Refugia for Rio Grande Silvery Minnow during flow intermittency

Thomas P. Archdeacon, USFWS

Justin K. Reale, USACE

Introduction

- In the past two decades, interest and research on intermittent waters has increased
- As human demand increases, coupled with global climate changes, perennial streams in many areas may become intermittent
- Research on how aquatic organisms persist in these areas is critical for managing these systems, and will only increase in importance (Magoulick and Kobza 2003)
- MRG provides an ideal study area, 10+ years of both drying data and RGS minnow data

Disturbance and Refugia

- Disturbance
  - Drought and channel drying is a major disturbance for aquatic organisms
  - Defined here by the damaging properties, number of RGS minnow stranded (killed), following Lake (2000)
- Refugia
  - Places where the negative effects of disturbance are lower than the surrounding area (Lancaster and Belyea 1997)
- Important to discover refugia and how and when organisms use them
  - Fish either move to refugial areas prior to drying or a trapped in them at the onset of drying

Disturbance—Drying

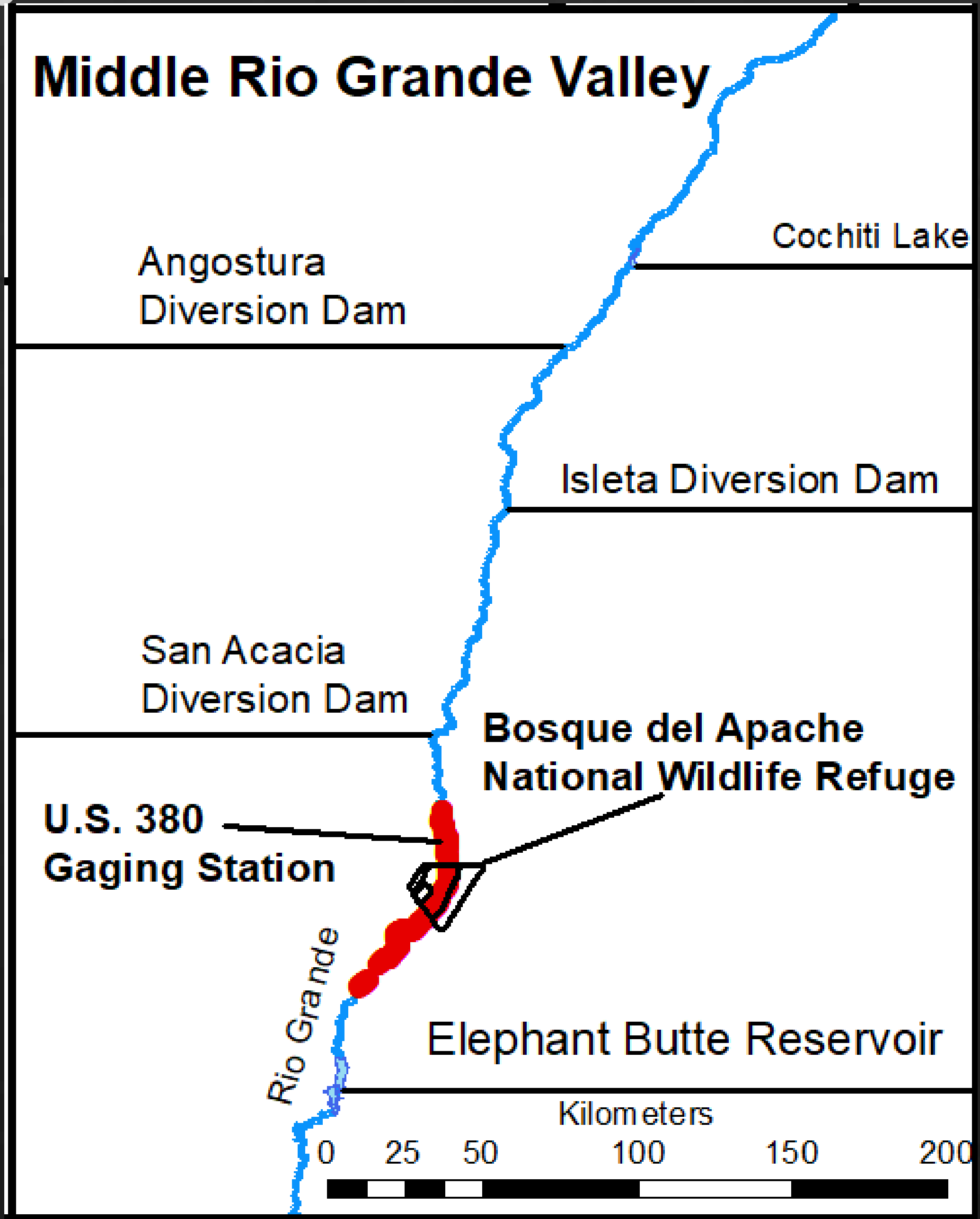
- Variable by year
- Earliest – 2018 (April)
- Latest 2017, 2019 (September)

