BIO 2.Rxx: Mainstem juvenile humpback chub monitoring (including Marble Canyon sampling). NEW COST (NNFCF); informs removal decisions near the Little Colorado River

Start Date

June 2012

End Date

September 2017

Principal Investigators

To be determined in cooperation with USGS/Grand Canyon Monitoring and Research Center

Geographic Scope

The mainstem Colorado River in Grand Canyon below the mouth of the Little Colorado River

Project Goals

The primary goal of the mainstem juvenile humpback chub (*Gila cypha*; HBC) assessment is to determine how abundance , growth and survival rates for this age-class responds to varying trout densities near the confluence of the Little Colorado River (LCR). This information is intended to help guide decision making regarding the control of nonnative fish in the mainstem.

The objectives addressed by this project are as follows:

- Quantify capture probabilities by habitat/gear type, species, and fish size using short-term, closed, mark-recapture experiments,
- Estimate localized abundance of juvenile HBC in selected areas using a closed population model approach,
- Estimate the annual apparent survival for multiple size classes of juvenile HBC (batch marks and unique identifiers),
- Estimate growth using a combination of modal progression (shifts in length-frequency) and direct ageing (individual capture histories),
- In coordination with Project BIO 2.E18.11, 12 monitor changes in rainbow trout (*Oncorhynchus mykiss*; RBT) and brown trout (*Salmo trutta*; BNT) relative abundance and distribution using data collected and relate results to HBC response.

Need for Project

The relationship between nonnative fish abundance and juvenile HBC abundance and survival in the mainstem is not well understood. While it is known that salmonids can prey on native fish species, including HBC, it is not known how predation affects recruitment to the adult population of HBC in the LCR. A diet study conducted in association with a mechanical removal experiment from 2003-2006 determined that the majority of native fish consumed by trout were juvenile and subadults (< age-3) (Yard

and others, 2011) and it has been inferred that the loss of so many young fish, especially HBC, may have affected recruitment to the adult HBC population (USBR 2011). Results from the age-structured mark-recapture model indicate an increasing trend in adult (≥ age-4) abundance of humpback chub (Coggins and others 2006; Coggins and Walters 2009) that corresponds with trout removal efforts during a system-wide decline in trout numbers (Coggins and others, 2011; Makinster and others, 2010). Although these data are compelling, the negative correlation between salmonid abundance and HBC recruitment cannot be inferred to be causal. Therefore, reducing trout abundance for the purpose of restoring native fish populations, especially HBC may not have the desired management response (Yard and others, 2011). This project in coordination with the Natal Origins Project and mainstem monitoring will improve our understanding of the relationship between HBC survival and abundance and variable nonnative fish abundance in the mainstem. Findings from this project are intended to provide information on if nonnative removal efforts are a useful management response.

Strategic Science Questions

Primary SSQs addressed:

SSQ 1-1. To what extent are adult populations of native fish controlled by production of young fish from tributaries, spawning and incubation in the mainstem, survival of young-of-year (YoY) and juvenile stages in the mainstem, or by changes in growth and maturation in the adult population as influenced by mainstem conditions?

SSQ 1-7. Which tributary and mainstem habitats are most important to native fishes and how can these habitats best be made useable and maintained?

SSQ 3-2. To what extent could predation impacts by nonnative fish be mitigated by higher turbidities or dam-controlled high-flow releases?

SSQ 5-6. Do the potential benefits of improved rearing habitat (warmer, more stable, more backwater and vegetated shorelines, more food) outweigh negative impacts due to increases in nonnative fish abundance?

Information Needs Addressed

RIN 2.1.3 What is the relationship between size of HBC and mortality in the LCR and the mainstem? What are the sources of mortality (that is, predation, cannibalism, other) in the LCR and the mainstem?

RIN 2.4.3 To what degree, which species, and where in the system are exotic fish a detriment to the existence of native fish through predation or competition?

RIN 4.2.6 To what extent are RBT below the Paria River predators of native fish, primarily HBC? At what size do they become predators of native fish, especially HBC, that is, how do the trophic interactions between RBT and native fish change with size of fish?

RIN 2.4.4 What are the target population levels, body size and age structure for nonnative fish in the Colorado River ecosystem that limit their levels to those commensurate with the viability of native fish populations?

RIN 12.9.1 What is the impact on downstream resources of short-term increases to maximum flow, daily fluctuations, and downramp limits?

RIN 4.2.5 To what extent is there overlap in the Colorado River ecosystem below the Paria River of RBT habitat and native fish habitat?

