United States Department of the Interior
BUREAU OF RECLAMATION
125 South State Street, Room 8100
Salt Lake City, UT 84138-1102

IN REPLY REFER TO:
UC-410
2.2.1.06

VIA ELECTRONIC MAIL ONLY

Mr. Jeff Humphrey
Field Supervisor, U.S. Fish and Wildlife Service
9828 North 31st Avenue, #C3
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Subject: Five-year Review of Action Triggers for the Management of Humpback Chub Consistent with the 2016 Biological Opinion for the Glen Canyon Dam Long-Term Experimental and Management Plan, October 2021

Dear Mr. Humphrey:

The 2016 Biological Opinion for the Glen Canyon Dam Long-Term Experimental and Management Plan includes action triggers for managing humpback chub and specifies that these triggers should be reviewed a minimum of every 5 years. The Bureau of Reclamation (Reclamation), working jointly with the U.S. Fish & Wildlife Service (Service), co-led a series of meetings over the course of summer 2021 to evaluate the action triggers and to consider potential updates. As I indicated in my April 16, 2021 communication to you, the number of sub-adult humpback chub near the Little Colorado River confluence recently declined to a level that has triggered a management response. As a result of this recent and practical application of the triggers, Reclamation, the Service, and our colleagues were well positioned to determine if any improvements to knowledge base, assessment methods, or implementation were warranted. The purpose of this communication is to transmit to you the subject document, which resulted from the 5-year review.

Overall, there were few updates made to the document; most edits were minor and served to add clarity or update scientific literature. During the review process, subject matter experts also identified a few topics and emerging issues that will be revisited during the next review, which will occur not later than five years from now, in 2026. These topics include the contribution of the relatively recent population of humpback chub in the Western Grand Canyon, further development and implementation of the aquatic predator index, and whether the bioeconomic model should be incorporated into the management action triggers. The attached update includes an appendix (Appendix A) to capture the review process and document conversations and ideas that were identified by subject matter experts during review.

We appreciate the consideration, input and time that the review team contributed to improving the report, both in attending meetings and reviewing the final document. Please let us know if you have any concerns with the attached. If you have any questions or if you would like to discuss further, please contact Ms. Lee Traynham, Adaptive Management Group Chief for the Upper Colorado Basin Region, at (801) 524-3752. For the hearing impaired please call the Federal Relay System at (800) 877-8339 (TTY).

Sincerely,

WAYNE PULLAN

Digitally signed by WAYNE PULLAN
Date: 2021.12.17 18:00:06 -08'00'

Wayne G. Pullan
Regional Director

Enclosure

cc: ASWS, GCMRC, NPS, UC-100 (WPullan), UC-110 (DPicard), UC-400 (KCallister), UC-410 (LTraynham), UC-411 (KPedersen), UC-600 (NWilliams)

Action Triggers for the Management of Humpback Chub Colorado River, Grand Canyon

October 2021

This document was revised in October 2021 and replaces the Proposed Action Triggers for the Management of Humpback Chub Colorado River, Grand Canyon November 2015.

Originally developed in 2015 by an Ad Hoc group of Grand Canyon Aquatic Biologists from USFWS, USGS-GCMRC, AZGFD, NPS, USBR (Kirk Young, David Van Haverbeke, Scott Vanderkooi, David Ward, Charles Yackulic, Mike Yard, Brian Healy, Melissa Trammell, David Rogowski, Marianne Crawford)

These action triggers were reviewed and updated in 2021 by Lucas Bair (GCMRC), Winkie Crook (Hualapai Tribe), Maria Dzul (GCMRC), Clarence Fullard (Reclamation), Jessica Gwinn (FWS), Brian Healy (NPS), Kerri Pedersen (Reclamation), David Rogowski (AZGFD), Melissa Trammell (NPS), Scott Vanderkooi (GCMRC), David Van Haverbeke (FWS), David Ward (GCMRC), Charles Yackulic (GCMRC), Kim Yazzie (Navajo Nation), and Kirk Young (FWS)

PURPOSE

Mechanical removal of nonnative species is an issue in the Colorado River through Glen and Grand Canyons. A spring 2015 meeting of Grand Canyon biologists (NPS, USFWS, AZGFD, GCMRC) to assess current trout removal triggers resulted in a concept of early conservation measure intervention to maximize conservation benefit to humpback chub (HBC) and minimize the likelihood of mechanical predator removal. The concept of tiered action triggers was documented and subsequently implemented as a provision of the 2016 Biological Opinion for the Glen Canyon Dam Long Term Experimental and Management Plan (USFWS 2016).

Consistent with the intent of the Biological Opinion, a 5-year review of the action trigger document was conducted by a multi-agency team in summer 2021. A summary of the discussions that occurred during the review process can be found in Appendix A. Updates recommended by the team and consistent with the 2016 Biological Opinion are incorporated herein and replace the November 2015 version of the Proposed Action Triggers for Management of Humpback Chub Colorado River, Grand Canyon. This document is focused on conservation of HBC in Grand Canyon, and because of the known primary and historical importance of the Little Colorado River (LCR) to HBC populations in the Grand Canyon, this document focuses on the LCR aggregation of HBC. This population includes the HBC in the LCR and in the mainstem from river mile (RM) 57-65.9.

Many factors are known or hypothesized to affect HBC population dynamics such as water temperature, predation, turbidity, food availability, nutrients, and water volume in the LCR (Dzul et al. 2016, Yackulic et al. 2018, Dibble et al. 2021). This restrains available conservation actions that can be implemented in the event of a declining population of HBC. We can translocate juveniles or young of the year to other areas within (Stone et al. 2020, Yackulic et al. 2021) and outside the LCR system (Spurgeon et al. 2015, Healy et al. 2020), juvenile HBC can be head-started at a hatchery, and we can attempt to remove predators. Other conservation tools may include parasite control (although this is unlikely from a population standpoint), non-native fish control, and protection from over-utilization for scientific purposes.

Methods to actively manage temperature releases from Glen Canyon Dam and sediment augmentation below the Paria River are not included in the Long-Term Experimental Management Plan (LTEMP) for Glen Canyon Dam. Inclusion of infrastructure options including these were eliminated from detailed study in the LTEMP alternatives for a variety of reasons. We mention them here because these methods may still represent the most important potential conservation tools that could be used for the long-term conservation of HBC in Grand Canyon and the concepts should not be lost.

