June 2009 Monitoring of Humpback Chub (*Gila cypha*) and other Fishes above Lower Atomizer Falls in the Little Colorado River, Arizona

TRIP REPORT
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in the annual report, along with spring and fall 2009 population estimates of humpback chub residing in the lower 13.57 km of the LCR.

The 2009 translocation trip:
In 2009, GCMRC also contracted the USFWS to conduct a fifth translocation trip from July 20-24, 2009. Although the results of the "2009" translocation above Chute Falls will be highly applicable to all subsequent monitoring efforts of translocated chub above Lower Atomizer Falls, they are not germane to the findings reported within this 2009 monitoring trip report. Therefore, the general details and results of the "2009" translocation trip are briefly summarized below for future reference, and for supporting a few statements made in this report.

The "2009" humpback chub translocation trip was conducted by Pam Sponholtz, Randy Van Haverbeke, Michael Pillow, Glen Knowles (USFWS), Brian Healy (Grand Canyon National Park), and Emily Omana (Wildlands Council). On July 20, 2009 all biologists flew by helicopter to Boulders camp (1.9 km above the mouth), whereby they deployed baited hoop nets from 1.15 km to 2.85 km, and intensively seined for 3 days in an attempt to meet the primary objective of translocating 300 PIT tagged juvenile chub (~80-130 mm TL) above Chute Falls (Figure 1). All captured juveniles ~80-130 mm TL were brought back to Boulders camp and placed in holding cans (32 gallon garbage cans with numerous 0.25 inch holes drilled 6 inches above the bottoms of the cans) that were secured in the LCR by ropes to the shoreline. Captures of juvenile chub were relatively high during the first day under the base flow, low turbidity conditions, but then markedly declined by the afternoon of the second day after a freshet arrived and turbidity increased; therefore, the original goal of 300 chub was not met. On July 22, 2009 a total of 199 chub were measured (mm TL) and implanted with 134.2 KHz PIT-tags and placed back into the holding cans until their next day's translocation. Other juveniles that had been previously PIT-tagged during the April and May 2009 monitoring trips were released immediately back into the LCR.

On July 23, 2009, the 199 juveniles targeted for the Chute Falls translocation were slung by helicopter to the 16.2 km release site in two aerated fifty-five gallon drums. At the 16.2 km translocation site, the 199 chub were slowly tempered by exchanging 1/3 of the oxygenated holding-tank water with fresh LCR water every 30 minutes until CO_2 levels in the tank were presumably within 10 mg/L of the release site (i.e., CO_2 levels could not be measured because of high turbidity). Five chub (104-116 mm) died during this tempering phase and were preserved in alcohol for other studies. Once the chub were adequately tempered to CO_2 levels of the LCR, they were transferred to holding cans secured in the LCR, where they were held overnight (~12 hours) and periodically examined for stress behaviors. Ultimately, 194 juvenile chub (mean $\pm$ SE = 118 $\pm$ 0.668 mm TL; range = 85-131 mm TL) were released alive at 16.2 km around 07:30 on July 24, 2009.

nets and the reach above Chute Falls with 33 baited nets, all of which were deployed for three consecutive ~24 h hauls. Many nets were re-deployed to new locations between hauls to reduce potential biases associated with catch rate differences among disparate habitats, and diminishing catch rates overtime.

All captured fishes were identified to species, and examined for the presence and number of external anchorworms, *Lernaea cyprinacea* and other visible parasites. Because of time limitations speckled dace (*Rhinichthys osculus*) were usually just tallied per net set, while all other native fishes were measured to total length (TL mm). In addition to above, all humpback chub, flannelmouth suckers (*Catostomus latipinnis*) and bluehead suckers (*C. discobolus*) were measured for fork lengths (mm), examined for PIT-tags, and adults inspected for sex, spawning condition (e.g., ripe, spent) and spawning characteristics (e.g., spawning tuberculation and coloration). With only a few exceptions, we abdominally inserted a 134.2 KHz PIT-tag into all chub and suckers that had not been previously tagged or only possessed an old 400 KHz PIT-tag. We released all native fishes back into the LCR alive, but sacrificed all nonnative fishes and examined the stomach contents of all large-bodied Ictalurids. Hereafter, all references to fish lengths infer TL measurements.

Nearly 99% of humpback chub that we captured were either PIT-tagged when we first captured them or had been previously PIT-tagged during a prior trip. Therefore, this report focuses entirely on "unique" chub, which refers to individuals counted only once within a trip, regardless of how many times they were recaptured. We did not record PIT-tag numbers on ten chub captured below Chute Falls because one individual (130 mm TL) was found dead in the net, four chub (150-340 mm TL) escaped prior to be scanned, and five chub (256-332 mm TL) had presumably been previously double 134.2 KHz tagged. Two chub captured above Chute Falls escaped before they were scanned for PIT-tags. Considering the high recapture rates within each monitoring trip, it is likely that we later recaptured some of the six chub that escaped and that there were actually fewer than five double-tagged chub. Therefore, all twelve chub with no recorded PIT-tag numbers were omitted from any further consideration in this report. It should be noted that throughout both monitoring trips before we inserted a PIT-tag into any fish, we checked to see if it might have been previously double-tagged by scanning the fish simultaneously with an unused PIT 134.2 KHz tag. Basically, the scanner would only read the unused PIT-tag if no other 134.2 KHz tags were present in the fish.

