HYDRAULIC HABITAT MODELING AND TIME SERIES ANALYSIS FOR GILA RIVER FISH SPECIES

Presentation to Interstate Stream Commission
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November 10, 2014

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GOAL OF THE STUDY

- SWCA and Normandeau were contracted by ISC to quantify ecological impacts of AWSA flow alterations on key species.
- Normandeau tasks:
  - Hydraulic habitat modeling
  - Habitat suitability criteria (HSC) development
  - Habitat time series analysis

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HYDRAULIC HABITAT MODELING

(also known as PHABSIM, RHABSIM, RHYHABSIM, etc.)

- Starts with surveys of river cross-sections
- Hydraulic models are built from the data
- Calibrated models simulate:
  - Water depth
  - Water velocity
  - Substrate and/or cover
- Models predict hydraulic variables over a range of flows

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HYDRAULIC HABITAT MODELING

- Predicted hydraulic variables are linked with Habitat Suitability Criteria (HSC)
- HSC indicate the suitability of the hydraulic variables as aquatic habitat
- Each hydraulic variable is assessed for suitability at any specified flow
- The suitability of each variable is linked and weighted to create a net index called Area Weighted Suitability (AWS)

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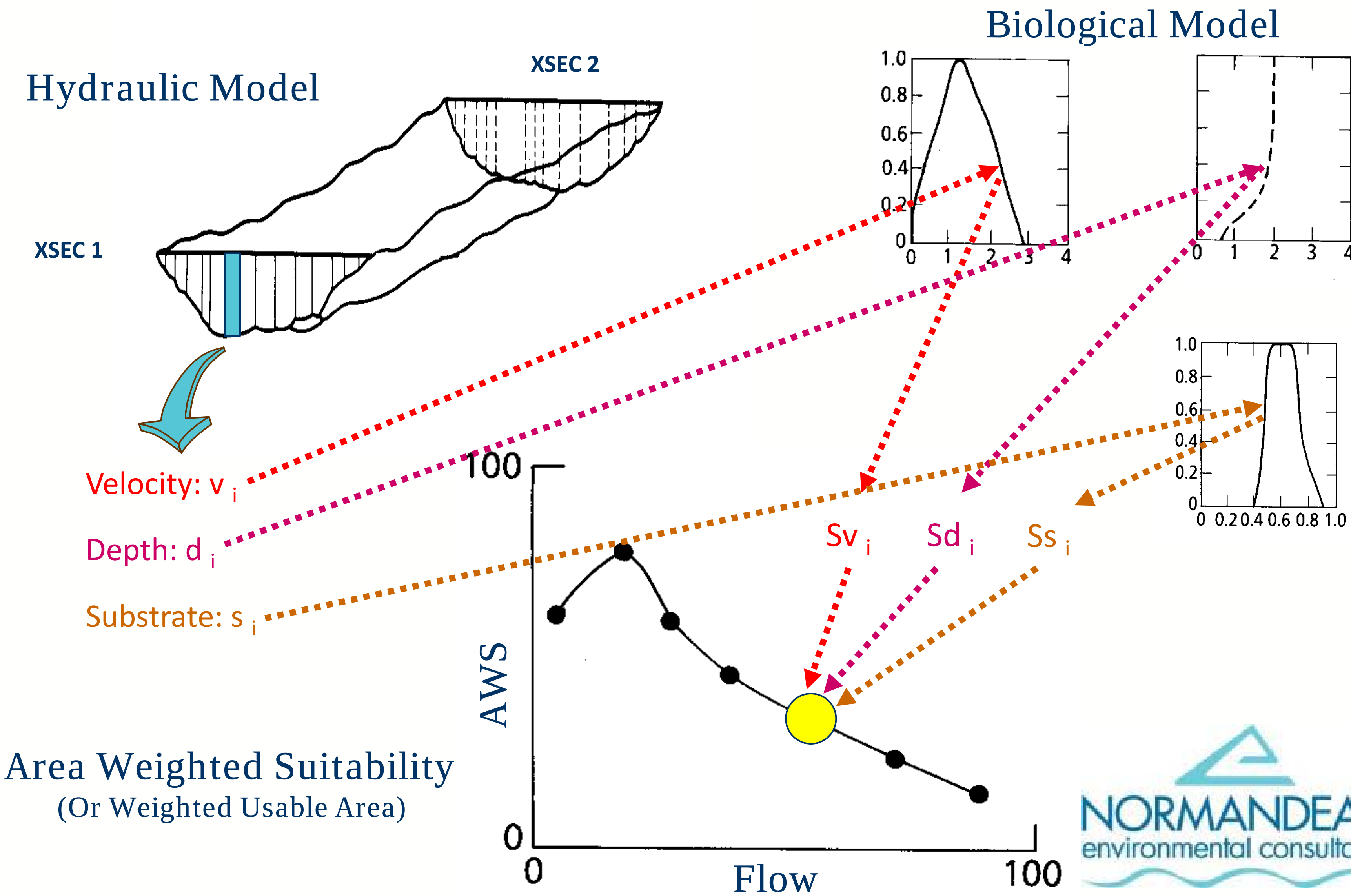
HYDRAULIC HABITAT MODELING



