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GCDAMP Goal 1: Protect or improve the aquatic food base so that it will support viable populations of desired species at higher trophic levels.

BIO 1.R4.08: Impacts of Various Flow Regimes on the Aquatic Food Base

Start Date
2008

End Date
2010

Principal Investigator(s)
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Geographic Scope
Two sites (Glen Canyon ~river mile (RM) -15–0, and Diamond Creek ~RM 225.

Project Goals/Tasks
This project will be done in close association with research project BIO 1.R1.08, which will quantify, on a monthly basis, the density and production of basal resources (i.e., algae, terrestrial leaf litter, etc.) and invertebrates, and will determine the amount of energy that is available to support production of fishes (e.g., monitoring). In addition, short-term experiments should be conducted to obtain a greater understanding of the responses of the aquatic food base to specific aspects of different flow regimes. The primary goal of such experiments would be to verify the range of flow magnitudes and flow fluctuations that could occur without significantly impacting the long-term sustainability of the aquatic food base. This would, in turn, help identify ways to accommodate power generation and water storage purposes at Glen Canyon Dam while protecting downstream aquatic resources.

Short-term experiments would be conducted over the course of several years in order to capitalize on the availability of specific hydrological conditions. During experiments, measurements would be made of algal and invertebrate standing crop, together with levels of invertebrate drift. To the extent possible, data collection methods should be consistent with the methods described in BIO 1.R1.08. Aspects of hydrographs that should be examined include fluctuation levels, ramp rates, and minimum flow levels. In addition, it may be desirable to evaluate effects of the proposed flow regime on fish (especially trout) activity levels, foraging success, and survival as related to fluctuation patterns and food conditions (e.g., concentrations and composition of the drift).

Benthic production is the source for food base items in the drift, so it is important to assess both how the source of drifting material and the quantity of drifting material is affected by dam operations. These measurements should be made in two locations, Glen Canyon and Diamond Creek. The effects of dam operations on benthic production and drift are likely very different in the tailwater relative to downstream reaches. The food base program (BIO 1.R1.08) will continue to make monthly measurements of benthic production and drift at Glen Canyon and Diamond Creek which will provide an excellent set of baseline data that can be used to compare results from experimental dam operations. In future years, the Little Colorado River confluence could be included in addition to the sampling at Glen Canyon and Diamond Creek, but is not included in

this proposal. Adding sampling at the Little Colorado River would significantly increase the cost of this research because it will require three full sets of sampling equipment and at least one downstream river trip. Based on comments, a program at the LCR should be considered after review and analysis of data collected from the Glen Canyon and Diamond Creek sites. This will also allow further time to develop a more detailed experimental plan to test dam operations and might be considered the Long Term Experimental Plan Environmental Impact Statement.

The objectives that are addressed by this project are:

- Quantify the abundance of the aquatic food base on substrates in response to changes in the flow regime
- Identify composition and quantity of drifting organic matter and invertebrates in response to changes in the flow regime
- Determine the effects of ramp rates on invertebrate productivity, standing crop, and drift
- Determine the effects on drift of short-term 5,000-cfs flow fluctuations during a fall steady flow experiment
- Determine effects of short-term flow reductions and subsequent (e.g., 2 hours later) increase in flow on drift rates

Need for Project

The food base in any aquatic system is an important factor that directly affects fish community dynamics including abundance, reproduction and recruitment, condition, and even distribution. Much of the diet of trout and humpback chub consists of food items that have been suspended and are drifting in the water column (Valdez and Ryel 1995). The drifting food base in the Colorado River ecosystem is generally composed of freely floating aquatic invertebrates and *Cladophora glomerata* (a long filamentous green algae) that are available to fish for consumption. Primary production at Lees Ferry is dominated by *Cladophora* which acts as a substrate for various types of epiphytic diatoms which provide a food source for chironomids and simuliids (aquatic insect larvae) and for the shrimp-like amphipod, *Gammarus lacustris* (Pinney 1991). The nutritional value of *Cladophora* to fish is enhanced by the presence of lipid-rich epiphytic diatoms, and diatoms have been shown to provide an important source of energy for rainbow trout (Leibfried 1988). Studies indicate that the abundance of invertebrates used as food by trout and other fishes in the Colorado River ecosystem is generally proportional to the abundance of *Cladophora.*