Conveying information solely on unique humpback chub provides a much clearer depiction of the actual distribution, size structure and numbers of humpback chub residing below and above Chute Falls, and is an essential component for calculating mark-recapture population estimates. Likewise, all ensuing statements made on nonnative fishes also refer to unique individuals because these fishes were all removed from the system. In contrast, all statements made

0.23 °C) trip. The mean dissolved CO_2 measured 188.91 mg/l during the marking trip, but this was not measured during the recapture trip. Over the past year the mean daily water temperatures above Chute Falls were generally much more conducive for humpback chub to grow than the temperatures occurring near the LCR confluence (Fig. 2). The 2008-09 temperatures above Chute Falls rarely dropped below 10.8 °C, where humpback chub are estimated to cease growing (Robinson and Childs 2001), and were usually much closer to humpback chubs' estimated 24 °C final thermal preferendum (Bulkley et al. 1981; Bulkley and Pimentel 1983) than those occurring near the confluence.

Sampling efforts:
Sampling efforts within each reach were very similar between monitoring trips (Table 1). Between Lower Atomizer and Chute Falls biologists deployed 51 net sets during both the marking (1,128 total fishing hours; mean ± SD = 22.1 ± 3.33 h/net set) and recapture (1,160 total fishing hours; 22.7 ± 3.23 h/net set) trips. Above Chute Falls, biologists deployed 99 net sets during both the marking (2,366 total fishing hours; 23.9 ± 4.47 h/net set) and recapture (2,360 total fishing hours; 23.8 ± 3.67 h/net set) trips.

Humpback chub:
General overview
During the 2009 monitoring efforts, humpback chub were the most commonly captured fish in the reach below Chute Falls, and were the second most commonly captured fish above Chute Falls, next to speckled dace (Table 1). A grand total of 890 unique chub (mean ± SE = 210 ± 2.2 mm, range = 105-435 mm) were captured during this 2009 study (i.e., unique to overall study), which included 734 chub (208 ± 2.59 mm, range = 105-435 mm) captured below Chute Falls, and 156 chub (221 ± 3.27 mm, 120-344 mm) captured above Chute Falls. In actuality, two unique chub had migrated between study reaches (i.e., one descended and one ascended Chute Falls) between the 2009 monitoring trips; therefore, they were only tabulated (above and hereafter) in the reaches where they were first caught during the marking trip. The size distributions of unique chub captured this year varied greatly between reaches (Fig. 3). Of the 734 unique chub captured below Chute Falls, 32% were <150 mm (N=234, 135 ± 0.52 mm, 105-149 mm) and 68% were ≥150 mm (N= 500, 243 ± 2.67 mm, 150-437 mm). In contrast, only 3% of the 156 unique chub captured above Chute Falls were <150 mm (N= 4, 134 ± 5.94 mm, 120-145 mm) and 97% were ≥150 mm (N=152, 223 ± 3.14 mm, 150-344 mm).

As mentioned above, one humpback chub descended and one chub ascended Chute Falls between the 2009 monitoring trips. The downriver migrant (3D9.1BF20F6F2B) measured 117 mm when it was initially translocated above Chute Falls on July 22, 2008, but had grown to 231 mm when it was recaptured above Chute Falls at 16.27 km on June 6, 2009, and then measured 238 mm when it was last recaptured 20 days later below Chute Falls at 14.11 km on June 26, 2009. More interesting was the 346 mm female (3D9.1BF24229B9) that was

between Lower Atomizer and Chute Falls in 2006-08, (D) 46 upriver migrants that had been originally PIT-tagged somewhere below Lower Atomizer Falls, and (E) 344 new "unknown origin" chub that had never been previously PIT-tagged. The 105 previously translocated fish included two "2003" translocated chub (306 & 365 mm), nine "2004" translocated chub (310 ± 8.9 mm, 267-350 mm), eight "2005" translocated chub (289 ± 10.4 mm, 263-335 mm), and 86 "2008" translocated chub (194 ± 1.94 mm, 153-251 mm).

