Initial Draft for Discussion

A Research and Monitoring Plan for Evaluating Trout Management Flows below Glen Canyon Dam

Introduction

This science plan was developed to support the Environmental Assessment for Non-Native Fish Control Downstream from Glen Canyon Dam dated December 30, 2011 (hereafter referred to as the Non-Native Fish Control EA). The purpose of the proposed action for the Non-Native Fish Control EA is to minimize the negative impacts of competition and predation by nonnative fish on the endangered humpback chub in Grand Canyon. Reclamation identified several mechanical removal and flow-related research questions to better manage non-native fish populations below Glen Canyon Dam in their EA. Data needs relating to mechanical removal of non-native fish were addressed in a science plan presented as an Appendix B to the Non-Native Fish Control EA. The science plan presented in this document addresses data needs relating to the flow-related management options identified in the EA. These data needs were identified as being:

- Determine if stranding flows could reduce rainbow trout recruitment in the Lees Ferry reach by dewatering redds or stranding juvenile trout;
- Evaluate the potential for utilizing changes in down-ramp rates to strand or displace juvenile trout and reduce recruitment;
- Evaluate different types and magnitudes of stranding flows;
- Determine if flow and non-flow actions at Lees Ferry would be effective in improving the Lees Ferry trout fishery.

A workshop coordinated by the Grand Canyon Monitoring and Research Center (GCMRC) at Saguaro Lake, AZ, on April 13-14, 2010, was held to discuss how to balance nonnative fish populations, specifically the rainbow trout fishery at Lees Ferry, with conservation of native and endangered fish species in Grand Canyon. Stakeholders, including representatives from Arizona Department of Fish and Game (AZDFG), U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (Reclamation), and private interest groups were involved with formulating ideas of how to best manage the Lees Ferry trout population without unduly impacting other resources associated with the Grand Canyon. These ideas were coalesced

into a discussion paper in May 2010 which was then provided to Reclamation to assist in the development of the Non-Native Fish Control EA. Trout management flows were identified as a potential treatment that would likely complement mechanical removal in reaching program objectives. Studies relating to mechanical removal are scheduled to begin in the fall of 2011with the start of the Natal Origins project and removal of rainbow trout in the Paria to Badger Creek Rapid (PBR) reach is scheduled to begin in 2012.

In 2011, the large rainbow trout cohort produced after the 2008 HFE spawned during high, steady equalization flows designed to transfer water from Lake Powell to Lake Mead. This has apparently led to another year of high rainbow trout recruitment below Glen Canyon Dam. Preliminary data from the 2011 Natal Origins field work have produced estimates of over 1 million age-0 trout in the Lees Ferry Reach (J. Korman, Ecometric, pers. comm. 2011). This is 17 times higher than the estimate made after the 2008 HFE is likely contributing to the 800 percent increase in rainbow trout densities in the Little Colorado River (LCR) reach since 2006. This has once again shown how influential the discharge patterns from Glen Canyon Dam are on the population dynamics of rainbow trout in the Lees Ferry reach. This also suggests that flow management, along with mechanical removal, will be necessary to effectively manage the trout population to achieve a desired density and size-structure for the fishery and to protect downstream resources such as humpback chub from increased competition and predation.

Objectives

The purpose of implementing trout management flows is to evaluate methods for using releases from Glen Canyon Dam to reduce the production of large numbers of age-0 rainbow trout in order to improve the quality of the Lees Ferry trout fishery and conserve the endangered humpback chub and other native fishes in Grand Canyon. This science plan describes how to determine whether releases from Glen Canyon Dam can be used to manipulate the age and size structure of the rainbow trout fishery at Lees Ferry.

One of the management goals described in the Nonnative Fish Management Plan for Grand Canyon (Hilwig et al. 2009) is to reduce the trout population in the LCR reach to 10-20% of the January 2003 trout abundance (approximately 600-1,200 individuals). This management

objective has not been evaluated for its feasibility or efficacy, thus we do not know if this level of removal is sustainable or how it will influence current or future humpback chub recruitment. It is believed, however, that some level of trout reduction in the LCR reach is necessary to improve recruitment and foster the recovery of the humpback chub population in the Grand Canyon.

We identified three objectives that need to be addressed to support management decision making:

- Sustain a healthy Lees Ferry trout population with a balanced age and size structure;
- Reduce annual production rates of rainbow trout in the Lees Ferry reach;
- Reduce emigration rates of rainbow trout from Lees Ferry to downstream reaches occupied by humpback chub.

Key Assumptions

To determine the effect of a trout management flows on either the rainbow trout population at Lees Ferry or the humpback chub population in the Grand Canyon, these experiments needs to be applied for a duration that approaches or exceeds the generation time for the two fish populations of interest (three to five years for rainbow trout and four to six years for humpback chub). Alternatively, inferences regarding the impact of trout management flows could be made using data on how the treatments affect the growth and/or survival of younger lifestages as long as any density dependant responses are taken into account. Regardless of which approach is taken to reduce uncertainty (that is, designing management actions that are long enough in duration to elicit a population response, or designing shorter duration management experiments and monitoring vital rates of juvenile life stages), variation in environmental factors (for example, the increases in water temperatures during 2003-2006 trout removal project) can complicate interpretation of results.

We identified eight key assumptions involving the use of trout management flows to improve conditions for both the recreational fishery at Lees Ferry and for humpback chub in the Grand Canyon. Although recent research and monitoring has identified some uncertainty associated with these assumptions, there has been enough concern expressed by management agencies to take reasonable actions to avoid jeopardy to the humpback chub population and

promote the development of potential trout management flows. The following assumptions are listed in order of precedence meaning if an assumption listed near the top of the list turns out to be incorrect, the relevance of resolving subsequent assumptions may be reduced.

