APPENDIX D

DRAFT FINAL

Proposed Action Triggers for the Management of Humpback Chub

Colorado River, Grand Canyon

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Developed 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 Trammel, David Rogowski, Marianne Crawford)

PURPOSE

Mechanical removal of nonnative species is a controversial 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.

Many factors affect HBC population dynamics such as water temperature, turbidity, and water volume in the Little Colorado River (LCR). This restrains available conservation actions that can be implemented in the event of a declining population of HBC. We can translocate juveniles and young of the year to other areas within and outside the LCR system, 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 in the LCR, and protect from over-utilization for scientific purposes.

Methods to actively manage temperature releases from Glen Canyon Dam sediment augmentation below the Paria River are not included in the Long-Term Experimental Management Program (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. For the purposes of these triggers, it is assumed that the primary drivers of HBC population dynamics are 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). It is suspected that cold water temperatures suppress growth and thus subject 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 an adult or sub-adult HBC population decline. The second tier would serve as a backstop prescribing predator removal (Threat Reduction) if conservation measures did not mitigate a decline in HBC abundance.

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 listed below will be immediately implemented either in the LCR or in the adjacent mainstem. Conservation actions will focus on increasing growth, survival and distribution of HBC in the LCR & LCR mainstem aggregation area.

Tier 2 Trigger - Reduce threat using mechanical removal if conservation actions in Tier 1 are insufficient to arrest a population decline:

Mechanical removal of nonnative aquatic predator 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 most recent 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 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. Hence, 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).

A three-year running average is used for sub-adults because production of younger life stages of HBC can be highly variable (Van Haverbeke et al. 2013). 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 from which to trigger actions to minimize large changes in adult HBC numbers.

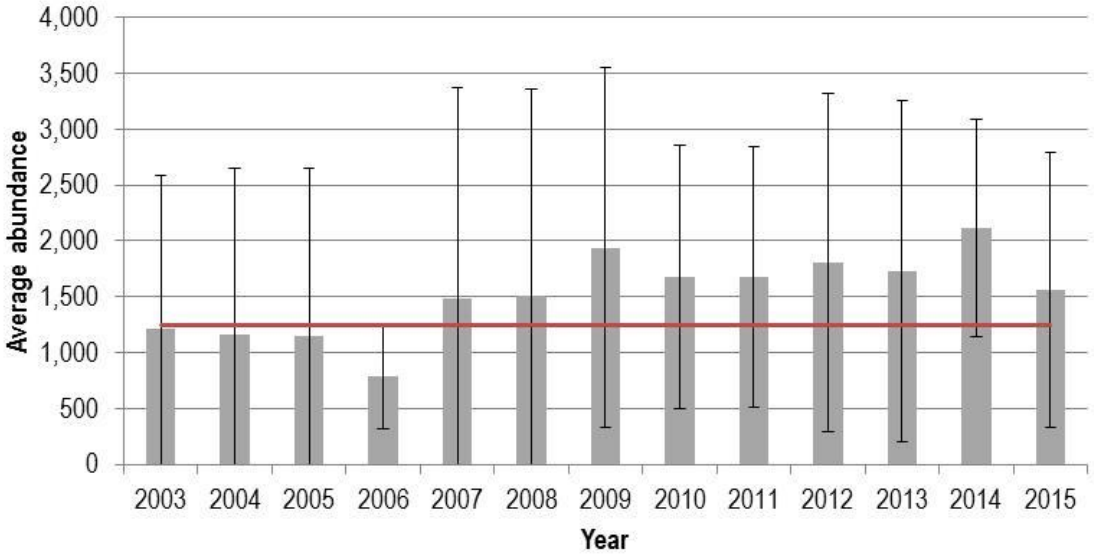

Figure 1. Running three year averages (± 95% CI) of sub-adult humpback chub abundances based on closed spring mark-recapture studies in the Little Colorado River (Van Haverbeke et al. 2013, 2015). For example, the bar for 2003 represents the average abundance of the 150-199 mm size class of humpback 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). 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 chub 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 years1 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).

