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In Reply Refer to:

AESO/SE/  
02EAAZ00-2012-F-0059  
02EAAZ00-2014-CPA-0029  
02EAAZ00-2022-0063848

### Memorandum

To: Regional Director, Bureau of Reclamation, Salt Lake City, Utah

From: Field Supervisor, Phoenix, AZ *Heather Whitlaw* Digitally signed by HEATHER WHITLAW  
Date: 2022.12.01 14:12:56 -07'00'

Subject: Response to Exceeding Tier 1 Trigger for Humpback Chub

Thank you for the Bureau of Reclamation's (Reclamation) summary reporting of the Humpback Chub Tier 1 Trigger being met. This responds to your memorandum requesting concurrence by the U.S. Fish and Wildlife Service (Service) that the response and conservation activities taken are in accordance with the 2016 LTEMP BO. In your summary you included the report entitled "LTEMP Biological Opinion – Humpback Chub Tier 1 Trigger Response Report, 2021-2022". This report explains the LTEMP BO triggers for Humpback Chub and outlines Reclamation's proposed response to exceeding the population trigger.

We have reviewed the materials provided and conclude that Reclamation's plans are in accordance with the LTEMP BO. All covered actions and implementation of the conservation measures are suitably described and documented. Reclamation is a strong partner for conservation in the Lower Colorado River Basin, and we commend the program's contribution.

Thank you for your continued coordination and commitment to conservation of threatened and endangered species. In all future correspondence on this project, please refer to the consultation number 2022-0063848. Should you require further assistance or if you have any questions, please contact Dan Leavitt, [daniel\\_leavitt@fws.gov](mailto:daniel_leavitt@fws.gov), of my office staff.

cc: Project Leader, Arizona Fish and Wildlife Conservation Office ([jess\\_newton@fws.gov](mailto:jess_newton@fws.gov))



# LTEMP Biological Opinion- Humpback Chub Tier 1 Trigger Response Report, 2021-2022



Photo Credit: R. Pedersen, Reclamation

## Long-Term Experimental and Management Plan

The Long-Term Experimental and Management Plan (LTEMP) provides a framework for adaptively managing Glen Canyon Dam and describes specific dam operations and actions that could be implemented to improve conditions and to minimize adverse impacts to natural, recreational, and cultural resources downstream. A Biological Opinion (BO) for the Glen Canyon Dam LTEMP was issued by the U.S. Fish and Wildlife Service (Service) in 2016 and describes three listed species that the LTEMP may affect<sup>1</sup>, including humpback chub (*Gila cypha*) and its critical habitat.

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<sup>1</sup> The Service concluded that “The proposed action may affect the endangered humpback chub (*Gila cypha*) and its critical habitat, the endangered razorback sucker (*Xyrauchen texanus*) and its critical habitat, and the endangered Kanab ambersnail (*Oxyloma kanabensis*).” Since finalization, humpback chub was [downlisted from endangered to](#)

The BO identifies ongoing conservation measures to protect humpback chub including establishment of a humpback chub refuge at a federal hatchery, recurring translocations to Colorado River tributaries, and monitoring of translocated fish. It also specifies the need to estimate the population by monitoring the humpback chub in the Little Colorado River aggregation, which is the primary spawning habitat for humpback chub.

Since incidental take of humpback chub is difficult to detect for a variety of reasons specified in the BO, abundance is estimated by modeling humpback chub in the Little Colorado River. This was established under the BO as the best available way to determine how many humpback chub could be incidentally taken without affecting species persistence. Consequently, the BO identifies a minimum threshold of sub-adult and adult humpback chub in the Little Colorado River aggregation, necessary to avoid the need for additional management actions (USFWS 2016). The management action triggers are based on a two-tiered approach that prioritizes additional humpback chub conservation actions before more invasive efforts to remove predaceous fish are employed. Tier 1 triggers are meant to serve as an early warning that a decline in adults or sub-adults is occurring. Tier 2 mechanical removal of non-native aquatic predators would only occur if the additional conservation actions were ineffective in slowing or reversing the decline in humpback chub numbers. The action triggers and potential responses are evaluated every 5 years and were most recently updated in [2021](#).