While healthy wildlife populations are rarely static, trigger objectives include prescribing actions to reverse/ameliorate impacts in order to maintain the LCR HBC population within an acceptable range; and, secondarily to reduce reliance on mechanical removal of predators. The rationale for these triggers is built from research identifying the primary drivers of HBC population dynamics as interspecific interactions with non-native species, especially rainbow

trout, and low water temperature in the mainstem of the Colorado River (Kaeding and Zimmerman 1983; Douglas and Marsh 1996; USFWS 2002; Coggins *et al*. 2011; Yard *et al*. 2011; Yackulic et al. 2018). Laboratory (Clarkson & Childs 2000; Ward and Morton-Starner 2015; Ward et al. 2016) and field studies (Dzul et al. 2016; Yackulic et al. 2018) provide strong evidence that non-native species impact juvenile survival and cold-water temperatures suppress growth subjecting young HBC to predation for extended periods of time. The approach described here puts the emphasis on managing humpback chub as opposed to managing predators. Predator removal will only occur if other conservation measures do not appear to be effective in maintaining targeted HBC population levels.

TWO TIER APPROACH

Two tiers of sequential actions were identified; the first would emphasize conservation actions that would take place early during a HBC population decline in adults (< 9,000) or in sub-adults (3-year average < 1,250 in LCR in spring or < 810 in mainstem JCM reach in fall). The second tier would serve as a backstop prescribing predator removal (Threat Reduction) if conservation measures did not mitigate a decline in HBC abundance (adults < 7,000).

ACTION TRIGGERS

Tier 1 Trigger – Early Intervention Through Conservation Actions

1a. If the combined point estimate for adult HBC (adults defined ≥200 mm) in the Colorado River mainstem LCR aggregation; RM 57-65.9) and Little Colorado River (LCR) falls below 9,000 as estimated by the currently accepted HBC population model (e.g., ASMR, multi-state).

-OR-

1b. If recruitment of sub-adult HBC (150-199mm) does not equal or exceed estimated adult mortality such that:

1) Sub-adult abundance falls below a three-year running average of 1,250 fish in the spring LCR population estimates.

-OR-

2) Sub-adult abundance falls below a three-year running average of 810 fish in the mainstem Juvenile Chub Monitoring reach (JCM annual fall population estimate; RM 63.45-65.2).

Tier 1 Trigger Response: Tier 1 conservation actions will be immediately implemented in the LCR, the adjacent mainstem, or elsewhere that can provide appreciable conservation benefit to HBC in the LCR aggregation. Conservation actions will focus on increasing growth, survival and distribution of HBC in the LCR & LCR mainstem aggregation area until HBC abundance increases above the trigger threshold for that particular age class (see 1a and 1b above for specific numbers).

Tier 2 Trigger - Reduce threat using mechanical removal if conservation actions in Tier 1 are unsuccessful in preventing the number of adult HBC in the LCR aggregation from declining below 7,000:

Mechanical removal of nonnative aquatic predators will ensue:

> If the point abundance estimate of adult HBC decline to <7,000, as estimated by the currently accepted HBC population model.

Mechanical removal will terminate if:

> Predator index (described below) is depleted to less than 60 RBT/km for at least two years in the JCM reach and immigration rate is low (the long-term feasibility of using immigration rates as a metric still needs to be assessed), or
>
> Adult HBC population estimates exceed 7,500 and recruitment of sub-adult chub exceed adult mortality for at least two years.

If immigration rate of predators into JCM reach is high, mechanical removal may need to continue. These triggers are intended to be adaptive based on ongoing and future research (e.g., Lees Ferry recruitment and emigration dynamics, effects of trout suppression flows, effects of Paria River turbidity inputs on predator survival and immigration rates, interactions between humpback chub and rainbow trout, other predation studies).

Action Triggers Background and Rationale

Tier 1 Trigger Target

Adult Humpback Chub population target: 9,000

Using an age-structured mark-recapture (ASMR) model, Coggins and Walters (2009) estimated the adult population of the LCR aggregation of HBC in 2008 was approximately 7,650 fish (6,000-10,000 fish considering a range of assumed mortality rates and ageing error). Using a multi-state model, Yackulic *et al*. (2014) obtained point abundance estimates of adult HBC between ~11,000-13,000 from 2009 through 2012. This increase in adult abundances roughly coincides with the significant increase of adult HBC that first appeared in the LCR post-2006 (Van Haverbeke *et al*. 2013). We suggest a population estimate of 9,000 adult fish as a desired future conditions target. Estimates falling below 9,000 would trigger additional conservation actions to increase recruitment until the HBC population recovered to 9,000 adult fish. A 9,000 adult chub target is below the 2009-2012 estimate of ~11,000-13,000 individuals and would preclude conservation measures from being initiated immediately, but also provides a "buffer zone" above 7,000 adult fish, at which point mechanical removal is warranted, as originally prescribed in the 2011 high flow Biological Opinion (USFWS 2011).

LCR and mainstem (LCR aggregation) population targets: 2,000 and 7,000 adult HBC, respectively

We separate the 9,000 total adult target number into an LCR component (2,000 adults), and a mainstem Colorado River component (7,000 adults). It is estimated that ~82% of adult HBC reside in the mainstem Colorado River during the non-spawning season (Yackulic *et al.* 2014, p. 1015). This proportion was based on estimates obtained during September/October 2011, so this proportion would be expected to vary, possibly considerably, on an annual basis. Nevertheless, objectives to maintain 2,000 adults in the LCR and 7,000 adults in the mainstem during the non-spawning season (i.e., September/October) are proposed. A desired target of 2,000 adults in the LCR is reasonable because the average fall population estimate for adults was 2,380 (SE = 518) from 2007-2014, compared to the average level of 789 adults (SE = 281) from 2000-2006 (Van Haverbeke *et al*. 2015).

