



— BUREAU OF —
RECLAMATION

LTEMP Biological Opinion – Progress Report on Compliance & Conservation Measures



Fiscal Year 2022

LTEMP Compliance Summary

This report serves to summarize the Bureau of Reclamation's (Reclamation) evaluation of progress regarding implementation of the U.S. Fish and Wildlife Service's (FWS) 2016 Biological Opinion for the Glen Canyon Dam Long-Term Experimental and Management Plan (2016 LTEMP BO) for fiscal year 2022. Reclamation has reviewed the reporting requirements of the 2016 LTEMP BO and offers this summary report, which reviews the status of listed species in the action area, describes progress on implementation of conservation measures, and assesses levels of incidental take. The humpback chub was reclassified from endangered to threatened on November 17, 2021, the razorback sucker was proposed for reclassification from endangered to threatened on July 7, 2021, and the kanab ambersnail was officially removed from the federal list of endangered and threatened species on July 26, 2021. These reclassifications have not affected the work reported here. As supporting documentation to the summary report, we have also attached the reports and publications that support implementation of the 2016 LTEMP BO conservation measures.

Incidental Take Summary for Fiscal Years (FY) 2020 – 2022

The measures described in the Incidental Take Statement of the 2016 LTEMP BO are non-discretionary and must be undertaken by Reclamation when triggered. To monitor the impact of incidental take, Reclamation must report the progress of the action and its impact on the species to the FWS as specified in the incidental take statement.

Humpback Chub

The tables below summarize data from the past three years to determine whether Tier 1 (early intervention) or Tier 2 (threat reduction) actions required by the 2016 LTEMP BO have been, or may be, triggered to prevent exceeding incidental take. Under Tier 1 parameters, early intervention action is required if the combined point estimate for adult humpback chub (HBC; adults defined as ≥ 200 mm total length) in the Colorado River mainstem and Little Colorado River (LCR aggregation) falls below 9,000. Similarly, early intervention action is required if recruitment of sub-adult HBC does not equal or exceed adult mortality. Early intervention consists of conservation actions such as expanded translocation efforts. As shown in Table 1, the point estimate for the number of adults and the three-year average population and recruitment estimates for the sub-adult spring estimate of the LCR population are above levels that would require Tier 1 action. However, the three-year average of the sub-adult fall estimate was below the 810 required for the period from 2018-2020, as reported in 2021, again for the period from 2019-2021, and as reported here (2022), thus triggering Tier 1 early intervention actions (see FWS Mark-Recapture & Fish Monitoring Activities in the LCR in Grand Canyon 2000-2022). In spring 2022, efforts were made to collect larval fish and to move additional sub-adults above Chute Falls. However, none were available. HBC moved above Chute Falls generally grow faster and have higher survival rates (Yackulic et al. 2021). A response to exceeding the sub-adult trigger in 2022 will be planned once larval estimates are available in spring 2023.

Under Tier 2 parameters, threat reduction actions are required if the combined point estimate for adult HBC in the Colorado River mainstem and Little Colorado River (LCR aggregation) falls below 7,000. Threat reduction actions consist of mechanical removal of nonnative predators from the LCR aggregation reach and immediate vicinity. Table 2 summarizes the conditions under

which Tier 2 actions would be terminated, either by reducing the predator index or by increasing HBC population and recruitment levels.

Table 1. Tier 1 thresholds that trigger additional conservation actions for humpback chub (HBC)

TIER 1 Early Intervention	# of HBC that triggers an action	ESTIMATED # of HBC			
		2020	2021	2022	3-year average
1. Combined adult (≥ 200 mm) HBC in the Colorado River mainstem aggregation ($\geq 2,000$) and in Little Colorado River ($\geq 7,000$)	$\leq 9,000^*$	**	**	15,000	
OR					
2. Recruitment of sub-adult (150-199 mm) HBC does not equal or exceed estimated adult mortality					
A. Sub-adult population estimate in LCR in spring	$\leq 1,250$ for 3 years	993	696	2,056	1,248
OR					
B. Sub-adult population estimates in mainstem in JCM Reach*** in fall	≤ 810 for 3 years	200	700	100	333

*If the number of adults declines below 7,000, tier 2 action is triggered.

**The number of adults is based on a point estimate which must be $>9,000$ to avoid triggering action.

***Juvenile Chub Monitoring Reach is RM 63.45-65.2 of the mainstem.

Table 2. Tier 2 triggers that terminate mechanical removal of non-native fish to protect humpback chub

TIER 2 Mechanical Removal	Action Termination Trigger	Observed	
		2021	2022
Nonnative Aquatic Predator index	< 60 rainbow trout/km	--	--
Immigration rate	Low (to be determined)	--	--
HBC population estimates	$> 7,500$	--	--
Survival rates of sub-adult chub	Exceeds adult mortality for at least 2 years	--	--

*This table remains blank unless the number of adult humpback chub $< 7,000$, which indicates mechanical removal is required. This table outlines the conditions necessary to terminate the action.