Objectives

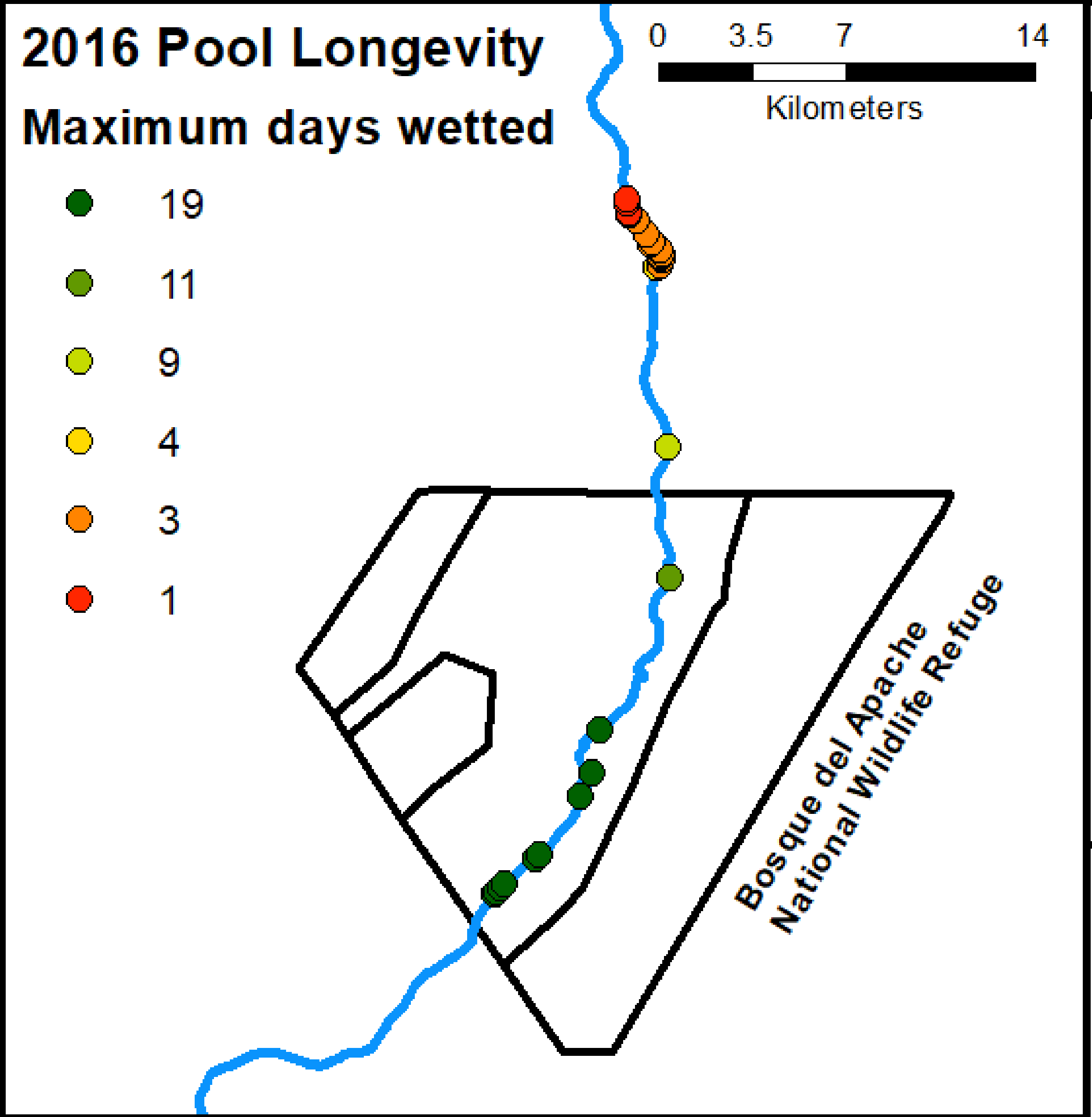
- Examine the frequency and persistence of pools and average sizes and depths in the San Acacia Reach
- Document and explain spatial and temporal patterns of RGS minnow trapped in isolated pools in the San Acacia Reach
- H_1: Deeper, larger pools persist longer than smaller pools
- H_2: Deeper, larger pools contain (relatively) more RGS minnow than smaller pools
- H_3: RGS minnow are more abundant in upstream areas
- H_4: Rate of channel recession will affect the number of RGS minnow trapped in isolated pools