LCR Humpback Chub recruitment target

To maintain a population of 2,000 adult HBC in the LCR during the non-spawning season, there must be sufficient recruitment of sub-adult chub (150-199 mm size class). We estimate that a sub-adult chub population of 1,250 fish annually, as measured during the annual spring spawning season in the LCR is sufficient to maintain the adult HBC target population. This number is derived from an assumption that the annual adult mortality rate *in the LCR* is estimated at 0.35 (Yackulic *et al*. 2014, updates Yackulic pers. com). Hence 2,000 x 0.35 = 700 new adults needed annually to replace adult mortality. To annually recruit 700 adults, we estimate that 1,250 sub-adults are annually needed (i.e., not all sub-adults will survive into adulthood). If annual mortality for sub-adults *in the LCR* is 0.44 (Yackulic *et al*. 2014, updates Yackulic pers. com.), then 700/(1-0.44) = 1,250 sub-adults needed to offset adult mortality.

Because production and survival of younger life stages of HBC can be highly variable (Van Haverbeke et al. 2013), a three-year running average for sub-adults was incorporated instead of an annual estimate. For long-lived species such as HBC, reduced recruitment of sub-adults in any one year can be compensated in subsequent years with increased recruitment. Three years is considered a reasonable timeframe to trigger actions to minimize large changes in adult HBC numbers. If the three-year running average point population size of sub-adult chub measured during the spring season in the LCR drops below 1,250 fish, additional conservation measures would be triggered (Figure 1).

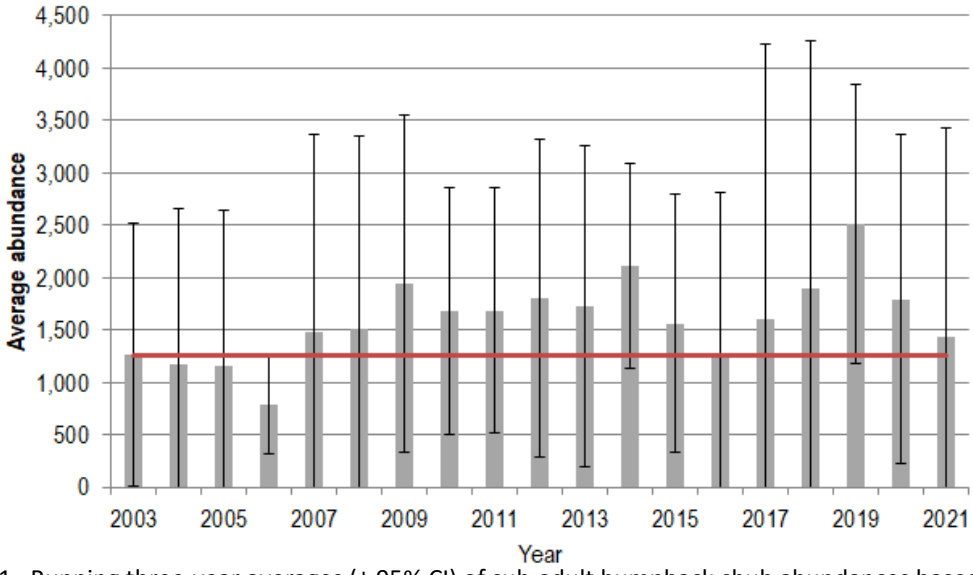

Figure 1. Running three-year averages (± 95% CI) of sub-adult humpback chub abundances based on closed spring mark-recapture studies in the Little Colorado River (Van Haverbeke *et al.* 2013, 2015, 2021). For example, the bar for 2003 represents the average abundance of the 150-199 mm size class of humpback chub for 2001, 2002 and 2003 obtained in the Little Colorado River during spring monitoring (note: error bars are large because of typically large annual variability in the abundance of this size class). If our current triggers were in place, additional conservation measures would have been triggered during 2003-2006. The red line represents a trigger value of 1,250 sub-adults, below which conservation measures would be initiated.

Mainstem LCR aggregation recruitment target

To maintain a population of 7,000 adults in the mainstem LCR aggregation reach outside of the spawning season, there must be sufficient recruitment of sub-adult fish (150-199 mm size class). The boundaries of the LCR aggregation in the mainstem traditionally extend from RM 57 (Malagosa Crest) to 65.9 (Lava-Chuar Rapid) (Valdez and Ryel 1995). Since 2009, most mainstem monitoring efforts in the LCR aggregation reach have focused in the JCM (Juvenile Chub Monitoring) reach (RM 63.45-65.2), which is below the LCR and contains ~18% of the adult HBC population found in the mainstem LCR aggregation reach (Yackulic *et al*. 2014). If ~18% of the population is in the JCM reach, then the desired number of adult HBC to maintain in the JCM reach is 7,000 x 0.18 = 1,260 adults. Annual adult mortality in the mainstem LCR aggregation is estimated at 0.15 (Yackulic et al. 2014, updates Yackulic pers. com.). To replace the adults in the JCM reach each year would require 1,250 x 0.15 = 189 adults. Annual mortality of sub-adult chub in the mainstem is estimated at 0.3. Replacing 189 adults annually would require 189/(1-0.3) = 270 sub-adults. Approximately 1/3 of sub-adult chub grow to adult size each year, and accordingly it may take ~3 years[1] for a chub in the mainstem to transition from the sub-adult to the adult size class (Yackulic *et al.* 2014). Therefore, an acceptable target population of sub-adults in the JCM reach each year would be 810 (270 x 3 = 810). As with the LCR component, a running three-year average of <810 sub-adults in the JCM reach would trigger conservation actions (Figure 2).

[1] The mainstem LCR population recruitment scenario assumes temperature in the LCR mainstem reach is suitable for growth. If LCR mainstem temperatures are cold (do not exceed 11 °C during the year in the JCM reach), HBC will take longer to reach adulthood, experience greater mortality, and therefore require a larger number of sub-adults targeted to maintain the adult population objective. Target number adjustments will be made prior to implementation of LCR mainstem trigger actions if thought necessary.

The above scenario assumes that population recruitment dynamics are operating more or less equally throughout the LCR aggregation reach in the mainstem, which is likely not true. Most juvenile chub exiting the LCR are displaced downriver from the confluence (Valdez and Ryel 1995). As such, we might expect that recruitment into adulthood might be more prevalent downstream of the confluence. As such, the proportional number of sub-adults measured in the JCM reach may not reflect the number actually needed to annually replace a total 7,000 adults. In other words, the JCM reach proportional calculation of 810 sub-adults could be low. For example, consider that if the JCM reach harbors a higher-than-average percent of the mainstem sub-adult chub that recruit into adulthood, then even more than 810 sub-adults in this reach may be needed to maintain a population of 7,000 adults.