In order to understand the current condition of the aquatic food base, measurements of epiphytic diatoms, aquatic invertebrates, and algal abundance in the Colorado River downstream of Glen Canyon Dam should be conducted. GCMRC's food base monitoring program (BIO 1.R1.08) would largely fill this need on a monthly basis. However, the response of these benthic and drifting resources to various flow management regimes remains uncertain. Thus, this research project should be conducted to identify the responses of the benthic and drifting food base to various aspects of the proposed flow regime. This adds an important component to the food base research program under BIO 1.R1.08 which may help to identify flow regimes likely to contribute to the recovery of humpback chub populations in Grand Canyon.

Strategic Science Questions

Primary SSQ addressed:

SSQ 1-5. What are the important pathways, and the rate of flux among them, that link lower trophic levels with fish and how will they link to dam operations?

Additional SSQs addressed:

SSQ 3-5. How is invertebrate flux affected by water quality (e.g., temperature, nutrient concentrations, turbity) and dam operations?

SSQ 1-6. Are trends in the abundance of fish populations, or indicators from fish such as growth, condition, and body composition (e.g., lipids), correlated with patterns in invertebrate flux?

Links/Relationships to Other Projects

Under Research Project BIO 1.R1.08—Aquatic Food Base, four broad tasks would be performed: (1) quantify basal resources using a carbon budget framework, (2) determine important trophic pathways linking basal resources to fish, (3) estimate fish density and production, and (4) model bioenergetics and the trophic basis of production calculations. We will work closely with this project, relying on much of their infrastructure and capabilities, to estimate primary and secondary biomass, productivity, and drift. This project builds upon the aquatic food base program by carrying more intensive observations during various experimental flow regimes with the intent of distinguishing the effects of various flow changes compared to "base" conditions.

Information Needs Addressed

This project focuses on quantifying food availability (drift) in the Colorado River ecosystem in Glen and Grand Canyons due to experimental changes in flow from Glen Canyon Dam. The distribution of multiple sampling sites over multiple years will allow a number of research information and core monitoring information needs to be directly addressed, as enumerated below:

Primary information needs addressed:

RIN: 1.1. What are the fundamental trophic interactions in the aquatic ecosystem?

RIN: 2.1.2. Quantify sources of mortality for humpback chub < 51 mm in rearing habitats in the LCR and mainstem and how these sources of mortality are related to dam operations.

RIN 12.9.2. What is the best combination of dam operations and other management actions to achieve the vision, mission, goals, and objectives of the GCDAMP management objectives?

Other information needs addressed:

RIN 1.4. What is the current carbon budget for the Colorado River ecosystem?

CMIN 1.2.1. Determine and track the composition and biomass of benthic organisms between Glen Canyon Dam and the Paria River in conjunction with measurements of flow, nutrients, water temperature, and light regime.

CMIN 1.3.1. Determine and track the composition and biomass of primary producers below the Paria River.

General Methods

Quantify algae production

The food base project has been successful in verifying that algae/macrophyte production in the Colorado River can be measured using open-system measurements. This technique involves constructing an oxygen budget for a reach of river, where all inputs (algae production, air-water gas exchange) and outputs (respiration) of oxygen are accounted for.

- Primary production and ecosystem respiration will be quantified using whole stream metabolism calculations: Use diel changes in dissolved oxygen concentration, a byproduct of algal photosynthesis, to determine rates of algae production for mile long reaches of the river. Use nighttime sags in dissolved oxygen concentration to determine ecosystem respiration, a measure of basal resource (both leaf litter and algae) consumption. If quantity of carbon consumed during respiration exceeds quantity of carbon produced by algal photosynthesis, this indicates allochthonous inputs may be an important basal resource fueling the aquatic food web. Data collected monthly at Glen Canyon and Diamond Creek and four times per year along the river corridor.

