Going with the Flow: Forecasting the Impact of Climate Change on Blue Crabs

Michael Childress
Department of Biological Sciences
Clemson University

ACE Basin National Estuarine Research Reserve

CLEMSON UNIVERSITY SOUTH CAROLINA 1889

NIDIS NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

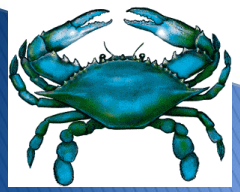
Sea Grant S.C. Sea Grant Consortium


MUD RUN

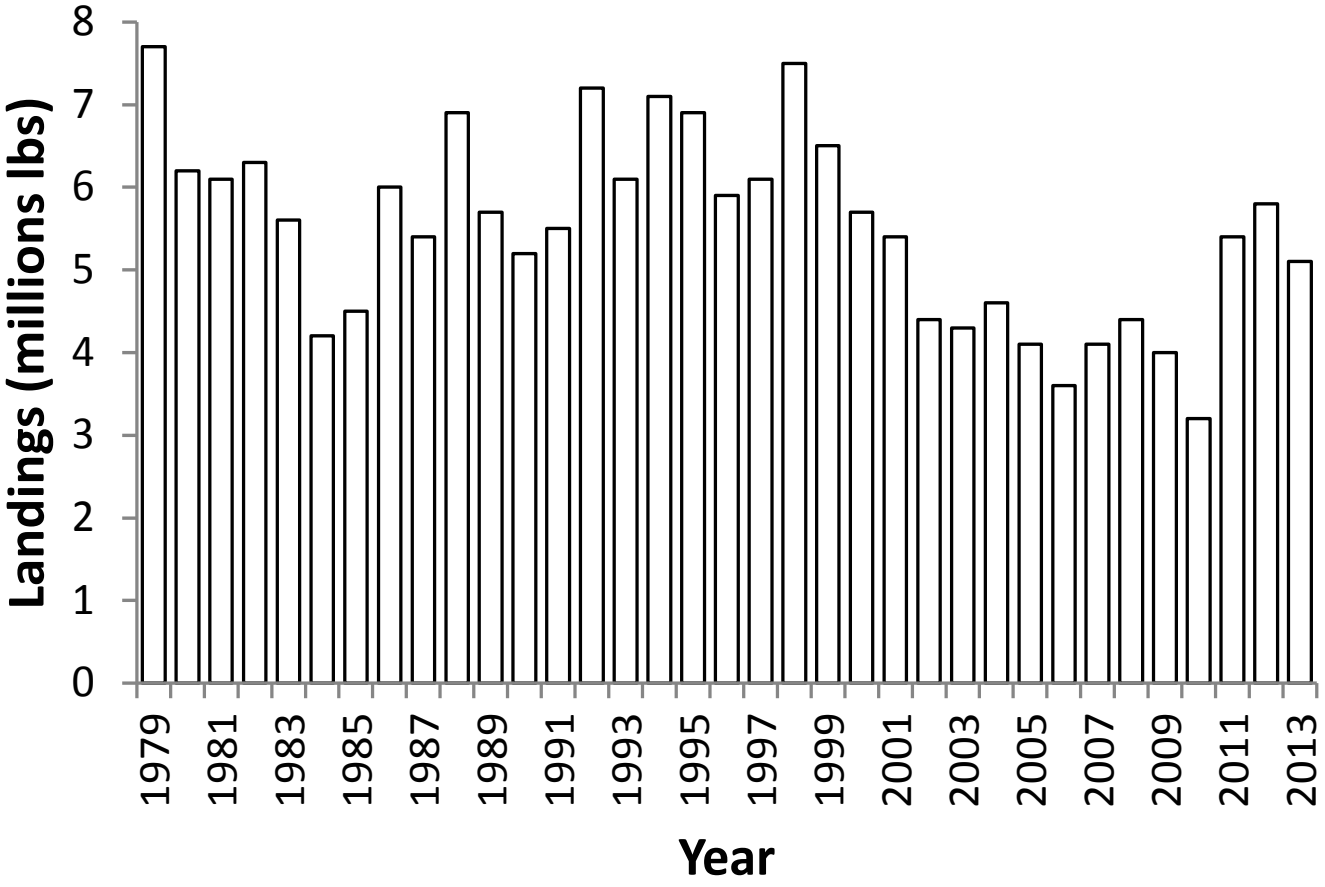

National Estuarine
RESEARCH RESERVE

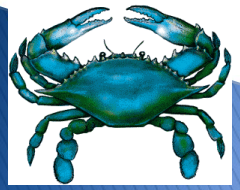
Presentation Outline

- **Why are blue crabs declining?**
- How does drought impact blue crabs?
- How do you model blue crabs?
- How will climate change affect crabs?
- What is the forecast for blue crabs?