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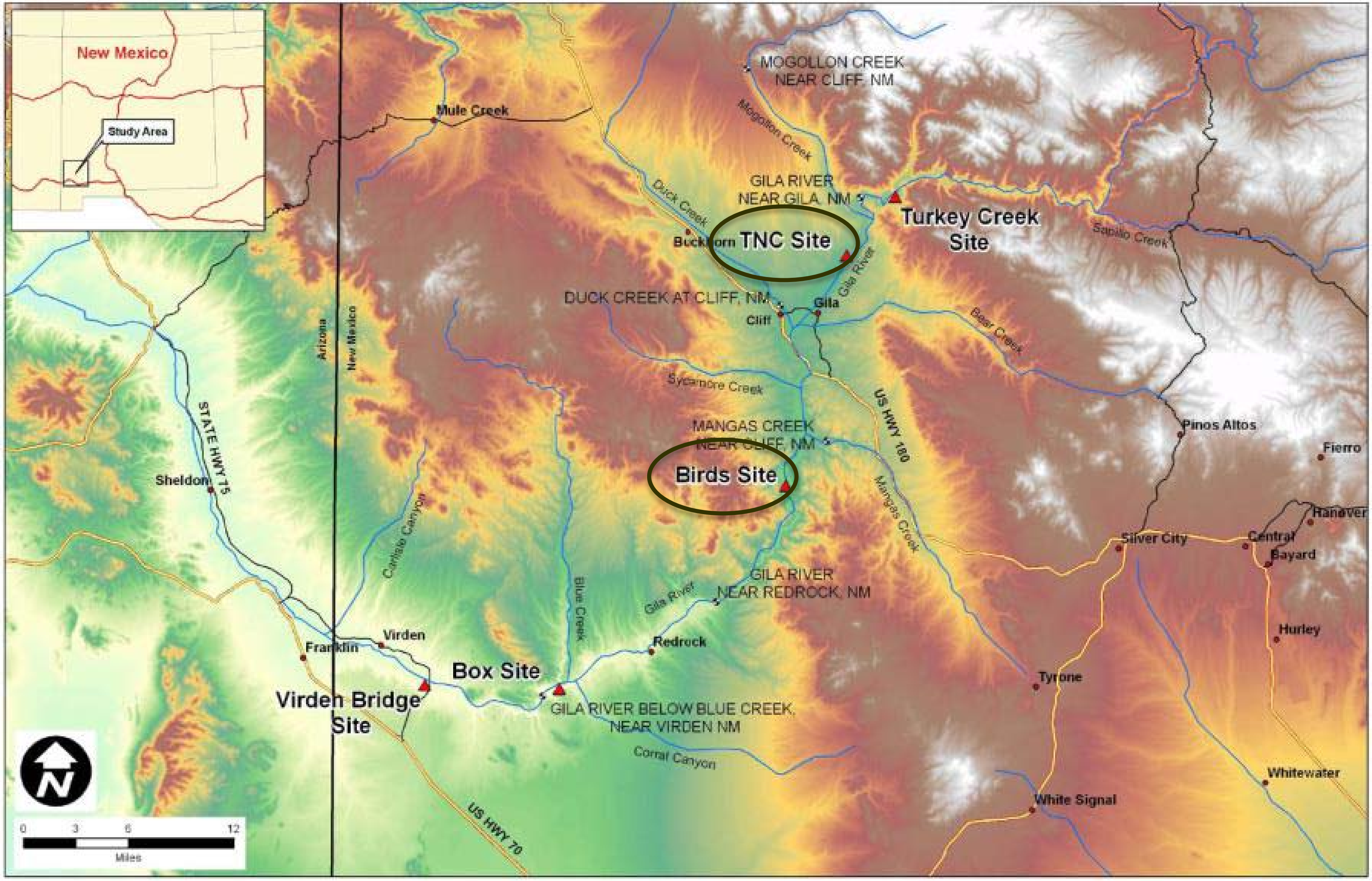
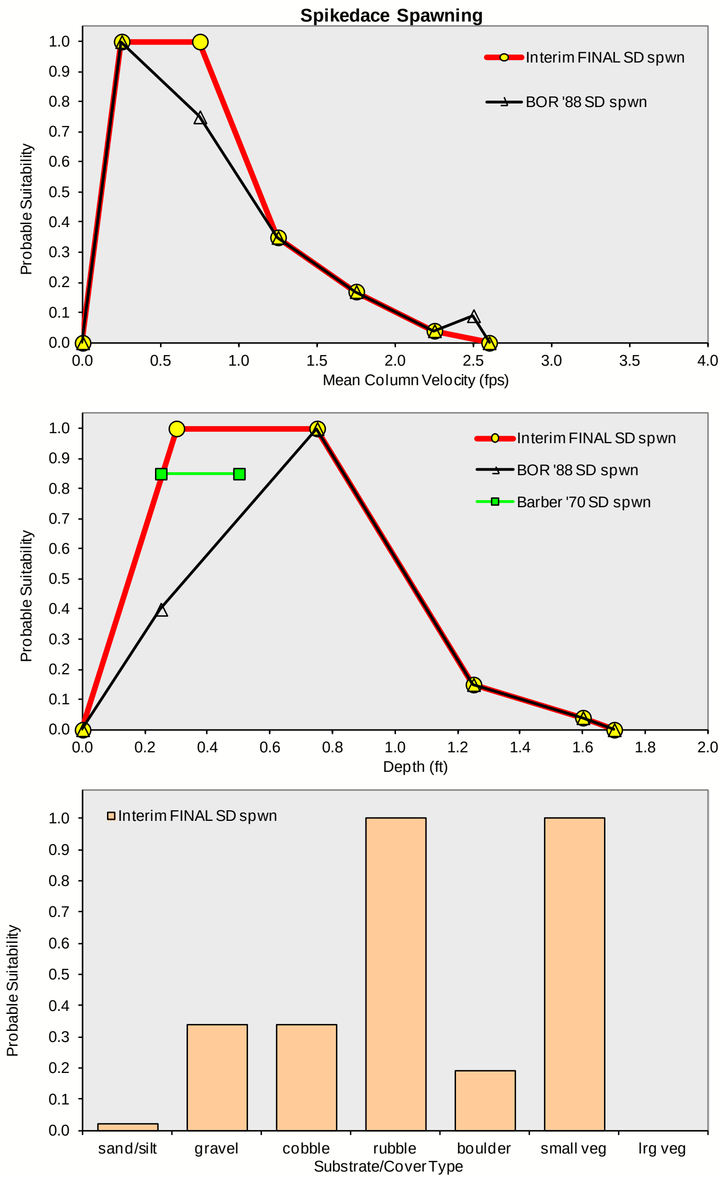
GEOMORPHOLOGY STUDY

