Forecasting the Effects of Angler Harvest and Climate Change on Smallmouth Bass Abundance in the Buffalo River, Arkansas

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Background

- Smallmouth Bass are an important lotic species in the Ozark-Ouachita Interior Highlands
- This region is at the southern extent of their native range
- Climate change could affect smallmouth bass populations in this region
  - Temperature increases
    - Growth (Middaugh et al. 2016)
  - Drought
  - Flooding

www.agfc.com

USGS.gov

Harvest

- Harvest can be severe for smallmouth bass
  - Survival can be < 50% in heavily exploited streams (Reed and Rabeni 1989)
- With climatic stressors, current harvest levels may be excessive
- How important is harvest mortality relative to climate change effects?

Objectives

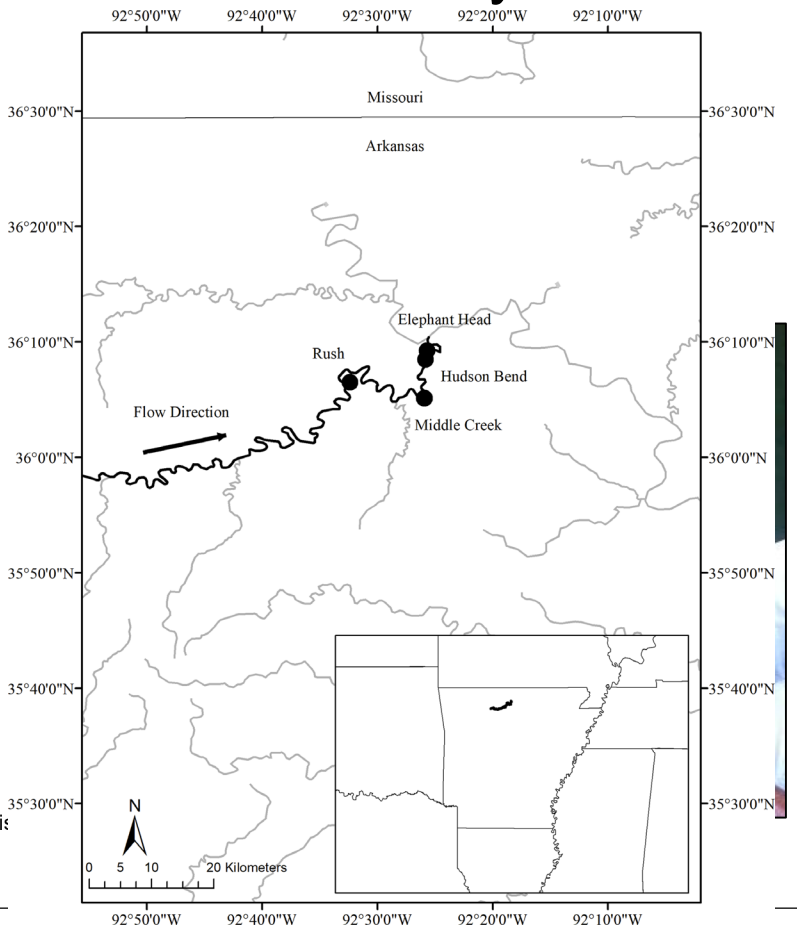
- Determine predictive relationship between environmental variables and age-0 smallmouth bass abundance
  - Create a Ricker recruit-spawner model
- Determine relative effects of climate change and angler harvest on adult SMB abundance (Peterson and Kwak 1999)

Data

- Data was obtained from the Arkansas Game and Fish Commission (AGFC) for the Buffalo River, AR
  - Selected 15 samples from four sites over six years
    - October
    - Boat electrofishing

