Science Questions and Information Needs identified in the 2013-14 Glen Canyon Dam Adaptive Management Program Biennial Budget and Work Plan

Technical Work Group
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Project A. Sandbars and Sediment Storage Dynamics: Long-term Monitoring and Research at the Site, Reach, and Ecosystem Scales

Project Element A.1. Sandbar and Camping Beach Monitoring

Project Element A.1.1. Monitoring sandbars using topographic surveys and remote cameras

Project Element A.1.2. Monitoring sandbars by remote sensing

Project Element A.1.3. Geomorphic attributes of camping beaches

Project Element A.2. Sediment Storage Monitoring

Project Element A.2.1. Bathymetric and topographic mapping

Project Element A.2.2. Bed-material characterization

Project Element A.3. Investigating Eddy Sandbar Variability and the Interactions among Flow, Vegetation, and Geomorphology

Project Element A.4. Quantifying the correlation between bed and transport grain size

Project Element A.5. Geochemical Signatures of Pre-Dam Sediment

Project Element A.6. Control Network and Survey Support

Questions

What is the largest, sustainable amount of fine sediment that can occur along the banks of the Colorado River, especially as eddy sandbars?

What flow regime, in relation to the natural supply of fine sediment from the Paria and Little Colorado Rivers, results in the largest distribution of fine sediment along the channel banks and in eddies?

Is pre-dam sand still being excavated and exported downriver under present operations of the dam? Is the rate constant, or has the amount of pre-dam sand changed during the past half century? If the rate is constant, is it because pre-dam sand is stable and protected, or is it because most pre-dam sand has already been removed?

Project B. Streamflow, Water Quality, and Sediment Transport in the Colorado River Ecosystem

Questions

Is there a “Flow-Only” operation that will restore and maintain sandbar habitats over decadal timescales? SSQ 4-1.

How do dam release temperatures, flows (average and fluctuating component), meteorology, canyon orientation and geometry, and reach morphology interact to determine mainstem and nearshore water temperatures throughout the CRe? SSQ 5-1.

Information Needs

Determine and track flow releases from Glen Canyon Dam, under all operating conditions, particularly related to flow duration, upramp, and downramp conditions. CMIN 7.4.2.

Determine and track LCR discharge and temperature near the mouth. CMIN 7.1.2.

Determine the water temperature dynamics in the mainstem, tributaries, backwaters, and near shore areas throughout the Colorado River ecosystem. CMIN 7.1.1.

Track, as appropriate, the monthly sand and silt/clay volumes and grain-size characteristics, by reach, as measured or estimated at the Paria and LCR, other major tributaries like Kanab and Havasu Creeks, and “lesser” tributaries. CMIN 8.1.3.

What are the monthly sand and silt/clay export volumes and grain-size characteristics, by reach, as measured or estimated at Lees Ferry, Lower Marble Canyon, Grand Canyon, and Diamond Creek Stations? CMIN 8.1.2.

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

Develop simulation models for Lake Powell and the Colorado River to predict water- quality conditions under various operating scenarios, supplants monitoring efforts, and elucidate understanding of the effects of dam operations, climate, and basin hydrology on Colorado River water quality. RIN 7.3.1.

What elements of RoD operations are most/least critical to conserving new fine sediment inputs, and stabilizing sediment deposits above the 25,000 ft^3/s stage? RIN 8.5.1.

Project C. Water-Quality Monitoring of Lake Powell and Glen Canyon Dam Releases

Information Needs

Determination of water-quality status and trends in Lake Powell and GCD releases.

Documentation of the historical record of Lake Powell water quality during various climatological and hydrological conditions.

Documentation of the effects of the structure and operation of GCD on the quality of water in Lake Powell and GCD releases.

Integration with GCDAMP information needs and downstream monitoring programs.

Documentation of the density structure of the water column in the GCD forebay and other locations in the reservoir to determine the quality of water available for release from GCD.

Assessment of the distribution and patterns of major ionic constituents.

Assessment of the distribution and patterns of nutrient constituents.

Assessment of the structure, status, and trends of the plankton community and its effect on primary and secondary production.

Project D. Mainstem Humpback Chub Aggregation Studies and Metapopulation Dynamics

Project Element D.1. Improve aggregation sampling to develop more rigorous approaches to monitor aggregations (includes ongoing monitoring)

Project Element D.2.1. Natal origins of Humpback Chub, adult condition and reproductive potential

Project Element D.2.2. Natal origins of humpback chub at aggregations by otolith microchemistry

Project Element D.2.2. Egg maturation studies using Ultrasonic Imaging and Ovaprim®

Questions

Can the mainstem Colorado River, under current dam operations, support self-sustaining populations of humpback chub?

What is the natal origin of fish that inhabit the aggregations and what implications does that have for management of humpback chub?

Project E. Humpback Chub Early Life History in and Around the Little Colorado River

Project Element E.1. July Little Colorado Marking

Project Element E.2. Describing food web structure and the potential for food limitation within the LCR

Project Element E.3. Population modeling

Questions

To what extent do survival and growth in the LCR aggregation vary annually and spatially (i.e., mainstem vs. LCR downstream of Chute Falls vs. LCR upstream of Chute Falls)?