Razorback sucker

The incidental take of razorback suckers is considered to be exceeded if actions associated with LTEMP base operations and experimental flows result in a statistically significant decline (95%

confidence intervals) in mean catch per unit effort (CPUE) of adult flannelmouth suckers for a consecutive 3-year period following the occurrence of experimental flows. Because razorback suckers are extremely rare in the project area and it is impossible to distinguish larval razorback suckers from flannelmouth suckers in the field, flannelmouth suckers are identified as a surrogate for incidental take of razorback suckers in the 2016 Biological Opinion. The most recent experimental flows that occurred were a fall High Flow Experiment (HFE) in November 2018, macroinvertebrate production flows (bug flows) in 2018, 2019, 2020 and 2022, and a spring disturbance flow in 2021.

CPUE data is collected by Arizona Game & Fish Department (AGFD) in lower Grand Canyon in spring and fall where flannelmouth suckers overlap with known locations of larval razorback suckers (approximately from RM 179.1 to RM 225 and >RM225).

Table 3. Catch per unit effort (CPUE) with 95% confidence intervals of adult flannelmouth suckers (>325 mm total length) in lower Grand Canyon (RM>179) by capture method. Incidental take is considered exceeded if a statistically significant decline is observed in CPUE of adult flannelmouth suckers for a consecutive 3-year period following the occurrence of experimental flow actions.

River Mile	Gear Type	2020	2021	2022
River Mile 179.1-225	Electrofishing (fish/hr)	7.34 (3.24, 11.40)	2.09 (0, 4.81)	2.92 (0.097, 5.74)
	Hoop net (fish/net)	3.28 (1.72, 4.84)	1.2 (0.36, 2.04)	2.57 (1.64, 3.51)
River Mile >225	Electrofishing (fish/hr)	0.29 (0, 0.69)	0.27 (0, 0.79)	1.57 (0.47, 2.66)
	Hoop net (fish/net)	0.17 (0.06, 0.28)	0.074 (0.000900, 0.14)	1.07 (0.42, 1.72)

Conservation Measure Progress, FY 2022

Humpback Chub

Ongoing Actions:

- 1) Reclamation would continue to support the NPS, FWS, U.S. Geological Survey’s (Survey) Grand Canyon Monitoring and Research Center (GCMRC), and GCDAMP in funding and implementing translocations of humpback chub into tributaries of the Colorado River in Marble and Grand Canyons, and in monitoring the results of these translocations, consistent with agencies’ plans and guidance (e.g., NPS Comprehensive Fisheries Management Plan [CFMP], FWS Humpback Chub Genetics Management Plan and Translocation Framework, and GCMRC Triennial Work Plan). Specifically, the following would occur:
 - i. Humpback chub would be translocated from the lower reaches of the Little Colorado River (LCR) to areas upstream of Chute Falls to increase growth rates and survivorship.

Efforts to translocate HBC upstream of Chute Falls in the LCR have been ongoing since 2003 with 4,872 juvenile (~80-130 mm TL) HBC translocated to date. Of these, 196 were released above Chute Falls (at river kilometer [RKM] 16.2) on October 28, 2022 (see 2022 GCMRC Annual Report for Project Element G.7, Chute Falls Translocations).

FWS conducts an annual trip to monitor the abundance of HBC translocated upstream of Chute Falls (RKM 13.6) and in the “Atomizer reach,” (RKM 13.6 - 14.1). This effort typically occurs in May or June, when there is no danger of flooding, and it is safe to conduct activities in this stretch of river. The abundance estimates obtained in May 2022 are listed in Table 4 (see 2022 GCMRC Annual Report for Project Element G.7, Chute Falls Translocations).

Table 4. The number of humpback chub (HBC) estimated by size with standard error (SE) for two sample reaches in the Little Colorado River (LCR) in May 2022.

Atomizer (RKM 13.6)	621 (41)	379 (25)
Chute Falls (RKM 13.6-14.1)	572 (13)	307 (7)

- ii. Monitoring would be conducted annually, or as needed, depending on the data required, to determine survivability, population status, or genetic integrity of the Havasu Creek humpback chub population. Intermittent translocations of additional humpback chub in Havasu Creek would be conducted if the FWS and NPS determine it is necessary to maintain genetic integrity of the population.

NPS conducted monitoring trips to Havasu Creek in October 2021 and May 2022. In October 2021, 74 HBC were captured during single-pass netting including juveniles and adults. Of these, 8 were translocated and 66 were non-translocated fish. In May 2022, 198 humpback chub were captured including juveniles and adults, with 14 previously translocated and 127 non-translocated fish. The abundance estimate was 145 individuals (95% CI: 138-170). The 2022 Havasu Creek population estimate indicates that 90% of the population are non-translocated fish, or wild fish. Population growth estimates in Havasu Creek are indicative of a stable population (2022 NPS Annual Report of Tributary Translocations and Monitoring).