Two humpback chub captured during the marking trip below Chute Falls contained both an old 400 KHz and new 134.2 KHz PIT-tag. Female chub 3D9.1BF22D58AF was originally tagged (43471B5E10) just below Atomizer Falls on April 9, 2002 (150 mm at ~13.56 km), then she migrated above Lower Atomizer Falls by May 24, 2006 (382 mm at 13.73 km), then returned to just below Lower Atomizer Falls by May 2, 2008 (402 mm at 13.56 km), then within 26 days migrated back above Lower Atomizer Falls by May 28, 2008 (408 mm at 13.68 km), where she was last captured on June 4, 2009 (405 mm at 13.74 km). Similarly, female chub 3D9.1BF24D7B8A was originally tagged (43471A0A19) just below Lower Atomizer Falls on May 16, 2002 (166 mm at ~13.56 km), where she was recapped on September 18, 2002 (204 mm at 13.56 km), then she migrated above Lower Atomizer Falls on May 24, 2006 (351 mm at 13.86 km), where she was recapped on June 27, 2007 (368 mm at 13.86 km), and again on June 3, 2009 (372 mm at 13.79 km). Hence, the recapture histories suggest that both of these females have spent their entire life spans since being 150-166 mm size fish in the vicinity of Lower Atomizer Falls (~7 years).

The 156 unique humpback chub captured solely above Chute Falls consisted of (A) 125 previously translocated chub, (B) 17 "unknown origin" chub that had been originally been PIT-tagged above the falls in 2003-08, (C) one "unknown origin", upriver migrant that had been originally PIT-tagged below Chute Falls during 2006, and (D) 13 "unknown origin" chub that had never been previously PIT-tagged. The 125 previously translocated chub included one "2003" translocated chub (326 mm), one "2004" translocated chub (287 mm), two "2005" translocated chub (284 mm & 303 mm), and 121 "2008" translocated chub (209 ± 1.74 mm, 157-265 mm).

Patterns of "unknown origin" chub

During the 2009 monitoring trips, nearly 70% of the unique humpback chub captured were of "unknown origin", which includes 583 of the 734 (~79%) unique chub caught below Chute Falls, and 31 of the 156 chub caught (~20%) caught above Chute Falls (Fig. 5). This constitutes the highest captures of "unknown origin" chub since annual monitoring trips began after the first "2003" translocation. We initially began capturing these "unknown origin" chub above Chute Falls during the fall 2004 monitoring trip (~11% of 72 unique chub), which were mostly assumed to be previously translocated "2003" or "2004" chub that lost their elastomer-tags. Then over 47% and 66% of the chub captured above Chute Falls during the fall 2005 (~3 months after the "2005" translocation) and

Migration patterns of "2003-05" translocated chub

The recapture histories of the "known" translocated humpback chub from the "2003-05" translocations provide some insight into the migratory patterns of these fish. As previously stated, the "known" translocated chub only included: 70 of the 283 "2003" chub (~25%), 61 of the 300 "2004" chub (~20%), and 95 of the 567 "2005" chub (~17%). During the 2009 monitoring trips above Lower Atomizer Falls, we caught three "2003" chub (1 above and 2 below Chute Falls), 10 "2004" chub (1 above and 9 below Chute Falls), and 10 "2005" chub (2 above and 8 below Chute Falls), which constitute ~4.3%, 16.4%, and 10.5% of the known "2003", "2004" and "2005" translocated chub, respectively. However, from 2004 to spring 2009 a total of eight "2003" chub, 13 "2004" chub, and 16 "2005" chub have been recaptured either below Lower Atomizer Falls in the LCR or in the Colorado River. Thirty-five of these 44 downriver migrants seem to have remained within the upper half of the LCR (i.e., only recaptured between 10.46-13.57 km), of which 14 chub have only been recaptured in the pool just below Lower Atomizer Falls (13.45-13.55 km). However, three "2003", three "2004" and one "2005" translocated chub had migrated all the way to the Colorado River. One "2004" translocated chub (3D9.1BF1D860A5) that was captured in the Colorado River on May 17, 2006, had migrated back up the LCR to be recaptured in the pool below Lower Atomizer Falls (13.52 km) on September 19, 2007, and was just recaptured on May 7, 2009 near the confluence at 3.70 km. A "2005" translocated chub (3D9.1BF24DC606) that was captured on April 5, 2007 near the confluence at 3.10 km had subsequently migrated back upriver to ~12.26 km where it has been repeatedly recaptured on September 23, 2007, April 6, 2008 and May 4, 2008. Thus far, there have been five "2003-05" translocated chub (one "2003", one "2004", and three "2005" chub) that have migrated downriver below Lower Atomizer Falls and then later returned to above Lower Atomizer Falls. If we assume that all these "2003-05" downriver migrant, translocated chub are still alive (they were all adults) and include those caught this year above Lower Atomizer Falls (minus the three that returned from downriver), then we can roughly assume that at least 14.3%, 36.1% and 26.3% of the PIT-tagged "2003-05" translocated chub, respectively, are still alive.