- Survival and recruitment of juvenile humpback chub rearing in the Colorado River mainstem are significant factors limiting the adult humpback chub population in the Grand Canyon;
- Competition and/or predation between humpback chub and rainbow trout in the Colorado River mainstem is significantly limiting survival and recruitment of juvenile humpback chub;
- Management actions being implemented to improve conditions for resources associated with the Grand Canyon river corridor are also increasing the production of age-0 rainbow trout in the Lees Ferry reach;
- The origin of rainbow trout near the confluence of the LCR is from the Lees Ferry reach;
- Maintaining moderate age-0 trout densities while preserving the aquatic foodbase in the Lees Ferry reach would result in fewer but substantially larger adult trout of better condition that are less likely to migrate downstream to the LCR reach;
- Decreasing the production of age-0 trout in the Lees Ferry reach would help reduce the need for long-term and continuous mechanical removal of rainbow trout in the LCR reach;
- Utilizing trout management flows to reduce the number of age-0 rainbow trout in the Lees Ferry reach would be more efficient, cost-effective, and culturally acceptable than relying solely on mechanical removal;
- Age-0 trout are more sensitive to flow variation during the period of their lifecycle when they are more likely to be found in low-angle shoreline habitat.

If all of these assumptions are relatively correct, then trout management flows will likely benefit both the rainbow trout fishery at Lees Ferry and the humpback chub population in the Grand Canyon. However, if the foremost assumption is found to be incorrect, it would negate the relevance of the remaining assumptions and the utility of the proposed management action. For example, if the Colorado River mainstem rearing environment is not contributing significantly to juvenile humpback chub growth, survival, and recruitment, then the observed changes in adult humpback chub abundance that have occurred since the early 1990's must be attributable to factors occurring in the LCR and are independent of what is occurring in the mainstem. If this is the case, it is unlikely that any management activity directed at the trout population in the mainstem would have significant positive benefits to humpback chub and the proposed action

would then need to be identified as a management tool solely to improve the trout fishery at Lees Ferry. On the other hand, if a relatively high proportion of humpback chub that move/disperse into the mainstem ultimately recruit into the adult population, then competition and predation by rainbow trout may in fact be limiting humpback chub recruitment and actions taken to change the dynamics of the trout population at Lees Ferry could improve conditions for the humpback chub population in Grand Canyon.

Critical Uncertainties and Hypotheses

In addition to assumptions identified above, five areas of critical uncertainty were identified that would have on the success or failure of any attempt to use flows to improve management the trout population at Lees Ferry.

- How would trout management flows impact the Lees Ferry fishery?
    - H_1: Trout management flows would decrease the number of age-0 trout competing with older cohorts for limited food resources thereby improving food availability for and condition of the larger trout which would in turn produce a higher quality trophy trout fishery.

- How would a reduction in age-0 trout impact the humpback chub population in the Grand Canyon?
    - H_2: Trout management flows would decrease emigration of age-0 trout from Lees Ferry to the LCR thereby decreasing competition and predation interactions between rainbow trout and humpback chub and improving the chances for humpback chub recovery.

- When do rainbow trout emigrate from the Lees Ferry reach to the LCR reach and when would trout management flows be most effective?
    - H_3: The majority of rainbow trout emigrating downstream of Lees Ferry do so at the end of their first year of life and they move primarily in spring. Trout management flows would be most effective during their first spring and summer when they are most likely to be found in shallow, near-shore habitats.

- What would be the most effective flow treatment to reduce age-0 trout densities without significantly impacting other resources?
    - H_4: Daytime dewatering of redds combined with mechanical removal of redds below the low water mark that would reduce the number of viable eggs.

- H_5: Age-0 trout habitat limiting flows that would reduce the habitat availability for age-0 trout making them more reliant on sub-optimal habitats where they would be subject to poor growing conditions.
- H_6: Age-0 trout stranding/displacement flows that would draw age-0 trout onto high elevation gravel bars and benches and then strand them by rapidly decreasing releases from Glen Canyon Dam.
- H_7: A combination of the aforementioned flow treatments, combined with mechanical removal of age-0 trout at the end of the summer, would result in a greater reduction in age-0 trout numbers than implementing any one treatment alone.

- What level of trout egg and alevin mortality would be necessary to overcome any density dependent compensatory response?
  - H_8: Redd-induced mortality of somewhere between 50% and 90% would be sufficient to overcome any density dependent compensatory response. This level of treatment, however, may significantly impact other resources such as aquatic foodbase.

- What is the target number of rainbow trout in the LCR reach that would keep competition with and predation of humpback chub sufficiently low to insure adequate recruitment?
  - H_9: Achieving the management goal of 10-20% of the January 2003 trout abundance (600-1,200 individuals) is necessary to maintain adequate recruitment of humpback chub.

Development of Treatments

The blue ribbon rainbow trout fishery at Lees Ferry is a valued and popular recreational fishery that has been the focus of a series of extensive monitoring projects by state and federal agencies since shortly after the closure of Glen Canyon Dam. High, steady releases from Glen Canyon Dam during the spring and summer of 2011 appear to have contributed to a recruitment event that is 10 to 20 times higher than any recruitment event since monitoring in the Lees Ferry reach began, including the high production year following the 2008 high flow experiment. Although this recruitment event may sound like a positive thing for the Lees Ferry fishery, monitoring by the AZDGF and the GCMRC from 1991-2009 has shown that the fishery is becoming increasingly dominated by smaller, subcatchable trout and the catch of larger, trophy-sized trout is becoming relatively rare. This monitoring has also shown that as the number of smaller trout increases, the condition index of larger trout decreases (Makinster et al. 2011). This

is believed to be because the dynamics of the trout population are primarily driven by food availability and competition between larger, older fish and these younger age classes. In a year of exceptional trout production, such as 2008 and 2011, these younger age classes can overwhelm the foodbase in the Lees Ferry reach resulting in less than optimal conditions for the larger, more desirable trout.