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.

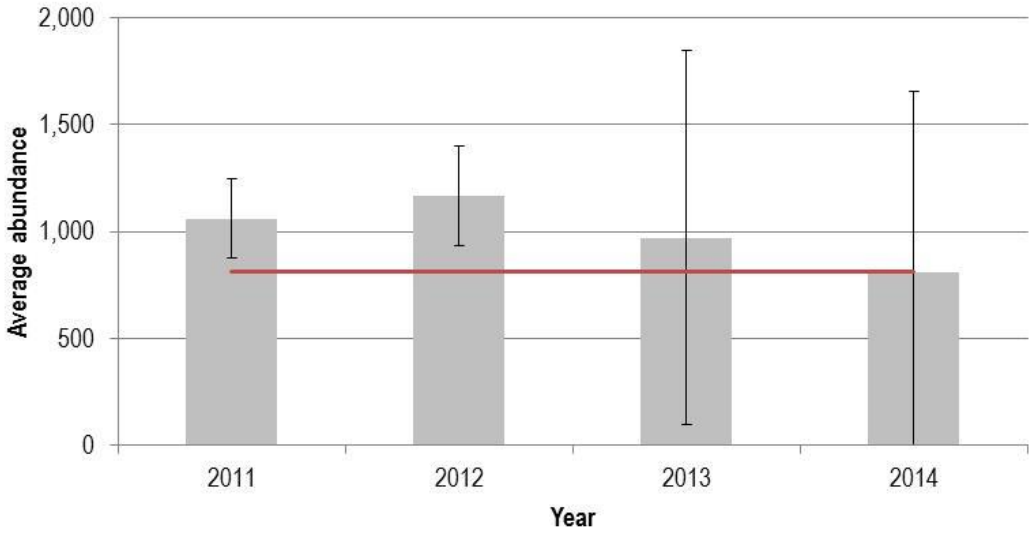

Figure 2. Running three year average abundances (± 95% CI) of sub-adult humpback chub (150-200 mm) abundances based on multi-state model in the mainstem Colorado River in the Juvenile Chub Monitoring reach (data from Yackulic pers. com.). For example, the bar for 2014 represents the average abundance 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, below which conservation actions would be enacted.

[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 oC 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.

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 from predation. 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 Tier 1 triggers are met or not. New conservation actions will include expansion of existing activities coupled with experimental actions:

- LCR - Expand translocation actions in the LCR by collecting an additional 300-600 young of the year (YOY) HBC and move to above Chute Falls in October.

- LCR - Assess efficacy of transporting larval HBC (April/May) into Big Canyon and above Blue Springs in the LCR system. Evaluate growth and survival of these transplants;

- Mainstem LCR Aggregation - Larval fish will be removed from LCR (April/May) and head-started at Southwest Native Aquatic Resources and Recovery Center (SNARRC). Once fish reach 150-200 mm 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.);

- Additional conservation actions as identified and evaluated.

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 will be developed in the JCM reach 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., small mouth bass, green sunfish), targeted removal efforts for these species may be initiated immediately, regardless of meeting any type of threshold. If initiated, mechanical removal would be terminated once the relative predator index declines to 60 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 to smallmouth bass (assumed at brown trout rate) and sums the hypothetical numbers of fish. If initiated, mechanical removal would be terminated once the relative predator index declines to 60 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
Smallmouth Bass	1	17	17
Predator index total			774

HBC population level triggers
Continue to use the existing adult HBC population estimate of 7,000, as the trigger for predator removal actions, as stated in the 2011 Biological Opinion (USFWS 2011). 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.

TRIGGER CAVEATS

- 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;

- Triggers will be reviewed and modified as necessary (evaluated; new information considered and included; etc.), 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.

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