No HBC were translocated to Havasu Creek in 2022. Annual monitoring continued in Havasu Creek to better understand the population dynamics.

- 2) Reclamation would continue to fund a spring and fall population estimate annually, using a mark-recapture based model for the Little Colorado River or the most appropriate model developed for the current collecting techniques and data.

In 2022, FWS and volunteers conducted monitoring trips in April and May and in September and October to monitor the population status and trends of humpback chub in the LCR. See Table 5 for the estimates of HBC by sampling period (see FWS Mark-Recapture & Fish Monitoring Activities in the LCR in Grand Canyon 2000-2022).

Table 5. The estimates of humpback chub (HBC) in the Little Colorado River by size (total length (TL)) with standard errors (SE) for each sampling period.

Sampling Period	# of HBC TL >150 mm ± SE	# of HBC TL ≥200 mm ± SE
Spring 2022	10,563 (727)	8,525 (665)
Fall 2022	2,320 (367)	1,888 (321)

- 3) Reclamation would continue to fund control or removal of nonnative fish in tributaries prior to chub translocations depending on the existing fish community in each tributary. Reclamation, NPS, and FWS would lead any investigation into the possibility of using a chemical piscicide, or other tools, as appropriate. Tributaries and the appropriate control methods would be identified by the FWS, NPS, Reclamation, and GCMRC, in consultation with AGFD. Depending on the removal methods identified, additional planning and compliance may be necessary.

NPS operated a weir at the confluence of Bright Angel Creek from September 30th - October 5, 2021, until it was destroyed in monsoonal flooding. No fish were captured in the weir while it was operational. Electrofishing was also conducted in Bright Angel Creek and other tributaries from October 2021 through January 2022 yielding removal of 4,274 brown trout and 4,216 rainbow trout (see 2021-2022 NPS Bright Angel Creek Brown Trout Control Season Report).

- 4) Reclamation would continue to fund the FWS in maintenance of a humpback chub refuge population at a federal hatchery (Reclamation has assisted the FWS in creating a humpback chub refuge at the Southwestern Native Aquatic Resources and Recovery Center [SNARRC]) or other appropriate facility by providing funding to assist in annual maintenance (including the collection of additional humpback chub from the Little Colorado River for this purpose). In the unlikely event of a catastrophic loss of the Grand Canyon population of humpback chub, the refuge would provide a permanent source of sufficient numbers of genetically representative stock for repatriating the species.

Reclamation continues to support FWS maintenance of the humpback chub refuge population at SNARRC. Collection of larval humpback chub to support the refuge was planned but due to poor recruitment no larval fish were transferred to the refuge in 2022.

5) Reclamation would continue to assist the FWS, GCMRC and the GCDAMP to ensure that a stable or upward trend of humpback chub mainstem aggregations can be achieved by:

- i. Continuing to conduct annual monitoring of the LCR humpback chub aggregation (e.g., juvenile chub monitoring parameters). Periodically, an open or multistate model should be run to estimate abundance of the entire LCR aggregation inclusive of mainstem fish.

In 2022, GCMRC conducted monitoring trips in May, July & October in the JCM-East reach (RM 62.7-66.0). Slow-shock electrofishing and hoop nets were used to capture fish, and 6-8 submersible antennas were deployed on each trip to supplement electrofishing and hoop netting efforts. During those efforts there were 794 captures of HBC > 79mm TL and 642 captures of HBC 40-79 mm TL.

A multi-state model was run to estimate abundance. For 2022, the estimate of abundance of the LCR aggregation was 15,000 adults.

- ii. Supporting annual monitoring in the mainstem Colorado River to determine status and trends of humpback chub and continuing to investigate sampling and analytical methods to estimate abundance of chub in the mainstem.

FWS conducted an annual trip to monitor HBC aggregations from August 31st to September 19, 2022, between Lees Ferry and Pearce Ferry with the objective of continuing long-term relative abundance (CPUE) index of HBC in known historical aggregation sites (2022 GCMRC Annual Report for Project Element G.5 & FWS Monitoring HBC in the CO River Grand Canyon 2021). During this trip 17 sites were sampled in Marble & Grand Canyon. The highest CPUE for adult HBC > 200 mm was in the 202-Mile reach (~RM 201.5-203.5).

In addition, by applying available capture probability data to catch data, FWS estimated abundances of adult HBC within specific reaches sampled in 2022. Abundance estimates were then transformed into density estimates (fish/mile, Table 6).

Table 6. Density estimates with 95% confidence intervals (CI) for adult humpback chub (total length \geq 200 mm) based on a trip conducted in September 2022.

Site	River Mile	Density estimates (95% CI)
Havasu (above)	155.8-157.2	138 (116-166)
Tuckup	165.2-166.9	183 (154-220)
182-Mile	182.2-183.7	1,225 (924-1,652)
190-Mile	189.8-191.1	285(239-342)
202-Mile	201.6-203.5	871 (731-1,047)

- iii. Conducting periodic surveys to identify additional aggregations and individual humpback chub.