Methods – Study Area

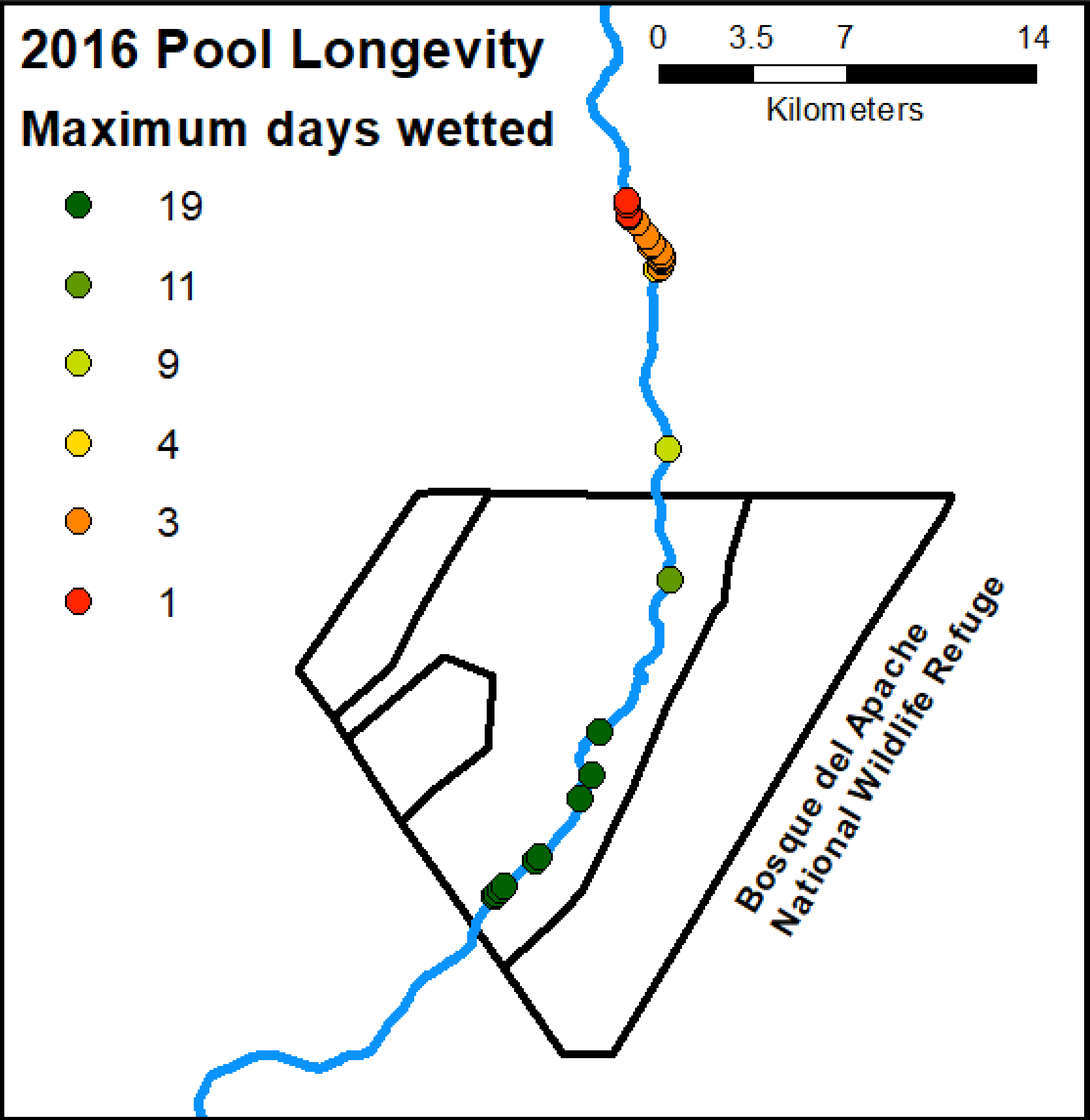
- San Acacia Reach of the Middle Rio Grande
  - San Acacia Diversion Dam to upper Elephant Butte
- 2009 – 2018
- Largest amount of data
- Focus on first drying
- Only wild fish