RIN 7.4.1 What is the desired range of seasonal and annual flow dynamics associated with power plant operations, BHBFs, and habitat maintenance flows, or other flows that meet GCDAMP goals and objectives?

EIN 2.1.1 How does the abundance and distribution of all size classes of HBC in the LCR and mainstem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 2.1.2 How does the year class strength of HBC (51–150 mm) in the LCR and mainstem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

EIN 2.4.1 How does the abundance and distribution of nonnative predatory fish species and their impacts on native fish species in the Colorado River ecosystem change in response to an experiment performed under the Record of Decision, unanticipated event, or other management action?

Methods and Tasks

The sampling area extends from Heart Island (just downstream of the Little Colorado River confluence, (RM 63.2) to just upstream of Carbon Canyon (RM 65.0). Two 3000-m sampling sites (~1500-m on each side of the river) have been selected for determining monthly juvenile chub (Age-0 to Age-4) abundance, and survival and growth rates. Sites will be sampled using a combination of electrofishing and hoop nets. A total of eight days per river trip are necessary for completing the monthly mark-recapture effort. Pine and others (2009 and 2010) findings would indicate that capture probabilities for juvenile HBC are generally low (about 4-13 %) with limited recaptures for both gear types (electrofishing and hoop netting). The cumulative catch between gears is similar; however, each gear type has been found to have different sampling selectivity. Typically, total catch of humpback chubs (all sizes) was higher in hoopnets; whereas, electrofishing catch of small humpback chubs (<100 mm TL) was greater than hoopnets. Shorelines will be sampled nightly using two electrofishing boats. Boats are to be operated slowly (average rate 0.1m/sec) (Korman and others, 2009a), with catch assigned to each habitat sampling unit (HSU; 50 m shoreline length). The electrofishing effort will alternate every other night (3-passes / 48 hr) between the two study sites. In addition, hoop nets (60) will be deployed for a total of seven days (24-hr sets) each trip. All fish collected with hoop nets are to be processed similarly to the fish captured via electrofishing. Hoop net processing will occur between morning and mid-day.

To spatially track the fish catch, all captured fish will be placed in distinct buckets that correspond to a specific HSU. Fish will be transported to a shore station for processing. Fish will be identified to species, measured (TL and FL) and given one of two tag types (batch mark or individual identifier) as per fish handling protocols in Grand Canyon (Persons and others, 2010). All native fish ≥ 150-mm TL (humpback chub ≥ 100-mm TL) will be scanned for the presence of a passive integrated transponder (PIT) tag and tagged if none are detected. All other native fish and fathead minnows > 40 mm and < 150-mm TL (humpback chub < 100 mm TL) will receive a batch mark referred to as a Visual Implant Elastomer (VIE) identifying the specific year (n ≤ 2), river trip (n = 3), capture gear (n = 2), and sampling site (n = 2). Once processed, fish are to be returned to their specific HSU capture location.

Recapture information will be used to estimate fish abundance for a particular site. Differences in abundance (batch and individual capture histories) associated with summer/fall sampling trips will be used to estimate survival rates among sampling sites, trips, and years. Nephelometric turbidity unit (NTU) measurements will be collected and used to account for differences in capture probabilities due to changes in water clarity.

Analysis will result in the following objectives being met

- Quantify capture probabilities by habitat/gear type, species, and fish size using short-term, closed, mark-recapture experiments,
- Estimate juvenile HBC abundance using a closed population model approach,
- Estimate the annual apparent survival for multiple size classes of juvenile HBC (batch marks and individual PIT tags),
- Estimate growth using a combination of modal progression (shifts in length-frequency) and direct ageing (individual capture histories),

Links/Relationships to Other Projects

This project shares a logistic schedule detailed in the Natal Origins Project (BIO 2.E18.11, 12) and is a component of that project in that it relates growth, survival and abundance of HBC to abundance and size of RBT variability. The data from this project also will help inform scientists and managers about the relationship between juvenile HBC abundance and survival and adult HBC population estimates for the LCR. The results of this project will help evaluate responses of small-size classes of fish to various dam release flows and will provide some of the information needed to assess the status and trends of humpback chub in the mainstem Colorado River.

Logistics

This project will require three trips, one each in July, August, September, for up to 5 years, FY2012–16, subject to permit approval and funding availability. All three trips are to be motor supported. The first part of each trip will be spent sampling the Marble Canyon Reach for marked RBT in support of the Natal Origins Project (BIO 2.E18.11, 12).