HBC specific surveys outside of recognized aggregations is performed every 3rd year. However, additional sites were surveyed during the annual aggregation monitoring trips in 2020-2022. In addition, because of concern about the encroachment of non-native fishes, an additional seining trip was conducted to monitor for the presence of these fishes, both inside and outside of the historical aggregations.

- iv. Evaluating existing aggregations and determining drivers of these aggregations, for example, recruitment, natal origins, spawning locations, and spawning habitat (e.g., consider new and innovative methods such as telemetry or the Judas-fish approach; Kegerries et al. 2015).

Estimates of vital rates and recruitment of HBC in the Little Colorado River (JCM-East) and Pumpkin Springs/Fall Canyon (JCM-West) aggregations have been developed. A mark-recapture model is currently being developed for fish in JCM-West. Preliminary results suggest that numbers of large adults (>250mm TL) have remained relatively stable since 2018. Adult survival is estimated to be lower than for adult humpback chub in JCM-East, but survival rates are highly uncertain. Growth of HBC in JCM-West is faster than in JCM-East (Table 7). Thus, the relatively high growth and low adult survival in JCM-West likely indicates faster rates of population turnover. Movement into and out of the JCM-West sampling reach is high and this complicates estimation of survival.

Sampling near JCM-west in 2022 consisted of six passes of hoop net captures and three passes of night-time electrofishing. In the JCM-West reach monitoring trips occurred in May, July, and October. During these

trips 879 HBC >79 mm TL and 1,479 HBC 40-79 mm TL were captured in JCM-West (2022 GCMRC Annual Report for Projects G.3 & G.6).

Table 7. The number of juvenile humpback chub of each size identified during mainstem monitoring trips conducted in May, July, and October 2022. The table only includes unique fish.

Location	May		July		October		TOTAL	
	40-79 mm	>79 mm	40-79 mm	>79 mm	40-79 mm	>79 mm	40-79 mm	>79 mm
JCM-East	21	64	33	434	588	296	642	794
JCM-West	45	222	139	240	1,295	417	1,479	879

- v. Exploring means of expanding humpback chub populations outside of the Little Colorado River Inflow aggregation. Evaluate the feasibility of mainstem augmentation of humpback chub that would include larval collection, rearing, and release into the mainstem at suitable areas outside of or within existing aggregations.

The initial intent of this measure was to explore the potential for expansion in mainstem areas with suitable thermal characteristics (warm) downstream of Havasu Creek. HBC have expanded unaided into the western Grand Canyon mainstem since 2014 and established multi-aged recruiting populations by 2017 (Van Haverbeke et al. 2017). Research to better understand the drivers behind this autonomous expansion is ongoing (Measure 5.iv.; JCM-West). Low abundances of non-natives and warm water temperatures are believed to be dominant drivers.

Based on conversations with FWS, work on this measure is not warranted at this time, but evaluation may be considered in the future. For example, it is possible that upriver movement of HBC in western Grand Canyon is occurring with warmer water temperatures, and telemetry studies could help answer these questions.

- 6) Reclamation would, through the GCDAMP, conduct disease and parasite monitoring in humpback chub and other fishes in the mainstem Colorado. The GCMRC is currently conducting parasite monitoring in the Little Colorado River. However, in order to better understand how/if disease and parasites (primarily Asian tapeworm) are affecting chub and how temperature differences may affect parasite occurrence, this work would be expanded to include investigations of parasites in humpback chub (and surrogate fish if necessary) in the mainstem.

In 2022, monitoring for Asian tapeworm was conducted in the spring in the LCR. Thirty-two humpback chub (129-287 mm total length (TL)) were held in a collapsible tank on the riverbank at Boulders Camp (river kilometer 1.8) and treated with Praziquantel at 6 mg/l for 48-hrs before release (Ward 2007). Four

tapeworms were detected in 3 individual fish (Table 8). Infestation rates from 2015-2019 indicated relatively low incidence of infestation (average = 20% infestation) with typically only a single worm found per fish, whereas assessments conducted from 2005-2007 averaged 40% infestation, with up to 182 tapeworms found in a single fish. The relatively low incidence of infestation, and the magnitude of infestation per fish in recent years, appears much lower than numbers reported from assessments conducted during 2005-2007 in the LCR.

In addition, tapeworm monitoring was also conducted in western Grand Canyon in 2022 at river mile 273 (near Columbine) on the mainstem Colorado River. Forty-seven humpback chub (129-295 mm TL) were treated using the same methods (Table 8). Two tapeworms were detected in 2 individual fish. This is the first time Asian tapeworm assessments have been conducted in the mainstem Colorado River using these methods.