These high recruitment events also raise the concerns of managers tasked with the conservation of the endangered humpback chub and the other native fish populations below Glen Canyon Dam. Rainbow trout have been identified as a competitor and a predator of humpback chub and other native fishes in the Colorado River below the dam. There are a number of ongoing studies intended to monitor the trout population at Lees Ferry and to track potential conflicts with native fish populations in Grand Canyon. Several management actions in the Non-Native Fish Control EA are currently being considered that may have a substantial impact on how the fishery is managed in the future. One such action, implementation of flow experiments to reduce the number of trout produced by high flow experiments, was recommended in the most recent biological opinion for operations at Glen Canyon Dam.

The objective of this paper is to describe a series of possible management actions that could reduce rainbow trout recruitment such that emigration out of the Lees Ferry Reach is minimized while enhancing the quality of rainbow trout within the Lees Ferry Reach. These treatments were developed by several stakeholders including AZDFG, GCMRC, USFWS, and Reclamation with the following objectives in mind:

1. Rebuild and maintain the blue-ribbon trophy trout fishery between Glen Canyon Dam and Lees Ferry;
2. Reduce emigration rates of rainbow trout from Lees Ferry to downstream reaches occupied by humpback chub and other native fishes.

This proposal is to experiment with releases at Glen Canyon Dam to determine if certain flow combinations are effective at manipulating the trout population at Lees Ferry to a more desirable state without unduly impacting other valued resources in the project area. The dual goals of improving the sport fishery while reducing conflicts between sport fish and native fish

management are considered equally important to the success of any trout management flow treatment. Also critical to the success of a flow treatment will be the assessment of other valued resources in the canyon including such things as conservation of the aquatic foodbase, sediment, cultural value and perspectives, and impacts to recreation and power production.

Treatment 1: Redd stranding flows with mechanical removal of redds below the minimum flow elevation.

This treatment uses flow manipulation at Glen Canyon Dam to periodically dewater redds (nests trout build to lay their eggs in) during the rainbow trout spawning period thereby reducing the number of viable eggs that could hatch and recruit to the age-0 trout population. The objective of this treatment would be to dewater and/or mechanically remove between 50% and 90% of the redds produced over the spawning season. These types of flows are thought to have limited age-0 trout recruitment under pre-ROD conditions.

Redd stranding flows could be implemented within current ROD guidelines and would consist of a period of high steady flows (between 17 and 21 kcfs) for an extended period of time (i.e. 18 hours to several days) to encourage fish to spawn on higher elevation gravel bars and benches during the peak spawning period (February-April). Flows would then be reduced to between 15 and 9 kcfs (or the monthly minimum flow of 5 or 8 kcfs) for a dewatering treatment lasting 10-12 hours and occurring every 2-4 weeks over the incubation period (mid-March to mid-May). This treatment should occur during the daytime to take advantage of heating the spawning gravels which is more effective at reducing the survival of eggs and alevins (newly hatched trout) than just dewatering them. Redds below the minimum flow elevation could be mechanically treated using a hydraulic pressure washer in shallow water or a suction dredge in deeper water to increase the effectiveness of this treatment.

This treatment would likely be most effective during periods of extended high flows (i.e. equalization flows) due to the tendency of trout to spawn higher on gravel bars under these flow conditions. The effectiveness of this treatment is limited by how low flows could be reduced without impacting other valuable resources in the canyon, such as aquatic foodbase resources used by adult rainbow trout. Mechanical removal of redds would be less labor intensive than

mechanical removal of age-0 fish. However, strong compensatory mechanisms of increased fry survival under low density conditions could result in little observable effect in age-0 trout unless redd removal was substantially greater than natural levels of egg and fry mortality combined.

Redd stranding flows would have negligible affects to adult and juvenile humpback chub in the mainstem since they occupy and utilize habitats that that are only minimally affected by flow fluctuations at this time of year. This treatment would conclude prior to age-0 humpback chub use of nearshore mainstem habitats. Flannelmouth suckers spawning in the Paria Rapid reach may be affected by these flows at this time of year. Impacts to power production could be mitigated by using a weekend treatment but this might negatively impact fishing and boating recreation by making the river more difficult to navigate. A daytime treatment, as prescribed here, would also be highly visible to anglers and other groups, thus extensive outreach would be needed to maintain public support for this treatment. Angler success might improve during the treatments due to lower water levels, concentration of fish, and the disturbance of the benthos (organisms living in the river bottom) during mechanical treatment of redds. Disturbance of the benthos from mechanical treatment would be a localized short-term effect. Redd stranding flows could be combined with any of the following treatments to increase the cumulative effect of conducting multiple treatments and in offsetting the impact of compensatory mechanisms at various life stages.

Treatment 2: Age-0 Trout Habitat Limiting Flows.

This treatment relies on daily flow fluctuations to reduce the habitat availability of age-0 trout (fry and juveniles) making them more reliant on sub-optimal habitats where they would be subject to poor growing conditions. Daily flow fluctuations have been shown to negatively impact age-0 trout without affecting larger trout (Makinster et al. 2011). Under this flow regime age-0 trout are more likely to remain in deeper, colder water exposing them to decreased growth. This treatment has already been implemented to some extent with MLFF and is considered to be a control mechanism that does reduce the fitness of age-0 trout under current operations.

Habitat limiting flows could be provided within ROD guidelines with MLFF or the treatment could be enhanced by increasing the allowable daily fluctuation when age-0 trout are

most sensitive to flow fluctuations (May-August). A nighttime minimum flow treatment would be more effective than a daytime treatment because age-0 trout typically come closer into shore at night. Currently, the ROD limits daily fluctuations from May to August to between 6 and 8 kcfs depending on monthly release volumes. Increasing limits on daily fluctuations beyond ROD limits on at least a weekly basis would likely increase the effectiveness of this treatment but may increase impacts to other resources in the canyon as well. A critical component of this treatment would be to ensure that flows drop to between 15 and 9 kcfs (or to the monthly minimum flow of 8 kcfs) for 12-14 hours on at least a weekly basis to dewater shallow gravel bars and benches in the Lees Ferry reach.