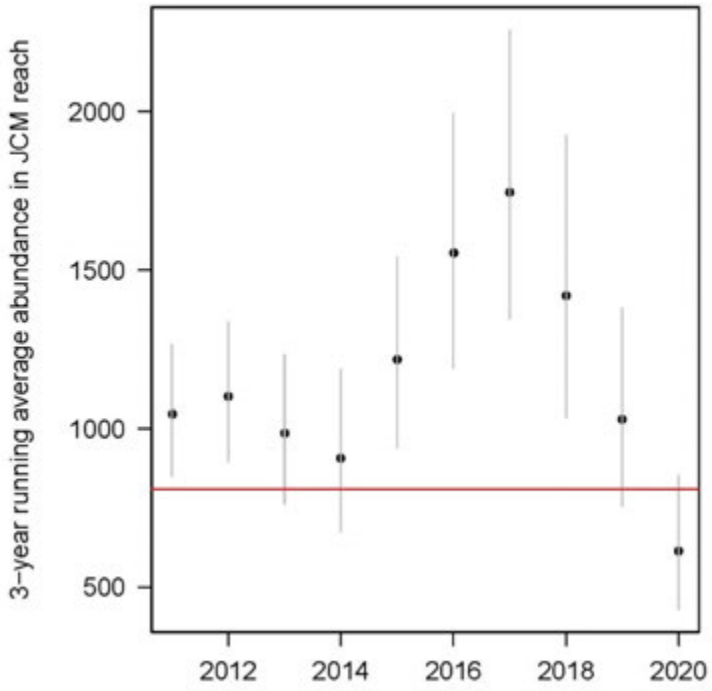

Figure 2. Running three-year average abundances (± 95% CI) of sub-adult humpback chub (150-200 mm) abundances based on multi-state model in the mainstem Colorado River in the Juvenile Chub Monitoring reach. For example, the bar for 2014 represents the average abundance of sub-adult humpback chub in the Juvenile Chub Monitoring reach during 2012, 2013, and 2014. The red line represents the approximate value of a 3-year running average of 810 (action trigger), below which conservation actions would be enacted.

Tier 1 Trigger response – HBC Conservation

It is expected that the conservation actions proposed below will assist in ameliorating HBC adult losses or recruitment failures. First, ongoing translocations in the LCR above Chute Falls (~300 fish/year) as well as outside the LCR population (e.g., to Havasu Creek, etc.) will continue, regardless of whether Tier 1 triggers are met or not. Conservation actions that are part of responding to the trigger may include expansion of existing activities or new actions, including experimental actions. Conservation actions may be comprised of a combination of the actions listed below or other actions determined to alleviate the specific conditions:

- Increase translocation actions in the LCR by moving additional HBC above Chute Falls (Yackulic et al 2021).
- Assess the efficacy of transporting HBC to other locations in the LCR such as into Big Canyon or above Blue Springs. Evaluate growth and survival of these transplants.
- Larval or sub-adult fish can be removed from LCR or other locations and head-started at Southwest Native Aquatic Resources and Recovery Center (SNARRC). Once fish are sub-adults or adults they will be translocated to the mainstem LCR reach the following year (currently grow-out space at SNARRC is limited to 750 HBC, use of fish for this purpose would reduce numbers available for other actions, e.g. Havasu, Shinumo.).
- Translocate sub-adults from the LCR directly into the mainstem LCR aggregation or other appropriate mainstem reaches in the Colorado River.
- Additional conservation actions may be implemented as identified and evaluated (see Appendix A for additional potential actions).

Tier 2 Trigger Targets

Aquatic Predator index

A trout or aquatic predator index is proposed as a means to terminate mechanical removal should it become initiated. Essentially, this is the level (60 predator index fish/km in the JCM reach) at which mechanical removal becomes a futile exercise (i.e., very small return for a high amount of effort). The predator index concept was originally intended to serve as an index whereby mechanical removal would be initiated (e.g., mechanical removal would be initiated once trout levels reached a certain density (~760 index fish/km in the JCM reach). However, because of uncertainty of the actual predation rates of trout on HBC (at differing temperatures, densities, turbidities, etc.), and on its population level effects on HBC, determining an appropriate density of trout at which to initiate mechanical removal is highly uncertain.

A predator index is under development to weigh each probable predator by its ability to prey on HBC. The index calculates predator densities by incorporating additional species besides rainbow trout and makes assumptions about their relative predation rates compared to rainbow trout. For example, brown trout are estimated to be about 17 times more predacious on HBC than rainbow trout (Ward and Morton-Starner 2015). Additional predators (e.g., smallmouth bass) could be included through an assignment of their piscivory level relative to rainbow trout. Thus, relative piscivory can be captured in a rainbow trout equivalent predator index (Table 1). For species for which population estimates cannot be estimated with mark/recapture methods, capture probabilities or relative abundance (e.g. catch per unit effort) will be used to estimate the population and incorporate into the density matrix. Also, for certain species regarded as potentially very piscivorous and dangerous (e.g., smallmouth bass, green sunfish), targeted removal efforts for these species may be initiated immediately upon detection, regardless of meeting any type of threshold. If initiated, mechanical removal would be terminated once the relative predator index declines to 60 or lower in the JCM reach for two years or HBC recover to a target level. A predator index of 60 in the JCM reach likely represents a point at which there is very diminished return for effort expended and is roughly

equivalent to densities at which mechanical removal was deemed to be not worthwhile as an effective tool to pursue in the past (i.e., mechanical was terminated).

Table 1. Hypothetical predator index. The predator index assigns a relative piscivory rate of 17 to brown trout (Ward and Morton-Starner 2015) and sums the hypothetical numbers of predators. If initiated, mechanical removal would be terminated once the relative predator index declines to 60 or lower in the JCM reach for two years or HBC recover to a target level.