The reason for the apparent recent decline in Asian tapeworm infestation is unknown (see 2022 GCMRC Annual Report Project I). Standardized monitoring protocols for HBC in the LCR and the mainstem require tracking of external parasites and are reported annually (FWS Mark-Recapture & Fish Monitoring Activities in the LCR in Grand Canyon 2000-2022; FWS Monitoring HBC in the CO River Grand Canyon 2021).

Table 8. The number of Asian tapeworms detected in humpback chub from 2018-2022 at 3 locations.

Year	Boulder's Camp (LCR)		Bridge City (below Diamond Creek)		Columbine (River mile 273)	
	# of HBC sampled	# of HBC with Asian tapeworm	# of HBC sampled	# of HBC with Asian tapeworm	# of HBC sampled	# of HBC with Asian tapeworm
2018	36	6	43	0	N/A	N/A
2019	43	12	0	0	N/A	N/A
2020*	0	N/A	0	N/A	N/A	N/A
2021**	0	N/A	0	N/A	N/A	N/A
2022	32	3	N/A	N/A	47	2

*No sampling was conducted in 2020 due to COVID-19. **No sampling occurred in 2021 to minimize handling stress on fish.

New Actions:

- 7) Reclamation would collaborate with the FWS, GCMRC, NPS, and the Havasupai Tribe to conduct preliminary surveys and a feasibility study for translocation of humpback chub into Upper Havasu Creek (above Beaver Falls). The implementation of surveys and translocations, following the feasibility study, would be dependent on interagency discussions, planning and compliance, and resulting outcomes of tribal consultation.

FWS is leading initial discussions about the feasibility of translocating humpback chub into Upper Havasu Creek. FWS initiated coordination with the Havasupai Tribe in 2019 with the objective of an initial field survey. No additional coordination or progress has been possible since the pandemic began due to continued closure of Havasupai Tribal lands. FWS will report back when progress has been made.

- 8) Reclamation would, in cooperation with the FWS, NPS, GCMRC, and AGFD, explore and evaluate other tributaries for potential translocations.

Reclamation funded NPS to conduct two monitoring trips to the Colorado River inflow areas around Bright Angel, Shinumo and Havasu Creeks. Shinumo Creek continues to be monitored to evaluate its potential for future humpback chub translocations (2022 NPS Monitoring Humpback Chub Translocated to Grand Canyon Tributaries Annual Report).

Razorback Sucker

Ongoing Actions:

- 1) Reclamation would continue to assist the NPS, FWS, and the GCDAMP in funding larval and small-bodied fish monitoring in order to:
- i. Determine the extent of hybridization in flannelmouth and razorback sucker collected in the western Grand Canyon.

Reclamation initiated a project with SNARRC to examine genetic hybridization between flannelmouth suckers and razorback suckers. The purpose of the study is to evaluate survival and growth rates of hybrids and examine the genetic and morphology of hybrids compared to non-hybrids.

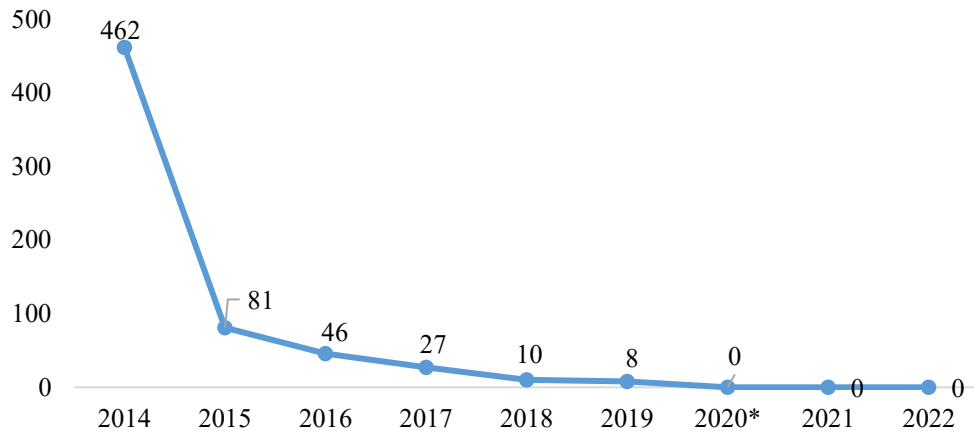
Larval fish are collected during 6 monitoring trips conducted from March through August and preserved in alcohol to allow for genetic testing. However, no larval razorback suckers have been collected upstream of Pearce Ferry Rapid since 2019.

- ii. Determine habitat use and distribution of different life stages of razorback sucker to assist in future management of flows that may help conserve the species. Sensitive habitats to flow fluctuations could be identified and prioritized for monitoring.

No larval razorback suckers were identified in 2022 (2022 Biowest Razorback Sucker Monitoring Annual Report). The number of larval

razorback suckers collected each year has continued to decline since this monitoring was initiated in 2014 (Figure 1).