This treatment would likely be most effective during periods of time when releases from Glen Canyon Dam are already fluctuating for power generation. This treatment could also be incorporated into other flows scenarios such as equalization as long as a periodic flow reduction below 15 kcfs could be achieved at least once per week. This treatment is already being provided to some extent under normal operations at Glen Canyon Dam with MLFF and it may be more effective at having a population level response than redd stranding flows because it is targeting an older age class that is less likely exhibit a density-dependent response.

Habitat limiting flows would have negligible affects to adult and juvenile humpback chub in the mainstem since at this time of year they occupy and utilize habitats that that are only minimally affected by flow fluctuations. This treatment may affect juvenile and age-0 humpback chub use of nearshore habitats in the mainstem but impacts would be similar to existing fluctuating conditions and indications are that survival of juvenile and age-0 humpback chub in the mainstem can be relatively high under these conditions (i.e., MLFF; See Reclamation's supplement to biological assessments for Development and Implementation of a Protocol for High-Flow Experimental Releases and Non-native Fish Control Downstream from Glen Canyon Dam. Arizona, 2011 through 2020 for a full discussion of recent science pertaining to the Near Shore Ecology project, 2008-2010, Dr. B. Pine, Univ. of Florida.). Other impacts to resources would be similar to those already identified in the 1995 EIS and ROD.

Treatment 3: Age-0 Trout Stranding/Displacement Flows.

This treatment relies on a period of high steady flows to draw age-0 trout (fry and juveniles) onto high elevation gravel bars and benches and then stranding those fish by rapidly decreasing releases from Glen Canyon Dam. The age-0 trout that do not get stranded would be displaced into less favorable habitats resulting in impacts similar to those discussed above for Treatment 2.

Age-0 trout stranding/displacement flows could be provided within ROD guidelines with the treatment consisting of a period of high steady flows (between 17 and 21 kcfs) for an extended period of time (i.e. 18 hours to several days or weeks) to encourage age-0 trout to inhabit high elevation gravel bars and benches. Flows would then be rapidly reduced to between 15 and 9 kcfs (or the monthly minimum flow of 8 kcfs) for a dewatering treatment lasting 10-12 hours and occurring every 2-4 weeks. This treatment would take place from May to August when age-0 trout are most likely to be in these near-shore habitats. A nighttime minimum flow treatment would be more effective than a daytime treatment because age-0 trout typically come closer into shore at night. Increasing downramp rates beyond ROD guidelines may make this treatment more effective. The ROD currently limits downramp rates to 1,500 cfs/hr to reduce the probability of stranding young fish in nearshore habitats. Operationally, down ramping from 33,200 cfs (maximum power plant capacity at Glen Canyon Dam) to the daily minimum of 8 kcfs could occur nearly instantaneously.

This treatment would be most effective during periods of extended high flows (i.e. equalization flows) due to the likelihood of age-0 fish of utilizing high elevation gravel bars and benches when flows are held high and steady for an expanded period of time. As with Treatment 2, this treatment may be more effective at having a population level response than redd stranding flows because it is targeting an older age class that is less likely to exhibit a density-dependent response. This treatment, however, may also strand larger, more desirable trout occupying nearshore habitat during the night as well. Any larger fish caught in the nearshore during a stranding event would likely be more susceptible to mortality than smaller, age-0 fish because they would not be able to escape or endure the stranding as readily as a smaller fish.

Age-0 stranding/displacement flows would have negligible affects to adult humpback chub since they occupy and utilize habitats that that are only minimally affected by flow

fluctuations. Rapid downramp rates may affect juvenile and age-0 humpback chub use of the nearshore in the mainstem with greater affects impacting humpback chub aggregations located nearer to Glen Canyon Dam. This treatment may negatively impact bluehead sucker spawning in June and July. The aquatic foodbase in the Lees Ferry reach may reset at a higher elevation with high steady flows and then be greatly reduced with the occasional drawdown. High steady flows generally have negative impacts on power production and sediment transport and off-schedule low flows may affect rafting safety in rapids and result in stranding large rafts on camping beaches.

Treatment 4: Mechanical Removal of Age-0 Trout.

This treatment calls for the mechanical removal age-0 trout in the Lees Ferry reach with boat-mounted electrofishing equipment. Mechanical removal of age-0 trout could be used to complement the aforementioned flow-based treatments when those treatments are not fully successful in reducing the age-0 trout population to an end-of-summer target or it could be used exclusively when conditions are such that using a flow-based treatment would not be effective. Mechanical removal studies are currently being considered to determine if a reduction in the trout population leads to a reduction in emigration into the LCR reach (e.g., Paria to Badger Rapid removals). This project could also be expanded into the Lees Ferry reach to see if a reduction in age-0 trout leads to improved condition of larger trout. Mechanical removal has been shown to be effective at reducing trout densities in the LCR reach.

Many of the methodologies for mechanical removal of trout in Grand Canyon have been developed by GCMRC and its partners. Mechanical removal would be done at night from September to October and in the Lees Ferry reach would only focus on the removal of age-0 trout. Removal would be done using a slow speed-multiple pass method from an electrofishing boat focusing on nearshore talus habitats. It is estimated that under relatively low age-0 trout abundance conditions, approximately 40 nights of effort could reduce the age-0 trout population by about 80% of its pre-removal abundance. For comparison, approximately 75 days per year were dedicated to nonnative fish removal during the LCR trout removal efforts from 2003 to 2006.

This treatment would be most effective during periods of time when nighttime releases from Glen Canyon Dam are relatively low (i.e. during MLFF flows). High steady flows not only lead to the production of large numbers of age-0 trout that can overwhelm such removal efforts but also increase fish dispersal into deeper, faster water making them more difficult to catch and remove.