http://www.state.nj.us/dep/fgw/images/fi

http://farm8.staticflickr.com/7278/7684557816_75de7deeb8.jpg



Data

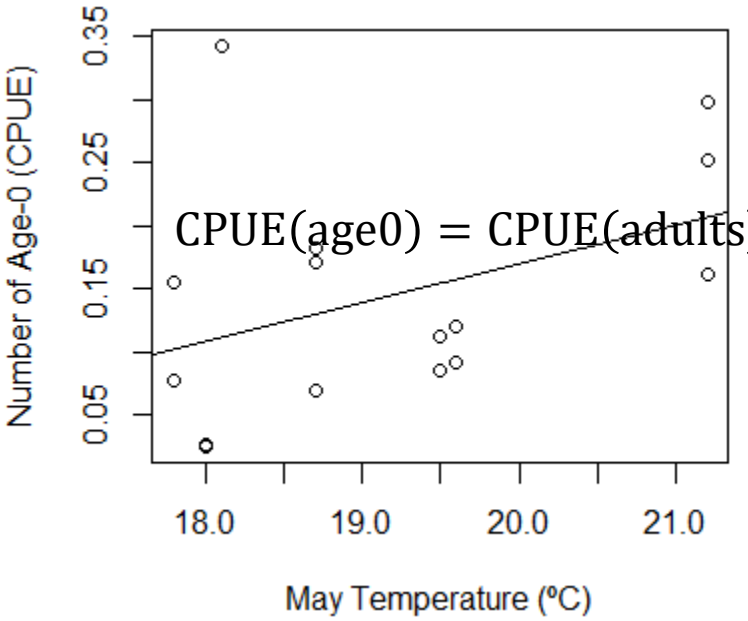
- Determined number of age-0 and adult SMB at each site for each year
  - Based on otolith age data and length frequency

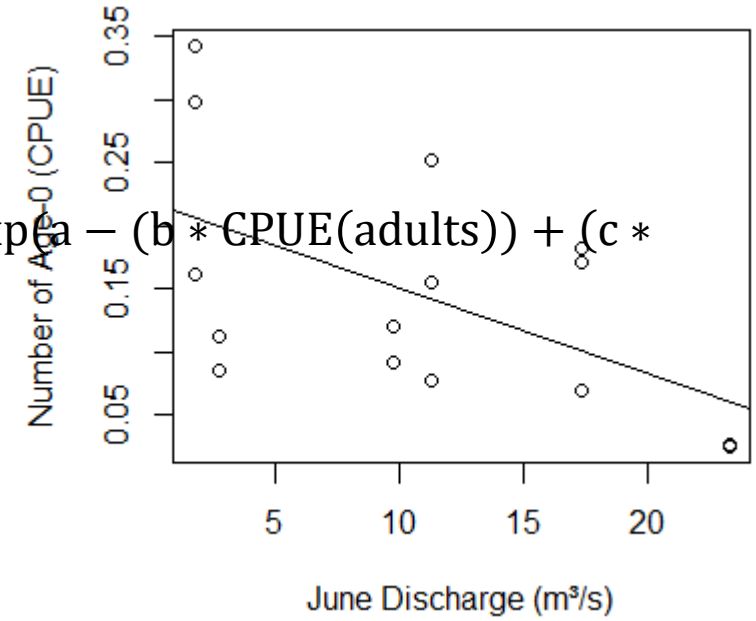
http://farm8.staticflickr.com/7278/7684557816_75de7deeb8.jpg

Analyses

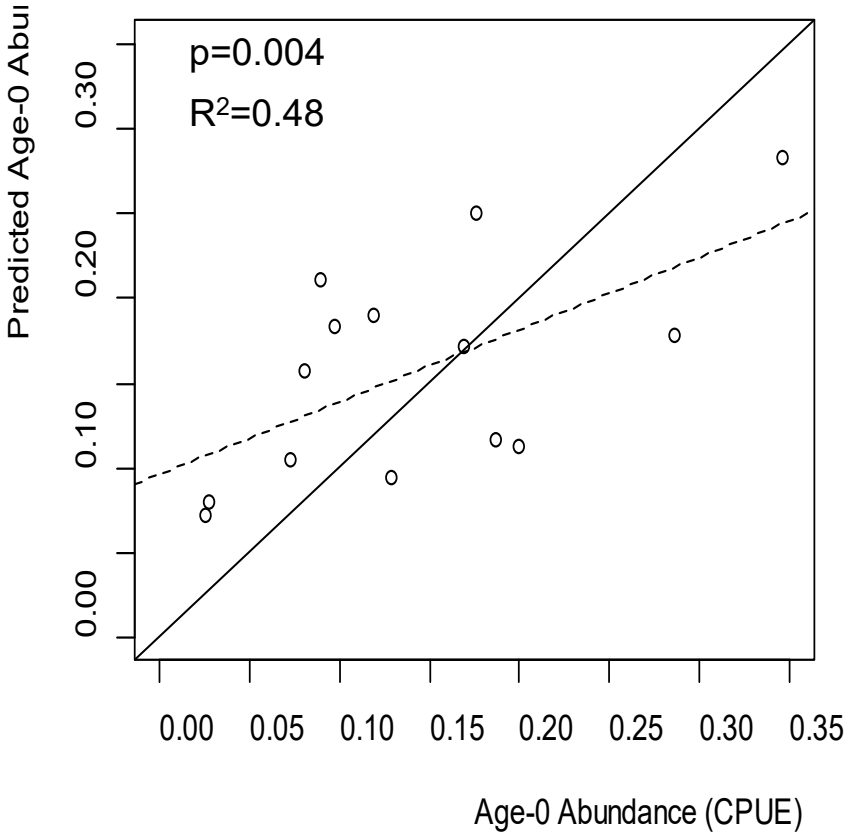
- First- determine best predictive relationships between age-0 fish and environmental parameters
  - May temperature, June discharge selected as best
  - Created a Ricker model with environmental variables added

