An Outline and Schedule for the Development of a Science Plan for WY 2000 Steady Flows

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Introduction

An element of Fish and Wildlife's Biological Opinion for humpback chub (*Gila cypha*) includes evaluating the utility of steady flows for native fish recruitment and survivorship. Testing flows of this type was also included in the Environmental Impact Statement for Glen Canyon Dam. Tests of these flows are to occur in low water years (8.23 maf). In a effort to respond to elements of the Biological Opinion, the Bureau of Reclamation has proposed instituting steady flows in WY 2000, even though water delivery is projected to be more than 8.23 maf.

A design of flows for native fish is in draft form (Valdez et al, in prep). The flows include steady flow elements as well as spring and fall spikes of magnitude 31,000 cfs (Fig 1). The spikes are anticipated to last 4 days. The experimental hydrograph crosses over water years, running from March to March the following year. For comparison, the design recommends following a similar hydrograph in another year, but under fluctuating flows. Consecutive years are not required to run each hydrograph, but water allocations between 2 years require some forethought. Otherwise, the spring and late fall component may be compromised. The draft report (Valdez et al, in prep) should become final in March 2000.

As a means of exploring the idea of testing steady flows this summer, the Bureau of Reclamation and Grand Canyon Monitoring and Research Center (GCMRC), convened meetings of researchers and stakeholders. The meetings were held in Flagstaff, and Marble Canyon, Arizona on February 9 and 16. The purpose of the meetings were to 1) review current basin hydrology; 2) introduce the experimental hydrograph (Valdez et al, in prep); 3) discuss the assumptions (see below) and hypotheses associated with steady flows and native fish; 4) elicit comment on the experimental hydrograph; and 5) to determine how the hydrograph might be shifted as the upper basin hydrology and inflow into Lake Powell change through the water year. Following the meeting on the 16th, researchers were asked to rank hypotheses as to their importance, and if they were likely to provide further understanding of the system (i.e., testability).

Responses from researchers and stakeholders included the requested rank, reasons why the flows should not be done at this time and data collection should not considered, and questions about the potential negative effect elements of the flow might have on other resources. The reasons for not conducting these flows and collecting data around them include:

1. Insufficient preparation time to develop a well planned experiment.
2. Insufficient baseline data (including insufficient understanding of the natural history and life history of native fish species).
3. Lack of consideration for controls (temporal or spatial).
4. Hydrograph that contains too many treatments and would confound results.
5. The spring portion of the hydrograph financially impacts the trout fishery.
6. The SWCA hydrograph suggests testing a fluctuating flow hydrograph first.
7. Fall spikes may effect the Lees Ferry trout fishery and food base.

Reasons for conducting these flows and collecting data around them include:

1. Information about patterns found in association with these flows (longitudinal, local scale) can serve to develop more refined hypotheses (the processes or mechanisms that underlie the patterns) to be tested in subsequent low flow years.
2. The current hydrology provides an opportunity to evaluate key assumptions about steady flows.
3. Similar data would need to be collected if it were steady or fluctuating under the ROD given the low hydrology predicted for WY2000.
4. Do it if you can learn something from it.
5. Data from 91-97 could be used in some cases for “baseline”.

Developing a Science Plan

Evaluating the effects of experimental flows for native fish encompasses variables associated with physical habitat, individual species life history traits, interactions between these species and the habitat, and interactions among species. Determining the cause-effect relationships of a treatment in a natural and regulated system is a complex task. The benefit of a regulated system is that flow can be planned to some extent. However, the task is complicated in a regulated system when flows that are planned become interrupted by natural climatic conditions that require changes in magnitude and duration of discharge.

The choice of what data to collect is influenced by the level of certainty that the effort will be useful. While there are recommended discharges associated with steady flows (Valdez et al, in prep), reservoir levels, and basin hydrology require responsiveness to spill avoidance issues. Hence, the recommended experimental hydrograph may be shifted in areas of duration (e.g., longer high spring discharge) and discharge volumes (e.g., higher than 8k cfs summer dishcarge) to respond to these hydrologic variables. In light of the uncertainty around climatic forecasts and reservoir inflows, the science plan GCMRC is providing focuses on steady flow questions and not necessarily questions that are specific to 8,000 cfs steady flow discharges. We do not anticipate collecting data that can make direct cause-effect relationships (mechanisms) given the short amount of planning time available and the uncertainty of the hydrology. With this in mind, the GCMRC has focused on those efforts that will provide 1) system-wide information on physical and biological parameters (sediment budget, temperature, habitat availability, distribution and fish distribution), and 2) local scale information on individual resources that are either the target of these flows or that may be impacted by these flows (native fish distribution/relative frequency, trout, aquatic food base, riparian vegetation).