Mechanical removal of age-0 trout in the Lees Ferry reach would have negligible affects to humpback chub and other native fish since native fish are largely absent from this reach of the river. An advantage of mechanical removal is that it eliminates many of the potential negative effects of trout management flows, such as reductions in the aquatic foodbase and impacts to the boating or fishing communities. Mechanical removal is also a very controllable action that can be stopped when the age-0 trout population has been reduced to a targeted level.

Treatment Implementation schedule

Differences in the efficiency of trout management flows and mechanical removal suggest that each of the four treatments discussed above may be more effective under some flow scenarios than others. For example, redd stranding flow and age-0 trout stranding flows would likely be more effective when releases can be held high and steady for an extended period of time (i.e. equalization flows) whereas age-0 trout habitat limiting flows and mechanical removal would likely be more effective at lower flows more typical of power operations. Releases from Glen Canyon Dam could also be manipulated for short periods of time to where the four treatments outlined above could be used sequentially to target different vulnerabilities of age-0 trout as they age over the course of the year. Several scenarios are presented below for how trout management flows could be incorporated into various release schedules for a range of upcoming water years.

Scenario 1. High and steady releases for the year.

This scenario describes a combination of possible trout management flows that could be implemented when releases from Lake Powell must be maintained at or near power plant capacity for an extended period of time (e.g. to meet equalization levels with Lake Mead). Beginning in February, set daytime maximums to between 17 and 21 kcfs (or higher if necessary) and hold for at least 18 hours at a time to encourage fish to spawn at higher elevations on gravel bars. Conduct a pre-treatment redd count to get an estimate of trout production. Once every 2-4 weeks beginning in mid-March, reduce releases early in the morning to between 15 and 9 kcfs (or the daytime minimum flow 8 kcfs or lower if allowable) and hold for 10-12 hours. During the day of the treatment when the water levels are low, remove redds located below the minimum flow elevation with a hydraulic pressure washer or a suction dredge. Repeat every 2-4 weeks until May. Beginning in May, downramp flows one day every 2-4 weeks as fast as allowable to between 15 and 9 kcfs (or the seasonal minimum flow of 8 kcfs) for a nighttime stranding treatment lasting 10-12 hours. Repeat every 2-4 weeks until August. During the first week of August, perform a population estimate on the age-0 trout population. If the population estimate exceeds production goals, proceed with mechanical removal. During each nighttime mechanical removal effort, reduce flows as low as permissible to concentrate age-0 trout. Continue mechanical removal until the age-0 trout population estimate reaches the annual production goal.

Scenario 2. High and steady releases in the early spring followed by fluctuating flows summer and fall.

This scenario describes a combination of possible trout management flows that could be implemented when releases from Lake Powell must be maintained at or near power plant capacity (e.g. to meet equalization levels with Lake Mead) from winter into the early spring but then switch to a fluctuating flow regime (e.g. MLFF) in the summer and fall. Beginning in February, set daytime maximums to between 17 and 21 kcfs (or higher if necessary) and hold for 18 hours at a time to encourage fish to spawn at higher elevations on gravel bars. Conduct a pre-treatment redd count to get an estimate of trout production. Once every 2-4 weeks beginning in mid-March, reduce releases early in the morning to between 15 and 9 kcfs (or the daytime

minimum flow 8 kcfs or lower if allowable) and hold for 10-12 hours. During the day of the treatment when the water levels are low, remove redds located below the minimum flow elevation with a hydraulic pressure washer or a suction dredge. Repeat every 2-4 weeks until May. Beginning in May proceed with age-0 trout habitat limiting flows (MLFF) making sure that flows at the very least drop below 15 kcfs for 12-14 hours on a weekly basis. Continue these flows until August. During the first week of August, perform a population estimate on the age-0 trout population. If the population estimate exceeds production goals, proceed with mechanical removal. Continue mechanical removal until the age-0 trout population estimates reach the annual production goal.

Scenario 3. MLFF for the year.

This scenario describes a combination of possible trout management flows that could be implemented when releases from Lake Powell are being operated under a fluctuating flow regime (e.g. MLFF) for the year. Beginning in February, set daytime maximums to between 17 and 21 kcfs (or higher if necessary) and hold for 18 hours at a time to encourage fish to spawn at higher elevations on gravel bars. During this time, reduce nighttime flows by 6 or 8 kcfs (depending on monthly release volumes) according to ROD guidelines. Conduct a pre-treatment redd count to get an estimate of trout production. Once every 2-4 weeks beginning in mid-March, reduce releases early in the morning to between 15 and 9 kcfs (or the daytime minimum flow 8 kcfs or lower if allowable) and hold for 10-12 hours. Remove redds located below the minimum flow elevation with a hydraulic pressure washer or a suction dredge when the water levels are low. Repeat every 2-4 weeks until May. Beginning in May proceed with age-0 trout habitat limiting flow treatments increasing daily maximum and minimum releases and ramping rates to as high of a level as allowable. Make sure that flows drop below 15 kcfs for 12-14 hours on at least a weekly basis. Continue with these flows until August. During the first week of August, perform a population estimate on the age-0 trout population. If the population estimate exceeds production goals, proceed with mechanical removal. Continue mechanical removal until the age-0 trout population estimates reach the annual production goal.