Figure 1. The number of larval razorback suckers identified in the Grand Canyon from 2014-2022.



* No trips occurred in April or May 2020 due to COVID-19 restrictions. These are the months when larval razorback suckers have been identified in previous years.

- iii. Assess the effects of Trout Management Flows (TMF) and other dam operations on razorback sucker.

No TMFs have occurred since implementing the 2016 LTEMP, nor have they been scheduled to be tested. In 2022, Reclamation authored a white paper (see attachment Trout Management Flows Implementation Considerations Reclamation 2022) to compile the current knowledge related to TMFs including the background, experimental design, hydrograph elements, and other considerations. Since the experiment was designed to target rainbow trout which are not currently an issue, a TMF is not currently considered for implementation. However, if conditions change in the future this white paper will serve as a starting point to move the conversation forward.

On November 5-8, 2018, the Department of the Interior conducted the most recent HFE release from Glen Canyon Dam. The HFE release included a peak flow of approximately 38,100 cubic feet per second for 60 hours (four days including ramping from baseflows to peak release) to move accumulated sediment downstream to help rebuild beaches and sandbars.

Macroinvertebrate production flows were conducted during weekends from May through August from 2018-2020, and 2022. During the experimental period regular fluctuating flows occurred on weekdays while steady low flows were maintained on weekends with the objective of providing a period

for insects to emerge over the weekends while minimizing impact to hydropower.

In spring 2021, a spring disturbance flow was designed to evaluate whether resources in the Colorado River Ecosystem would be improved. The flow took advantage of an apron repair that was necessary to drop to a low flow and then bring it back up to a high flow.

Baseline data collected during Biowest monitoring for razorback suckers from March through September was used to evaluate the effect of flows. Native catch rates in 2022 were significantly lower compared to 2014, 2017, and 2018, but higher than 2015, 2016, 2019, 2020, and 2021 (reported in 2022 Biowest Razorback Sucker Monitoring Annual Report, page 59). Due to the low numbers of razorback suckers in the Grand Canyon, the impact specifically on this fish species could not be evaluated. However, the impact is expected to be similar to that of other native fish species. Additional data will be collected during and after future flow experiments to assess the effects on razorback suckers and other native fish species.

Actions to Benefit All Native Species

Ongoing Actions:

- 1) Reclamation, in collaboration with the NPS and FWS, and in consultation with the AZGFD, would investigate the possibility of renovating Bright Angel and Shinumo Creeks with a chemical piscicide, or other tools, as appropriate. Additional planning and compliance, and tribal consultation under Section 106 of the NHPA, would be required. This feasibility study is outlined in the NPS CFMP (2013; see “Feasibility Study for Use of Chemical Fish Control Methods”).

NPS continues to monitor the recovery of Shinumo Creek to evaluate its potential for future humpback chub translocations and/or chemical piscicide treatment. Following completion of the NPS Expanded Nonnative Aquatic Species EA and FONSI in 2019, and in cooperation with the AGFD, NPS began to plan for a future chemical piscicide treatment in the upper reaches of Bright Angel. The treatment is planned to remove invasive trout to protect the humpback chub that have been translocated into the creek. As stipulated in the programmatic agreement between NPS, Arizona State Historic Preservation Office, and Tribes, additional consultation will be completed during planning for piscicide use.

- 2) Reclamation would continue to fund efforts of the GCMRC and NPS to remove brown trout (and other nonnative species) from Bright Angel Creek and the Bright Angel Creek Inflow reach of the Colorado River, and from other areas where new or expanded spawning populations develop, consistent with the NPS CFMP. After 5 years of removal efforts are completed (in 2017), an analysis of success would be conducted. Piscicides

may be considered for removal of nonnative species if determined to be appropriate and following completion of the necessary planning and compliance actions.

From September 30, 2021-October 5, 2021, a modified resistance board weir with a downstream-orientated fish trap was operated in Bright Angel Creek near its confluence with the Colorado River. High-magnitude monsoonal flooding on October 5th destroyed the weir rendering it inoperable. No trout were captured during the brief period it was operable.

Electrofishing was conducted in Bright Angel Creek and other tributaries from October 21, 2021 – January 22, 2022, with 4,274 brown trout and 4,261 rainbow trout removed (2021-2022 NPS Bright Angel Creek Brown Trout Control Season Report).

NPS is planning for a chemical treatment in the upper reaches of Bright Angel Creek. Further coordination and consultation with tribal partners, the AGFD, and federal collaborators will be necessary.

New Actions:

- 3) Reclamation would explore the efficacy of a temperature control device at the dam to respond to potential extremes in hydrological conditions due to climate conditions that could result in nonnative fish establishment. Evaluations would be ongoing for all current and evolving technological advances that could provide for warming and cooling the river in both high- and low-flow discharge scenarios, and high and low reservoir levels. These studies should include evaluating and pursuing new technologies, an analysis of the feasibility, and a risk assessment and cost analysis for any potential solutions.