## Humpback Chub Life History

Humpback chub are a threatened native fish species found in canyon-bound reaches of the Colorado River and its tributaries. Although once distributed across a large portion of the river, the species is now limited to six isolated reproducing populations (Gorman and Stone 1999). The largest of these populations occurs in the lower basin of the Colorado River below Glen Canyon Dam. The Little Colorado River has been an important stronghold for humpback chub within the Grand Canyon ecosystem because it is a warmwater tributary that provides habitat for spawning and rearing of young of the year fish. A more recent population of humpback chub was first detected in the western Grand Canyon in 2014 and has experienced rapid population growth since then (Van Haverbeke et al. 2017). However, this population is relatively young, its population dynamics are not well understood, and it may be less stable than the Little Colorado River aggregation. There is also uncertainty about the connectivity between the humpback chub in the western Grand Canyon and the Little Colorado River aggregation.

Many juvenile humpback chub move from the Little Colorado River to the mainstem during summer monsoons; those that remain in the Little Colorado River until they are larger tend to have higher survival rates as adults when they move to the mainstem compared to adults that remain in the Little Colorado River. Declines in juvenile humpback chub abundance tend to be observed when mainstem water temperatures are colder and salmonid abundances are high (Yard et al. 2011; Yackulic et al. 2018). Adults reared in the Colorado River return to spawn and a portion of the population reside in the Little Colorado River year-round (Yackulic et al. 2014).

Non-native fish including rainbow trout, channel catfish and brown trout are known predators of humpback chub (Marsh and Douglas 1997). Humpback chub are opportunistic generalist feeders that consume various foods including invertebrates, seeds, algae, and other fish (Stone et al. 2020).

## Current Conditions in the Little Colorado River Aggregation

The tier 1 trigger for additional conservation actions includes thresholds for both adult and sub-adult humpback chub, and population estimates are evaluated annually to ensure that any declines are detected

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[threatened](#), razorback sucker was proposed for [downlisting from endangered to threatened](#), and the Kanab ambersnail was [removed from the list of endangered and threatened wildlife](#).

early. Tier 1 management actions are triggered if the estimate<sup>2</sup> for adult humpback chub<sup>3</sup> in the Little Colorado River aggregation<sup>4</sup> falls below 9,000 (Table 1; as listed in Biological Assessment - Appendix O of EIS). Tier 1 actions may also be triggered if recruitment (transition of fish to the next age class) of sub-adult humpback chub<sup>5</sup> does not exceed adult mortality. Specifically, the 3-year average of sub-adult humpback chub in the Little Colorado River in the spring must be equal to or above 1,250 fish (Table 2). In addition, the 3-year average of sub-adult humpback chub in the mainstem Colorado River from river miles 63.45 to 65.2<sup>6</sup> in the fall must be above 810 fish. Sub-adult thresholds are based on a 3-year average since production of younger life stages can be highly variable (Van Haverbeke et al. 2013), and reduced recruitment in any one year can be compensated in subsequent years with increased recruitment.

**Table 1.** The threshold for adult ( $\geq 200$ mm) humpback chub (HBC) that triggers additional conservation actions along with estimates for 2020 and 2021. The threshold is based on the number of adults in the mainstem Little Colorado River (LCR) aggregation ( $\geq 2,000$ ) and in the LCR ( $\geq 7,000$ ).

# of adult humpback chub ( $\geq 200$ mm) that triggers additional conservation actions	Estimated # humpback chub	
	2020	2021
$\leq 9,000$	11,000	11,000

Tier 2 management actions are triggered if the estimate for adult humpback chub in the Little Colorado River aggregation falls below 7,000. These thresholds were developed based on estimates of data collected from 2009-2012 and maintained following the required [5-year review of the triggers](#).

In 2020 and 2021, the number of adult humpback chub in the Little Colorado River aggregation was 11,000 fish (Table 1). While adult numbers have declined in recent years, estimates are still well above the tier 1 threshold. Similarly, the average number of sub-adults in the Little Colorado River in the spring was above the trigger of 1,250 for the period from 2018 through 2020 and from 2019 through 2021 (Table 2). However, the average number of sub-adults for the same 3-year periods in the mainstem Colorado River in the fall from river miles 63.45 to 65.2 was below the threshold of 810 (Table 2).

**Table 2.** The threshold that triggers additional conservation actions for humpback chub (HBC) based on when recruitment of sub-adults (150-199 mm) HBC does not equal or exceed estimated adult mortality.