Linkages to Existing Monitoring and Research Projects

As part of the Glen Canyon Adaptive Management Program, there are five existing long-term monitoring projects that will also provide additional data to evaluate the efficacy of using trout management flows to meet the aforementioned objectives. These long-term monitoring projects include:

- Monitoring Lees Ferry Fishes (BIO 4.M2.10) – Ongoing status of the Lees Ferry trout fishery (adult and juvenile fish);
- Monitoring Mainstem Fishes (BIO 2.M4.10) – Ongoing downstream monitoring of nonnative fish distribution and relative abundance in the mainstem (includes Diamond down);
- Stock Assessment of Native Fish in Grand Canyon (BIO 2.R7.10) – Age-structured mark recapture (ASMR) recruitment modeling update for adult humpback chub (Age- 4+);
- Little Colorado River Humpback Chub Monitoring (BIO 2.R1.10) – Annual point estimates for HBC population in the lower 13.57 km;
- Mainstem HBC Aggregation Trips – Distribution and relative abundance of humpback chub in the mainstem.

Research and reporting efforts that are part of the monitoring and research programs associated with the mainstem and its tributaries will also help inform the adaptive decision-making process.

- Annual Nonnative Fish Workshop – A scientists/manager workshop to review current data/finding and adapt the program as needed, GCMRC biannual work plan project (BIO 2.R17.11-12);
- Evaluate Lees Ferry Recreation Experience Quality – To assess how will multiple high flows and other flow experiments conducted over the next 10 years affect recreational experience quality in the Colorado River corridor in Glen Canyon (REC 9.R4.11,12);
- Brown trout removal at Bright Angel Creek conducted by the National Park Service;
- Continued ecosystem modeling (PLAN 12.P1.11,12).

Annual Reporting

Annual reporting is scheduled to occur in early December as part of the GCMRC's Annual Fish Cooperators Meeting. A written summary will also be provided that includes the annual resource assessment and criteria for supporting the decision making process to be used for the coming year. The primary information provided will include:

1) Lees Ferry redd count and estimate of number of redds dewatered and mechanically removed;
2) Lees Ferry age-0 trout marking numbers and recaptures in the Lees Ferry, PBR, and Marble Canyon/LCR reaches [data from the Monitoring Lees Ferry Fishes (BIO 4.M2.10) and Monitoring Mainstem Fishes (BIO 2.M4.10) projects];
3) Lees Ferry age-0 trout abundance estimates and total fish catch and removal.

General Budget

Under development

References Cited

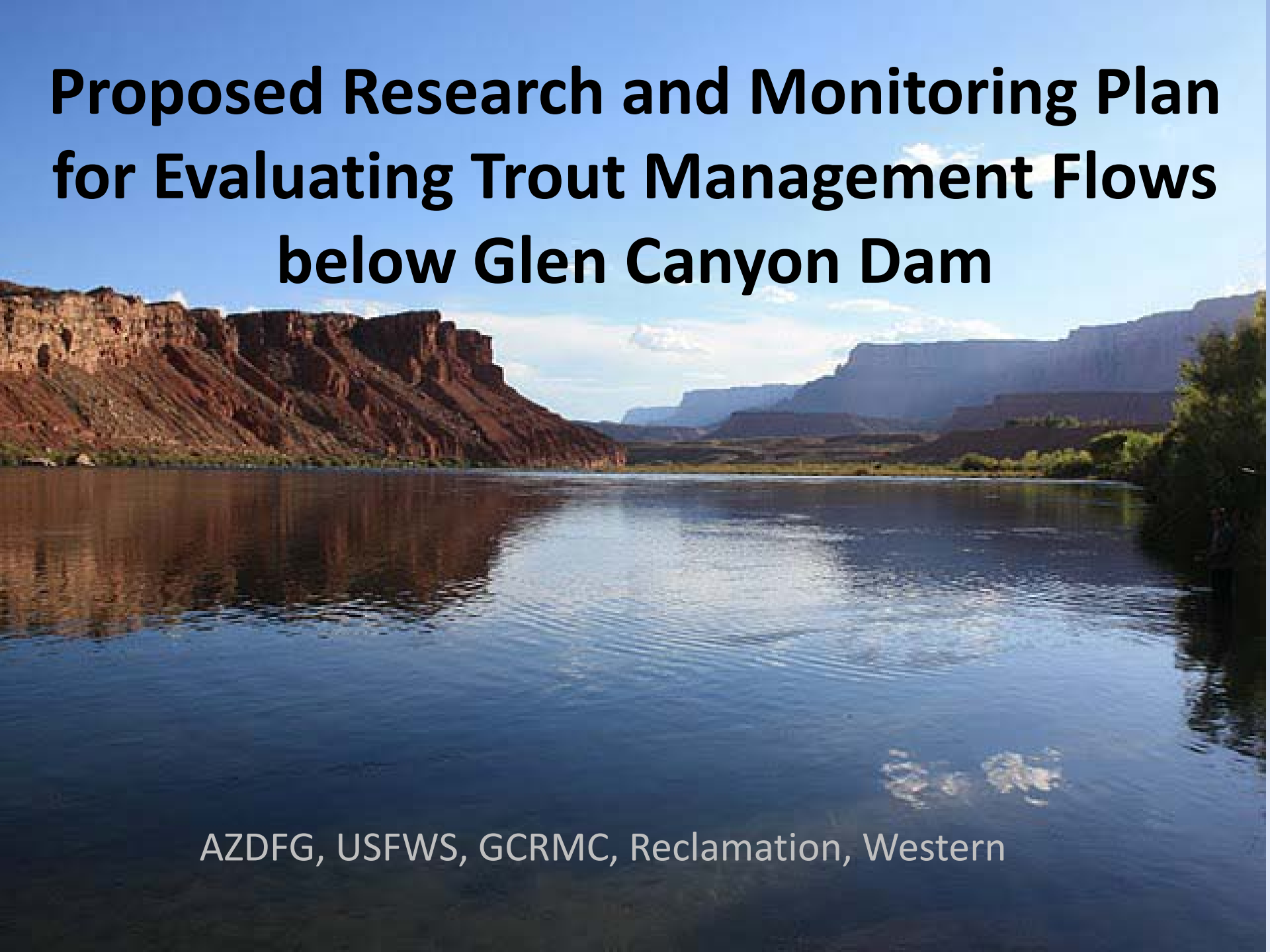
Hilwig, K.D., Andersen, M.E., Coggins, L.E., Jr. 2009. Nonnative fish management plan for Grand Canyon—a comprehensive approach to management and research of nonnative fish species. U.S. Geological Survey Planning Document. 79 p.