$$\mathrm{CPUE(age0)} = \mathrm{CPUE(adults)} * \exp(a - (b * \mathrm{CPUE(adults)}) + (c *$$

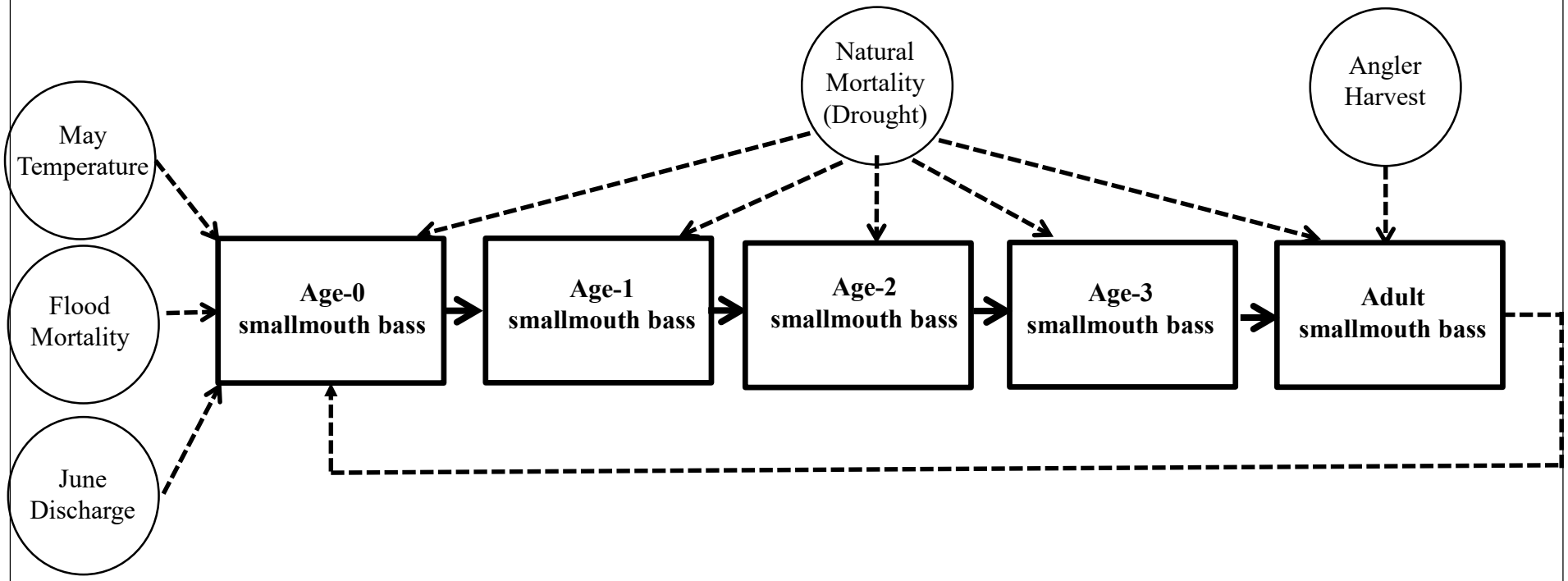




Model Fit


p=0.004
R2=0.48
Predicted Age-0 Abu
0.00
0.10
0.20
0.30
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Age-0 Abundance (CPUE)