Reclamation’s Research and Development Office (based in Denver) completed a report reviewing the temperature control options for reservoir releases in January 2020. A technology search was recommended as a next step to seek industry cross-cutting ideas. In March 2020, Reclamation contracted with the company yet2 to complete a Technology Search to explore innovative water temperature control devices. Reclamation received and reviewed the report 2021, but none of the options were applicable to Glen Canyon Dam. The bypass cooling capacity of Glen Canyon Dam was reviewed and discussed during the June Technical Work Group and the August Adaptive Management Program Meetings. Reclamation is also pursuing a value planning study for bypass generation that may provide information on temperature control.

- 4) Reclamation would pursue means of preventing the passage of deleterious invasive nonnative fish through Glen Canyon Dam. Because Glen Canyon Dam release temperatures are expected to be warmer under low reservoir elevations that may occur through the LTEMP period, options to hinder expansion of warmwater nonnative fishes into Glen and Grand Canyons would be evaluated. Potential options to minimize or eliminate passage through the turbine or bypass intakes or minimize survival of nonnative fish that pass through the dam would be assessed (flows, provide cold water, other). While feasible options may not currently exist, technology may be developed during the LTEMP period that could help achieve this goal.

Reclamation continued a project through Utah State University to characterize the fishes above the dam to better understand the potential for passage of non-native fish through the dam. Sampling was conducted in March, June, August, and October 2022. Hydroacoustic monitoring & fish netting across various depths and seasons are used to better understand when fish are in the forebay and what species are found at different depths. Smallmouth bass and channel catfish were implanted with ultrasonic transmitters which will also be used to better understand movements and use of different depths.

The engineering group at the Technical Services Center reviewed the potential options for reducing entrainment at Glen Canyon Dam and compiled them into a report (Glen Canyon Dam Fish Escapement Options Reclamation 2022). Reclamation initiated a subject matter expert panel to evaluate and recommend one of the options for installation.

- 5) Reclamation would, in consultation with the FWS and AGFD, fund the NPS and GCMRC on the completion of planning and compliance to alter the backwater slough at River Mile (RM) -12 (commonly referred to as “Upper Slough”), making it unsuitable or inaccessible to warmwater nonnative species. Depending on the outcome of NPS planning and compliance, Reclamation would implement the plan in coordination with the FWS, AGFD, NPS and GCMRC. Additional coordination would be conducted to determine and access any habitats that may support warmwater nonnatives.

Reclamation produced a report of possible engineering options for modifying the slough in 2018. Due to the changing environmental conditions, Reclamation, through the Technical Services Center, is reevaluating the options for modifying the slough. A site visit was conducted in October 2022 and a report with recommendations for modification is anticipated to be completed in 2023.

- 6) Reclamation would support the GCMRC and NPS in consultation with the FWS and AGFD on the completion of planning and compliance of a plan for implementing rapid

response control efforts for newly establishing or existing deleterious invasive nonnative species within and contiguous to the action area. Control efforts may include chemical, mechanical, or physical methods. While feasible options may not currently exist, new technology or innovative methods may be developed in the LTEMP period that could help achieve this goal. Rapid response to new warmwater fish invasions may become a more frequent need in the future with lower reservoir elevations and warmer dam releases.

Reclamation provided funding and personnel to support an NPS-led effort to remove smallmouth bass from the 16 mile stretch of river below the Glen Canyon Dam. This included support of a chemical treatment of the -12-mile slough in September 2022 to remove smallmouth bass and other warmwater invasive fishes as well as electrofishing and netting removal efforts in fall 2022. During the fall electrofishing trips, 251 smallmouth bass were captured.

- 7) Reclamation, will consider, in consultation with the GCDAMP, the experimental use of TMFs to inhibit brown trout spawning and recruitment in Glen Canyon, or other mainstem locations. Inhibiting brown trout spawning and recruitment will benefit chub by reducing the potential for brown trout to predate upon humpback chub.

GCMRC recently conducted a literature review related to TMFs to determine characteristics of flow regimes that lead to higher levels of fish stranding. Key factors identified in the literature that influence the extent of stranding include: fish size class and life history stage, flow factors (down-ramp rate, magnitude of stage change, duration of high and low flows, and frequency of flow fluctuations), diel cycle, and channel morphology factors (lateral slope, substrate composition, habitat complexity). Stranding studies included in this review were found to be site-specific and key factors influencing stranding are highly interdependent. General findings suggest that faster down-ramp rates during the daytime between May and July (February-April if targeting brown trout) at lower flow elevations could optimize young-of-year stranding. Repeated cycles of TMFs could decrease the compensatory survival response. TMFs remain experimental to determine exact metrics for each factor required to optimize stranding specific to the Colorado River below Glen Canyon Dam.