What are the drivers of observed variation in survival and growth? Specifically, to what extent are endogenous (e.g., intraspecific predation and competition for food) versus exogenous factors (e.g., interspecific competition and predation, mainstem conditions— including dam operations—and variation in LCR hydrology, etc.) responsible for temporal and spatial variation in survival and growth?

To what extent does outmigration of humpback chub from the LCR vary over time?

To what extent do survival and growth in the LCR aggregation vary temporally (i.e., among years) and spatially (i.e., mainstem vs. LCR upstream of Chute Falls vs. LCR downstream of Chute Falls)?

What are the drivers of observed variation in survival and growth? Specifically, to what extent are endogenous (e.g., intraspecific predation and competition for food) versus exogenous factors (e.g., interspecific competition and predation, dam operations, variation in LCR hydrology, etc.) responsible for temporal and spatial variation in juvenile survival and growth?

To what extent does outmigration of humpback chub from the LCR vary from year to year?

Hypotheses

Survival of humpback chub eggs in the LCR is limited in years when snowmelt flooding is negligible or small because of poor spawning substrate conditions. (H1)

Large snowmelt floods in the LCR stimulate production of the prey base through improvements in both the quantity and quality of food resources consumed by humpback chub, which leads to high juvenile humpback chub survival and low outmigration. (H2)

In years without large LCR snowmelt floods, more yearlings remain in the system and there are higher levels of cannibalism and competition than in years with large LCR snowmelt flood. (H3a) The lack of yearlings in the LCR in the following spawning season (2003 and 2007) led to especially large cohorts of young-of-year in those birth years because of reduced cannibalism and competition. (H3b)

Outmigration rates of juvenile humpback chub from the LCR are directly linked to the intensity of monsoon flooding in the summer and fall. (H4)

The observed variation in humpback chub growth rates among locations and times is that growth rates are mainly driven by concomitant changes in water temperature. (H5)

Humpback chub growth among locations and times is mainly driven by differences in the quantity and quality of prey available to juvenile humpback chub. The quality of food resources could be related to the nutritional quality of the organic matter and invertebrates eaten by chub (e.g., the amount of nitrogen and phosphorus they contain). Alternatively, concentrations of metals and other toxins in food resources could be a more important determinant of resource quality for chub than nutrient content. (H6)

Interspecific and intraspecific competition for food resources is the main driver of humpback chub growth rates among locations and times. (H7)

Project F. Monitoring of Native and Nonnative Fishes in the Mainstem Colorado River and the lower Little Colorado River

Project Element F.1. System Wide Electrofishing

Project Element F.2. Glen Canyon Monitoring

Project Element F.2.1. Rainbow Trout Monitoring in Glen Canyon

Project Element F.2.2. Rainbow Trout Early Life Stage Studies

Project Element F.3. Mainstem Monitoring of Native and Nonnative Fishes Near the LCR Confluence; Juvenile Chub Monitoring

Project Element F.4. Little Colorado River Monitoring

Project Element F.4.1 Annual Spring and Fall Humpback Chub Abundance Estimates in the Lower 13.6 km of the Little Colorado River

Project Element F.4.2. Monitoring Native and Nonnative Fishes in the Lower 1.2 km of the Little Colorado River

Project Element F.4.3. Translocation and Monitoring above Chute Falls

Project Element F.4.4. PIT Tag antenna monitoring

Project Element F.5. Stock Assessment and Age Structured Mark Recapture Model humpback chub abundance estimates

Project Element F.6. Detection of Rainbow Trout Movement from the Upper Reaches of the Colorado River below Glen Canyon Dam/Natal Origins

Project Element F.7. Foodbase Monitoring

Project Element F.7.1. Linking Invertebrate Drift with Fish Feeding Habits

Project Element F.7.2. Citizen Science Monitoring of Emergent Aquatic Insects

Project Element F.7.3. Primary Production Monitoring

Project Element F.7.4. Benthic Algae and Invertebrate Biomass

Questions

Can humpback chub sustain a viable population upstream of Chute Falls?

Can estimates of abundance, survival, and movement probabilities by life stage be determined with remote PIT tag arrays with as much precision as manual catch data?

Is Glen Canyon the natal source of trout emigrating into the downstream reaches of Marble and Grand Canyons? If so, how do trout move from Lees Ferry to the LCR? Is PBR trout removal feasible?

How does spatial and temporal variation in drift rates affect food availability for rainbow trout and humpback chub?

Can tracking the flux of emergent insects might represent a useful surrogate for traditional benthic invertebrate monitoring programs?

Is algae growth different among reaches, especially due to differences in canyon orientation, channel depth, and turbidity?

Information Needs

Identify when to implement mechanical removal of nonnative fish to protect humpback chub.

Evaluate the response of the rainbow trout population to GCD dam operations. How are early rainbow trout life stages are affected by their own density?

Provide data for use in the Age-Structured-Mark-Recapture Model (ASMR).