Age-Structured Population Model



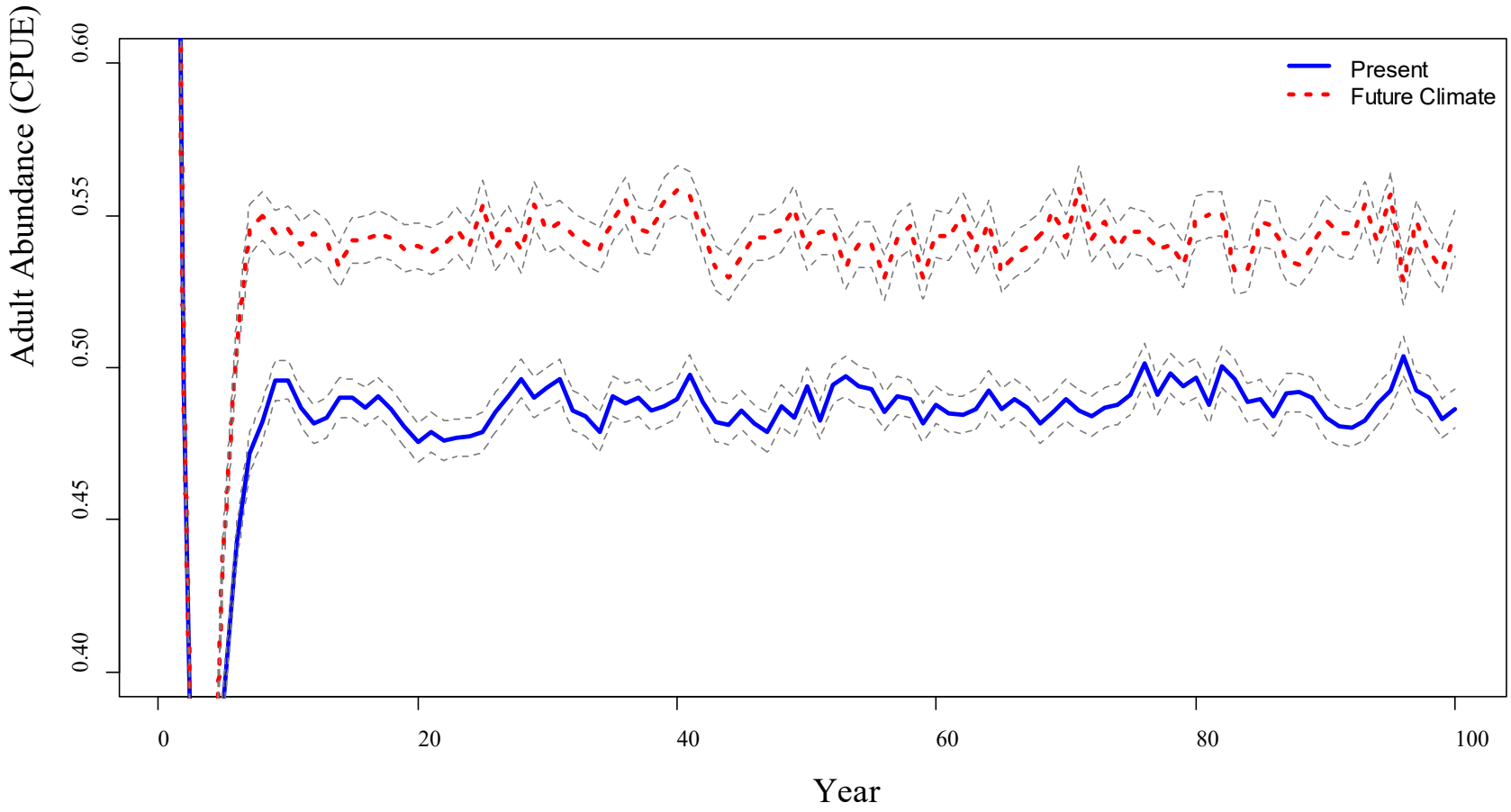
- Ran 10 simulations
  - Each simulation was run for 100 years and replicated 1,000 times

