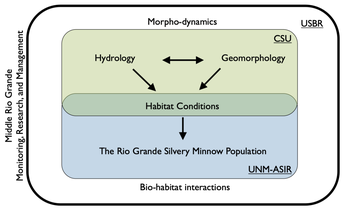

Linking hydrology and geomorphology on the Middle Rio Grande with habitat conditions for the Rio Grande Silvery Minnow

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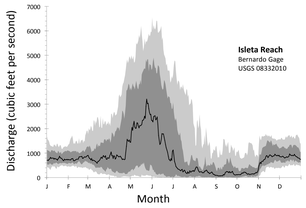
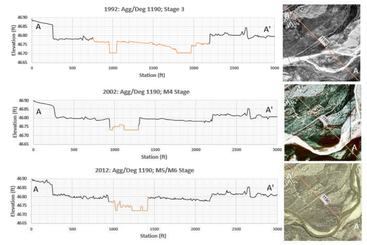
Background

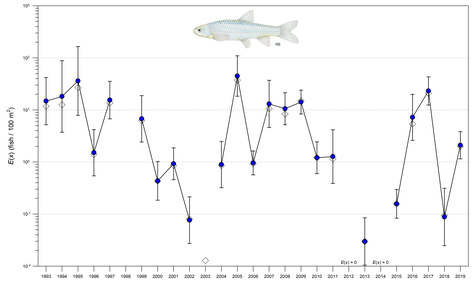
The Middle Rio Grande has experienced considerable geomorphic change resulting from river engineering, reduced magnitude and frequency of peak flows, increased duration and frequency of low flows, establishment of invasive riparian vegetation, and complex sediment dynamics. Hydrologic and geomorphic impacts have contributed to the decline of the remnant wild population of Rio Grande Silvery Minnow *Hybognathus amarus*, motivating research and conservation of this federally-listed endangered species. There is a need to link our knowledge of the morpho-dynamics (i.e., interaction of hydrologic and geomorphic processes) of the Middle Rio Grande with the habitat conditions required by the Rio Grande Silvery Minnow to improve holistic understanding of this complex and dynamic ecosystem.



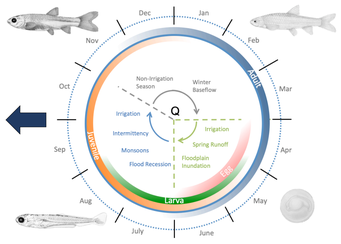
Highly variable hydrologic conditions



Dynamic geomorphology (LaForge et al., 2020)



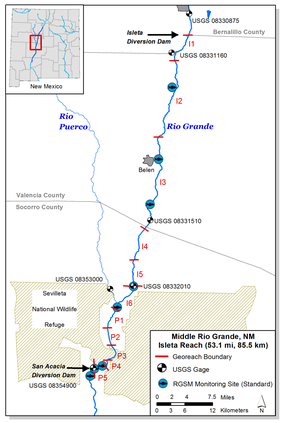
High interannual variation in abundance of the RGSM (Dudley et al., 2020)



Life history of the Rio Grande Silvery Minnow (Mortensen et al., 2019)

The goal of this study was to perform spatiotemporal analyses of species-specific habitat conditions on the Middle Rio Grande using long-term, systematically collected datasets (e.g., stream gaging, channel surveys, ichthyofaunal monitoring).

The Isleta Reach of the Middle Rio Grande was selected as the initial study area (Isleta Diversion Dam to San Acacia Diversion Dam). Sub-reaches were delineated based on geomorphic characteristics (LaForge et al., 2019; Yang et al., 2019). Analyses of the Isleta Reach and subreaches targeted relationships between discharge and habitat availability for the principal life-stages of the Rio Grande Silvery Minnow (Mortensen et al., 2019). Results characterized interactions among hydrology, geomorphology, and the population of the Rio Grande Silvery Minnow.