Process for prioritizing areas of focus

Planning for data collection and experimentation around operations of Glen Canyon Dam is dictated by a hydrologic forecast that provides researchers and planners short notice, roughly one month, of what will be released from the dam. Releases can be planned, but up to a month in advance, the releases are still predicted, not assured. Data collection planning can take place prior to a month, but the implementation and budgeting for any data collecting efforts will still be driven by hydrology and the month by month releases. Experimental hydrographs are less compromised by climatic uncertainty when reservoir levels are low.

The uncertain hydrology requires a science plan that can be flexible in its approach. As the hydrograph changes, some projects that may be initiated, may have to be concluded early or abandoned, other efforts may still provide information about steady flow dynamics (e.g., single value measurements like channel velocities at stage x). The latter example helps discern patterns of response to the treatment, and is a step in learning about the mechanisms underlying the observed response. The mechanisms are the interactions between variables that ultimately provide information about the effects of flows on resources and subsequently influence management decisions.

Biological resources were not the primary focus of study under research flows conducted in 1990. True, there were periods within this time frame that included steady flows, but the time period around these events were not sufficient to determine effects on biological resources. In contrast, a prolonged period of steady flows is an opportunity to learn about physical parameters in a habitat context, and to compare patterns known to occur under fluctuating flows to patterns that might occur under steady flows. This is not to say that observations made during one set of steady flows provide definitive information about steady flows and biologic resources. The biological program at GCMRC has taken into consideration the need for a flexible study plan, and has used the rankings of hypotheses by researchers to provide a focus for data collection efforts. We have also incorporated comments/questions about the hydrograph to recommend studies that may help resolve these questions and refine the experimental hydrograph. In a sense, the later elements represent a review process of the experimental hydrograph. We have developed system wide questions around patterns that can be viewed relative to historic data, and developed local scale questions around variables we can confidently measure and the response determined to be associated with steady flows.

Hypotheses were built around the following eight assumptions about steady flows and the native fish community. Some of the assumptions address physical habitat variables, while others address biological resources (fish, aquatic foodbase, vegetation). Some of these assumptions are not immediately testable or verifiable.

Assumptions Underlying Endangered Fish Research Flows

1. Steady flows (i.e., 8,000 cfs) will provide consistently available low-velocity near shoreline habitats.

2. Water temperature will increase during summer steady flows both longitudinally and in and along near shoreline habitats, and 8,000 cfs flow provide greater warming than higher discharges.

3. Productivity (primary and secondary) is enhanced by steady flows and food availability is sufficient to compensate for the increased energetic demands of younger faster growing fish.

4. Steady flows stabilize habitats used and will benefit young fish survivorship.

5. Hydrology that simulates the seasonal patterns of the natural hydrograph benefits native fish more than non-native fish.

6. Predator-prey and competitive interactions between non-native and native fish will not offset the positive effects on native fish derived from the increased availability of suitable habitat for rearing.

7. Impounding tributary mouths, primarily the LCR, retains larvae and immediate post-larvae allowing them sufficient growth to survive when they enter the mainstem in the summer and find increased suitable habitat.

8. A spike flow of 33,000 cfs for 4 days in spring will create suitable habitat and displace non-native fish, and a spike flow of 33,000 cfs for 4 days in fall will disadvantage non-native fish relative to native fish.

These assumptions were stepped down to hypotheses that we categorized into 1) Physical habitat, 2) Biotic habitat, 3) Aquatic foodbase 4) Fish response. These are the hypotheses that we recommend focussing data collection efforts around. In some cases, monitoring should cover these hypotheses, other cases will require data collection efforts specifically tied to these hypotheses.

1. Hypotheses addressing physical habitat parameters

Ho: Current velocities for near shoreline habitats (e.g., talus, debri fans, vegetated shoreline) will not differ significantly between fluctuating and <u>low</u> steady flow conditions.