Makinster, A.S., Persons, W.R., and Avery, L. A., 2011, Status and trends of the rainbow trout population in the Lees Ferry Reach of the Colorado River downstream from Glen Canyon Dam, Arizona, 1991-2009: U.S. Geological Survey Scientific Investigations Report 2011-5015, 17 p.

Table 1. Description of parameters for the three flow-related treatments and mechanical removal to manage the rainbow trout fishery at Lees Ferry.

	Treatment 1: Redd stranding flows with mechanical removal of redds	**Treatment 2: Age-0 Trout Habitat Limiting Flows**	**Treatment 3: Age-0 Trout Stranding/ Displacement Flows**	**Treatment 4: Mechanical Removal of Age-0 Trout**
Effective flow conditions	High steady flows (equalization)	Operations (MLFF)	High steady flows (equalization)	Operations (MLFF)
Time frame	February-April	May-August	May-August	September-October
Frequency	One day every 2-3 weeks (weekend)	Nightly to one night per week	One night every 2-3 weeks	Five, week-long, nightly treatments
Duration	Daytime	Nighttime	Nighttime	Nighttime
Maximum release	Daytime (non-treatment): 17k to 21k up to 25k	Daytime: 17k to 21k up to 25k	Daytime: 17k to 21k up to 25k	Daytime: up to 25k (ROD)
Minimum release	Daytime (treatment): Dewatering: 9k to 15k or as low as permissible Mechanical removal: 8k (ROD) or as low as permissible Nighttime (non-treatment): 5k to 25k	Nighttime: 9k to 15k or as low as permissible (ROD: 5k)	Nighttime: 9k to 15k or as low as permissible (ROD: 5k)	Nighttime (treatment): As low as permissible (ROD: 5k) Nighttime (non-treatment): 5k to 25k
Up ramp rate	4kcfs/hr (ROD)	4kcfs/hr (ROD)	4kcfs/hr (ROD)	4kcfs/hr (ROD)
Down ramp rate	1500 cfs/hr (ROD)	1500 cfs/hr (ROD)	As fast as permissible	1500 cfs/hr (ROD)

Proposed Research and Monitoring Plan for Evaluating Trout Management Flows below Glen Canyon Dam



AZDFG, USFWS, GCRMC, Reclamation, Western

Initial thoughts/collaboration

- BiOp & EA require trout management flows
- Discussion paper developed in 2010
- Draft science plan developed by AZDGF, GCMRC, USFWS, and Western for TWG consideration and discussion
- Idea is that TWG will work with GCMRC to develop a science-based recommendation

Objectives

2011 Non-Native Fish Control EA

- Sustain a healthy Lees Ferry trout population with a balanced age and size structure (Blue Ribbon trophy);

- Reduce annual production rates of rainbow trout in the Lees Ferry reach;

- Reduce emigration rates of rainbow trout from Lees Ferry to downstream reaches occupied by humpback chub.

Data Needs

2011 Non-Native Fish Control EA

- Determine if stranding flows could reduce rainbow trout recruitment in the Lees Ferry reach by dewatering redds or stranding juvenile trout;
- Evaluate the potential for utilizing changes in down-ramp rates to strand or displace juvenile trout and reduce recruitment;
- Evaluate different types and magnitudes of stranding flows;
- Determine if flow and non-flow actions at Lees Ferry would be effective in improving the Lees Ferry trout fishery.

Trout Management Treatments

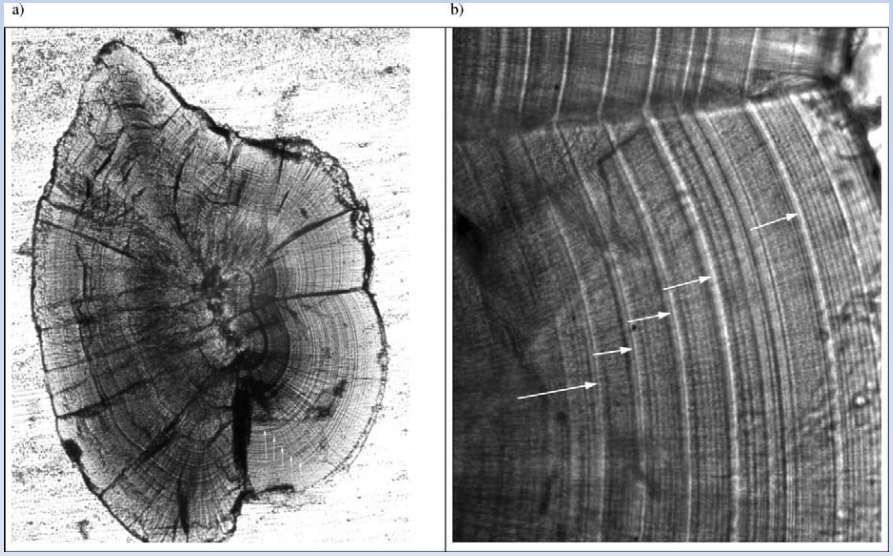
- Redd stranding flows
- Age-0 Trout Habitat Limiting Flows
- Age-0 Trout Stranding/Displacement Flows
- Mechanical Removal of Age-0 Trout

Treatment 1: Redd stranding flows with mechanical removal of redds below the minimum flow elevation

- February-April (peak spawning period)
  - High steady flows above 17-21 kcfs
  - Hold for 18 hours or longer
- Mid-March to mid-May (incubation period)
  - Reduce flows below 15-9 kcfs
  - During the daytime for 10-12 hours every 2-4 weeks
- Mechanical removal of redds
  - Shallow: hydraulic pressure washer
  - Deep water: suction dredge