Model Simulations

- Present simulation based on long term data from USGS gage in Buffalo River and NOAA temperature records
- Future conditions based on ensemble average of climate models (Mid-century, high emissions)
  - Higher May temperature (+3.5 ºC)
  - Lower June discharge (-1 m^3/s; higher variability)
- Flood frequency
  - Low and high (10%, 20%)
  - Flooding causes 90% mortality of age-0
- Drought
  - Natural mortality is modified by drought chance
  - High drought scenario: moderate drought is 5% more likely and high drought is 9% more likely
- Harvest mortality
  - Low and high (0.2, 0.35; MDC unpublished data)

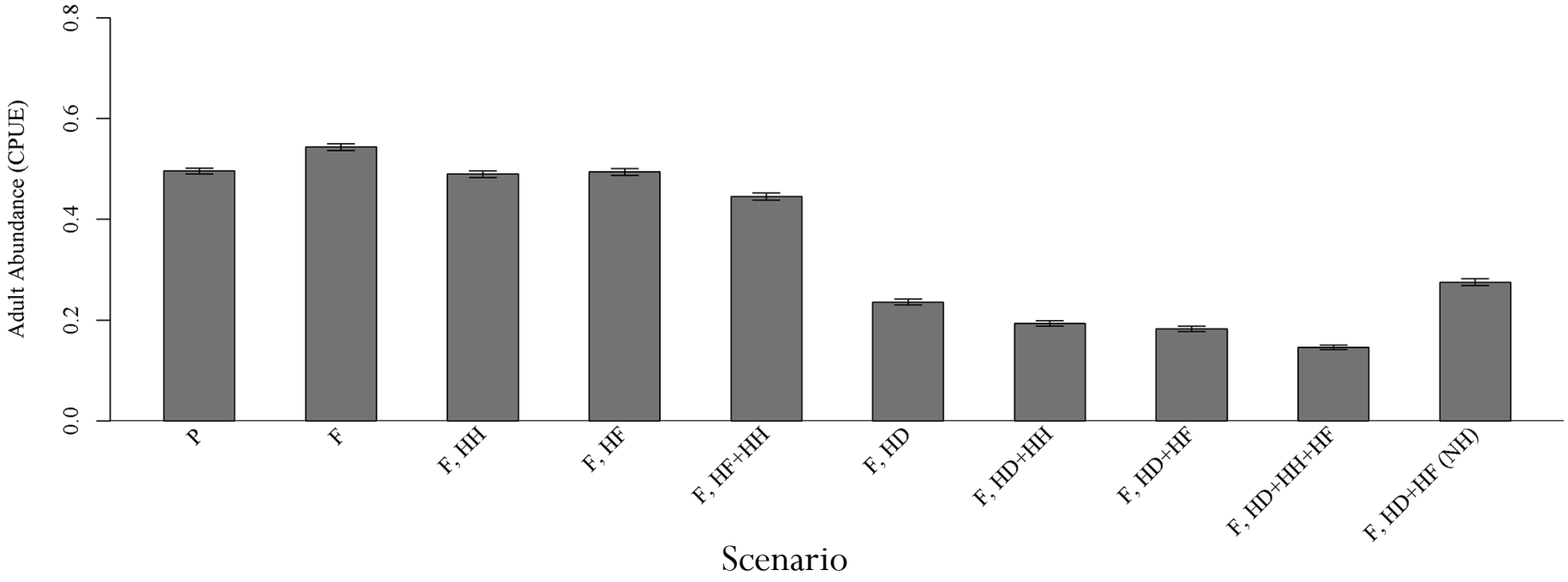
Model Results

- Predicted greater adult SMB abundance in future than present
  - Based only on May temp and June discharge changes