GCMRC analyzed bathymetry and predictions from a 2-dimensional flow model from Glen Canyon to predict relative changes in young-of-year stranding risk under different TMF scenarios. Given current limitations in water availability, results suggest a steady TMF high flow of 12,000-16,000 ft³/s, combined with a minimum flow of 3,000- or 5,000 ft³/s may effectively strand age-0 fish while also minimizing

risk to water storage in Lake Powell and other resources. The report is complete but still under internal review.

Southwestern Willow Flycatcher

- 8) Reclamation would partially assist in funding NPS to conduct Southwestern Willow flycatcher (SWFL) surveys once every other year for the life of the LTEMP.

No surveys were conducted for Southwestern Willow Flycatchers in 2022. The next surveys are planned for 2023.

Yuma Ridgway's Rail

- 9) Reclamation would partially assist in funding NPS to conduct Yuma Ridgway's rail surveys once every three years for the life of the LTEMP.

Surveys for Yuma Ridgway's rail were conducted in 2022; however, no rails were detected (2022 NPS YRRA Surveys Annual Report).

Conservation Measures Summary

The table below shows, for each conservation measure, the project that addresses it and the agency responsible for implementing the work.

Table 9. Summary of Conservation Measures as identified in the 2016 Biological Opinion

RESOURCE PROTECTED	CONSERVATION MEASURE	DETAILS	TWP PROJECT or OTHER FUNDING	AGENCY CONDUCTING WORK
Humpback Chub	Support translocations of humpback chub into tributaries and monitoring the translocations	Translocation above Chute falls	GCMRC G7	FWS
		Annual monitoring to determine survivability, population status in Havasu Creek	Reclamation	NPS
	Conduct spring & fall population estimates annually using a mark-recapture based model for the LCR		GCMRC G2	FWS/GCMRC
	Control or removal of non-native fishes in tributaries prior to translocations		Reclamation	NPS
	Support FWS maintenance of humpback chub population at federal refuge (SNARRC)		Reclamation	FWS
	Ensure a stable or upward trend of HBC mainstem aggregations	Annual monitoring of the LCR aggregation	GCMRC G1, G2, G3	GCMRC/FWS
		Annual monitoring of mainstem CO River	GCMRC G5	FWS/GCMRC
		Conduct periodic surveys to identify additional aggregations & individual HBC	GCMRC G5	FWS/GCMRC
		Evaluate existing aggregations & determine drivers of aggregations	GCMRC G1	GCMRC
		Explore means of expanding population outside of LCR (mainstem augmentation)		
	Conduct disease & parasite monitoring in mainstem & LCR		GCMRC G2, Project I	FWS/GCMRC
Conduct preliminary surveys for translocation into Upper Havasu		Reclamation	NPS/FWS	
Explore other tributaries for potential translocation				
Razorback Sucker	Determine extent of hybridization with flannelmouth suckers		Reclamation	AGFD
	Determine habitat use & distribution of different life stages of RBS		Reclamation	Bio-West
	Assess effects of TMFs & other dam operations		Reclamation	
Benefit Native Aquatic Species	Evaluate use of piscicide or other tools to renovate Bright Angel and Shinumo		Reclamation	NPS
	Remove brown trout from Bright Angel, inflow & and other new areas		Reclamation	GCMRC/NPS
	Explore efficacy of a temperature control device		Reclamation C10	Reclamation
	Pursue means of preventing passage of non-native fish through dam		Reclamation C9	Reclamation
	Complete planning and compliance to alter the backwater slough		Reclamation Technical Report #SRH 2018-17 completed in 2018	Reclamation/NPS
	Complete planning and compliance of a plan for implementing rapid response control efforts		GCMRC I1, I2, I3	AGFD/GCMRC/NPS
	Consider the experimental use of TMFs to inhibit brown trout spawning & recruitment		GCMRC H2	GCMRC
Yuma Ridgway's Rail	Partially assist in funding surveys every 3 years		Reclamation C11	NPS

Supporting Documentation

Work on the 2016 LTEMP BO conservation measures is ongoing. Reclamation has received several final reports detailing activities supporting conservation measures in the 2016 BO. These reports are attached with the transmittal of this document and are identified below.

Attached reports

2021-2022 NPS Bright Angel Creek Brown Trout Control Season Report

2022 Biowest Razorback Sucker Monitoring Annual Report

2022 GCMRC Annual Report

2022 NPS Annual Report of Tributary Translocations and Monitoring

2022 NPS YRRA Surveys Annual Report

FWS Mark-Recapture & Fish Monitoring Activities in the LCR in Grand Canyon 2000-2022

FWS Monitoring HBC in the CO River Grand Canyon 2021

Glen Canyon Dam Fish Escapement Options (Reclamation 2022)

Trout Management Flows Implementation Considerations (Reclamation 2022)

Van Haverbeke DR, Stone DM, Dodrill MJ, Young KL, Pillow MJ. 2017. Population expansion of humpback chub in Western Grand Canyon and hypothesized mechanisms. *Southwestern Naturalist* 62:285-292.