Treatment 2: Age-0 Trout Habitat Limiting Flows

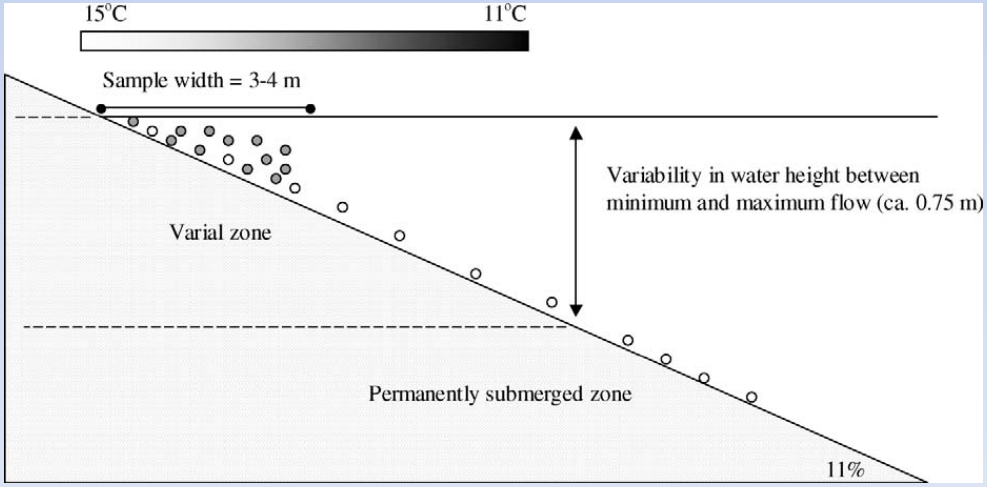
- Fluctuating flows
  - May-August
  - Reduce flows to between 15 and 9 kcfs
  - Nighttime low flows for 12-14 hours
  - At least 1x week



Korman and Campana 2009. Effects of Hydropeaking on Nearshore Habitat Use and Growth of Age-0 Rainbow Trout in a Large Regulated River

Treatment 3: Age-0 Trout Stranding/Displacement Flows

- Rapid downramps
  - May-August
  - Hold high steady flows above 17-21 kcfs
    - for 18 hours to several days
  - Reduce flows below 15-9 kcfs as fast as permissible
    - Nighttime low flows for 10-12 hours
    - 1x every 2-4 weeks



Korman and Campana 2009. Effects of Hydropeaking on Nearshore Habitat Use and Growth of Age-0 Rainbow Trout in a Large Regulated River

Treatment 4: Mechanical Removal of Age-0 Trout

- Nighttime electrofishing
  - Implement if August age-0 trout estimates are still above target levels
  - Restricted to age-0 trout
  - Continue until age-0 trout population estimates reach target levels
  - August-October

Scenario 1. High and steady releases for the year

- **Redd stranding flows**
  - February: hold flows above 17-21 kcfs
  - Conduct a pre-treatment redd count
  - Mid-March: reduce daytime flows below 15-9 kcfs, once every 2-4 weeks, for 10-12 hours
  - Mechanically remove redds
- **Age-0 Trout Stranding/Displacement Flows**
  - Rapid down ramps
    - High steady flows above 17-21 kcfs
    - 18 hours to several days
    - Reduce flows below 15-9 kcfs as fast as permissible
    - Low flows for 10-12 hours every 2-4 weeks
    - May-August.
- **Mechanical Removal of Age-0 Trout**
  - August: estimate the age-0 trout population
  - If the population estimate exceeds production goals, proceed with mechanical removal.
  - Reduce nighttime flows during treatment
  - August-October

Scenario 2. High and steady releases in the early spring followed by fluctuating flows summer and fall

- **Redd stranding flows**
  - February: hold flows above 17-21 kcfs
  - Conduct a pre-treatment redd count
  - Mid-March: reduce daytime flows below 15-9 kcfs, once every 2-4 weeks, for 10-12 hours
  - Mechanically remove redds

- **Age-0 Trout Habitat Limiting Flows**
  - Fluctuating flows
    - May-August
    - Reduce flows to between 15 and 9 kcfs
    - Low flows at night
    - for 12-14 hours
    - At least 1x week

- **Mechanical Removal of Age-0 Trout**
  - August: estimate the age-0 trout population
  - If the population estimate exceeds production goals, proceed with mechanical removal
  - August-October

Scenario 3. Fluctuating flows for the year

- **Redd stranding flows**
  - February: hold daytime flows above 17-21 kcfs for at least 18 hours
  - Conduct a pre-treatment redd count
  - Mid-March: reduce daytime flows below 15-9 kcfs, once every 2-4 weeks, for 10-12 hours
  - Mechanically remove redds
- **Age-0 Trout Habitat Limiting Flows**
  - Fluctuating flows
    - May-August
    - Reduce flows to between 15 and 9 kcfs
    - Low flows at night
    - for 12-14 hours
    - At least 1x week
- **Mechanical Removal of Age-0 Trout**
  - August: estimate the age-0 trout population
  - If the population estimate exceeds production goals, proceed with mechanical removal
  - August-October

Discussion

- How can we as a Program better collaborate with fishing interests and the Marble Canyon business community?
  - For example: What is the difference between Nonnative Fish Suppression Flows and Trout Management Flows?
  - Are there other non-removal/non-flow management tools that should be implemented as well?

- How do we better incorporate tribal perspectives and values when working to resolve concerns with fish management protocols in the canyon?

- How do we incorporate trout management flows into a comprehensive Fish Management Plan?
  - Recommendations should be compatible with a
    - Management plan for a Blue Ribbon Trout Fishery (AZDFG)
    - Native Fish Management Plan (NPS, AZDFG, USFWS)