Species	Number	Relative predation factor	RBT equivalent
Brown Trout	21	17	357
Rainbow Trout	400	1	400
Predator index total			757

HBC population level triggers

Continue to use the existing adult HBC population estimate of 7,000, as the trigger for predator removal actions. Population estimates of sub-adults are not incorporated in Tier 2 triggers, as in Tier 1 triggers.

Tier 2 Trigger response – Threat Reduction.

Mechanical removal of predators from the LCR aggregation reach (& immediate vicinity) will be conducted until adult HBC population estimates exceed 7,500 and recruitment of sub-adult chub exceed adult mortality for at least two years

TRIGGER CAVEATS

- If HBC decline and the identified actions are not working, USFWS, in coordination with action agencies and traditionally associated Tribes, will identify appropriate actions.
- Triggers will be reviewed and modified as necessary but no less than every five years.
- Actions and triggers will need to adapt if HBC are found to be impacted by other factors.
- If estimating abundances of small size classes of chub becomes problematic because of population decline (i.e., if numbers get so low capture probability cannot be estimated for each trip), catch divided by the best estimate of capture probability will be used to estimate abundance.
- Evaluation will ensue immediately if a new deleterious nonnative aquatic species is detected in or adjacent to the LCR Reach followed by mechanical removal or other appropriate action if necessary.

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Appendix A: 2021 Evaluation of Proposed Management Triggers for Humpback Chub

Background

In 2016, the Record of Decision for the Long-Term Experimental and Management Plan Environmental Impact Statement and the corresponding Biological Opinion (BO) were issued. Included in these documents are proposed action triggers for the management of humpback chub in the Colorado River, Grand Canyon. These triggers were meant to be evaluated every 5 years. The first year for evaluation was 2021 which coincidentally was also the first year that the number of sub-adult humpback chub declined to a level that triggered a response. This provided a unique opportunity to apply the proposed management actions and to guide any changes to the document. A series of meetings was held in 2021 to discuss the response (February) and to evaluate the action triggers (Summer).

Summary of Meeting to Respond to Humpback Chub Decline

In January 2021, GCMRC finalized the Little Colorado River (LCR) mainstem humpback chub population estimates and confirmed the Tier 1 recruitment trigger conditions had been met. Specifically, the three-year average of sub-adults in the section of the Colorado mainstem referred to as the juvenile chub monitoring (JCM) reach (river miles 63.45-65.2) was determined to be below the threshold of 810 individuals. This prompted U.S. Bureau of Reclamation (Reclamation) and the U.S. Fish and Wildlife Service (FWS) to contact representatives from the agencies involved in conducting fish research and management in the Grand Canyon to meet virtually to discuss the action triggers (See Attachment A for meeting agenda). The purpose of the meeting was to discuss the potential reasons for the decline in humpback chub and to brainstorm conservation actions for responding to the decline.

Potential Reasons for Decline

Poor recruitment, which was observed from 2016-2018, was discussed as the primary driver of the decline in sub-adult fish. Slow growth, due to cold water temperatures in the Colorado River, means that juveniles take approximately 4-6 years to recruit to the adult population (Yackulic et al. 2014, Yackulic et al. 2018) so these poor years are just beginning to affect adult numbers. Recruitment tends to be very low following years without winter or spring flooding (Van Haverbeke et al. 2013), and in 2018 and 2021 no spring runoff occurred. Condition of humpback chub in the mainstem, habitat quality in the Little Colorado River and predators such as catfish were discussed as causes of poor/moderate recruitment in years when spring runoff occurs. In recent years, abundances of rainbow trout in the mainstem have been variable and rainbow trout are known to have moderate negative impacts on juvenile survival of humpback chub (Yackulic et al. 2018).

Importance of Translocations

Translocation of humpback chub above Chute Falls in the LCR occurs annually. In a recent publication (Yackulic et al. 2021) the value of translocations compared to the cost of mechanical removal was evaluated. The authors concluded that translocations not only positively impact adult abundance but also reduce the need for mechanical removals and are more cost-effective. Due to the cost efficiencies reported in this publication, the group discussed translocating additional humpback chub above Chute Falls and to other locations in the LCR as a conservation action.

Key Uncertainties

While the importance of rainbow trout to humpback chub success is better understood now than it was a few years ago, increasing brown trout populations in Lees Ferry have become more of a concern (Runge et al. 2018). The future impact of this population increase in Lees Ferry on humpback chub is a key uncertainty. The effect of catfish on juvenile and sub-adult humpback chub in the LCR and the role of monsoons and flooding on humpback chub demographics were identified as other key uncertainties.

Conservation Action Ideas

Several ideas were offered as potential additional conservation actions (Table 1). Some of these were focused on immediate response to the current trigger (listed in Table 1 under the column heading “least invasive ideas”) while others were meant to be explored further to inform actions for future conservation actions. The consensus of the group was to focus on the least invasive ideas first to address or offset the decline, as these actions could be implemented expediently. The ideas were further categorized based on their applicability of response to the trigger for the LCR humpback chub population. The least invasive ideas were incorporated into the Action Triggers for the Management of Humpback Chub Colorado River, Grand Canyon October 2021. All other ideas are documented in Table 1 and may be applied in the future after additional analysis is completed consistent with the Tier 1 conservation action that specifies that additional conservation actions may be implemented as identified and evaluated.

Table 1. Ideas identified by subject matter experts to address the decline in humpback chub.