Study Site Location map



HABITAT SUITABILITY CRITERIA

Observational data modified by professional judgment



SPECIES OF INTEREST

- ✓ Fish
  - Native
    - Spikedace (E)
    - Loach Minnow (E)
    - Gila Chub (E)
    - Desert Sucker
    - Sonora Sucker
    - Longfin Dace
  - Non-native
    - Green Sunfish
    - Smallmouth Bass
    - Channel Catfish
    - Common Carp
    - Red Shiner
- x Birds
  - Native
    - Southwest Willow Flycatcher (E)
- x Reptiles
  - Native
    - Northern Mexican Garter Snake
    - Narrow-headed Garter Snake
- x Amphibians
  - Native
    - Chiricahua Leopard Frog (T)
  - Non-native
    - Bullfrog
- x Crustaceans
  - Non-native
    - Crayfish

✓ HSC developed

x HSC not developed

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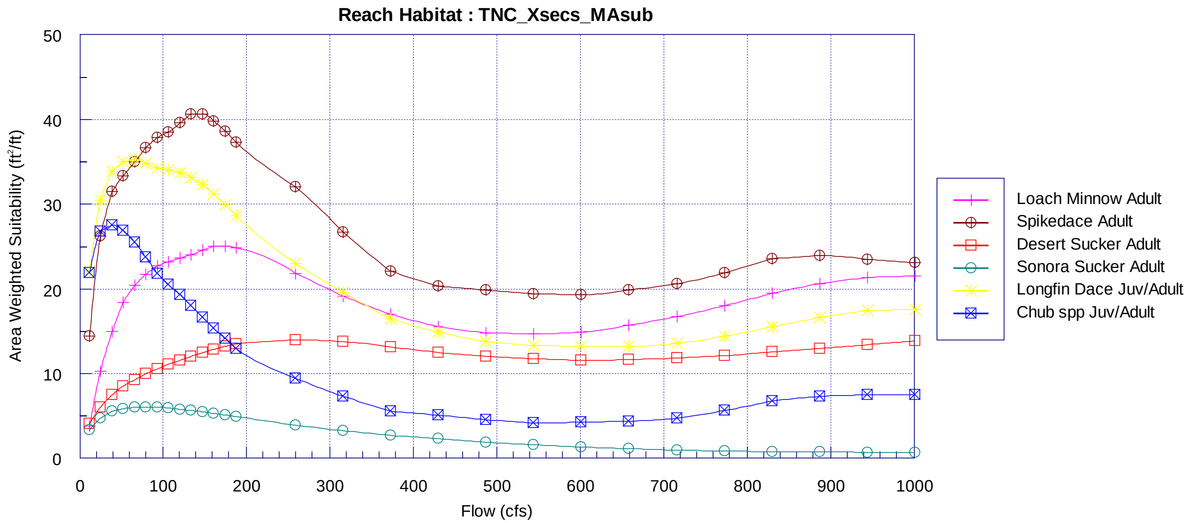
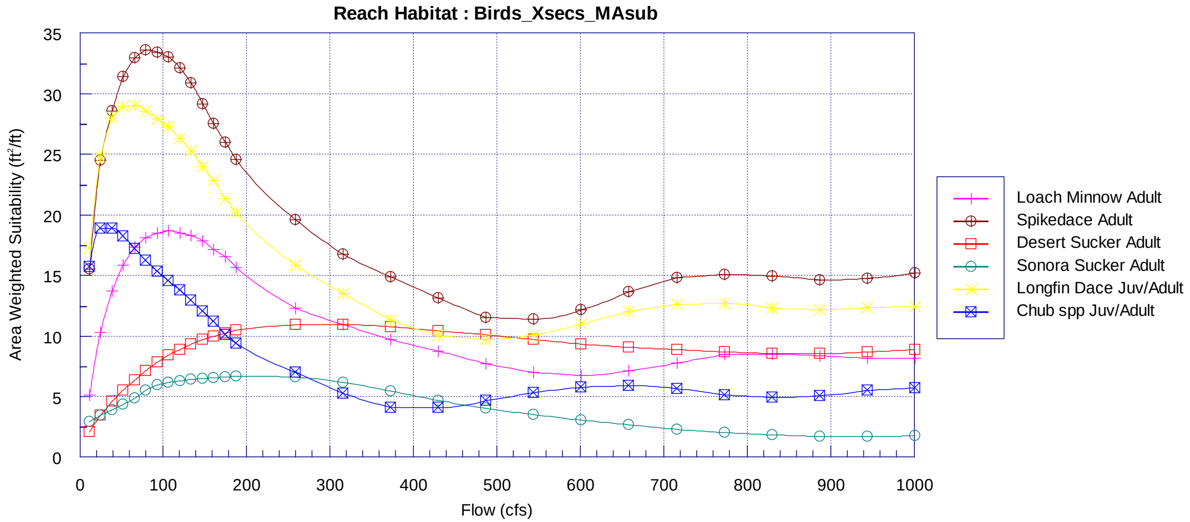
AREA WEIGHTED SUITABILITY