Location of population	# of sub-adult humpback chub (150-199 mm) triggers additional conservation actions	2018-2020	2019-2021
Sub-adult population estimate in Little Colorado River in spring	$\leq 1,250$ for 3 years	1,800	1,426
Sub-adult population estimates in mainstem in JCM Reach* in fall	$\leq 810$ for 3 years	600	433

<sup>2</sup> Estimates are derived from the currently accepted humpback chub population model.

<sup>3</sup> Adults are defined as those fish with length of 200 millimeters (mm) or greater.

<sup>4</sup> The Little Colorado River aggregation includes those fish in the Little Colorado River, as well as those in the mainstem Colorado River from river miles 57 to 65.9.

<sup>5</sup> Sub-adults are defined as fish with length between 150 to 199 mm.

<sup>6</sup> River miles 63.45 to 65.2 are referred to as the Juvenile Chub Monitoring Reach of the mainstem Colorado River.

## Potential Factors Contributing to Decline

There are various reasons that the number of sub-adults in the mainstem may have declined and continues to decline.

- Larval Production. There was poor mainstem recruitment from 2016-2018 and in 2021 ([Van Haverbeke et al. 2022 Annual Reporting Meeting Presentation](#)), possibly due to minimal monsoonal and flooding activity in the Little Colorado River. Lack of flooding typically leads to lower numbers of larval fish and monsoonal activity typically leads to increased outmigration of age-0 fish from the Little Colorado River to the mainstem. Due to the delay for larval fish to grow large enough to be classified as sub-adults, it is possible a decline in sub-adults is only now detectable.
- Poor Sub-Adult Recruitment. Larval production in the Little Colorado River in 2019 and 2020 ([Van Haverbeke et al. 2022 Annual Reporting Meeting Presentation](#)) was sufficient to expect an increase in sub-adults to be observed in 2021. However, the number of sub-adults continued to decline, and it is unclear where the fish went. It is possible they moved out to the mainstem later than usual (winter rather than summer or fall) because monsoons were weak or non-existent and monsoons typically trigger movement into the mainstem.
- Mainstem Adult Condition. Another possibility is that the humpback chub in the mainstem have experienced a long-term decline in body condition (ratio of weight to length). As a result, they may have stayed in the mainstem rather than move into the Little Colorado River to spawn because the energetic costs of moving were too high. This may have led to lower recruitment.
- Unmeasured Predation. The effect of some aquatic predators such as channel catfish in the Little Colorado River has not been measured. The size and impact of the catfish population in the Little Colorado River is unknown.
- Habitat Quality. Due to minimal monsoons and lack of flooding in the Little Colorado River in winter 2020/spring 2021 there was an accumulation of marl which provided poor habitat for humpback chub. This may have led to low survival of humpback chub eggs and larval fish in the Little Colorado River.

## Response Options

The BO includes four proposed responses (listed below) with the fourth option allowing flexibility to identify additional conservation actions for implementation.

The conservation actions listed in the BO are as follows:

1. Expand translocations in the Little Colorado River by collecting an additional 300-600 young of the year (YOY) humpback chub and moving them above Chute Falls in October.
2. Assess the efficacy of transporting larval humpback chub into Big Canyon and above Blue Springs and evaluate growth and survival of these transplants.
3. Larval fish will be removed from the Little Colorado River and head-started at the Southwestern Native Aquatic Resources and Recovery Center. Once fish reach 150-200 mm they will be translocated to the mainstem Little Colorado River the following year.
4. Additional conservation actions as identified and evaluated.

The options listed below were proposed by subject matter experts during the [Five-Year Review of Action Triggers for the Management of Humpback chub](#) completed in 2021 as additional conservation actions to consider (part of #4). These ideas could be incorporated into ongoing activities and require no additional compliance.

- a. Move >300 humpback chub above Chute Falls until the carrying capacity is reached.
- b. Translocate large sub-adults (up to 160 mm) from the Little Colorado River in spring or fall to the mainstem where presumably survival rates will be higher

- c. If normal Chute Falls translocations are limited, translocate bigger (up to 150-160 mm instead of 80-130 mm) humpback chub.

Moving sub-adults from the Western Grand Canyon and releasing them in the mainstem near the Little Colorado River and collecting 30-60 ripe humpback chub to translocate above Chute Falls or Blue Springs were identified as other ideas that may be successful at addressing the decline in humpback chub but would require additional planning prior to implementation.