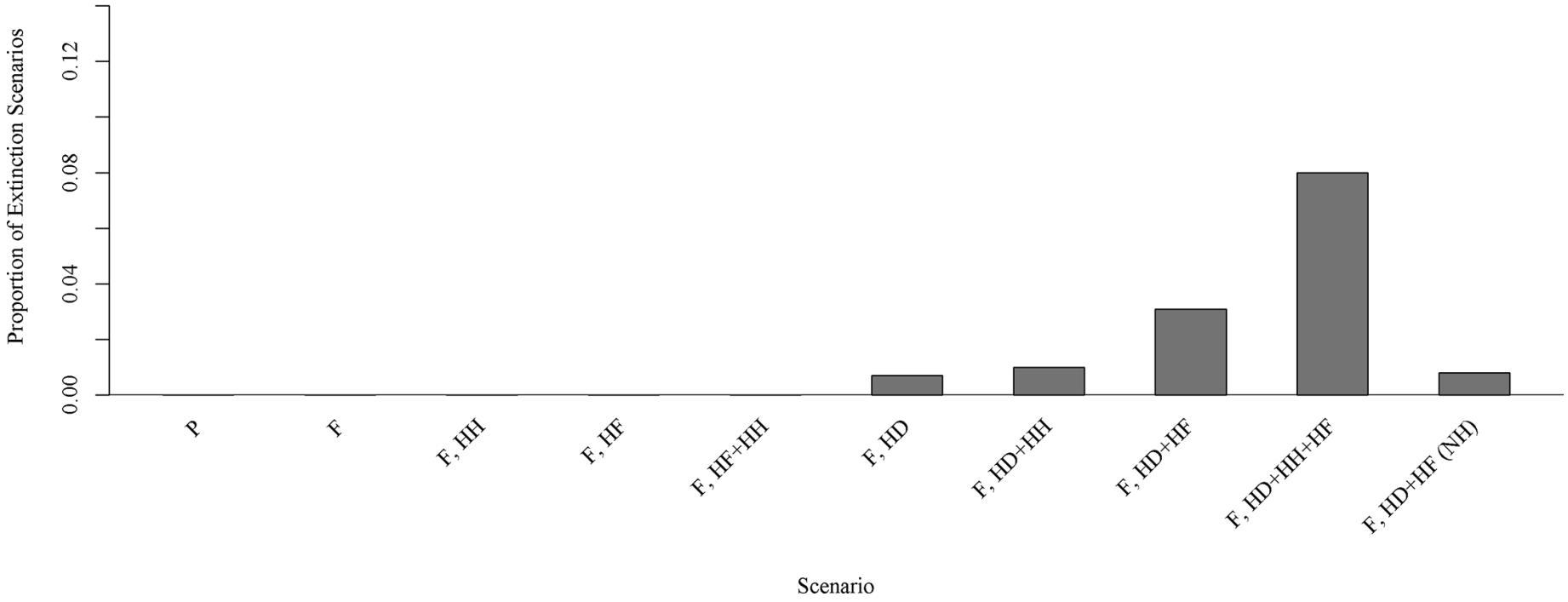
Model Results

- Harvest, flood and drought all reduced SMB abundance
- Drought has largest negative impact on SMB abund
- The three combined show greatest SMB reduction
- No harvest can ameliorate effect of drought and flood somewhat



Model Results

- In all drought scenarios extinction risk >0
- Extinction risk >0.08 with combined drought, flood and harvest



Conclusions

- Future temperature and discharge conditions could increase smallmouth bass recruitment
- Increased drought conditions could strongly affect smallmouth bass abundance
- Protecting smallmouth bass from harvest could help mitigate the effects of climate change

Limitations

- There are other climate effects that we do not model
  - Growth
  - Prey
  - Physical habitat
- This model was developed for one river

http://getmyboat.com

Acknowledgements

- Arkansas Game and Fish Commission
  - Stan Todd, Jeff Quinn, Mark Oliver, Steve Filipek
- University of Arkansas
  - Kusum Naithani, J.D. Wilson


Any Questions?

Variable	Mean	SD
	Environmental Parameters	
Present May Temperature	18.33 °C	0.3
Future May Temperature	21.97 °C	0.59
Present June Discharge	12.87 m^3/s	8.84
Future June Discharge	11.83 m^3/s	10.51
Minimum Discharge	0.5 m^3/s	
Flood chance low flood	10%	
Flood chance high flood	20%	
	Mortality Parameters	
Age-0 Flood Mortality	0.9	0.01
Age-0 Overwinter Mortality	0.3	0.1
Age-0 Mortality High Drought	0.2	0.1
Age-1 Mortality Low Drought	0.4	0.1
Age-1 Mortality High Drought	0.6	0.1
Age-2 Mortality Low Drought	0.3	0.1
Age-2 Mortality High Drought	0.45	0.1
Adult Natural Mortality Low Drought	0.3	0.1
Adult Natural Mortality High Drought	0.45	0.1
Adult Fishing Morality Low	0.2	0.1
Adult Fishing Morality High	0.4	0.1
Mortality Lower Limit (all ages)	0.05	
	Population Parameters	
Initial number of age-0 fish	1.2	0.2
Initial number of age-1+ fish	0.15	0.1