Habitat Index Functions vs. Flow for TNC and Birds Study Sites





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HABITAT TIME SERIES

- Typically starts with daily flow values
- Converts each daily flow to its equivalent AWS index
- Sorts and graphs the converted AWS index by magnitude
- Quantifies AWS habitat index change with flow over time
- Allows comparison of flow scenario effects on fish habitat

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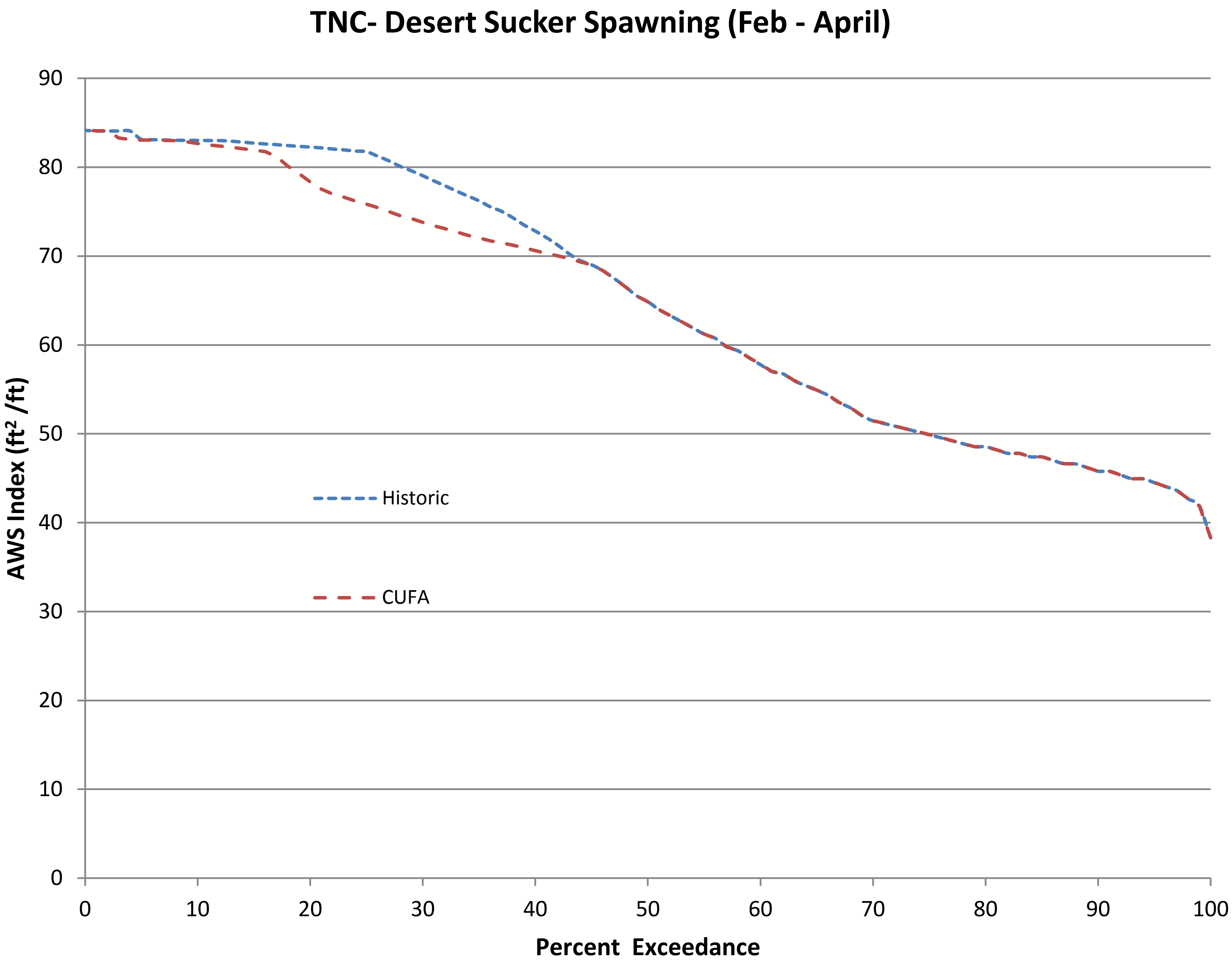
HABITAT TIME SERIES ALTERNATIVES