Stock assessment information

The mark-recapture population estimates for humpback chub residing below and above Chute Falls, which will be presented in the 2009 final report, could include most of the 890 unique humpback chub ≥105 mm captured during this study. Thus, the ensuing stock assessments could be calculated from the following ratios of unique fish. Below Chute Falls, we accrued a total of 576 "marked" chub (mean TL ± SE = 210 ± 2.97 mm, range = 105-437 mm) from the marking trip, 500 "captured" chub (212 ± 2.98 mm, 113-425 mm) from the recapture trip, and 341 "recaptured" chub (217 ± 3.62 mm, 114-431 mm) in the recapture trip from the marking trip. Above Chute Falls, we accrued a total of 142 "marked" chub (222 ± 3.53 mm, 120-344 mm), 124 "captured" chub (225 ± 3.82 mm, 129-346 mm), and 109 "recaptured" chub (226 ± 4.08 mm, 143-344 mm).

A total of 13 unique common carp (*Cyprinus carpio*) were captured, four were caught below Chute Falls (160-218 mm) and nine above Chute Falls (163-508 mm). The 508 mm common carp caught above Chute Falls was ripe with thousands of eggs. Only four unique black bullhead (*Ameiurus melas*) were captured during this study, two were caught below Chute Falls (225 & 260 mm) and two above Chute Falls (113 & 163 mm). The stomach of the 260 mm black bullhead caught below Chute Falls contained a 77 mm speckled dace. The last two nonnative species that were captured included a 46 mm red shiner (*Cyprinella lutrensis*) and 47 mm plains killifish (*Fundulus zebrinus*), both of which were captured above Chute Falls.

Fishes parasitized by *Lernaea cypinacea*:
The external anchorworm, *Lernaea cyprinacea*, was detected on 82 and 22 humpback chub captured below and above Chute Falls, respectively, during this 2009 study. Lernaea was also occasionally detected on some speckled dace, but not on any other species of fish during this study.

DISCUSSION

During the 2009 monitoring trips we captured a total of 734 unique humpback chub residing between Lower Atomizer and Chute Falls and 156 unique chub above Chute Falls. In comparison, we captured 319 unique chub below and 30 above Chute Falls during the 2008 monitoring trips; 432 below and 72 above Chute Falls during the 2007 monitoring trips; and 531 below and 313 above Chute Falls during the 2006 monitoring trips (Stone 2006b, 2007, 2008). Presumably, these catches of unique chub over the past four years represent valid population trends since all 2006-09 monitoring trips were conducted under similar base flow discharges, low turbidities, relatively warm water temperatures, and sampling efforts. Thus, this year's number of unique humpback chub captured between Lower Atomizer and Chute Falls was the highest thus far, while the number captured above Chute Falls was the highest since 2006 (Fig. 5). Obviously, part of these increases resulted from recapturing 69% of the 299 "2008" translocated chub, but even if we omit the 86 and 121 "2008" chub that were recaptured below and above Chute Falls, respectively, we still have captured 648 and 35 unique chub below and above Chute Falls, respectively. Hence, this year's number of unique chub captured between Lower Atomizer and Chute Falls still remains the highest of the 2006-09 surveys (actually, it's the highest ever recorded), and we still captured more unique chub above Chute Falls than during last year's low of 30 chub. Unfortunately, nearly 70% of the unique chub caught this year were of "unknown origin"; therefore, the alleged increase of chub cannot be irrefutably linked to the translocation experiment. Presumably, many of the "unknown origin" chub that have been captured above Lower Atomizer Falls since the initial "2003" translocation were previously translocated chub that lost their elastomer-tags or the progeny of translocated chub, but there is no way to distinguish them from the other "unmarked" chub,

2006-08, respectively, were of "unknown origin". Then 299 PIT-tagged chub were translocated on July 22, 2008, whereby 20% and 79% of all unique chub captured above and below Chute Falls, respectively, during this year's 2009 monitoring trips were of "unknown origin".

Undoubtedly, not all "unknown origin" humpback chub that have been captured above Lower Atomizer Falls since the first "2003" translocation were previously translocated individuals that lost their elastomer-tags, but a large proportion of them probably were. Although the historical sampling efforts within this upper LCR corridor were highly sporadic, all available information indicates that humpback chub were never captured above Chute Falls before the initial 2003 translocation and that they were relatively rare between Lower Atomizer and Chute Falls during the 1980-90s but became somewhat more abundant by an April 2000. For example, Kaeding and Zimmerman (1983) conducted the most historical, relatively thorough fish survey from Blue Spring to the LCR confluence in 1980-81, but discontinued sampling the upper 5 km after two intensive sampling efforts yielded no chub. During five 1992-93 monitoring trips, Bill Mattes (1993) sampled this upper LCR corridor fairly intensively for his Master's thesis, but only captured nine chub in 167 net sets deployed between Lower Atomizer and Chute Falls, and no chub in 139 nets deployed above Chute Falls. Arizona State University personnel captured 40 chub between Lower Atomizer and Chute Falls in 18 hoop nets deployed in 1991-1992, but made no other captures, thereafter, despite some occasional sampling attempts. In contrast, during April 2000 we captured 119 unique chub in 54 net sets deployed between Lower Atomizer and Chute Falls, but this still only amounts to ~26% of the 457 "unknown origin" chub that were captured in this reach during 2006 after 1,150 chub had been translocated. Lastly, just prior to initial August 1, 2003 translocation, we intensively sampled above Chute Falls for 2.8 km with 60 baited hoop nets to collect baseline ichthyofauna data from July 7-11, 2003, but captured no chub (Stone 2006a). Thus, all historical surveys indicate that numbers of humpback chub residing between Lower Atomizer and Chute Falls dramatically increased following their "2003-05" translocations, and that no humpback chub were ever captured above Chute Falls before they were translocated there.