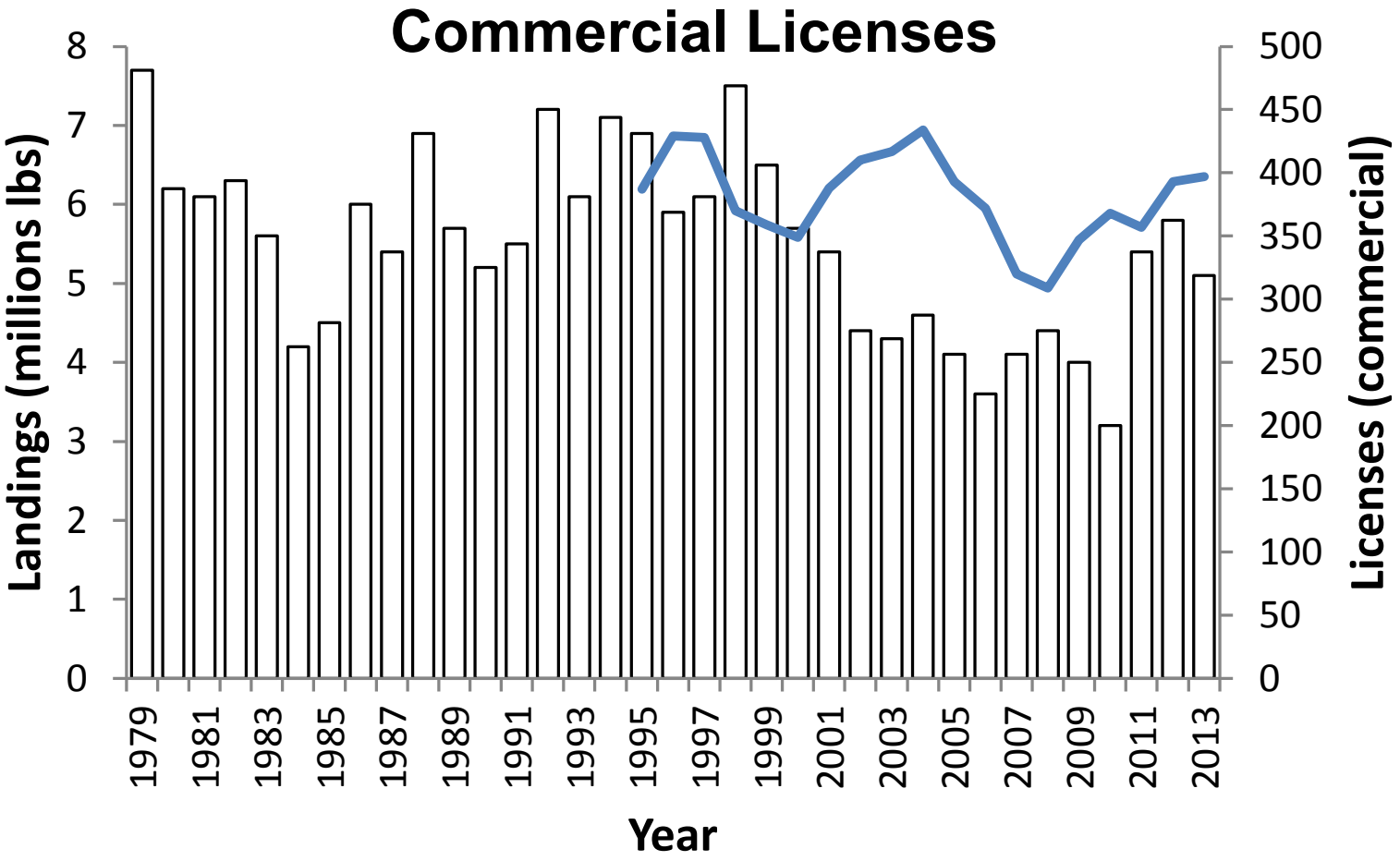
Why are blue crabs declining?

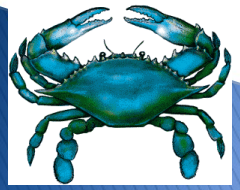




SCDNR Data

Why are blue crabs declining?