Comparing two alternative flow regimes with habitat duration



FLOW SCENARIOS EVALUATED

Quantify fish habitat change for:

1. Historical flow after AWSA diversions for TNC & Birds sites:
   i. without climate change
   ii. with climate change of 8% overall flow reduction
2. Historical flow after AWSA diversions minus Upper Gila and Ft. West ditch flows with environmental flow augmentation for TNC site:
   i. without climate change
   ii. with a climate change of 10% overall flow reduction

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GILA RIVER HABITAT DURATION

Area under the curve for TNC Reach

	TNC Reach					
	Without Climate Change			With Climate Change		
	Historic	CUFA	% Diff.	Historic	CUFA	% Diff.
Loach Minnow Spawning	1210	1243	2.8	1216	1251	2.8
Loach Minnow Larvae	923	931	0.8	951	959	0.9
Loach Minnow Juvenile	3270	3321	1.6	3239	3291	1.6
Loach Minnow Adult	1987	2016	1.5	1944	1972	1.5
Spikedace Spawning	1059	1077	1.7	1076	1096	1.9
Spikedace Larvae/Fry	568	571	0.5	585	588	0.5
Spikedace Juvenile	2410	2444	1.4	2413	2448	1.5
Spikedace Adult	3360	3422	1.9	3331	3396	1.9
Desert Sucker Spawning	6496	6383	-1.8	6350	6231	-1.9
Sonora Sucker Spawning	5556	5497	-1.1	5389	5328	-1.1
Sucker spp Larvae	439	442	0.6	450	453	0.7
Desert Sucker Juvenile	3000	3040	1.3	2960	3000	1.3

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MAJOR RESULTS

Scenario 1

- Natives:
  - Loach Minnow: 0.8% to 3.2 % increase in all life stages habitat
  - Spikedace: 0.3% to 1.9% increase in all life stages habitat
  - Chub spp: up to 2.3% reduction in larval habitat
  - Sucker spp: up to 2% reduction in spawning habitat
  - Longfin Dace: up to 2.7% reduction in spawning habitat
- Non-natives:
  - Smallmouth Bass: up to 2.5% increase in spawning habitat
  - Common Carp: up to 5.0% decrease in spawning habitat

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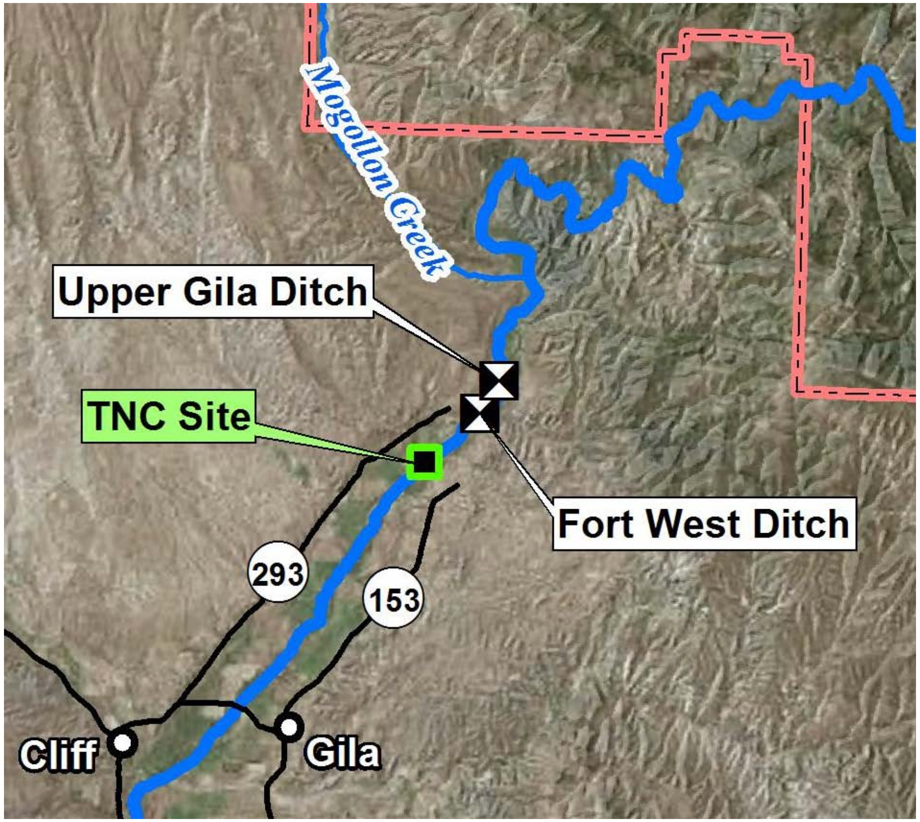
MAJOR RESULTS