Though marking all "2003-05" translocated humpback chub with elastomer-tags has resulted in an undetermined number of "unknown origin" chub, which in turn has resulted in major information gaps to the translocation experiment, other important information has been saved by PIT-tagging "known" subsets of these translocated fish. Moreover, much of the missing information can eventually be recouped (i.e., estimated) by the information gleaned from the "2008", "2009" and ensuing batches of translocated PIT-tagged chub. For example, we definitely recaptured 22 of the 1,150 "2003-05" translocated chub (1.91%) below Lower Atomizer Falls during the 2006 monitoring trips, but this only amounted to 4.14% of the 531 unique chub captured there. Moreover, we also captured 457 "unknown origin" chub and presumed that many of these fish were actually

Of the 299 "2008" chub (mean ± SE = 117 ± 0.57 mm, 85-136 mm) released at 16.2 km on July 22, 2008, we recaptured 121 individuals above Chute Falls (209 ± 1.74 mm, 157-265 mm) and 86 between Lower Atomizer and Chute Falls (194 ± 1.94 mm, 153-251 mm) during June 2009, and seven others below Lower Atomizer Falls (162 ± 9.89 mm, 126-193 mm) during the April-May 2009 monitoring trips. Basically, since being translocated ~11 months prior, the 121 "2008" chub recaptured above Chute Falls showed the highest growth (91 ± 1.55 mm, 49-145 mm), followed by the 86 "2008" recaps between Lower Atomizer and Chute Falls (75 ± 1.78 mm, 40-123 mm), and lastly by the seven "2008" recaptured below Lower Atomizer Falls (50 ± 6.35 mm, 26-64 mm) earlier this spring. Although high food availability, such as macroinvertebrates and speckled dace, is considered a major factor behind their high growth rate above Chute Falls (Robinson et al. 1996; Stone and Gorman 2006), we also know that the water temperatures within this upper corridor remain more conducive for growth throughout most of the year than the temperatures occurring in the lower reaches of the LCR (Robinson and Childs 2001; Bulkley et al. 1981; Bulkley and Pimentel 1983; Fig. 2).

Presumably, humpback chub have been actively spawning above Chute Falls for at least five years. During the spring 2005 monitoring trip, we captured three ripe "2003" translocated males, four ripe "unknown origin" males, and one spent "2003" female above Chute Falls (Stone 2006a). In ensuing years during the marking and recapture summer trips, respectively, we captured 18 and 14 ripe males in 2006, 29 and 9 ripe males in 2007, 19 and 9 ripe males in 2008, and 57 and 22 ripe males this year above Chute Falls (Stone 2006b, 2007, 2008). Although no ripe females have ever been captured above Chute Falls, one female was described as "spent", and numerous females displayed bright orange spawning colorations and sometimes tuberculations during all of the above trips.

We hypothesized that that some of the 101 "unknown origin" chub (141± 6.5 mm; 70-350 mm) that were captured above Chute Falls in the fall 2005 were actually produced from earlier spawning activities (Stone 2006a); however, it wasn't until the summer 2007 that we captured three "non-translocated" YOY humpback chub (54-63 mm) above Chute Falls (Stone 2007). Still, the degree that chub successful spawn, the quantity of offspring produced, and the level of recruitment to adulthood that has occurred above Chute Falls remains highly speculative. For example, during 2009 sampling efforts above Chute Falls we captured five previously "unmarked" juvenile chub between 120-150 mm, which are all smaller than the smallest recaptured "2008" chub (i.e., 157 mm), so were these juveniles originally hatched above the Chute Falls? Furthermore, this year we also captured 281 previously "unmarked" juvenile chub between 105-156 mm between Lower Atomizer and Chute Falls, whereby a portion of these juveniles could have been hatched above Chute Falls and then migrated downriver. Perhaps, adult chub commonly reproduced above Chute Falls, but their resulting offspring have not been identified as such because these YOY chub were growing atypically fast to what is typically considered age-1 or age-2 chub and

relatively accurate (described above). Obviously, if these five upriver migrants were translocated chub, then the question arises whether they had become imprinted to this area, possibly to spawn? The upriver migrants captured in 2007 consisted of three males displaying spawning colorations, of which two were ripe, and one female that was captured in a net with eight ripe males. The female chub that had migrated above Chute Falls between monitoring trips of this year did not display spawning coloration when she was caught below Chute Falls, but did when she was recaptured 28 days later above Chute Falls. Furthermore, she migrated above Chute Falls under base flow conditions, which refutes the hypothesis that upriver migrating chub require elevated discharges to bypass Chute Falls, and makes us question the actual degree that upriver migrating chub are impeded by Chute Falls. Potentially, chub migrating above Chute Falls could be a relatively common occurrence that we have been unable to document during our summer monitoring trips before most chub have migrated back downriver. The fact that Chute Falls can no longer be considered a complete barrier to upriver migrating chub opens the possibility that many other translocated fishes will eventually return to this area.

