RECLAMATION
Managing Water in the West

Geomorphology, hydrology, and Rio Grande silvery minnow

Michael D. Porter[1,5], Tamara M. Massong[1], Hugo Magaña[2,4],
[1]US Bureau of Reclamation, [2]US Forest Service, [3]US Army Corps of Engineers,

Abstract

The Rio Grande silvery minnow (*Hybognathus amarus*) is an endangered species that produce semi-buoyant pelagic eggs; survival of larval silvery minnows may be decreasing due to habitat availability. The nursery habitat concept was developed from the comparison of geomorphic trends with collection records for the silvery minnow. The concept generated hypotheses on the fate of floating fish eggs and larvae, and some features of the habitat needed for survival to the juvenile stage.

Habitat restoration is a cornerstone of endangered species recovery plans. The Rio Grande historically was an aggrading, braided, sand-bedded river due principally to high sediment loads. Dam construction reduced the sediment load and resulted in a shift toward an incising, single-thalweg, gravel-bedded river. The decreased peak flows and sediment supply which initiated changes in channel morphology has lead to degraded fish habitat.

Endangered Rio Grande Silvery Minnow

The silvery minnow was listed as endangered in 1994 (US Dept of Interior). Decreasing populations have been attributed to habitat fragmentation by diversion dams (US Fish and Wildlife Service, 1999) or the degradation of habitat by channel incision (Porter and Massong 2003). Minnow eggs and larvae drift downstream until they are retained in suitable nursery habitat. Habitat use by larval fishes collected in the Middle Rio Grande (Pease 2004). Results indicate that water velocity was the critical environmental variable determining spatial distribution of larval and juvenile fishes. Abundances were highest in the available habitat types with water velocities of zero. Still-water habitats were provided in small, temporary backwaters created by high flow events.

Rio Grande Silvery Minnow

Photo by Michael Porter.

Geomorphology of the Middle Rio Grande

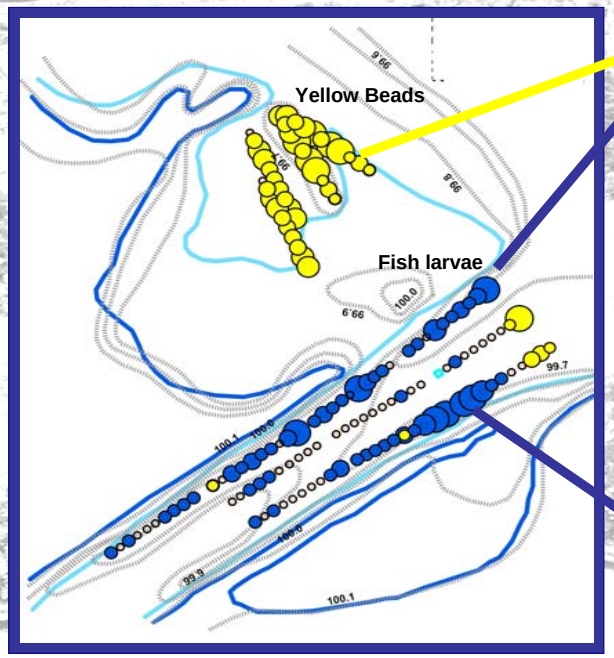
The middle Rio Grande valley (Cochiti Dam in the north to Elephant Butte Reservoir) has changed from an aggrading reach is mostly degradational plan form. Large sections of the reach have converted from a braided, sand-bed channel to a narrow single-threaded, gravel-bed channel. Extensive channelization, from 1930 to 1980, still controls much of the channel's character (Massong et al. 2002).

The Rio Grande has narrowed from a wide braided channel (1,500 feet in locations) to a relatively narrow channel (~550 feet). Vegetated bars split the channel flow at higher flows, creating an anastomosing plan form. The riparian area becomes inundated only at high flows (>4,000 cfs), which have been scarce in the last 10 years. Wide side channels with slow flowing water are abundant in this reach of the Rio Grande. A dominant thalweg is emerging, resulting in a channel incision (1-2 feet) and channel narrowing. This channel incision will increase the flows necessary to inundate the floodplain.