Scenario 2

- AWS of natives tend to peak at a much lower flow than those of the predators.
- 10 cfs chosen as environmental flow.
- Natives: 0.3% to 9.0% habitat increase
- Non-natives: 0 to 10.7% habitat increase



CONCLUSIONS

- 11 fish species were evaluated in this study (6 natives, 5 non-natives)
  - Habitat analysis for species other than fish is generally not compatible with this method.
  - This method does not address the very complex ecological functions (competition, predation, food availability) for and between species.
- Up to ±5% habitat change for natives and non-natives in their various life stages
- Releasing 10 cfs back to the river: up to 11% habitat increase for all species

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Population Viability Analysis of Spikedace and Loach Minnow

Bill Pine, PhD working with

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Goals of the Study

- ISC hired SWCA/Dr. Bill Pine to:
  - Develop a preliminary Population Viability Analysis (PVA) for loach minnow and spikedace
  - Estimate extinction probability of key species using PVA

Spikedace and Loach Minnow

- Federally protected – Endangered
- Small, benthic fish species
- Endemic to Gila River basin
- Populations have declined due to habitat changes and negative effects of invasive species
- Short lived - spikedace ~ 2 years loach minnow ~3 years

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Simulation scenarios

Scenario	Purpose	Assumption/key trait	Female fish count	Long-term carrying capacity
1	Viability of small populations	Based on best info + Variability in survival	20-100	NA
2	Resilience and recovery	Based on best info + Variability in survival	20	500
3a	Low recruitment for 5 years due to drought, then 45 years normal conditions	Based on best info + Variability in survival Flow-fish survival relationship	400	400
3b	Persistent low recruitment due to non-native predataors	Based on best info + Variability in survival High predation on native fish by nonnative predators	400	400