Potential imprinting:

As mentioned above, the five chub that migrated above Chute Falls and the migratory patterns exhibited by most of the "2003-05" translocated chub seem symptomatic of imprinting. In other words, it is plausible that some of the translocated chub may have developed an imprint (i.e., long-term memory) to this upper corridor by the distinctive water chemistry via the olfactory imprinting hypothesis (Hasler and Wisby 1951), which they associate with positive attributes, such as high food availability, ideal water temperatures, spawning habitats etc. Generally, chemical imprinting is used to describe the mechanism that allows various migratory species to navigate from foraging locations to specific spawning areas (e.g., homing salmon); however, it does not necessarily have to be for reproduction. For example, Hasler and Wisby (1983) were able to imprint the distinctive odors from two different streams on bluntnose minnow (*Hyborhynchus notatus*), and train these fish to discriminate the odors of one stream with a reward (food) and the odors of the other stream with a punishment (electric shock). Hence, from this standpoint many of the translocated chub that remained above Chute Falls for an extended period of time could have imprinted a positive memory of this area. However, Hasler and Wisby (1983) also found that the imprinted memory lasted longer in the younger than older trained fish, which suggest that proportionally more of the 1,150 "2003-05" chub (mean ~70 mm, range = 50-100 mm) will longer retain an imprinted memory of the waters above Chute Falls (if this does in fact occur) than the 299 "2008" (117 $\pm$ 0.57 mm; 85-136 mm) and 194 "2009" (118 $\pm$ 0.668 mm; 85-131 mm) chub.

Though it has yet to be substantiated whether humpback chub imprint to the water odors affiliated with specific spawning areas, there exists a possibility that some of the translocated chub, and especially any progeny that hatched above Chute Falls, have become imprinted to the LCR corridor above Chute Falls.

translocations of PIT-tagged humpback chub. In some ways it was actually advantageous that we initially marked the chub with elastomer-tags rather PIT-tags because this allowed for the release of much smaller chub during the "2003-05" translocations (N= 1,150, mean ~70 mm, range = 50-100 mm), than during the "2008" (N= 299, 117 ± 0.57 mm; 85-136 mm), "2009" (N= 194, 118 ± 0.67 mm; 85-131 mm) and presumably other ensuing translocations. Therefore, we know that many YOY chub can definitely survive and grow quickly to adulthood above Chute Falls. Moreover, if humpback chub do in fact imprint to specific LCR locations by unique odors in the water, then the literature indicates that this should more commonly occur among the smaller, rather than larger chub that were translocated and remained for some time above Chute Falls. If some translocated chub or progeny, thereof, have indeed imprinted to the waters above Chute Falls, then someday this uppermost LCR corridor could eventually become a natural expansion of the spawning and rearing habitats used by this species. This scenario may not be that far fetched, considering the five upriver migrants that have thus far been identified, the increasing densities of chub that are amassing just below Chute Falls, and the high captures spawning conditioned fish within this area.

Aside from humpback chub, also noteworthy was this year's captures of three previously untagged, juvenile flannelmouth suckers (169-212 mm) above Chute Falls, which constitutes the first records of this species being captured above Chute Falls. Perhaps, these suckers were upriver migrants that ascended Chute Falls, but this seems unlikely considering their historically low captures for miles downriver below Chute Falls. It is also plausible that these suckers were unintentionally transported and released above Chute Falls during the "2008" translocation trip, but it seems that one of the biologists of that trip would have noticed them in the containers with the juvenile chub. I suggest that these suckers might be what Minckley (1973) refers to as Little Colorado suckers, and were originally from somewhere in the upper LCR basin, perhaps in Clear Creek or Chevelon Creek, but were able to disperse downriver through the intermittent LCR corridor to this Chute Falls area during prior freshets (Stone et al. 2007). If many nonnative fishes cannot make this run, why not flannelmouth suckers!