### Important Time Points

The Annual Reporting Meeting for the Glen Canyon Adaptive Management Program (GCDAMP) occurs every January. During this meeting Grand Canyon Monitoring and Research Center (GCMRC) reports the abundance estimates for sub-adult and adult humpback chub. The Service conducts annual trips to the Little Colorado River as part of the GCDAMP Triennial Work Plan to monitor humpback chub. These trips are conducted in April, May, September, and October. The data collected on these trips are used to calculate the annual abundance estimates reported the following January. The estimates are not only valuable for determining whether the threshold has been exceeded, but they will also be used to evaluate the success of conservation actions. Conservation actions are not expected to have an immediate effect on the trigger because the actions target larval fish or sub-adults to prevent a decline in adults and there is a delay as fish transition between life stages.

**Table 3.** Important time points for actions related to humpback chub

Month	Activity
January	Humpback chub estimates reported for previous year during Annual Reporting Meeting
April	Mark humpback chub in Little Colorado River
May	Recapture humpback chub for abundance estimates
July	Sample humpback chub in the Little Colorado River and Juvenile Chub Monitoring reach (RM 63.45-65.2)
September	Mark humpback chub in Little Colorado River
October	Recapture humpback chub for fall abundance estimates and annual Chute Falls translocations; sample humpback chub in Juvenile Chub Monitoring reach

These activities delineate important time points when data is available to determine whether the humpback chub threshold has been exceeded and/or if action is needed to determine what that action might be. Once larval recruitment is assessed in April, a decision can be made if sufficient fish are available to collect larval fish for conservation actions or to support the federal hatchery. During the September trip an assessment of the number of sub-adults is used to determine the number of sub-adults that are available to move above Chute Falls where growth rates are higher. Reclamation has and will continue to coordinate closely with the Service after each of these time points to ensure that the best decision is made to support humpback chub recovery.

### Timeline of Detection and Communication

Reclamation supports translocations, monitoring, and a refuge population of humpback chub as part of the conservation measures listed in the 2016 LTEMP BO. The partners that conduct the work related to the conservation measures provide annual reports that detail the activities and data collected to support the conservation measures. Reclamation realized the potential initiation of this trigger when the annual reports were received in December 2020 and immediately initiated contact with the Service. Since then, Reclamation has communicated and coordinated frequently with the Service regarding the actions taken. The major timelines when Reclamation communicated with the Service related to the tier 1 trigger are reported in Table 4. This does not include communication that occurs on a regular basis.

**Table 4.** Timeline of Detection and Communication Related to Exceeding the Tier 1 Trigger

<b>Timeframe</b>	<b>Action</b>
<b>December 2020</b>	Reclamation received annual reports from partner agencies summarizing 2020 work and observations. Preliminary humpback chub population estimates suggested that one of the tier 1 triggers may have been met. Final numbers are typically reported at the Annual Reporting Meeting in January.
	Reclamation notified the Service and scheduled further discussion.
<b>January 2021</b>	Reclamation met with the Service to discuss preliminary population data and next steps to develop an appropriate response, if warranted.
	GCMRC finalized the humpback chub population estimates and confirmed the tier 1 recruitment trigger conditions had been met.
	Reclamation, in close coordination with the Service, contacted subject matter experts to schedule further discussion and planning.
	Reclamation notified the Glen Canyon Dam Adaptive Management Program Technical Work Group that tier 1 trigger conditions had been met.
<b>February 2021</b>	Reclamation met with subject matter experts to discuss the potential responses outlined in the Biological Opinion and additional ideas for conservation actions.
	Reclamation notified the Adaptive Management Work Group that the tier 1 humpback chub recruitment trigger had been met.
<b>March 2021</b>	Reclamation continued discussions with the Service regarding a potential response.
<b>April 2021</b>	Reclamation finalized and submitted an annual report documenting the conservation measures progress for 2020, as well as formal notification to the Service that the trigger had been exceeded.
	Reclamation and the Service continued discussions regarding a potential response.
	Reclamation started to draft a proposed response plan.
	Reclamation provided an update to the Technical Work Group.
	The Service conducted a routine monitoring trip to the Little Colorado River to mark humpback chub and assess the recruitment success. Initial findings suggested that recruitment was poor and there was a buildup of marl due to lack of spring runoff.
<b>May 2021</b>	Reclamation and the Service continued to discuss the plan and updated it based on the current conditions.
	The Service conducted a monitoring trip to the Little Colorado River to recapture humpback chub and translocated 535 sub-adults (300 as part of the normal translocations and 235 additional fish in response to the trigger) above Chute Falls as part of the response.