Low velocity habitats are assumed to be a requirement of young fish. Decreased velocities presumably accompany lower discharges. The lower velocity environments may be reflected in an elongation of a particular low velocity environment or an increase in the number of these environments.

Ho: Current velocities will increase in tributary confluence areas under higher mainstem flows.

Valdez et al. (2000) recommends a high spring steady flow to pond tributaries and retain young of the year, assuming that velocities will be reduced in tributary confluences. This hypothesis could be tested with flows at 17,500 cfs or higher and if flows are reduced to 14-12 cfs for a sustained period of time.

Ho: Areal extent of low velocities does not vary for a range of steady flows.

Discharge may affect current patterns (eddies may get wider or longer), but total area of low velocity environments should remain the same. This helps determine if size of low velocity environment matters.

Ho: Water temperatures in the mainstem will not increase downstream greater than temperatures previously observed under other flow conditions (e.g., fluctuating, higher discharge).

We have an estimate for rate of warming in the mainstem. It would be useful to determine if steady flows affect this rates, and if discharge and steady flows affect this rate (this is particularly applicable for the temperature control device).

Ho: Near shoreline temperatures in structurally complex habitats will not differ significantly from those observed for the mainstem.

The intent of steady flows is to warm shoreline low velocity environments, if the amount of warming is negligible then perhaps temperature along the shoreline is not a limiting factor for recruitment of native fish, but low velocities are.

Ho: Thermal input from tributaries will not contribute significantly to the increase in mainstem temperatures during the LSSF.

Tributaries are warm relative to the mainchannel, the low discharge in the mainstem coupled with the instream flow from the tributaries may affect mainstem warming, or at least provide a gradient of warming at the confluence.

Ho: Turbidity levels will remain constant during the LSSF experiment.

Turbidity does affect sight feeders like trout and affects photosynthetic activity (primary productivity). Interactions between this physical variable and the biotic components may affect growth of fish or predation rates. We are not recommending predator-prey studies at this time, but do advocate determining a relationship between flow and suspended sediment (turbidity).

2. Hypotheses addressing biotic habitat questions

Ho: Backwater number and total area will not differ significantly from values measured during previous fluctuating flows at equivalent stages.

Historic data regarding backwaters is associated with fluctuating flows and documented by overflights at 8,000 cfs. Antecedent conditions may not effect backwater number and areas at 8,000 cfs.

Ho: Backwater number and total area will not differ significantly throughout the period of steady flows.

Addresses sedimentation rates in eddy return current channels and the change in backwaters over time. Do they become less available over time?

Ho: The proportion of macro-habitat characteristics (near shoreline, hydrologic and substrate units) will not differ significantly from those observed at higher flows.

The question is if all shoreline types and hydrologic units are proportionately represented under all flows. Addresses the question of does discharge matter, if all the same macro-habitats are proportionately still available?

Ho: Germination and densities of *Tamarix ramosissima* will not significantly differ from preceding years during fluctuating flows.

Tamarisk and other exotic species may be advantaged by the high spring discharge and low steady flow regime resulting in increased shoreline of tamarisk seedlings and eventually tamarisk encroahment along shorelines of camping beaches.

3. Hypotheses addressing productivity (primary and secondary) questions

Ho: There will be no significant difference observed in the benthic or macrophytic community for biomass or composition due to spike flow treatments.

The 31,000 cfs spike has been suggested to be of sufficient magnitude to negatively affect aquatic food base biomass and composition, particularly in the fall. The effect needs to be determined.

Ho: There will be no significant difference in biomass, densities or composition observed for the benthic and macrophytic communities due to a LSFF treatment.

Low steady flows may increase water clarity and allow for increase productivity, but the area available for productivity may be decreased by discharge, and result in no significant increase or change in the benthic and macrophytic community.

Ho: The quantity and composition of drift will not significantly vary during the duration of the LSFF treatment.

Fluctuating flows are suggested to help maintain drift downstream by causing desiccation and subsequent renewed growth. If this is true, one would see a decline in quantity of drift over time under steady flows. Also the composition of the drift may change over time associated with different rates of senescence of benthos and macrophytes and tributary inputs.

Ho: The quantity and composition of drift during a LSFF treatment will not significantly vary in comparison with years of other steady or fluctuating flows.