Methods – Pool Longevity



- Followed 290 pools during first drying in 2016
- Measured depth on every other day, out to 19 days when the river reconnected
- If a pool dried, we calculated the maximum number of days it persisted
- Modified densiometer reading
- Used a generalized linear model to predict days persisted by initial depth, densiometer, and the interaction
- Used AICc to rank candidate models, model-averaged competing models



Results – Pool Longevity

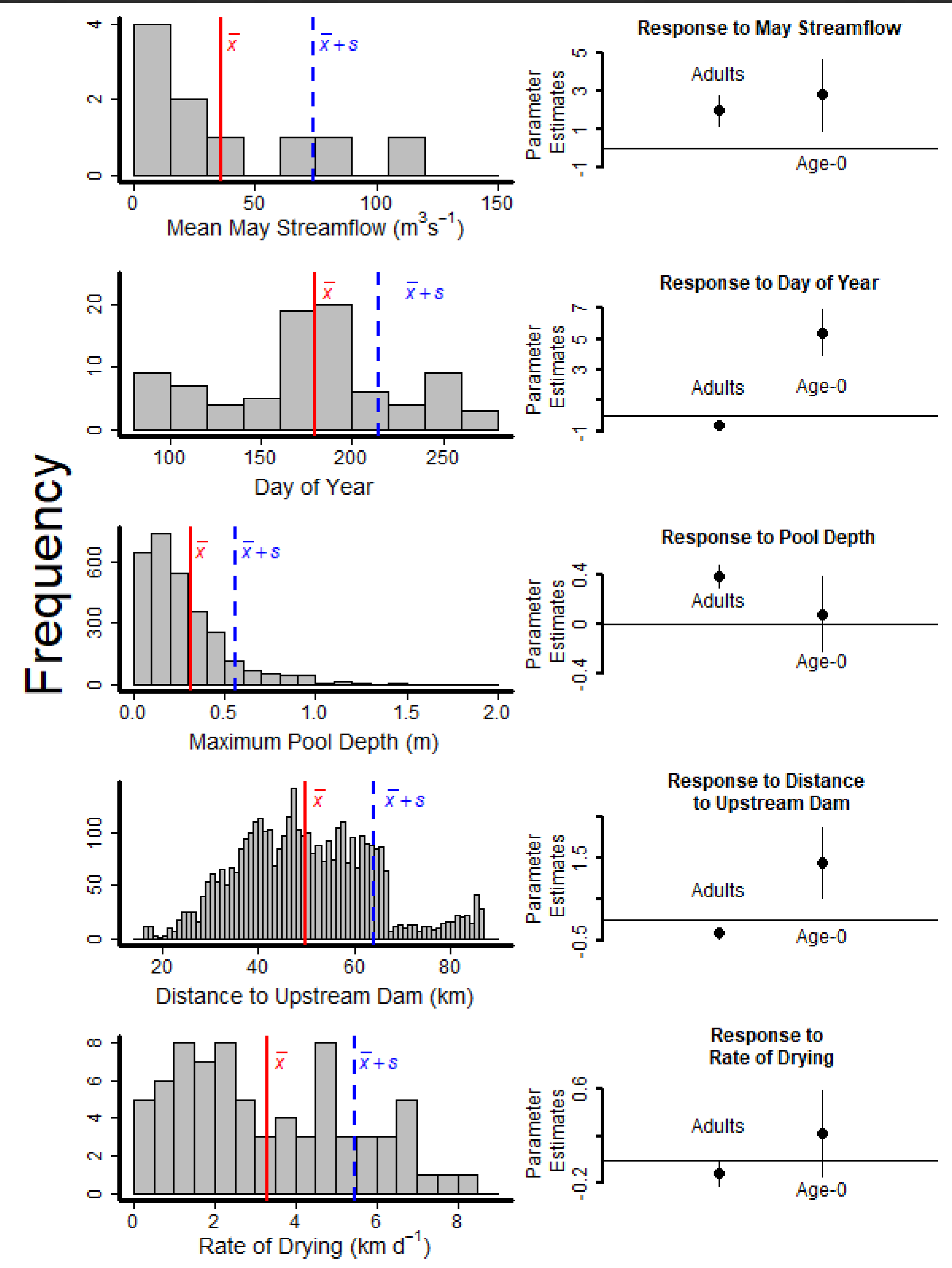
- Average initial depth ~0.25 m
- Deeper pools persisted longer
- Canopy cover not meaningful
- Average persistence 3.7 days
- 27 pools persisted to reconnection (9.3%)
- 1.4% of RGS minnow occurred in those pools
  - 66 of 4,749
- We lack the data, but at the time of reconnection, long-lasting pools had Gambusia or no fish at all