<b>June 2021</b>	Reclamation initiated discussions with the Service about the process for conducting a 5-year review of the Humpback Chub Triggers
	Reclamation provided an update on the response to the trigger and the process for conducting a 5-year review of the Humpback Chub Triggers
<b>July/August 2021</b>	Reclamation organized and co-led three discussions with biologists from the management agencies related to updating the Humpback Chub Triggers.
	Reclamation and the Service met several additional times during these months to coordinate on the approach for updating the Humpback Chub Triggers
<b>September 2021</b>	Reclamation and the Service met with Department of Interior solicitors to update them on the proposed approach for finalizing the 5-year review.
<b>December 2021/ January 2022</b>	Reclamation received the annual report with updated trigger numbers from partner agencies and notified the Service.
<b>March 2022</b>	Reclamation submitted the 2021 LTEMP Compliance Conservation Measures Progress Report to the Service including an update on the status of the triggers.
<b>April 2022</b>	The Service conducted annual monitoring of humpback chub in the Little Colorado River and reported that recruitment was too low to collect larval fish for the federal fish refuge in Dexter, NM.
<b>May 2022</b>	The Service conducted the annual recapture trip to determine spring estimates of humpback chub.
<b>July 2022</b>	Reclamation scheduled a call with the Service to discuss the appropriate documentation for Tier 1 actions.
<b>August 2022</b>	Reclamation and the Service discussed options for responding to the trigger including moving additional fish above Chute Falls in fall 2022.

## Evaluation of Potential Response Actions

The response actions from the BO (listed below in regular print) were considered and the explanation of how that action was addressed is in italics.

1. Expand translocations in the Little Colorado River by collecting an additional 300-600 (YOY) humpback chub and moving them above Chute Falls in October. *Poor habitat conditions in the Little Colorado River in winter/spring 2021 caused by a lack of flooding led to low numbers of larval fish in spring 2021. Since the number of larval fish in the spring serves as a predictor of the number of YOY fish available for translocations in the fall, the Service determined that there would not be sufficient fish to move to Chute Falls in October 2021. The Service will assess the number of YOY fish in the Little Colorado River in September 2022 to determine whether there are sufficient fish for translocation in October 2022. This option will likely continue to be considered in the future if humpback chub numbers continue to decline.*
2. Assess efficacy of transporting larval humpback chub into Big Canyon and above Blue Springs and evaluate growth and survival of these transplants. *Poor habitat conditions in the Little Colorado River in 2021 resulted in reduced recruitment success and no larval fish were collected in 2021. Conditions were improved in spring 2022 but there were still insufficient larval fish for*



*collection despite attempts by the Service and GCMRC. Since the success of this action is unclear compared to other actions, this option would be considered in the future only if there were sufficient fish for other purposes. This option is included in a prioritized list for larval fish in case there is a need in the future to take additional actions (as described below in the actual and proposed response section).*

3. Larval fish will be removed from the Little Colorado River and head-started at the Southwestern Native Aquatic Resources and Recovery Center (SNARRC). Once fish reach 150-200 mm they will be translocated to the mainstem Little Colorado River the following year. *Lack of flooding is typically associated with lower humpback chub recruitment success. The lack of flooding in the Little Colorado River in 2021 led to an accumulation of marl (calcium carbonate mud) which created poor habitat conditions for humpback chub recruitment. During the annual monitoring trip in April 2021, the Service noted that due to poor habitat conditions, it was unlikely that sufficient larval fish could be collected to transfer to the refuge for future translocations/refuge augmentation. In May 2021, the Service confirmed that there were no larval fish available. In fall 2021/winter 2022, there were several flooding events which cleared out the accumulated marl and improved the habitat significantly. Despite these habitat improvements, the Service and GCMRC attempted to collect larval fish in May 2022, but there were insufficient larval fish for collection. However, even if larval fish had been collected in 2021 or 2022, this option would not have been considered to address the trigger since translocation into the Little Colorado River would not address the trigger of too few sub-adult humpback chub in the mainstem.*

*Maintaining the refuge population is a high priority and SNARRC personnel have requested 200 humpback chub for that purpose. Due to the lack of larval fish in 2021, age-1 fish were considered for transport to SNARRC with the idea that they could be used for translocations in the future if needed. However, the first priority was to move additional humpback chub above Chute Falls and there were not enough fish to move to SNARRC. In September 2022, the Service will assess whether there are sufficient fish to move above Chute Falls and to transfer to SNARRC. If sufficient fish are available, translocations will occur in October 2022. This option will be considered each year since maintaining the refuge is a high priority to ensure there are fish available for translocations.*