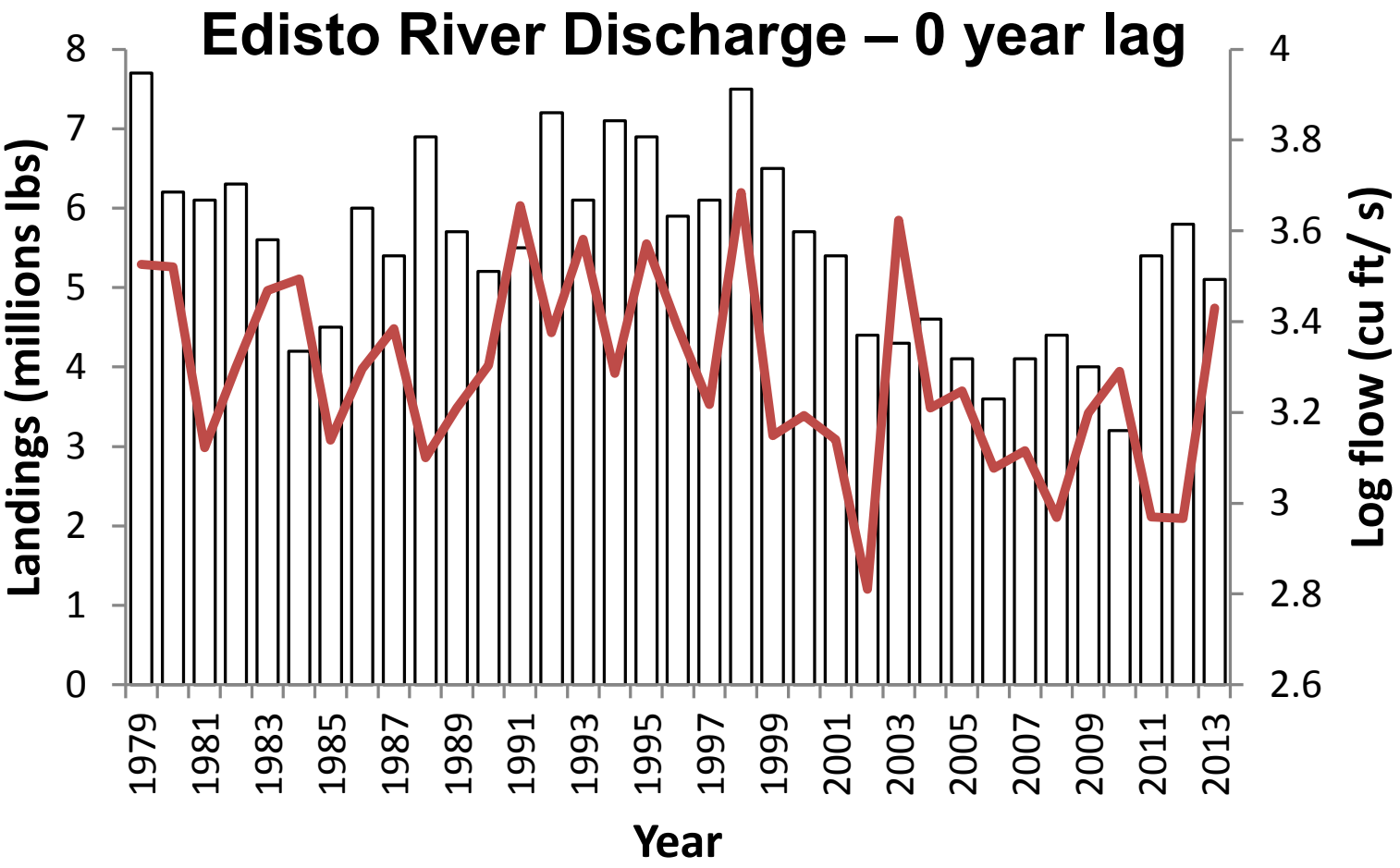


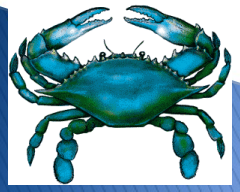


$r^2 = 0.027$, $p = 0.5009$

SCDNR Data

Why are blue crabs declining?