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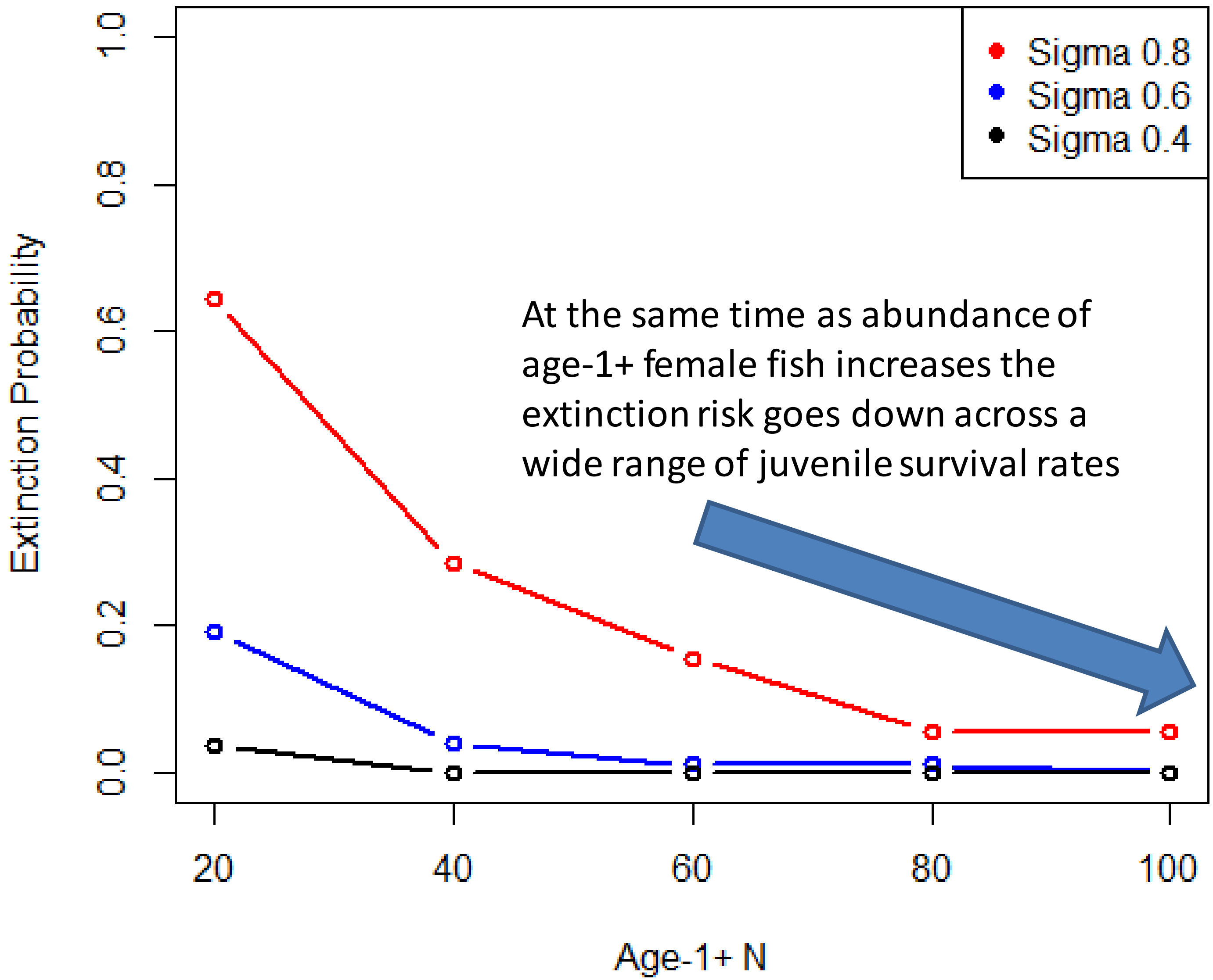
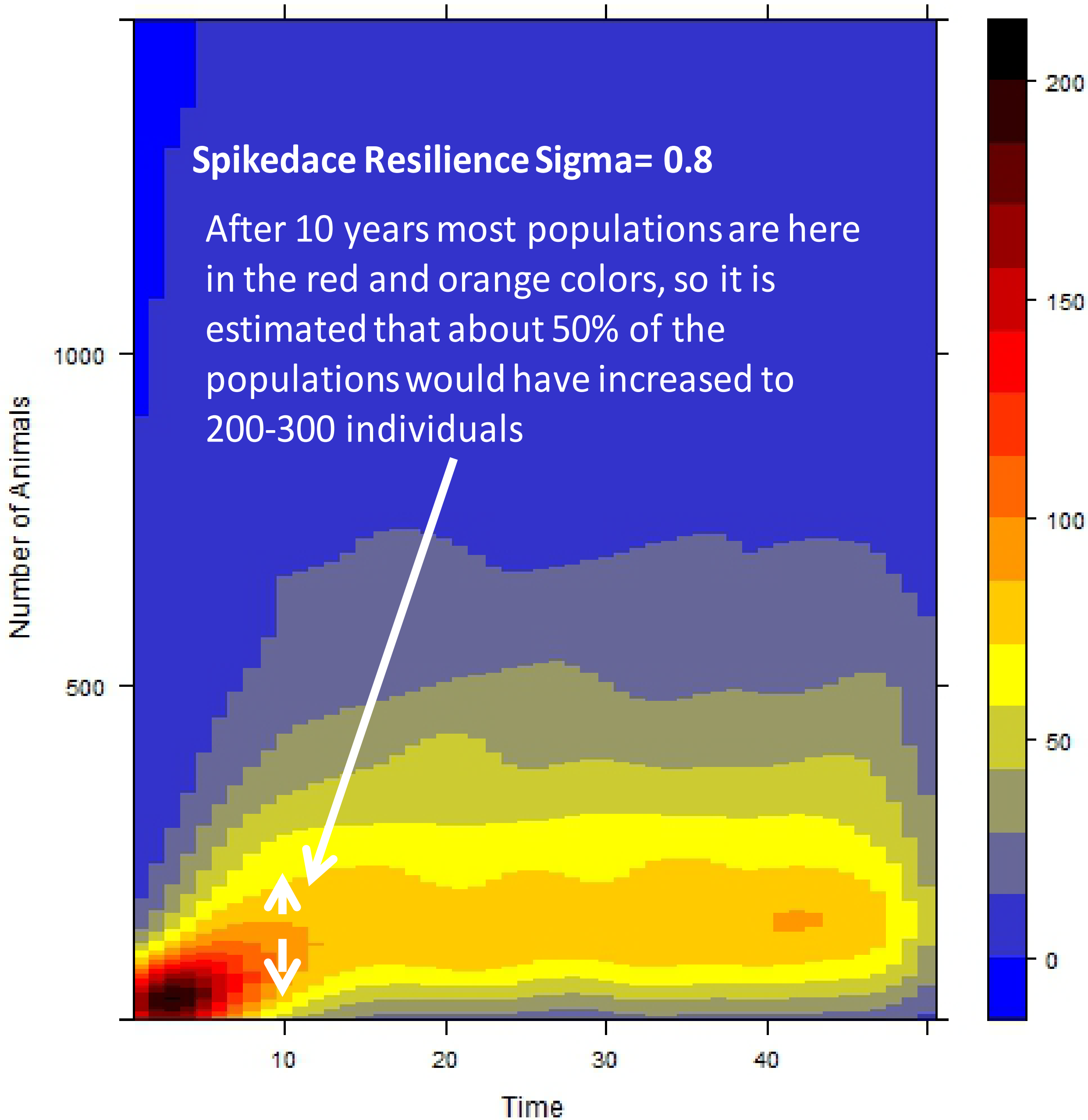
Spikedace extinction probability vs age-1+ N