Least Invasive ideas	Ideas Requiring More Planning/Follow-up Prior to Implementation	Potential Actions Outside of Current Tier 1
Move >300 humpback chub above Chute Falls	Move sub-adults from Western Grand Canyon and release them in the mainstem near the LCR	Use the Paria River as a translocation site – take ripe females upstream so that juveniles move into mainstem
If normal Chute Falls translocations are limited, translocate bigger humpback chub (age 1 (up to 150-160 mm) instead of 80-130 mm)	Collect 30-60 ripe HBC (identified by ultrasound) to translocate above Chute Falls (or above Blue Springs)	Near-shore (submerged) vegetation removal at Lees Ferry as a way of potentially removing brown trout habitat and disadvantaging brown trout
Translocate sub-adults from LCR in spring or fall to mainstem where presumably survival rates would be higher		Add sub-adult humpback chub into the slough (RM 12) to help remove green sunfish
		Remove predator fish in the LCR such as plains killifish, common carp and channel catfish
		*Remove non-native vegetation in LCR to improve flooding/remove marl
		*Bug flows to improve recruitment

*These ideas were proposed during the first trigger evaluation meeting

Summary of Process for 5-year Review of Action Triggers

As specified in the 2016 Long-Term Experimental and Management Plan, the management triggers for humpback chub were meant to be reviewed every 5 years. Coincidentally, this was also the first year that a trigger threshold was exceeded, and action was required. In order to comply with the 5-year review, during summer 2021, a series of 3 meetings was held to review the action triggers document and to assess whether any adjustments should be made to the document. The discussions involved many of the fish biologists that were involved in developing the original document as well as some additional representatives from various agencies responsible for research and management of humpback chub. Agendas were developed prior to each meeting and meeting notes were sent out after to ensure that the

topics were accurately captured. At the conclusion of the meetings updates were made to the management triggers document and reviewed by the participants. This document was created to capture the process and discussions that occurred to serve as a basis for the next evaluation. Some of the suggestions were important and may be incorporated in future iterations but require additional exploration and research prior to incorporation.

Review Meeting #1 (Agenda - Attachment B)

The original purpose of the management triggers was reviewed by the trigger review team. The tiered system was meant to allow sufficient time to implement additional conservation actions and population response to minimize the likelihood for future mechanical removal. The management triggers were incorporated into the 2016 LTEMP Biological Opinion and the implications of what that means and re-initiation criteria were reviewed for the benefit of the review team. The conversation during this meeting focused on the Western Grand Canyon population of humpback chub and the connection to the LCR population. The drivers of population and other conservation actions that could be included in Tier 1 actions were also discussed. Summaries of the conversations are included below.

Western Grand Canyon & Relevance to Triggers

There was considerable discussion regarding the population of humpback chub that was first detected in the Western Grand Canyon (WGC) in 2014. Evidence of a multi-aged, multi-sized humpback chub population did not become evident until approximately 2017. There was not agreement on whether this population is connected or separate from the LCR aggregation. The importance of Pearce Ferry Rapid serving as a barrier for preventing non-native species from moving upstream and its role in creating habitat for humpback chub were discussed. Warmer water temperatures, especially in the western part of the Grand Canyon due to lower lake levels have also likely contributed to providing habitat for humpback chub. However, it is uncertain what would happen to the humpback chub population in WGC if the Pearce Ferry Rapid changes. The management triggers were originally developed to protect the LCR population of humpback chub because it has been important historically and is likely to be the last stronghold against population declines in the future. Information related to vital rates, basic population dynamics and drivers related to the WGC population is still lacking because it is a recent population expansion. While the trigger review team did not agree on whether the WGC population should be incorporated into the trigger, there was consensus that this population is important. Additional information is needed prior to incorporating it into the triggers documents including a better understanding of population viability and how the population contributes to overall Grand Canyon population conservation.

Drivers of Population

Predation was another topic discussed as an important driver of the population. GCMRC has conducted lab predation trials to compare different humpback chub predators found in the LCR. The results indicate that in the LCR different predators are more likely to be predominant depending on the time of year. Consequently, it may make sense to shift efforts toward that specific predator and utilize tools that will be effective for managing them. For example, in March and April common carp may be the dominant predator on fish eggs and larval fish whereas in April and May it is likely to be plains killifish. From May through August the biggest concern might be related to channel catfish. In the mainstem Colorado River there have not been many non-natives observed since 2011-2013; they are primarily located in the tributaries.

Although predation is still a factor, other contributing factors such as water temperature, food availability, phosphorous, turbidity, and the connection of recruitment with flooding were discussed as potentially important population drivers. However, the dynamics of these factors and how they inform the triggers remains uncertain.

Tier 1 Trigger

The tier 1 approach to serve as an early warning system for population declines was discussed. The group agreed that this is still an appropriate approach. Since additional conservation actions were discussed extensively during the February meeting, there was not much time devoted to this topic. Additional potential conservation actions identified are listed in Table 1 above.

Review Meeting #2 (Agenda - Attachment C)

During the second meeting there was more discussion about the WGC population and how it contributes to humpback chub recovery. It was suggested that the management triggers document should include clarification that the focus of the triggers is on the LCR aggregation of humpback chub. Whether or not the 3-year average for estimating sub-adult numbers is still relevant was another discussion topic. Both the approach and whether there were other ideas that could be implemented under Tier 2 were discussed. A bioeconomic model (Donovan et al. 2020) which provides information on scenarios when it makes sense to implement mechanical removal was presented to the group. There was considerable discussion and interest in incorporating this model into the triggers. However, the model does not incorporate recruitment or migration and there was agreement that a sensitivity analysis was needed. Although this model may not be ready for incorporation into the management triggers, this may be applicable in the future.

Three-Year Average of Sub-Adults

The sub-adult triggers are based on a three-year average to account for variability between years. The trigger review team discussed how this three-year average was decided on originally

and whether it is still an appropriate time frame. Every year 1/3 of the sub-adults become adults. Although the number was not originally quantitatively based, the trigger review team agreed that 3 years is still a good timeframe to account for annual variation, detect a decline and have time to respond. However, the trigger review team also emphasized the importance of not waiting for recruitment numbers to fall below the trigger if a problem is identified that warrants immediate action. This caveat was already incorporated into the 2015 triggers document in the Trigger Caveats and in the Tier 2 section.

Tier 2 Trigger

The group discussed whether the Tier 2 approach of implementing mechanical removal after additional conservation actions had been unsuccessful was still a good approach or whether other ideas should be considered.

GCMRC has been developing a bioeconomic model to identify cost-effective management strategies for removing rainbow trout that also achieve conservation objectives for humpback chub. The model helps to identify the conditions when it would make the most sense to implement mechanical removal. The group was interested in applying the model to the triggers but determined that a sensitivity analysis and examination of recruitment variability and immigration may be necessary prior to incorporating it into the trigger document. With the current bioeconomic model it is possible that mechanical removals would be specified when there are >7,000 humpback chub or not specify removals when there are <7,000 humpback chub which is not aligned with the BO.