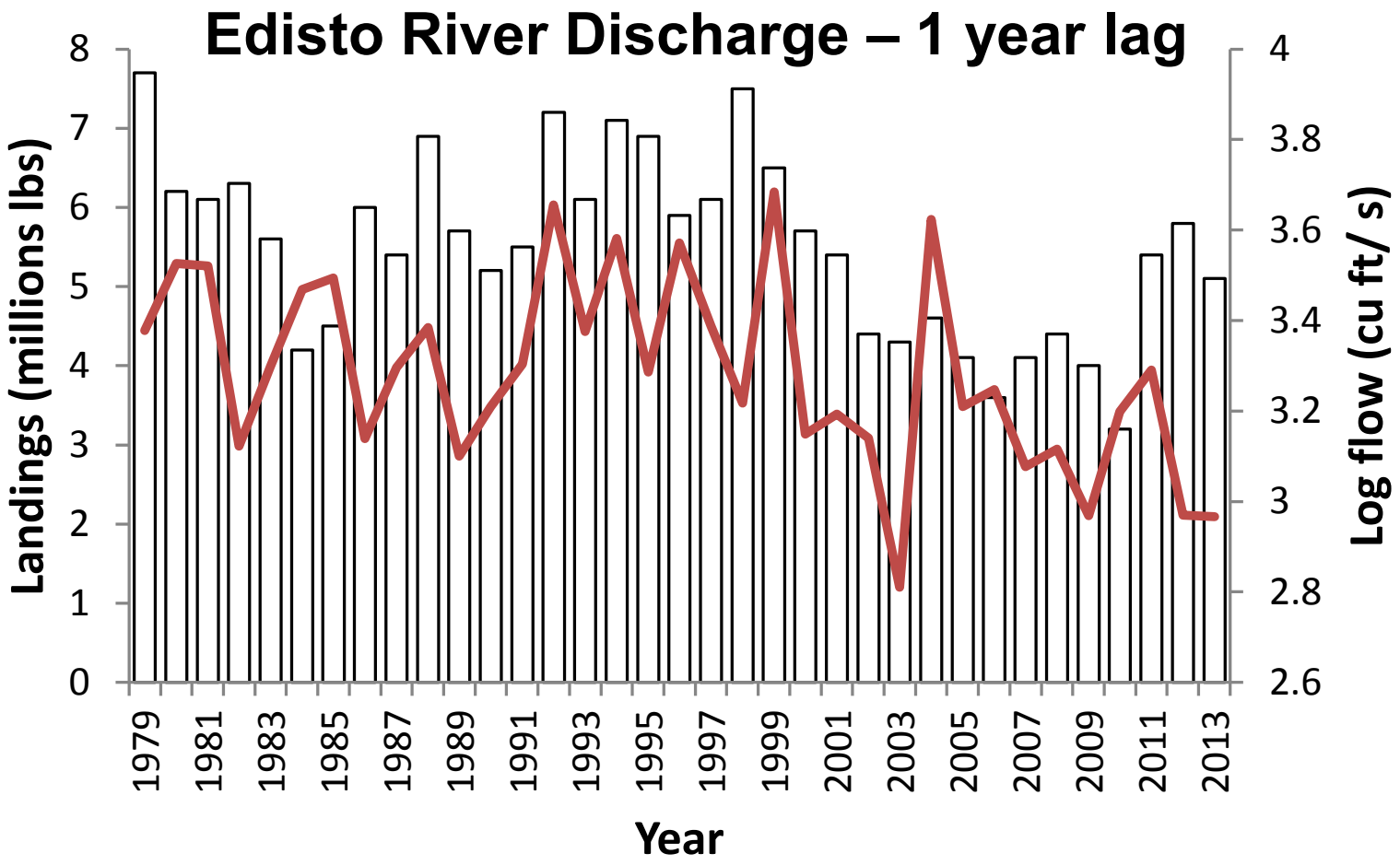


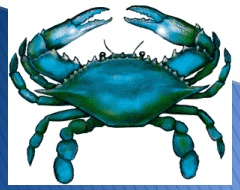


$r^2 = 0.113$, $p = 0.0483$

Childress 2010 SCWRC

Why are blue crabs declining?