Resilience (Scenario 2)

- Scenario designed to assess recovery time for very small populations (~20 adult females)
- Similar to what may happen if downstream populations "seeded" from upstream
- Designed to mimic natural variation in survival that likely occurs



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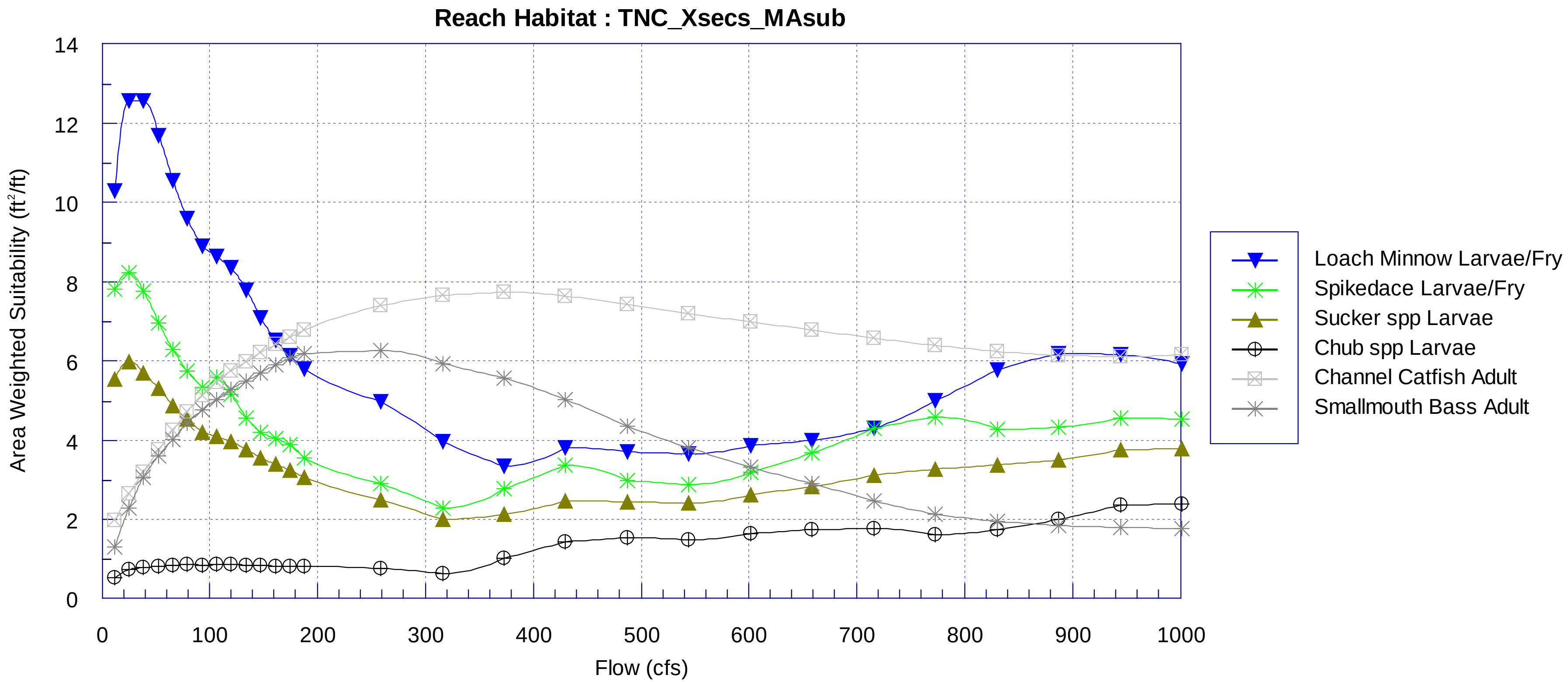
Results

Scenario	Purpose	Extinction risk	Take home message
1	Examine viability of small populations	High (65-98%) over 500 years for very small populations and high variation in survival Low for larger populations or low survival variation	Populations > 100 females robust
2	Resilience and recovery	Very small over 50 years in a source-sink framework	Rapid recovery potential
3a	Low recruitment for 5 years due to drought, then 45 years normal conditions	1.5 % (loach minnow) 8% (spike dace) – occurs during low recruitment Zero if low recruitment does not occur and mortality normal	Resilient to short-term low recruitment (5 years)
3b	Persistent low recruitment due to non-native predators	High extinction risk (100% both species) in less than 10 years if low recruitment persists	Be wary of non-native predator expansion



- “Sweet spot” are flows that benefit natives but do not promote non-native species (e.g. Catfish & Bass)
- As an example ~20-40 CFS may promote natives but limit non-natives (based on PHABSIM outputs)

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Conclusion

- Flow augmentation must be carefully considered
  - May reduce risk of habitat fragmentation
  - Could increase risk of non-native expansion potentially reducing native fish survival (and increasing extinction risk)
- Robust monitoring efforts and surveys should be undertaken to track fish community response to any flow augmentations.
- Linking “flow models” with the “fish models” will help to make better management decisions in the Gila River to benefit native fish species.

Thank you!

- Questions?