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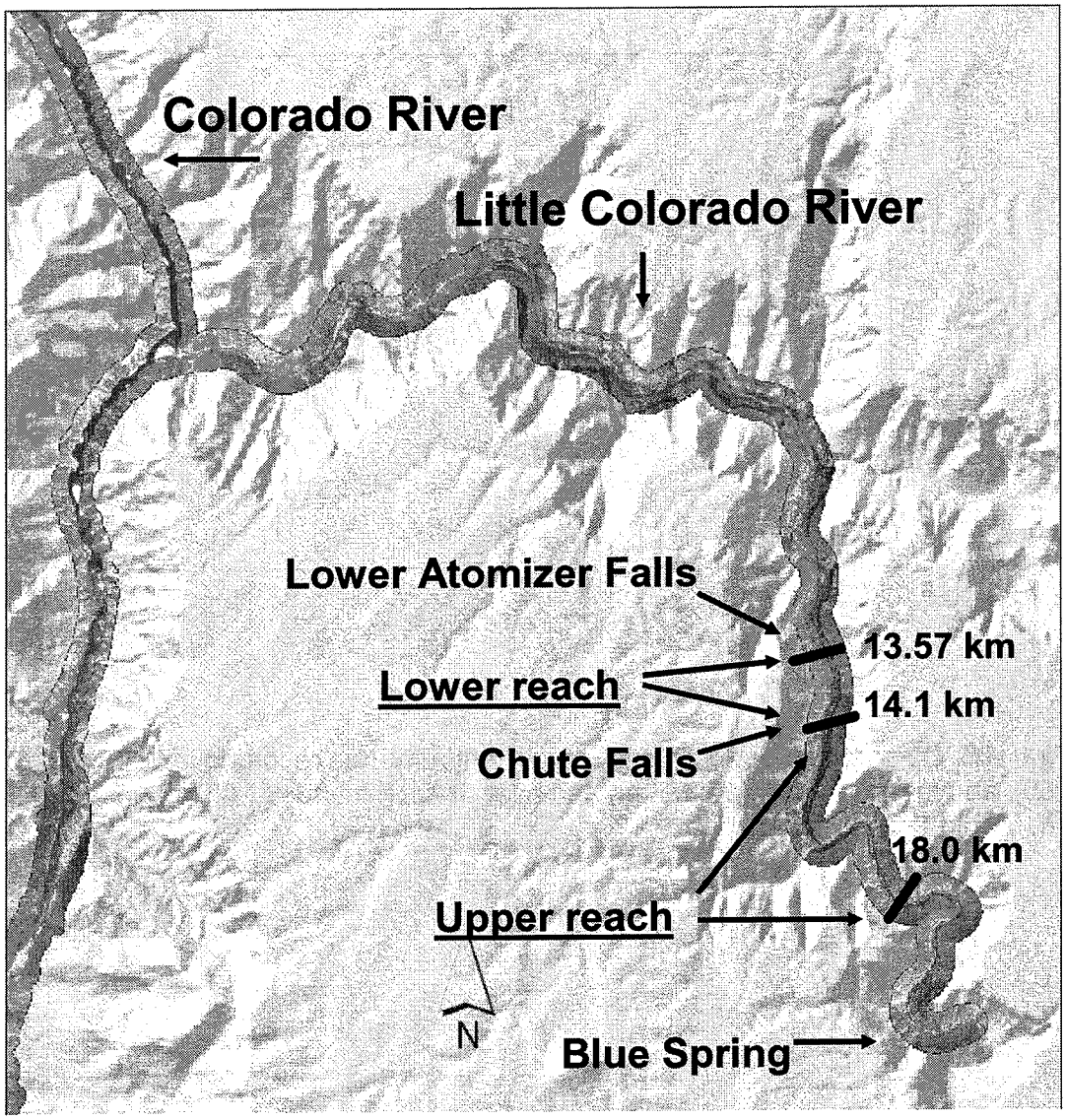

Figure 1.- Map showing the two sampling reaches surveyed for fishes in the Little Colorado River, Arizona during the marking (June 2-8) and recapture (June 25-July 1) 2009 monitoring trips. The lower reach included the river corridor from the top of Lower Atomizer Falls (13.57 km) to below Chute Falls (14.11 km) and the upper reach included the corridor from the top of Chute Falls to ~17.89 km. During both trips, the lower reach was sampled with 17 baited hoop nets and the upper reach with 33 baited nets, all of which were deployed for three consecutive ~24 h hauls.

