub (16%) recently translocated on October 26, 2017.

Some Humpback Chub have remained in our study reaches for prolonged periods of time. A 2010 (287 mm), two 2011 (305 & 361 mm), and six 2013 (229-362 mm) translocated chub have been repeatedly recaptured solely above Chute Falls for 5-8 years. Likewise ten chub (278-432 mm) caught in the Atomizer reach have also been repeatedly recaptured within this reach and/or above Chute Falls for over five years. The longest known resident was a local female chub that was first captured in the Atomizer reach in 2009 (at 155 mm) and has been repeatedly recaptured in this reach for the next nine years (now 432 mm).

*Growth of Humpback Chub.-* During the 202-208 winter/spring days of primarily baseflow discharges, the 51 chub recaptured from the October 2017

translocation grew a median of 0.30 mm/day (0.19-0.39 mm/day). This reflects much higher growth rates than the 25 chub recaptured in spring 2017 from the October 2016 translocation under a more variable hydrological regime (median = 0.19 mm/day; 0.14-0.28 mm/day). In fact the winter-spring growth rates of chub translocated last year were higher than all five previous batches of chub that were likewise translocated in October-November (Fig. 4). A Spearman's correlation (2-tailed) test reflected a highly significant positive relationship ( $r_s = 0.943$ ; P = 0.005) between the winter-spring growth rates of chub translocated in October-November of days of baseflow discharges.

Median daily growth rates of translocated Humpback Chub recaptured in the combined reaches from the June 2017 trip (338-343 days prior) were (A) 0.24 mm/day for six "2016" chub, (B) 0.13 mm/day for 41 "2015" chub, and (C) 0.07 mm/day for 26 "2014" chub. In comparison, median growth rates of chub recaptured in June 2017 from May 2016 were all lower than the analogous batches of translocated chub from this spring: (A) 0.21 mm/day for "2015" chub (akin to "2016" chub above), (B) 0.09 mm/day for "2014" chub (akin to "2015" chub above), and (C) 0.05 mm/day for "2013" chub (akin to "2014" chub above).

This May we captured 199 adult Humpback Chub  $\geq$  200 mm, which included 104 individuals above Chute Falls (median=248 mm; range = 200-362 mm), and 95 individuals in the Atomizer reach (277 mm; 200-432 mm); 132 of these chub (66%) were previously translocated. Forty-one chub were  $\geq$  300 mm, of which 12 were caught above Chute Falls (301-362 mm) and 29 in the Atomizer reach (300-432 mm); 20 of these chub (49%) were previously translocated.

#### Other native fish:

Speckled Dace was the only other native fish captured in May 2018, which included the relatively low captures/recaptures of 969 dace above Chute Falls and 185 dace in the Atomizer reach for a total of 1,154 dace (Table 1). These captures reflect a small increase from those of spring 2017 monitoring (762 and 84 dace above and below Chute Falls, respectively). In comparison, during May 2016 monitoring we captured 6,914 and 243 dace in the reaches above and below Chute Falls, respectively for a total dace were observed schooling above Chute Falls this spring, the relative size of their 2018 cohort cannot be predicted. This species was captured in 82% of the net sets deployed above Chute Falls, and showed no obvious distributional patterns suggestive of an avoidance to the higher  $CO_2$  levels in the uppermost net sets.

# Nonnative fishes:

Fishes of only two nonnative species were captured in May 2018 (Table 1). A total of 34 and 31 Fathead Minnows were caught above Chute Falls and in the Atomizer reach, respectively. These captures included seven ripe females and 15 tuberculate males above Chute Falls and five ripe females and 13 tuberculate males in the Atomizer reach. Although this provides evidence that Fathead Minnows were spawning in both reaches, successful reproduction of progeny

that recruit to adulthood could be curtailed by the high CO<sub>2</sub> levels in these reaches (see Stone et al. 2018). Most Fathead Minnows above Chute Falls (91%) were caught within 0.44 km of Chute Falls, suggesting that these fish were also moving downriver. A sole Black Bullhead (226 mm) caught above Chute Falls constituted the only other nonnative species captured this spring; it had two Speckled Dace in its stomach. We also saw a Plains Killifish (*Fundulus zebrinus*) and five adult Common Carp (*Cyprinus carpio*) in the Atomizer Reach, but never observed these fishes above Chute Falls under much high water clarity conditions. Presumably, most of these nonnative fishes invaded the study reaches from upriver sources during late summer 2017 flood events because three Black Bullhead (110-132 mm) caught in the Atomizer reach during the earlier June 2017 monitoring trip were the only nonnative fish caught in that trip.

#### Fishes parasitized by Lernaea cypinacea:

The external anchorworm, *Lernaea cyprinacea*, was not detected on any fish this May.