A reduction in channel width will create new bank lines with the possibility to create 'scallop' in the bank line that may act as inlets with small drift zones for larval habitat, but not egg retention (the drift zone would be too small). In-channel habitat features will develop faster flow velocities and reduce off-channel areas as side channels are abandoned. Faster water velocities increase the grain size on the channel bed.

Methods

- Fish and surrogate eggs were collected using quadrats deployed between metal posts.
- Larval fish were collected with light traps and quadrats.
- Water velocities and depth were measured.
- Data was transferred to GIS for spatial analysis and visualization.
- Algae samples were collected, cultured, and identified to genera.
- Nitrate and phosphorous concentrations were measured.



Fish Species	Total	Abundance peak	Habitat type
Cyprinella lutrensis	561[a]	Mid-June through dry-up	isolated pool
Hybognathus amarus	249[a]	Late May to mid-June	side channel, isolated pool
Pimephales promelas	260[a]	Mid-May to early June	backwater, isolated pool

a. Combined data from Pease 2004 and Magaña pers comm.

Drift Zone Habitat

The loss of floodplain interactions has drastically reduced the amount of 'off-channel' and 'extremely-low-velocity' habitat. Arroyo confluences appear to create complex alluvial fans and inlets that function as nursery habitat for several fish species. This type of habitat appears necessary for egg retention and larvae growth (nursery habitat). Nursery habitat is created to connect low-velocity areas with the main river channel.

ecology of constructed nursery habitat for (*Hybognathus amarus*)

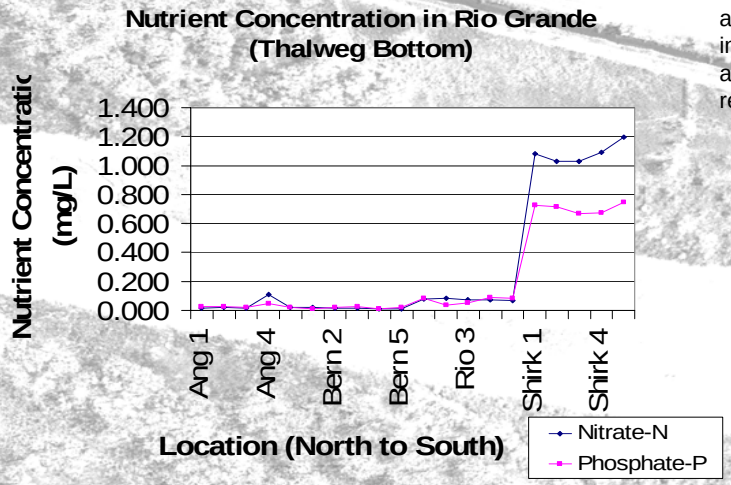
Mark Horner[3], Allison Pease[4], Robert Doster[1], and Dwight Slaugh[1]
[4]University of New Mexico, [5](505) 462-3596 email: mporter@uc.usbr.gov

Riparian Habitat

The decline in floodplain connectivity, has changed both aquatic and terrestrial habitats at a variety of scales. Habitat restoration attempts to restore ecological function by reconnecting the aquatic and terrestrial environments through mechanical lowering of the aggraded floodplain. Riparian restoration includes establishing dense stands of native coyote willow (*Salix exigua*) for southwestern willow flycatcher (*Empidonax traillii extimus*) breeding habitat.

Avian Nutrient Cycling

Nursery habitat for Rio Grande silvery minnow attracts waterfowl during the winter (e.g., *Anas* spp., *Branta canadensis*, *Chen caerulescens*) and other waterbirds (*Grus canadensis)* during the summer. These birds may enrich the area with nutrients from defecation and carrion decomposition. Decomposition of these birds have been shown (Parmenter and Lamarra 1991) to be sources of some elements (N, K, Na, and S) in freshwater ecosystems. Although the importance of carrion-derived elements to ecosystem budgets is site-specific, carrion decomposition can contribute significant amounts of important nutrients that ultimately influence the structure and functioning of the aquatic ecosystem. These nutrient inflows in nursery habitat features of the Rio Grande can help to enrich these littoral habitats for enhanced survival of Rio Grande silvery minnow eggs and larvae.