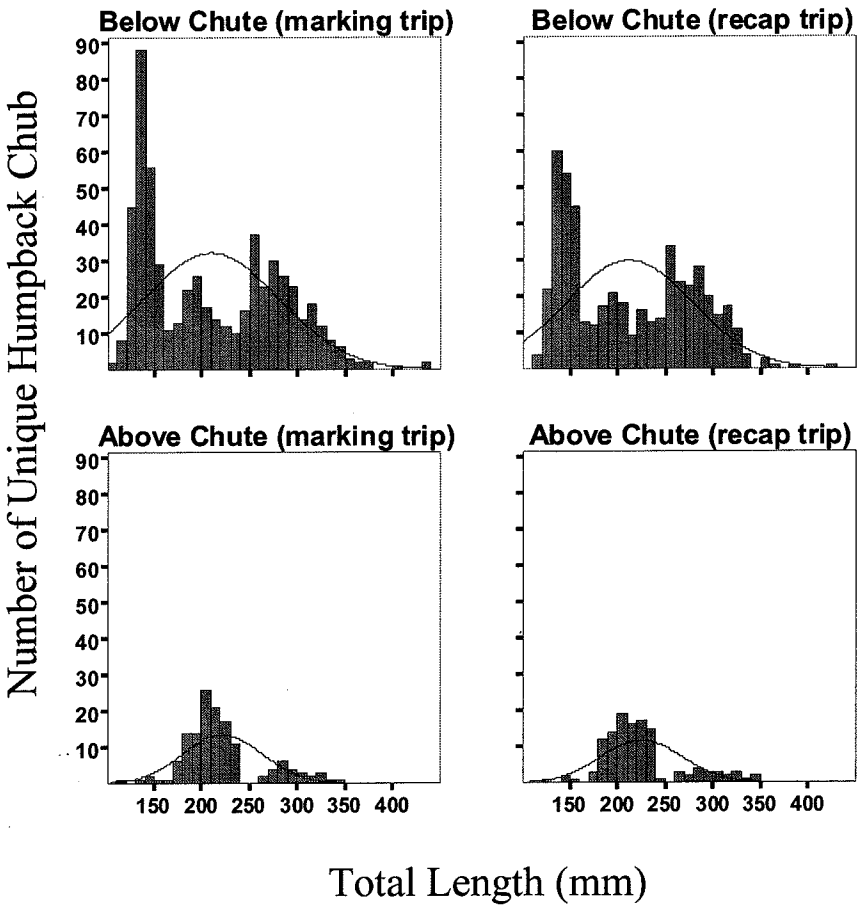

Figure 3.- Length frequency histograms of all unique humpback chub captured below and above Chute Falls of the Little Colorado River, Arizona during marking (June 2-8) and recapture (June 25-July 1) 2009 monitoring trips.

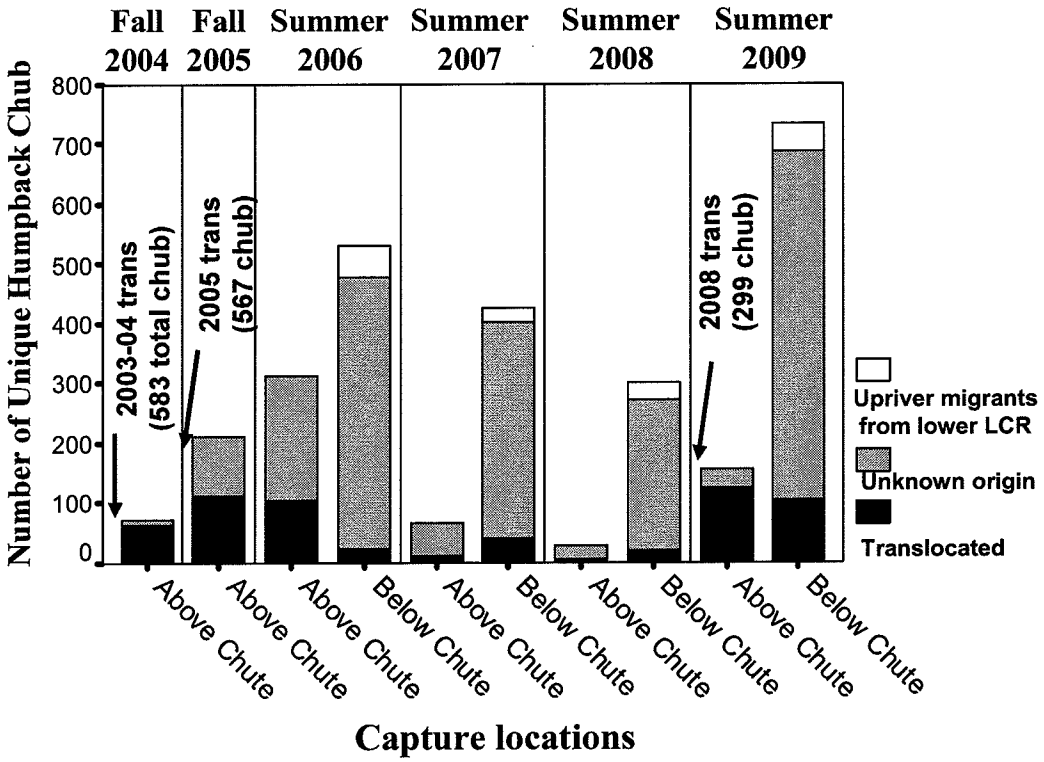

Figure 5.-Comparisons between the numbers of translocated, "unknown origin", and "upriver migrant" unique humpback chub that were captured above Chute (>14.11 km) and between Lower Atomizer and Chute Falls (13.57-14.11 km) in the Little Colorado River, Arizona since 2004. All translocated chub possessed identifying marks (elastomer or PIT-tagged) from the 2003-05 and 2008 translocations upon being initially captured; "unknown origin" chub possessed no identifying marks upon being initially captured, and upriver migrants were chub caught above Lower Atomizer after being previously PIT-tagged in the LCR corridor below the falls. Note that annual sampling between Lower Atomizer and Chute Falls did not begin until three years after the first "2003" translocation.