Other potential alternatives to mechanical removal were discussed including increasing the turbidity in Marble Canyon, chemical control, trout management flows, and impacting early life stages of trout.

There was brief discussion about the predator index that was included in the triggers document. The predator index is relative to rainbow trout piscivory and since many predatory fish are much more piscivorous than rainbow trout, fewer fish may still have a big impact. Immigration is another element for which there are still many uncertainties. There were no suggestions on how to adjust or expand the predator index or predator immigration, and this remains a future information need. We recommend further evaluation as part of the next iteration of this document.

Technical Work Group Input

The Glen Canyon Dam Adaptive Management Program's Technical Work Group was offered the opportunity to provide comments or suggestions regarding the management triggers. The only stakeholders that provided any input were the recreational anglers. The comments were reviewed and prompted discussion regarding temperature control and whether predators such

as channel catfish may be having a larger impact on the population than originally thought. Temperature control is an ongoing topic within the GCDAMP, but similar to the 2015 effort, was identified as outside the scope of the trigger document. GCMRC is continuing to conduct research to assess the importance of channel catfish and other species in the LCR. However, not enough is known currently to incorporate this into the management triggers. One of the suggestions by the recreational anglers was that consistent with a publication in 2021 (Yackulic et al. 2021), efforts should be focused on translocations since, ultimately, they are more cost effective. The group agreed and continues to emphasize the value in translocations.

Review Meeting #3 (Agenda - Attachment D)

During the third meeting the inputs related to the multi-state model for estimating humpback chub abundance were reviewed. The differences in survival and growth rates between humpback chub in the LCR and the Colorado River near the LCR were compared. There was also discussion regarding the connection between flooding and recruitment. Winter or spring flooding appears to be a key component to good recruitment. An initial review of the changes proposed by FWS and Reclamation to the management triggers document were reviewed during the meeting and there was some initial discussion. The group was asked to review the document and provide written feedback on the proposed changes.

Connection Between Growth & Survival

The vital rates that have the biggest impact on humpback chub abundance are survival and growth. In the LCR, "resident" humpback chub become adults more quickly but annual survival rates are lower which could be referred to as a "fast" life history. In the Colorado River, humpback chub grow slowly but survival rates are higher referred to as a "slow" life history. As humpback chub grow larger, survival rates increase in both locations.

Juvenile Abundance

In the mainstem Colorado River it takes about 4-6 years for juvenile humpback chub to grow to adults (depending on mainstem temperatures). Over the last 3 years, 2019 was a pretty good recruitment year with some outmigration, 2020 was likely better than 2019, but 2021 will likely be one of the lowest juvenile production year on record in the LCR due to drought conditions. Most sub-adults in the LCR do not move out to the Colorado River, but if they were to move out into the mainstem their survival would increase and provide a net increase in the number of adults.

Conclusions Based on Analysis of LCR Aggregation Multi-State Model

No changes are recommended to the model inputs for vital rates and corresponding trigger action levels. It is likely a further decrease in adult abundance in the LCR aggregation will be observed in the future. Since water temperatures are expected to increase over the next few

years this may increase growth of humpback chub in the mainstem, but it may also create additional problems such as more warmwater non-natives.

Flooding and Temperature Connection to Recruitment

Consistent with the current hypothesis, the model indicates that winter or spring flooding in the LCR is the best predictor of recruitment. The timing of floods is key to improving conditions and increasing juvenile production. A winter or spring flood of 2,000-4,000 cfs may be sufficient to trigger recruitment unless there have been several consecutive dry years in which case additional flooding may be needed to clear spawning substrate of marl (carbonate-rich mud). There was discussion about this connection between recruitment and flooding and how this might be applied. Removal of non-native vegetation in upper reaches of the LCR to improve flooding was discussed further. There is some evidence that nonnative vegetation in the upper LCR may be slowing floodwaters and thus reducing the scouring effect (Topping, pers. comm.), but it is uncertain how much removal would be needed to produce an effect. Since there appears to be a warming trend of Colorado River temperatures there was discussion about how this was incorporated into the model and what impact this might have on humpback chub. It is expected that juvenile humpback chub will grow faster as water temperatures increase but it is uncertain whether there may also be a concurrent increase in non-native warmwater predators that would limit humpback chub recruitment. The survival rates of humpback chub in WGC compared to those in the JCM east reach were discussed but there is some evidence of the WGC fish being transient and some temporary immigration making survival estimates difficult thus far.

Rationale for Updates Made to Management Triggers Document

There was considerable discussion during the review process, but there were few substantive updates to the document either because there was lack of consensus among the group, not enough information to incorporate into the document, or because the suggested change required extensive analysis/reanalysis. Updates made to the document were made to address confusion or add clarity to specific sections and to facilitate quickly identifying trigger numbers and off-ramps.

<u>Updates to Document</u>

Edits and Updates

The timeframe the document was revised and the names and affiliations of the team members that were involved in the review process were included on the revised document. This update was considered to serve as a record for guiding the next review.

Purpose

Under the purpose section, reference to the 2016 BO was made and clarification was added that the primary focus of the management triggers was on the LCR aggregation of HBC. Since the WGC population emerged after the document was written, there are still many unknowns related to this population, its resilience, and its connection to the LCR. It was considered important to clarify the purpose and focus of the document on the LCR population.

Figures

The figures with abundance estimates of sub-adults were updated to include all of the years since the BO was signed in 2016.

Clarifications

The Tier 1 trigger responses were clarified. Since this year was the first year that the triggers as listed in the document had been applied, the timing was opportune for identifying wording that was not clear or adjustments that might be needed. For example, during 2021 the availability of larval fish was unanticipated and was not accounted for when the trigger actions were originally identified. As such, adjustments were made to the trigger to clarify the flexibility to collect or translocate fish of varied size classes depending on availability.