Quantify benthic biomass/drift

- Standing stocks: the standing stock of algae and organic matter will be quantified using a Hess sampler and by scraping algae off rocks. These data will provide a measure of basal resource availability within each reach. Collections will occur monthly at Glen Canyon and Diamond Creek and four times per year at the confluence with the Little Colorado River.

- Invertebrate density, production, and growth measurements. Sample all benthic habitats (i.e., cobble bars, cliff faces, boulders, talus slopes, sandy bottom, etc.) to quantify density of invertebrates. Habitat specific density estimates will be made using shoreline and bed classification data from the Physical Science and Modeling Program. Growth measurements for the most common invertebrates (e.g., New Zealand mudsnails, Gammarus, chironomids, simuliids) in controlled chambers. Production of invertebrates will be calculated using density estimates coupled with growth measurements. Invertebrate density will be estimated monthly at Glen Canyon and Diamond Creek and four times per year at downstream locations. Growth measurements will be taken four times per year at Glen Canyon and Diamond Creek.

- Transported organic matter and invertebrates: The amount of organic matter and invertebrates transported into and out of each reach will determine the extent to which downstream reaches are linked to upstream processes. Depth integrated water samples will be used to quantify transported organic matter and invertebrates.

Products/Reports

Publications

Tentative subjects for publications include:

- Response of primary production and secondary production of invertebrates in the Colorado River to various flow regimes from Glen Canyon Dam.

- Affect of various flow regimes from Glen Canyon Dam on the availability of drifting food base for humpback chub and trout.

Reports

A final report summarizing major results and recommendations will be submitted at the close of the project.

Monitoring Protocols

A report describing potential monitoring protocols will be submitted at the close of the project. Some potential monitoring tools that will be evaluated during the course of the project include:

- Measurement of primary production and ecosystem respiration using whole stream metabolism methods

- Organic and invertebrate drift measurements

Budget

We already have four sondes equipped with dissolved oxygen sensors, but would need to purchase two additional sondes in order for these measurements to be made simultaneously at Glen Canyon and Diamond Creek. The Clark-type dissolved oxygen sensors that we currently using for making these measurements can be calibrated with a good degree of precision and accuracy, but the calibration of those sensors is only reliable for 5-7 days because the sensors tend to 'drift'. Optical Dissolved Oxygen sensors are a relatively new technology that can be calibrated more accurately and precisely than Clark-type sensors, and they hold their calibration for over a month. With the purchase of optical dissolved oxygen sensors we will be able to make continuous measurements of algae production, which are more accurate and precise, for the duration of any flow experiments.

We already have all of the equipment needed to make measurements of benthic biomass (i.e., algae, invertebrates, terrestrial leaf litter), but we only have one set of this equipment. We will need to purchase an additional set of equipment so that these measurements can be simultaneously at both Glen Canyon and Diamond Creek. We already have enough wet suits and winches (needed for ponar dredge) to accommodate simultaneous sampling at two or three locations.

BIO 1.R4.08				
Impacts of Various Flow Regimes on the Aquatic Food Base (FY08-09)				
Item	Purpose	Unit Cost	Quantity	Total
YSI 6920 Sondes	Open-system measurements of algae production	$4500	2	$9,000
YSI ROX Optical Dissolved Oxygen Probe	Open-system measurements of algae production	$1500	6	$9,000
Wildco Standard Ponar Dredge	Benthic Biomass	$1249	1	$1,249
Benthic Suction Sampler	Benthic Biomass	$300	1	$300
Wildco plankton/drift nets 20 in diameter mouth, 5:1 mouth-length ratio, 250 µm-mesh	Algae/Leaf litter/Invertebrate Drift	$500	1	$500
Misc. Supplies	Bottles, preservative grade alcohol, etc.	$1500		$1,000
Full-time technician (GS 7)	Field and lab work	$40,000 (salary + benefits)	1	$40,000
Subtotal				$61,049
Overhead (19.091%)				$11,655
Total				**$72,704**

Sites: Glen Canyon and Diamond Creek