Products/Reports

Annual reports of project results will be delivered in December of each year. A final, synthetic report will be delivered by September 2017.

BIO 2.E18.11, 12: Formerly: Detection of rainbow trout movement from the upper reaches of the Colorado River below Glen Canyon Dam **– Revised: as Natal Origins of Rainbow Trout in Marble Canyon/LCR Confluence Area**

Start Date

October 2011

End Date

September 2017

Principal Investigators

To be Determined in cooperation with U.S. Geological Survey, Grand Canyon Monitoring and Research Center

Geographic Scope

Colorado River between Paria River inflow and the confluence of the Little Colorado River, River Mile 61.

Project Goals

This project is one of a number of research and prescriptive studies intended to support the US Bureau of Reclamation's Environmental Assessment (USBR 2011). The primary purpose of this study is to determine the natal sources of rainbow trout (*Oncorhynchus mykiss*; RBT) found in and around the confluence of the Little Colorado River (LCR) and the Colorado River mainstem. The underlying hypothesis supporting this study is that young fish emigrate from Lees Ferry and contribute solely to the downstream RBT population. Alternative explanations are that the downstream population is sustained by a combination of local reproduction and immigration from known spawning areas upstream (Lees Ferry) or is entirely supported by local reproduction. The project goal is to test this hypothesis by understanding the origin of RBT in Marble Canyon and determining the emigration rate for multiple year classes out-migrating from Lees Ferry, into Marble Canyon and down to the LCR confluence.

This study is proposed as an experimental research project to determine if Lees Ferry is the natal source of trout emigrating into the downstream reaches of Marble and Grand Canyons (Korman and others, 2011). This information will help to resolve some of the uncertainties about prescribing nonnative fish control activities in locations that are geographically distant to the area of concern (LCR confluence area). This project contains three study components, which include (1) annual age-0 trout marking at Lees Ferry, (2) recapture of marked RBT, and (3) development of a RBT emigration model. This project is linked to another project (Mainstem Juvenile Humpback Chub Assessment).

Primary project objectives are to:

- Estimate age stratified downstream movement of RBT from the Lees Ferry reach through Marble Canyon

- Estimate age stratified capture probability of RBT in the Lees Ferry reach and in the Marble Canyon reach

- Estimate age stratified abundance of RBT in the Lees Ferry reach and in the Marble Canyon reach

If the hypothesized movement of RBT out of the Lees Ferry reach, passing the mouth of the Paria River, is correct, this project will provide information about the age classes of fish that may be moving downstream. Understanding population movement characteristics is an important first step in being able to assess the potential for successful control of RBT immediately below Lees Ferry, a potential alternative to removing RBT from reaches near the LCR confluence as has been conducted previously. Information from this project will be integrated with ongoing monitoring of RBT upstream from Lees Ferry to assess any potential correlation between RBT density in the Lees Ferry reach and potential emigration out of the reach.

The most complete understanding of potential RBT movement patterns is most likely achievable with multiple observations over several years. Based on downstream observations, Coggins (2008) predicted RBT movement is seasonal, with most movement taking place in the fall and winter months. Additional sampling in future years would be necessary to fully address the seasonal component of movement, as well as potential correlation with RBT population sizes upstream. This project is proposed as an experimental research project to be conducted in FY 2012 through FY 2017 to increase knowledge of RBT movement patterns, a necessary precursor to any attempts to act on RBT movement, such as removal in the reaches immediately below the mouth of the Paria River.

This project would be useful for immediately assessing potential effectiveness of RBT capture and/or removal in the Paria River/Badger Rapid reach, but fully determining the most effective times of the year to conduct the work will require sampling in different seasons in multiple years. Because RBT density in the Lees Ferry reach is hypothesized to play a role in RBT movement, it would be useful to conduct this study with a variety of RBT densities in the Lees Ferry reach.

Need for Project

The underlying motivation for the RBT emigration study has come from recent findings showing that both RBT and brown trout (*Salmo trutta*) are consuming native fish in the Colorado River in Grand Canyon (Yard and others, 2011). The majority of native fish consumed by trout were juvenile and subadults (< age-3) (Yard and others, 2011), and it has been inferred that the loss of so many young fish, especially humpback chub (*Gila cypha*; HBC) may have affected recruitment to the adult chub population (USBR 2011). Results from the age-structured mark-recapture model indicate an increasing trend in adult (≥ age-4) abundance of HBC (Coggins and others 2006; Coggins and Walters 2009) that corresponds with trout removal efforts during a system-wide decline in trout numbers (Coggins and others, 2011; Makinster and others, 2010). Although these data are compelling, the negative correlation between RBT abundance and HBC recruitment cannot be inferred to be causal. Therefore, reducing trout abundance for the purpose of restoring native fish populations, especially HBC may not have the desired management response (Yard and others, 2011).