### Acknowledgments:

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# Data archiving:

Data for the monitoring trip are archived at the Grand Canyon Monitoring in an Access file entitled LC20180515\_LAtomizer.mdb.

#### **References:**

- Cooley, M.E. 1976. Spring flow from pre-Pennsylvanian rocks in the southwestern part of the Navajo Indian Reservation, Arizona. U.S. Geological Survey Professional Paper 521-F.
- Kaeding, L.R., and M.A. Zimmerman. 1983. Life history and ecology of the Humpback Chub in the Little Colorado and Colorado Rivers of the Grand Canyon. Transactions of the American Fisheries Society 112:577-594.
- Mattes, W.P. 1993. An evaluation of habitat conditions and species composition above, in and below the Atomizer Falls complex of the Little Colorado River. Master's thesis. The University of Arizona. 105pp.
- Persons, W.R., D.L. Ward, and L.A. Avery. 2015. Standardized methods for Grand Canyon fisheries research 2015. U.S. Geological Survey, Techniques and Methods, Book 2, Chapter A12. 19 pp.

- Robinson, A.T., D.M. Kubly, R.W. Clarkson, and E.D. Creef. 1996. Factors limiting the distributions of native fishes in the Little Colorado River, Grand Canyon, Arizona. The Southwestern Naturalist 41:378-387.
- Stone, D.M. 2005. Effect of baiting on hoop net catch rates of endangered Humpback Chub. North American Journal of Fisheries Management 25: 640-645.
- Stone, D.M. 2010a. Overriding effects of species-specific turbidity thresholds on hoop-net catch rates of native fishes in the Little Colorado River, Arizona. Transactions of the American Fisheries Society 139:1150-1170.
- Stone, D.M. 2010b. June 2010 monitoring of Humpback Chub (*Gila cypha*) and other fishes above Lower Atomizer Falls in the Little Colorado River, Arizona. Trip report submitted to U.S. Geological Survey's Grand Canyon Monitoring and Research Center by the U.S. Fish and Wildlife Service's Arizona Fish and Wildlife Conservation Office in Flagstaff.
- Stone, D.M., K.L. Young, W.P. Mattes, and M.A. Cantrell. 2018. Abiotic Controls of invasive nonnative fishes in the Little Colorado River, Arizona. American Midland Naturalist 180:115-138.

Table 1.- Sampling efforts and fishes captured above Chute Falls (RKM 14.20 - 17.67) and in the Atomizer reach (RKM 13.58 - 14.11) during the May 15-24, 2018 monitoring trip in the Little Colorado River, Arizona. Numbers of Humpback Chub, Fathead Minnows, and Black Bullhead only include unique individuals, while numbers of Speckled Dace also include recaptured individuals.

	Above Chute Falls	Atomizer reach	Total
Effort Hoop nets deployed Total Hours Mean hours/net ± SD	99 2,391 24 ± 3.8	51 1,145 22 ± 2.5	150 3,535 24 ± 3.5
Native fishes Cyprinidae Humpback Chub ( <i>Gila cypha</i> )	161 (121-362 mm)	106 (46-432 mm)	267 (46-432 mm)
Speckled dace (Rhinichthys osculus)	969	185	1,154
Nonnative fishes Cyprinidae Fathead minnow ( <i>Pimephales promelas</i> )	34	31	65
Ictaluridae Black Bullhead ( <i>Ameiurus melas</i> )	1 (226 mm)	-	1 (226 mm)



Figure 1.- Map showing the two reaches sampled for fishes in the Little Colorado River, Arizona during the May 15-22, 2018 monitoring trip. The Atomizer reach included the river corridor from the top of Lower Atomizer Falls (RKM 13.58) to below Chute Falls (RKM 14.11) and the upper reach included the corridor from the top of Chute Falls to RKM 17.67.



Figure 2.- Length frequency histograms of all unique Humpback Chub captured in reaches above and below Chute Falls in the Little Colorado River, Arizona during the May 2018 monitoring trip.



Figure 3.- Capture locations of all unique Humpback Chub caught above Chute Falls in the Little Colorado River, Arizona during spring 2016-18 monitoring trips. Translocation Camp at RKM 16.20 (X-axis reference line) was the release site for all previously translocated chub. The 2018 trip ensued a prolonged period of baseflow, high CO<sub>2</sub> conditions, while the 2016 and 2017 trips were preceded by an intermingling of baseflow and flood discharges.



Figure 4.- Winter-spring growth rates of juvenile Humpback Chub translocated in October-November of six different years and recaptured during the ensuing spring monitoring trips. The X-axis is organized by the ascending number of intervening days of baseflow discharges ( $\leq 232$  ft<sup>3</sup>/s) that the chub were exposed to between their releases and recaptures; translocation release dates are in parentheses.