Study Area – Isleta Reach

Objectives

1) Synthesize data and knowledge of the Rio Grande Silvery Minnow and Middle Rio Grande across diverse river sciences (e.g., biology, ecology, hydrology, geomorphology, and engineering).
2) Identify and assess linkages between morpho-dynamic processes and habitat conditions in the Middle Rio Grande.
3) Improve understanding of the specific morpho-dynamic processes that are suspected to influence the habitat conditions and population dynamics of the Rio Grande Silvery Minnow.

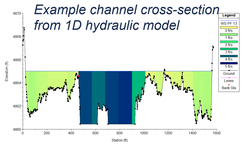
Methods

Primary Datasets
- USBR Channel Surveys (1962, 1972, 1992, 2002, 2012)
- USGS Stream Gages (1993–2019)
- RGSM Population Monitoring Program (1993–2019)

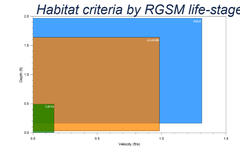
Selected Analyses
- Flow-Habitat Relationships
- Time Integrated Habitat Metrics
- Flow Metrics
- Long-term Ecological Relationships (RGSM-Flow-Habitat Comparisons)

Methods
- 1D Hydraulic Modeling (HEC-RAS)
- RGSM Habitat Criteria (velocity, depth)

Example channel cross-section from 1D hydraulic model



Habitat criteria by RGSM life-stage



Time Integrated Habitat Metrics

A metric was developed to quantify habitat availability over seasonal periods corresponding to the principal life-stages of the Rio Grande Silvery Minnow (larva, juvenile, and adult).

The Time Integrated Habitat Metric (TIHM; ft² day/mi) is represented by the integral of mean daily habitat availability, *H(t)*, over time for each respective life-stage period:
Larva (May–June), Juvenile (July–Sept.), and Adult (Oct.–April)

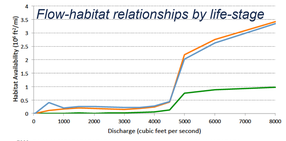
$$TIHM = \int_{t0}^{t1} H(t)dt$$

TIHMs are represented by shaded areas in the habitat availability graph

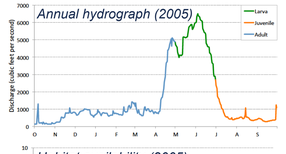
Flow Metrics

Metrics were derived for flow conditions corresponding to each life-stage period. Flow metrics included 28d peak flow May–June, 7d low flow July–Sept and Oct–April, and mean flow for each period.

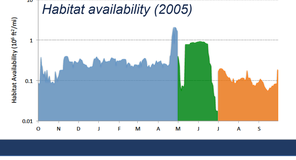
Flow-habitat relationships by life-stage



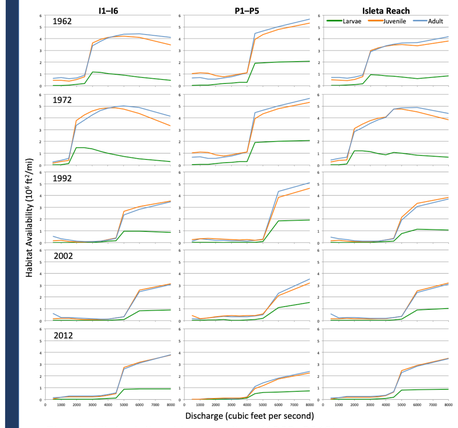
Annual hydrograph (2005)



Habitat availability (2005)



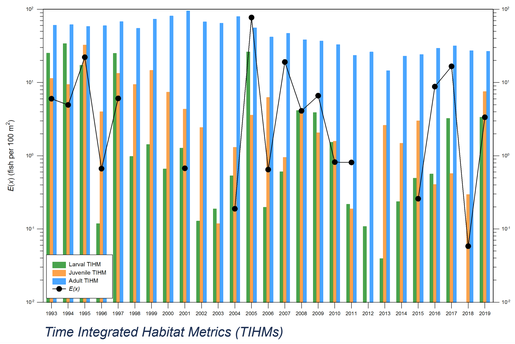
Results



Flow-habitat relationships over time (1962–2012)

- Flow-habitat relationships showed spatial and temporal variation in the Isleta Reach.
- Sharp increases in habitat availability occurred when flows exceeded bankfull discharge representing floodplain inundation.
- Bankfull discharges generally increased over time likely caused by progressive channel incision in the Isleta Reach.
- Peak habitat availability generally decreased over time likely caused by channel narrowing and habitat loss.
- Flow-habitat relationships were used to relate annual hydrologic conditions to habitat availability for the Rio Grande Silvery Minnow.
- Habitat availability over time was used to calculate temporally sensitive habitat metrics for the principal life-stages of the Rio Grande Silvery Minnow (TIHMs).