Methods – Multi-season Abundance

- 2009 – 2018
  - Complete cases (depth, location, count)
  - Sum of 1 to 4 passes per pool*
- Generalized linear mixed-effects model; year random effect
- Response – counts of either adults or young-of-year per pool
- Predictors – May mean discharge, day of year, distance to SADD, rate of drying, depth
  - Fixed effects: overall population level effects
  - Used combinations of main effects only
- Scaled predictors, used AICc to rank models, model-averaged
- Marginal R^2: variance explained by fixed effects

Results – Multi-season Abundance

- Marginal R^2 ~ 0.63 adult; ~ 0.77 YOY
- May streamflow and day of year had strong effects
- More adults earlier, more young of year later
- More adults in deeper pools, no effect on YOY
- More adults upstream, more YOY down
- Rate of drying - ?



Discussion

- H_1: Deeper, larger pools persist longer than smaller pools
  - Deeper pools do last longer; however few large pools
- H_2: Deeper, larger pools contain (relatively) more RGS minnow than smaller pools
  - 66 of 4,749 RGSM in pools that persisted
  - Pool depth had small effect on adult fish numbers, no effect on YOY

Discussion

- H_1 and H_2 summary:
  - RGS minnow are not specifically choosing pools that persist
  - Isolated pools are not refugia for RGS minnow or other species

Discussion

- H_3: RGS minnow are more abundant in upstream areas
  - True for adults, but not YOY
  - Pelagic broadcast spawning – non-adhesive eggs and larvae drift downstream
  - Adults disperse upstream until hitting a barrier

Discussion

- H_4: Rate of channel recession will affect the number of RGS minnow trapped in isolated pools
  - Data is inconclusive: Faster drying strands FEWER adults, and no effect on YOY
- Lack of data, lack of range of rate of drying
- Small effect in a complex system (spring discharge, day of year, etc.)

Summary

- If drying of this magnitude, duration, and frequency occurred through the evolution of RGS minnow, there would be stronger evidence of movement or pool selection
- Historically, persisted through periods of drying by being widespread and abundant
- Channel drying poses a novel environment for these species and causes catastrophic mortality in the MRG; refugia exist but fish must occur there prior to drying