Overarching Themes from Review Process

The intent of the original document was to ensure that if humpback chub populations declined to a certain level there was a process in place for taking additional conservation actions before more drastic mechanical removal of non-native fish was necessary. The assumption was that predators in the system would be the most likely cause of any declines observed in the humpback chub population. However, discussions during the review process and the current response indicate that predation may not always be the primary factor affecting the Little Colorado River humpback chub population. With that in mind, thoughtful discussion and evaluation of the situation may be needed if a Tier 2 trigger is met to ensure that the action that is taken is in direct response to the situation. Trigger caveats in the original document were meant to address some of these potential unforeseen circumstances. However, we think it important to emphasize that additional evaluation and adaptation may be necessary. For example, hypothetically, if the humpback chub population continues to decline to a point where the Tier 2 trigger threshold is exceeded, it is possible that the cause may be due to poor recruitment from lack of flooding or reduced food availability or parasites/disease. In these hypothetical examples, a reduction of predators may have very little or no impact toward improving humpback chub survival, and if predator numbers are very low, little benefit would be obtained.

The management triggers continue to be important to ensure recovery of humpback chub in the Grand Canyon, but careful evaluation and any subsequent response should be dependent

on the particular situation. This approach was conceived during development of the document and addressed in the original document (and maintained in this review) through the following statements/caveats:

- *For certain species regarded as potentially very piscivorous and dangerous (e.g., small mouth bass, green sunfish), targeted removal efforts for these species may be initiated immediately, regardless of meeting any type of threshold.*
- *If HBC decline and the identified actions are not working, USFWS, in coordination with action agencies and traditionally associated Tribes, will identify future appropriate actions.*
- *Actions and triggers will need to adapt if HBC are found to be impacted by other factors.*

Attachment A: Humpback Chub Trigger Response Meeting Agenda

Humpback Chub Trigger Response Meeting

February 23, 2021 (10 AM – 12 PM MST)

10:00-10:10 - Review triggers and response (Pedersen)

10:10-10:15 - Meeting objectives (Gwinn)

10:15-10:30 - Overview of sub-adult decline, future trends, presumed cause – (Yackulic/VanHaverbeke)

10:30-10:50 - Discussion (by all - facilitated by Young, Gwinn, Pedersen)

- What are some additional thoughts on cause of the decline in sub-adults?
- What new information is available since the trigger document was developed?
- What are some of the key uncertainties?
- What is the population level benefit of translocation?
- What is the role of spring runoff?
- What is the role of summer monsoons?

10:50 – 11:35 - Discussion (by all - facilitated by Young/Pedersen)

- What are some conservation actions that could be considered that are not already listed in LTEMP as a Tier 1 Conservation Action?

11:35-11:55 - Discussion (by all- facilitated by Young, Gwinn, Pedersen)

- What are some of the benefits/risks of actions described?

11:55-12:00 - Wrap up (Young)

Attachment B: Humpback Chub Trigger Evaluation Meeting #1 Agenda

Humpback Chub Trigger Review

July 8, 2021 (9-11 MST)

9:00-9:20 - **Meeting Objectives** (next meetings August 5 & 24) - Pedersen

Trigger Purpose/Goal (Young)

- Early conservation intervention
- Minimize likelihood of large LCR population decline
- Minimize the need for future mechanical removal efforts

Trigger and the LTEMP-BO – review constraints (Gwinn)

9:20-9:50 – **WGC Population Expansion and Relevance to LCR triggers** (Group discussion; Young)

- Large but recent expansion.
- Role in population resilience and redundancy?
- What do we know about demographics and drivers of this population?

9:50-11:00 – **Assessment, Discussion and Recommendations** - Trigger Assumptions, Approach, Metrics et al.

- **Is Predation still primary population driver?**
  - Learning since 2015 – predators, predator movement (Ward, Rogowski, all)
- **Do we know enough about other drivers to incorporate**? (Nutrients - Soluble Reactive Phosphorus; Temperature; Climate; Food, turbidity…) (Group discussion; Yackulic)
- **Tier 1 Trigger**
  - Is this still a biologically sound approach? Are there other approaches we should consider? (all)
  - Survival and other demographics review, update and trigger threshold recalculation if needed (Yackulic/Dzul/VanHaverbeke)
  - Are there new conservation responses that meet Trigger Purpose? (all)
  - Is the 3-year running average still appropriate?
- **Tier 2 Trigger**
  - Is this still a sound approach? Are there other approaches or targets that should be considered?
  - Mechanical Removal – are there other options to consider?

    - Predator Index and mechanical removal off ramp. Is this still valid, useful? Off ramp for highly piscivorous species can be a small number (e.g. 60 predators/km = < 4 BNT)?
    - Predator immigration. Do we understand this factor better? How does this inform the Tier 2 trigger and updates?
- **Stakeholder Comment** – Evaluation and integration if viable
    - Review input from stakeholders
- **Wrap Up and Final Discussion/Input**

Attachment C: Humpback Chub Trigger Evaluation Meeting #2 Agenda

Humpback Chub Trigger Review

August 5, 2021 (1-3 MT)

1:00-1:30 - **Review of last meeting**

- Additional thoughts?

1:30-1:40 - **Tier 1 Trigger**

  - Is the 3-year running average still appropriate?

1:40 – 2:40 **- Tier 2 Trigger**

  - Is this still a sound approach? Are there other approaches or targets that should be considered? (Bair update on bioeconomic model)
  - Mechanical Removal – are there other options to consider?
  - Predator Index and mechanical removal off ramp. Is this still valid, useful? Off ramp for highly piscivorous species can be a small number (e.g. 60 predators/km = < 4 BNT)?
  - Predator immigration. Do we understand this factor better? How does this inform the Tier 2 trigger and updates?

2:40- 2:50 - Stakeholder Comment – Evaluation and integration if viable

  - Review input from stakeholders (comments from only 1 group)

2:50 – 3:00 - Wrap Up and Final Discussion/Input

Potential plan for next meeting (August 24th):

- Survival and other demographics review, update and trigger threshold recalculation if needed (Dzul/VanHaverbeke)
- Incorporate comments/review draft revision of triggers document

Attachment D: Humpback Chub Trigger Evaluation Meeting #3 Agenda

Humpback Chub Trigger Review

August 24, 2021 (9-11 MT)

9:00-9:45 – **Model Updates (Maria Dzul)**

Survival and other demographics review, trigger threshold recalculation if needed

9:45-10:30 – **Review draft revision of changes in Management Triggers Document (Kirk & Kerri)**

10:30-11 **– Questions or Comments on Approach (All)**

Comments/review of document requested from group by September 17th