4. The following additional conservation actions (in regular print) identified during the 5-year review of the Humpback Chub Triggers in 2021 were considered and how they were addressed is in italics.
  - a. Move >300 humpback chub above Chute Falls until carrying capacity is reached. *This option is considered minimally invasive because it is simply moving additional fish during trips that are already planned. Humpback chub moved above Chute Falls have higher growth rates which translates to higher survival rates. New research indicates that translocations increase adult abundance and reduce the need for non-native fish removal (Yackulic et al. 2021). This option is also considered to be relatively cost effective since it would be incorporated into work that is already occurring.*
  - b. Translocate large sub-adults from Little Colorado River in spring or fall to mainstem where presumably survival rates would be higher. *GCMRC modeled this example to determine the difference in survival and the net benefit of moving the sub-adults compared to the cost. However, there were several reasons for deciding against implementing this option. This option was labor-intensive, and the net benefit was uncertain and likely to be low given the number of sub-adults that could feasibly translocated. If larger sub-adults were moved (i.e., the 2019-year class), a relatively small percentage would be expected to survive. Due to the costs, logistics, and risks*

*associated with a helicopter in the Grand Canyon, this option was removed from consideration.*

- c. If normal Chute Falls translocations are limited (YOY fish moved in October), translocate bigger humpback chub (age-1 (up to 150-160 mm) instead of 80-130 mm). *Larger humpback chub are better able to avoid predation and consequently would be expected to have higher survival rates. The Service conducts annual translocations of sub-adults above Chute Falls. This action would target moving slightly larger fish to further increase growth and survival rates.*

## Priority for Fish Collected

Humpback chub are needed for various purposes including conservation actions, routine translocations, and for the federal hatchery. It is unlikely that there will be enough fish every year for all needs. Consequently, we have developed a priority for collection to help guide decisions.

### Larval fish priority

Larval collections were cancelled in 2020 due to COVID-19 and insufficient fish were available for collection in 2021 and 2022 meaning that there are very few humpback chub currently available at the refuge.

*The priority for larval collections (all of these would be transported to SNARRC initially, but could be used for conservation actions the following spring if needed) is as follows:*

1. Transport to refuge (to improve genetic diversity)
2. Translocations
  - a. routine translocations to the tributaries (Havasu, Bright Angel Creek)
  - b. translocate to the mainstem if needed due to observance of further declines
  - c. translocate to Big Canyon to assess efficacy

Larval collections are included as a conservation measure in the BO, but additional larval fish could be collected to respond to the trigger. If there are a limited number of larval fish, they may be collected for the refuge with the stipulation that they would be used for translocations over the following couple of years if the humpback chub population continues to decline.

The next priority would be to collect larval humpback chub for future translocations. This would include translocations to Havasu or Bright Angel Creeks as part of the conservation measures. Humpback chub transferred to the refuge could also be translocated to the mainstem in the future if the population continues to decline. The larval fish could be translocated to Big Canyon if all other objectives have been met. This option is thought to be higher risk because the habitat is considered marginal, and it is unknown whether humpback chub would thrive. Nonetheless, this could be a good opportunity to evaluate whether this is a viable option, and if successful would help contribute towards improving the decline.

### Sub-adult priority

Sub-adult humpback chub considered for translocations include age-0 (YOY) to age-1 fish (approximately 60-149 mm).

*The priority for collection of sub-adults if there are a limited number of translocations would be as follows:*

1. Translocate 600 sub-adults (300 additional) above Chute Falls
2. Translocate 200 sub-adults to SNARRC

Sub-adult fish are translocated above Chute Falls as part of the Service's routine annual efforts. Recent research indicates that translocations positively impact adult humpback chub abundance and are cost effective because they decrease the necessity of conducting non-native removals (Yackulic et al. 2021). Fish moved above Chute Falls grow faster and have higher survival rates. Since these translocations are minimally invasive and require minimal additional resources, this option is one of the highest priorities.

Larval fish are typically the priority for transfer to SNARRC for grow out and future translocations. However, due to recent conditions in the Little Colorado River preventing collection (COVID-19, poor production, etc.), transfer of sub-adults to SNARRC to preserve genetic integrity was considered in 2021 and will be considered again in 2022.