Does magnitude of discharge matter or pattern of discharge affect drift quantity or composition? This hypothesis collects the same data as the above hypothesis, but compares it to other flows.

Ho: There is no lag time in the rate of colonization for *C. glomerata* and epiphytes.

Does time since exposure affect colonization rates of cladophora. If colonization rates are the same for similar substrate subjected to different levels of exposure, then other factors may be affecting colonization.

4. **Hypotheses addressing fish response questions**.

Ho: Relative frequencies (CPUE) of young-of-year native and non-native fish species in rearing habitats will not differ significantly during the LSSF, BHBF nor in comparison with prior fluctuating flow periods.

Steady flows are assumed to be beneficial to young-of-year fish. If stable environments foster survivorship of young fish relative frequency should increase, provided sampling effort is sufficient to capture this information.

Ho: Relative frequencies (CPUE) of young-of-year native and non-native fish species will be the same in all rearing habitats during steady flows.

Does the pattern of occurrence of young-of-year fish change among shoreline habitats or are all shoreline habitats used equally by young-of-

year. This may help determine if one habitat type is used disproportionately more than another.

Ho: Condition factor of native and nonnative fish species will not change significantly during the experimental flow period.

Condition factor is a measure of food availability over time and is most likely to be reflected in older fish.

Ho: Spike flows preceding and following steady flow conditions will not actively displace non-native fish species in near shoreline nor backwater habitats for prolonged periods of time.

Spike flows of a magnitude of 31,000 cfs are recommended to remove small bodied exotics and reduce the competitive advantage these species may have incurred over the course of steady flows.

Ho: Relative frequency of YOY trout will not vary significantly during the entire experimental flow period inclusive of spike and LSSF.

Reduced available habitat and food resources in the Lees Ferry reach may exclude young-of-year and may result in reduced number (i.e, relative frequency) of young-of-year compared to baseline data.

Suggested hydrograph

Because of the uncertainty associated with basin hydrology, reservoir filling and potentials for spills, and questions about pooling levels and spikes, we suggest the following:

1. March discharges that will ensure low, steady flow in June – September.
2. An April/May hydrograph that reaches at least 17,500 and does include a spike, but that also includes a shoulder of 15 and 12,500 on the descending limb of one day each. This will allow area, velocity and temperature at tributary mouths at different discharges to be evaluated and compared. The limb of 15 and 12,500 should be of sufficient duration to allow surveying of these parameters (4 days). (Serves as a review component of the hydrograph)
3. If the hydrology by May indicates that low steady flows (8,000 cfs) are not possible, then steady flows at any discharge would be informative, but may have greater implications for sediment budgets as volumes increase and may compromise some data collection efforts.
4. Include the fall spike to determine if small bodied exotics are displaced and to determine the effect on the food base in Lees Ferry. The effect of exotic displacement will be evaluated on the winter fish monitoring trip, so motor

use in non-motor season will not be an issue. (Serves as a review component of the hydrograph).

Under this hydrograph, data collection, beyond already planned monitoring trips, will potentially not start until approximately a week prior to the spring spike, to document pooling at a high steady discharge level. Monitoring of fish in the LCR will be taking place in mid-April, and we can redirect efforts around this ponding event, to some extent.

Development of Research Plan with associated hypothese

GCMRC recommends using the expertise of researchers to help develop plans of study around the hypotheses listed above. We will collaborate with these researchers to develop a plan that will adequately address the hypotheses. In some cases, portions of the plan will be covered by an existing monitoring trip, but may need to be augmented by additional trips. In other cases additional trips may be required to address the hypotheses. We would modify existing cooperative agreements and use unsolicited proposals to develop cooperative agreements for new contractors.

Schedule for Planning.

February 25	Send out science plan draft document to contracted researchers. Researchers develop preliminary study plan for hypotheses pertinent to their expertise.
February 28-March 2	Contact researchers to determine methods, logistics, and budgets.
March 6	Provide BOR and WAPA with estimated costs for steady flow work.
March 5-10	BOR determines if steady flows will occur and provides the hydrograph.
March 15-20	Submit modifications to contracts for funding. Submit modified logistics schedule to Park Service.

3-1-00 B. Ralston
Presented at TWG Meeting 3/2 - 3/3/00
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