Korman and others (2009b, 2011) have shown that age-0 RBT abundance, growth and survival are influenced by fluctuating flows and high flows in the Lees Ferry reach. Also that observed declines in age-0 abundance over the summer period were greatest for years when abundance was high, indicating that mortality and possibly emigration may be density-dependent. If RBT move downstream into Marble Canyon, this study project will help inform trout control actions proposed for 2012 (Paria-Badger Rapid); as well as potential actions that might occur near the LCR confluence. Therefore, understanding how trout population dynamics influence movement of different age classes of trout is an important first step in being able to assess the potential for successful control of RBT immediately below Lees Ferry. If fish from Lees Ferry are found to be the source of most or all RBT downstream, then removing fish in this reach of river may be less intrusive and more culturally acceptable than proposed control efforts conducted at the LCR confluence. Information from this project will include ongoing monitoring data for RBT upstream from Lees Ferry to assess any potential correlation between RBT density in the Lees Ferry reach and downstream emigration.

Strategic Science Questions

This project will provide preliminary information that will be necessary to answer the following strategic science questions.

SSQ 1-2. Does a decrease in the abundance of rainbow trout and other cold and warm water nonnatives in Marble and eastern Grand Canyons result in an improvement in the recruitment rate of juvenile humpback chub to the adult population?

SSQ 1-3. Do rainbow trout immigrate from Glen to Marble and eastern Grand Canyons, and, if so, during what life stages? To what extent do Glen Canyon immigrants support the population in Marble and eastern Grand Canyons?

SSQ 1-4. Can long-term decreases in abundance of rainbow trout in Marble and eastern Grand Canyons be sustained with a reduced level of effort of mechanical removal or will recolonization from tributaries and from downstream and upstream of the removal reach require that mechanical removal be an ongoing management action? This question also applies to future removal programs targeting other nonnative species.

Information Needs Addressed

The primary research information needs that are informed by the project are the following.

RIN 4.2.1 What is the rate of emigration of rainbow trout from the Lees Ferry reach?

RIN 4.2.2 What is the most effective method to detect emigration of rainbow trout from the Lees Ferry reach?

RIN 4.2.3 How is the rate of emigration of rainbow trout from the Lees Ferry reach to below the Paria River affected by abundance, hydrology, temperature, and other ecosystem processes?

General Methods/Tasks

Methods and tasks are detailed for each study component.

Study Component 1. Annual Age-0 Trout Marking at Lees Ferry

The primary goal of the first study component is to apply sufficient number of marks to age-0 RBT such that the proportion of marked fish is ≥15% of the entire age-0 population as estimated in October of each year. The fish marking reach extends 25 km from Glen Canyon Dam to Lees Ferry. As described by Korman and others, (2009a and 2011), a slow (average rate 0.1m/sec) single-pass electrofishing method will be used to catch and mark age-0 RBT. Sampling is scheduled for October following stabilization of monthly mortality rates of age-0 trout. Fish of targeted size (70-110 mm TL) will be marked with passive integrated transponder (PIT) tags and released at capture sites. A stratified sampling design will be used; potential strata include longitudinal sections and major habitat types [examples that could be incorporated include low-angle (cobble and vegetated sand bars and debris fans), and high-angle (talus) shorelines]. Approximately 10 field days will be required to effectively sample the entire study reach and mark approximately 15,000 fish. Shorelines will be sampled nightly using two electrofishing boats. To optimize capture efficiency, electrofishing will be conducted only at night during low discharge levels. Additional days may be required to conduct a number of mark-recapture, and tagging mortality experiments for age-0 trout at representative sites within the fish marking reach.

Tasks

(1) Estimate fall abundance for age-0 trout in the Lees Ferry reach,
(2) Determine size-specific capture probabilities for age-0 trout,
(3) Determine tagging mortality for age-0 trout,
(4) Determine length-weight relationship age-0 trout, and
(5) Apply marks to ≥15% of the estimated age-0 trout population.