Project G. Interactions between Native Fish and Nonnative Trout

Project Element G.1. Laboratory Studies to Assess the Effects of Trout Predation and Competition on Humpback Chub

Project Element G.2. Efficacy and Ecological Impacts of Brown Trout Removal at Bright Angel Creek

Questions

What are the mechanisms by which nonnative trout impact humpback chub?

What is the relative predation risk for humpback chub to rainbow trout and brown trout under varying temperature, flow, and turbidity conditions? Do rainbow and brown trout present more or less of a predation threat to juvenile chub than predation by adult chub?

What is the efficacy and feasibility of using electrofishing to control brown trout populations through a coordinated mainstem and tributary removal effort in and around Bright Angel Creek?

Does brown trout removal have a measurable positive effect on native fish abundance and distribution in the mainstem near Bright Angel Creek or within Bright Angel Creek?

Project H. Understanding the Factors Limiting the Growth of Large Rainbow Trout in Glen and Marble Canyons

Project Element H.1. Laboratory Feeding Studies

Project Element H.2. Understanding the Links among Dam Operations, Environmental Conditions, and the Foodbase

Project Element H.2.1. Developing a Mechanistic Model of Primary Productivity

Project Element H.2.2. Characterizing Invertebrate Drift

Project Element H.3. Developing a Bioenergetics Model for Large Rainbow Trout

Project Element H.4. Learning from other Tailwaters—a Synthesis of Tailwaters in the United States

Project Element H.5. Contingency Planning for High Experimental Flows and Subsequent Rainbow Trout Population Management

Hypotheses

The strain of rainbow trout present in Glen Canyon is incapable of growing to large sizes (i.e., >20 inches). (H1)

The current prey base, composed chiefly of midges and black flies, can support the growth of smaller rainbow trout, but does provide enough energy to allow for growth in large rainbow trout. (H2)

The growth of large rainbow trout is limited by exploitative competition for limited prey items. (H3)

Operational constraints that occurred in 1990 limit the growth of large rainbow trout. (H4)

Project I. Riparian Vegetation Studies: Response Guilds as a Monitoring Approach, and Describing the Effects of Tamarisk Defoliation on the Riparian Community Downstream of Glen Canyon Dam

Project Element I.1. Monitor Vegetation and Channel Response using Response Guilds and Landscape Scale Vegetation Change Analysis

Project Element I.1.1. Periodic Landscape Scale Vegetation Mapping and Change Analysis using Remotely Sensed Data

Information Needs

Monitor riparian vegetation response guilds to dam operations within a hydrogeomorphic framework

Determine the response of ground dwelling arthropods and pollinators to tamarisk beetle defoliation.

Project J. Monitoring of Cultural Resources at a Small Scale and Defining the Large-Scale Geomorphic Context of those Processes

Project Element J.1. Cultural Site Monitoring in Glen Canyon

Project Element J.2. Monitoring of Select Cultural Sites in Grand Canyon

Project Element J.3. Defining the Extent and Relative Importance of Gully Formation and Annealing Processes in the Geomorphic Context of the Colorado River Ecosystem

Questions

Do dam-controlled flows affect (increase or decrease) rates of erosion, and vegetation growth, at archaeological sites and TCP sites in the CRE, and if so, how? SSQ 2-1.

How effective are various treatments (e.g., experimental flows, check dams, vegetation management, etc.) in slowing rates of erosion at archaeological sites over the long term? SSQ 2-4.

Is the magnitude of aeolian transport to and deposition at sites from river sand bars sufficient to protect archaeological resources?

> -Is the magnitude of aeolian deposition at appropriately situated archaeological sites in Grand Canyon sufficient to outpace erosion caused by high-intensity precipitation and gullying events?
>
> -In areas with active aeolian deposition, do sites that are subjected to significant gullying (i.e., >30 cm down cutting) undergo net topographic lowering such that archaeological resources are impacted?

How does the relative abundance of active and inactive aeolian sediment vary in different regions of the Colorado River corridor? *Hypothesis: The proportion of active aeolian sand will be less in wide reaches of the river corridor and greater in narrower reaches of the river corridor.*

How does the degree of gully incision differ in sediment deposits that are active vs. inactive (with respect to aeolian sand transport)? *Hypothesis: Gullies will be larger and longer-lived in inactive aeolian sand deposits than in active aeolian sand deposits.*

To what extent does aeolian sediment transport counteract gully erosion in Marble and Grand Canyon? *Hypothesis: Aeolian sediment substantially limits gully incision of river-corridor sediment deposits in Marble–Grand Canyon such that the modeled extent of gully development will be greater than the actual extent.*

Information Needs

Determine the condition and integrity of prehistoric and historic sites in the CRe through tracking rates of erosion, visitor impacts, and other relevant variables. Determine the condition and integrity of TCPs in the CRe. CMIN 11.1.1 (SPG revised).

Determine the efficacy of treatments for mitigation of adverse effects to historic properties. EIN 11.1.

How effective is monitoring, what are the appropriate strategies to capture change at an archaeological site - qualitative, quantitative? CMIN 11.1.4

Project K. GCMRC Economist and Support

Project L. Independent Reviews and Science Advisors

Project M.USGS Administration

Project N. Incremental Allocations in Support of Quadrennial Overflights