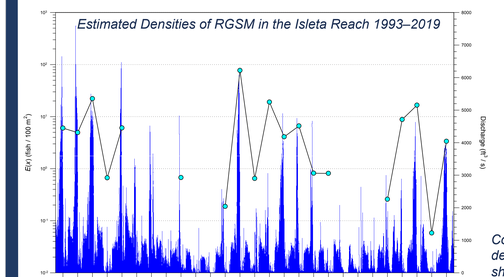
- Time Integrated Habitat Metrics (TIHMs) showed variation in habitat availability across life-stages with notable interannual variation for larval and juvenile life-stages.
- Ecological relationships between environmental conditions and the RGSM population were evaluated for the Isleta Reach using generalized linear models. Covariates selected included TIHMs and flow metrics by the life-stages of the RGSM.



Time Integrated Habitat Metrics (TIHMs)

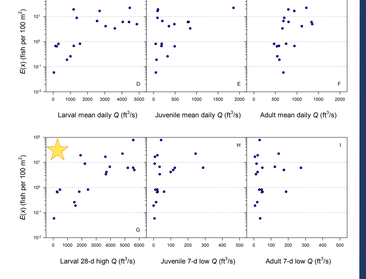
Discussion

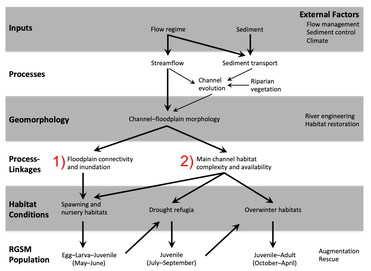
Estimated Densities of RGSM in the Isleta Reach 1993–2019



Comparisons between flow/habitat metrics and densities of the RGSM in October (1993–2019) showed long-term ecological relationships

Long-Term Ecological Relationships
- Generalized linear models revealed that variation in the occurrence and abundance of the RGSM were reliably predicted by changes in flow and habitat metrics.
- Flow and habitat metrics corresponding to the larval life-stage (May–June) were the strongest predictors of positive population responses of the Rio Grande Silvery Minnow (i.e., increased abundance and occurrence of the species).
- The top ranking ecological model was characterized by spring flow metrics (28d peak flow May–June).
- Varied performance of flow and habitat metrics might indicate phenomena unaccounted for in habitat models.





Conceptual diagram of key process-linkages

Process-Linkages
- The primary process-linkages identified from analyses of the Isleta Reach were:
  1) Floodplain connectivity and inundation
  2) Main channel habitat complexity and availability
- Process-linkages illustrate complex multi-scale dynamics occurring in the Middle Rio Grande ecosystem.

Acknowledgments

Middle Rio Grande Endangered Species Collaborative Program
University of New Mexico
Division of Fishes, Museum of Southwestern Biology
Colorado State University
Dept. of Civil and Environmental Engineering, Dept. of Fish, Wildlife, and Conservation Biology
U.S. Bureau of Reclamation
Albuquerque Area Office, Technical Services Center

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Mortensen, J. G., R. K. Dudley, S. P. Platania, and T. F. Turner. 2019. Rio Grande Silvery Minnow biology and habitat syntheses. Report to U.S. Bureau of Reclamation, Albuquerque, New Mexico.
Yang, C. Y., K. LaForge, P. Y. Julien, and S. Doidge. 2020. Isleta Reach: Hydraulic modeling and Silvery Minnow habitat analysis. Report to U.S. Bureau of Reclamation, Albuquerque, New Mexico.