Study Component 2. Recapture of Marked Rainbow Trout

Each year, three monthly sampling trips are scheduled for the summer/fall (July - October) that sample for marked fish throughout the entire Marble Canyon reach (8-56 RM). The purpose of the river trips is to intercept marked fish of multiple cohorts that have emigrated downstream from the Lees Ferry reach. These three river trips have been scheduled for summer/fall due to another related study (refer to BIO 2.Rxx: Mainstem Juvenile Humpback Chub Monitoring). Electrofishing will be the primary gear used for capturing RBT. Shorelines will be sampled nightly using two electrofishing boats. Owing to changes in the size of available marked fish (≥ age-1) the electrofishing sampling rates (0.5 – 1.0 m / sec) may be faster than the predefined rates used for the marking age-0 fish in Lees Ferry reach. To optimize capture efficiency, electrofishing will be conducted during night time operations. Approximately seven field days will be required to effectively sample the entire Marble Canyon reach. For logistical purposes, we will use a stratified sampling design that subdivides Marble Canyon into multiple sampling sites with sampling units equally distributed between sites. Not all of the shoreline and habitat types are sampleable within the designated reach. Shorelines containing cliff habitat (<19%) have low catchability, this habitat type as well as rapids will be excluded from the sampling design. Multiple sampling sites will be established throughout the study area based on the distribution of navigable rapids or stream length (approximately 10 to 13 km/site). Spatially referenced sampling units (≈ 500 m) will be established within each study site. GCMRC has estimated that the cumulative sampling coverage for three trips would represent approximately 85% of the sampleable shoreline in Marble Canyon. Data will be collected on all fish (native and nonnative) using the most updated GCMRC fish sampling protocol (Persons and others, 2011). The catch metrics used will include fish density (fish/shoreline distance) and catch per unit effort (CPUE, fish/hr). All trout and native fish encountered are to be scanned for the presence of PIT tags (134.2 kHz). Other types of tags that may be present (e.g., floy tags, VIE-tags and fin clips) will also be accounted for.

Tasks

(1) Estimate monthly and average summer/fall RBT relative abundance for marked and unmarked fish (density and CPUE); as well as other fish species encountered,
(2) Determine the spatial distribution of RBT relative abundance for marked and unmarked fish,
(3) Determine length frequency distributions of marked and unmarked RBT,
(4) Determine the spatial distribution of length frequencies of marked and unmarked fish,
(5) Determine growth rates of recaptured RBT,
(6) Determine if RBT recruitment in Marble Canyon is due to immigration or natural reproduction.

Study Component 3. Rainbow Trout Emigration/Immigration Model

The intended purpose of this Emigration/Immigration model (EIM) is to ascertain the probability that the Lees Ferry acts as the primary natal source of RBT observed in Marble Canyon and confluence area of the LCR. Repeat marking efforts over multiple years are necessary for addressing the modeling questions that concern (1) does trout emigration from Lees Ferry occur; and if so, 2) when does it occur (season), 3) what age-class(es) are likely to move downstream, 4) do emigration rates vary annually, and 5) what factors (i.e., density dependent, hydrological, life-history) are responsible for inducing the emigration response in RBT. Additional sources of information to populate models developed as part of Study Component 3 will come from the marking and recapture components of this study (refer to Study Components 1 & 2); as well as data from other monitoring and research programs including (1) Lees Ferry tri-annual monitoring, (2) RBT early life stage survival, (3) Nonnative fish monitoring, (4) Paria-Badger Nonnative Fish Control, and (5) LCR Nonnative Fish Control.

Modeling tasks

(1) Estimate emigration rates for the RBT population in Lees Ferry,
(2) Estimate immigrations rates for RBT in Marble Canyon,
(3) Determine the likely age-class(es), seasons, and distances traveled by emigrating trout,
(4) Determine the season(s) when RBT emigration is likely occurring,
(5) Determine the spatial distribution of immigrants (random, uniform, normal, etc.).
(6) Determine the natal source of Marble Canyon recruits.

Links/Relationships to Other Projects

The work proposed in this project is closely linked with RBT monitoring in the Lees Ferry reach because of the hypothesized linkage of RBT movement to density of this species in the Lees Ferry reach. Logistically, study component 2 is linked to project BIO 2.Rxx: Mainstem Juvenile Humpback Chub Monitoring. Finally information from the Natal Origins project may inform observed abundance and survival response of HBC in the mainstem. Because of the competition and predation effect of RBT on humpback chub and other native fishes, there is a close linkage of this project to the status and trends of humpback chub and other native fishes.

Products/Reports

Standard trip report within 30 days of completion of each trip with summary statistics and preliminary analysis

- Draft annual report with full analysis by September 30, 2012

- Data delivered in standard USGS annual report format
- Final report in USGS Open File Report format by December 1, 2012