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Environmental Parameters		
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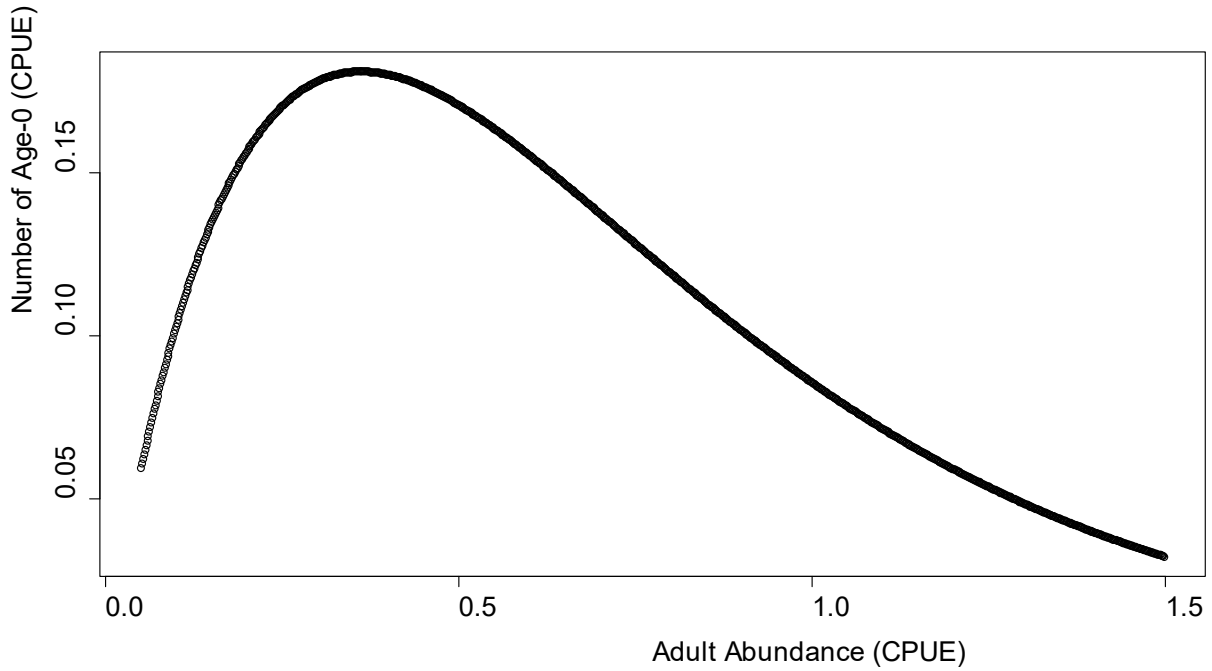
Present June Discharge	12.87 m^3/s	8.84
Future June Discharge	11.83 m^3/s	10.51
Minimum Discharge	0.5 m^3/s	
Flood chance low	10%	
Flood chance high	20%	
Moderate/strong drought chance (present drought frequency)	34%; 14%	
Moderate/strong drought chance (future high drought frequency)	39%; 23%	
Mortality Parameters		
Age-0 Flood Mortality	0.9	0.01
Age-0 Natural Mortality	0.1	0.1
Age-0 Mortality Moderate Drought	0.3	0.1
Age-0 Mortality High Drought	0.5	0.1
Age-1 Natural Mortality	0.4	0.1
Age-1 Mortality Moderate Drought	0.6	0.1
Age-1 Mortality High Drought	0.8	0.1
Age-2 Natural Mortality	0.3	0.1


Number of Age-0 (CPUE)
0.05
0.10
0.15
0.0
0.5
1.0
1.5
Adult Abundance (CPUE)