Future Research

- Ongoing studies will examine energy dynamics of silvery minnow habitat in the Middle Rio Grande for production of diatoms.
- Understanding the interaction of egg specific gravity and nursery habitat.
- Compare results to other riverine cyprinids with semi-buoyant pelagic eggs.
- Examine use of inlet habitats by other fish species for rearing larvae or other life history components.
- Describe the nutrient sources and cycling within the river.
- Describe the nutrient cycling between aquatic and terrestrial interfaces at habitat inlets.

Results

Changing geomorphology has changed essential silvery minnow habitat
Effective drift zones had low velocities and depth.
The drift zones retained fish eggs, larvae, and organic debris.
Inlet and alluvial fan shape, surface flow, and sediment deposition influence egg retention.
Larval silvery minnows are initially found in or near inlets and associated features.

Feeding Habitat

The Rio Grande silvery minnow is an herbivore with an elongated gastro-intestinal tract that feeds on diatoms and other materials (Shirey 2004). Episammic and epiphytic algae established on the shallow sand substrate may be important food supplies. Low nutrient availability (N,P) may limit upstream primary productivity. Channel incision may reduce the area of available substrate for diatoms and algae. Increasing turbidity due to increasing average depth may reduce algal production.

Acknowledgements

The research was supported by the US Bureau of Reclamation Science and Technology Program and Albuquerque Area Office, the New Mexico Interstate Stream Commission, the Middle Rio Grande Endangered Species Act Collaborative Program, the Army Corps of Engineers, the US Forest Service, and the University of New Mexico.

E. Weber, J. Secrist, and R. Bark from Reclamation assisted in the field. SWCA staff including J. Fluder, S. Shoup, L. Curry, P. Castiglia, S. Goldman, J. Kehmeier, K. Bonafantine, N. Kastning, K. Hilwig, K. Wellman, H. Neail, B. Hines, and Dave Barz provided invaluable assistance in collecting field data. Dave Barz produced base maps for the analysis.

References

Massong, T., Smith, K.I., Glover, A., Candelaria, K., and Bullard, M. 2002. Overview of Geomorphology for the Middle Rio Grande. Technical Report, U.S. Bureau of Reclamation, Albuquerque, New Mexico. 8 pp.

Parmenter, R. R. and V. A. Lamarra. 1991. Nutrient cycling in a freshwater marsh: the decomposition of fish and waterfowl carrion. Limnology and Oceanography 36:976-987.

Pease, A.A. 2004. An Assessment of Critical Nursery Habitat Features for Larval and Juvenile Fishes in the Middle Rio Grande, New Mexico. Masters Thesis, University of New Mexico. 34 pp.

Porter, M.D. and T.M. Massong 2003. Progress Report on Rio Grande Silvery Minnow Egg Habitat Study – FY 2003. U.S. Bureau of Reclamation. 11 pp. http://www.usbr.gov/uc/albug/envprog/mrg/research/2003_nursery_habitat_proj.pdf

Shirey, P.D. 2004. Foraging Habits and Habitat Utilization of Rio Grande Silvery Minnow (*Hybognathus amarus*) as Inferred by Diatom Frustules. Masters Thesis, New Mexico State University. 50 pp.

U.S. Department of the Interior. 1994. Endangered and Threatened Wildlife and Plants; Final Rule to List the Rio Grande Silvery Minnow as an Endangered Species. Federal Register 59: 36988-36995.

U. S. Fish and Wildlife Service. 1999. Rio Grande Silvery Minnow Recovery Plan. New Mexico Ecological Services Field Offices, Albuquerque, NM. 141 pp.