## Actual & Proposed Response

### 2021

Reclamation and the Service coordinated closely in 2021 to determine the most effective response to exceeding the trigger based on the conditions. Larval fish were unavailable for collection which eliminated any potential responses that required larval fish. The Service typically translocates 300 sub-adult humpback chub annually above Chute Falls where growth rates are higher. Research suggests that translocations are a cost-effective way of increasing adult abundance and minimizing the need to implement more controversial mechanical removals (Yackulic et al. 2021). Based on this research and the recommendation of subject matter experts, moving an additional 300 fish above Chute Falls was determined to be the most effective action to address the decline in 2021. If additional fish were available, they were proposed to be transferred to the federal hatchery (SNARRC) to improve genetic diversity of the refuge population of humpback chub. In May 2021, the Service moved 535 sub-adult humpback chub (235 additional fish beyond the normal translocations of 300) above Chute Falls. This was slightly below the goal of 600. Additional translocations to move additional fish were considered for fall 2021, but there were insufficient fish to warrant an additional translocation effort.

### 2022

In 2022, Reclamation and the Service discussed the continued decline in sub-adult humpback chub. Habitat conditions improved in the Little Colorado River after winter and spring flooding cleared out the accumulated marl. However, the Service and GCMRC attempted to collect larval humpback chub in May 2022, but there were insufficient fish available. If larval fish had been available, they would have been transferred to SNARRC to improve genetic diversity at the hatchery. In September 2022, during the Service's routine recapture trip, the abundance of YOY fish will be assessed to determine if there are enough fish available to move above Chute Falls (beyond the normal translocations) in October 2022 to respond to the trigger.

## Conclusions

The thresholds for triggering a response for humpback chub were set based on information available when the 2016 LTEMP BO was developed. Due to the controversial use of mechanical methods, the thresholds were set to allow enough time to recognize a decline and implement additional conservation actions to lessen the need for more drastic management actions including mechanical removal.

The additional conservation actions selected as responses to the trigger for 2021 and 2022 are consistent with the compliance obtained for the conservation actions listed in the BO. Consequently, no additional compliance was necessary to implement the actions which ensured a timely response. In addition, since the actions expanded on activities that were already planned, the cost was minimal. The selected options were considered both feasible and minimally invasive to minimize any unnecessary effects.

Monitoring is a key component to measure the success of additional conservation actions. Currently, relative abundance estimates of humpback chub aggregations are calculated to monitor the status of the population in the Colorado River. In addition, a multi-state model applied annually to assess the Little Colorado River aggregation and several closed Chapman Peterson mark-recapture abundance estimates are conducted opportunistically in west Grand Canyon. In the Little Colorado River, humpback chub are marked in April and September, and then recaptured in May and October respectively. This data is used to conduct closed Chapman Petersen mark-recapture abundance estimates of humpback chub of various size classes. These estimates along with mainstem Colorado River estimates by GCMRC form the basis for abundance estimates that are calculated annually to determine whether the trigger thresholds are exceeded. These same monitoring metrics along with the multi-state model that GCMRC conducts can be applied to assess whether the additional conservation actions are effective. Since changes in the population cannot be detected immediately, we expect there to be a delay before an increase in the population is observed even if the conservation actions are effective.

Although the sub-adult population estimates in the mainstem in the Juvenile Chub Monitoring reach (river miles 63.45-65.2) in fall are currently the focus of the response, Reclamation continues to monitor the number of sub-adults in the Little Colorado River which is also declining. Due to the decline in the number of sub-adults, an ensuing decline in adults is expected in the next couple of years. Despite the current actions to address the trigger, it is likely that it will take time before an effect is observed in the population. Ideally, a decline in adults below the trigger would be avoided with these conservation actions but it is possible that the number of adults may drop below the threshold before the sub-adults transition to adults. Although additional conservation actions may result in an increase in the population, the population may also recover without intervention since fluctuations are normal.

Conditions in the Colorado River are changing rapidly with water temperatures below Glen Canyon Dam much warmer than they have been since the dam was completed. Although humpback chub grow faster in warmer water, it also means that other warmwater invasive species, such as smallmouth bass, may become established. Smallmouth bass were detected in the lower slough (river mile -12) in June 2022. Reclamation recognizes the threat and is pursuing several avenues to prevent establishment.

## Literature Cited

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