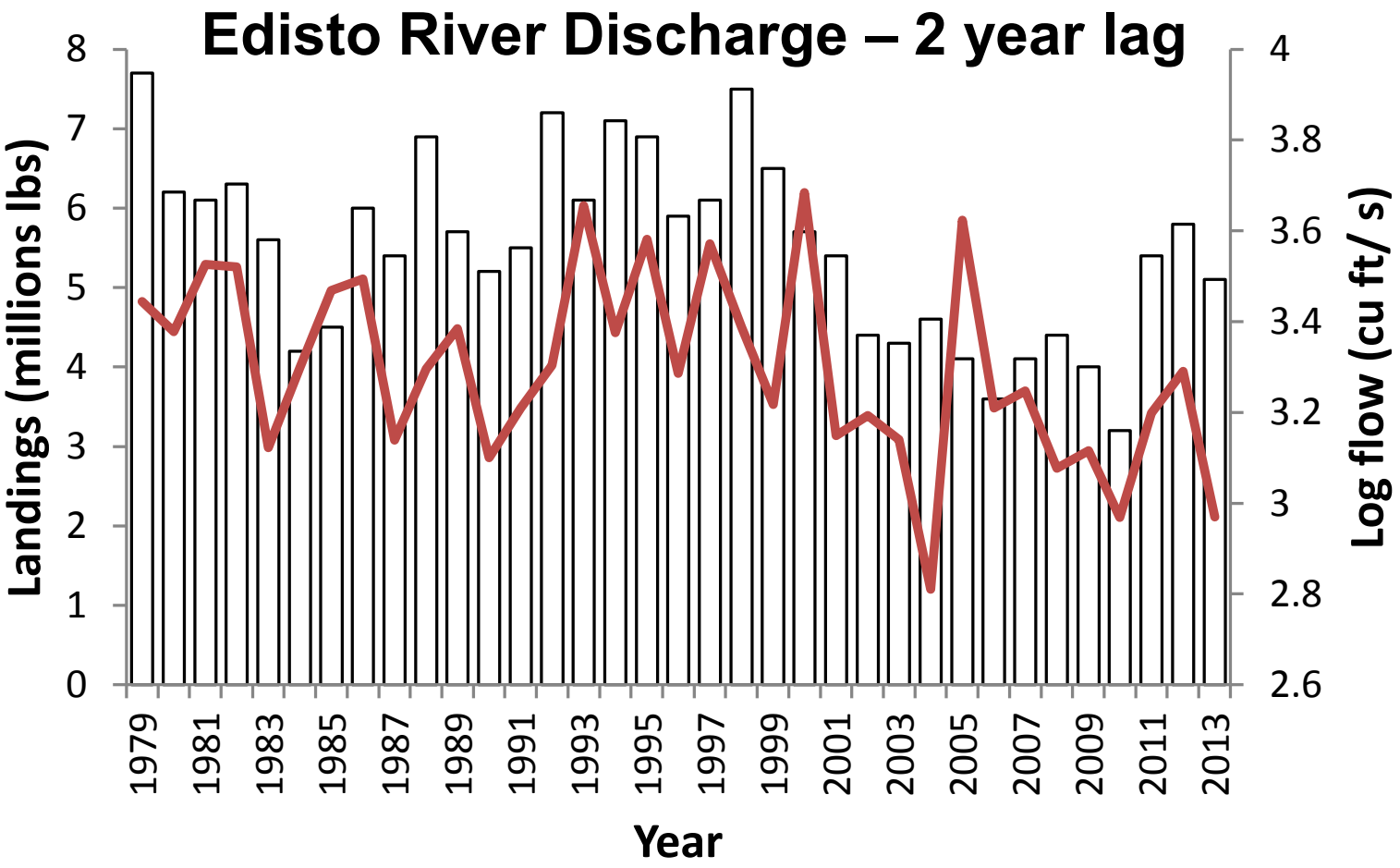


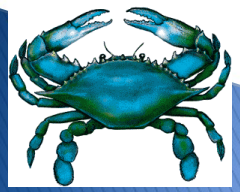


$r^2 = 0.161$, $p = 0.0168$

Childress & Parmenter 2012 SCWRC

Why are blue crabs declining?





$r^2 = 0.209$, $p = 0.0056$

Childress 2014 SCWRC

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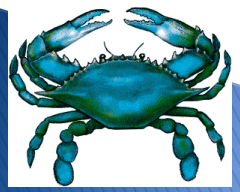
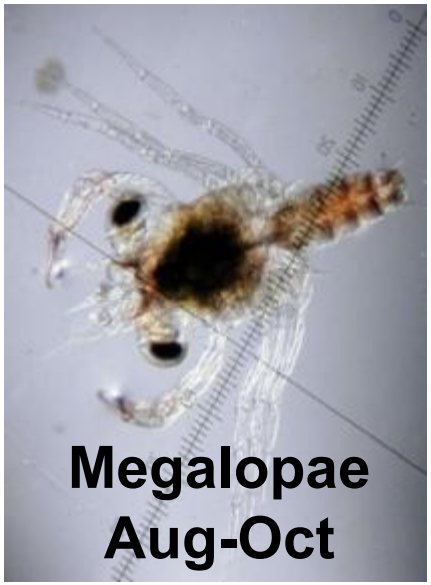
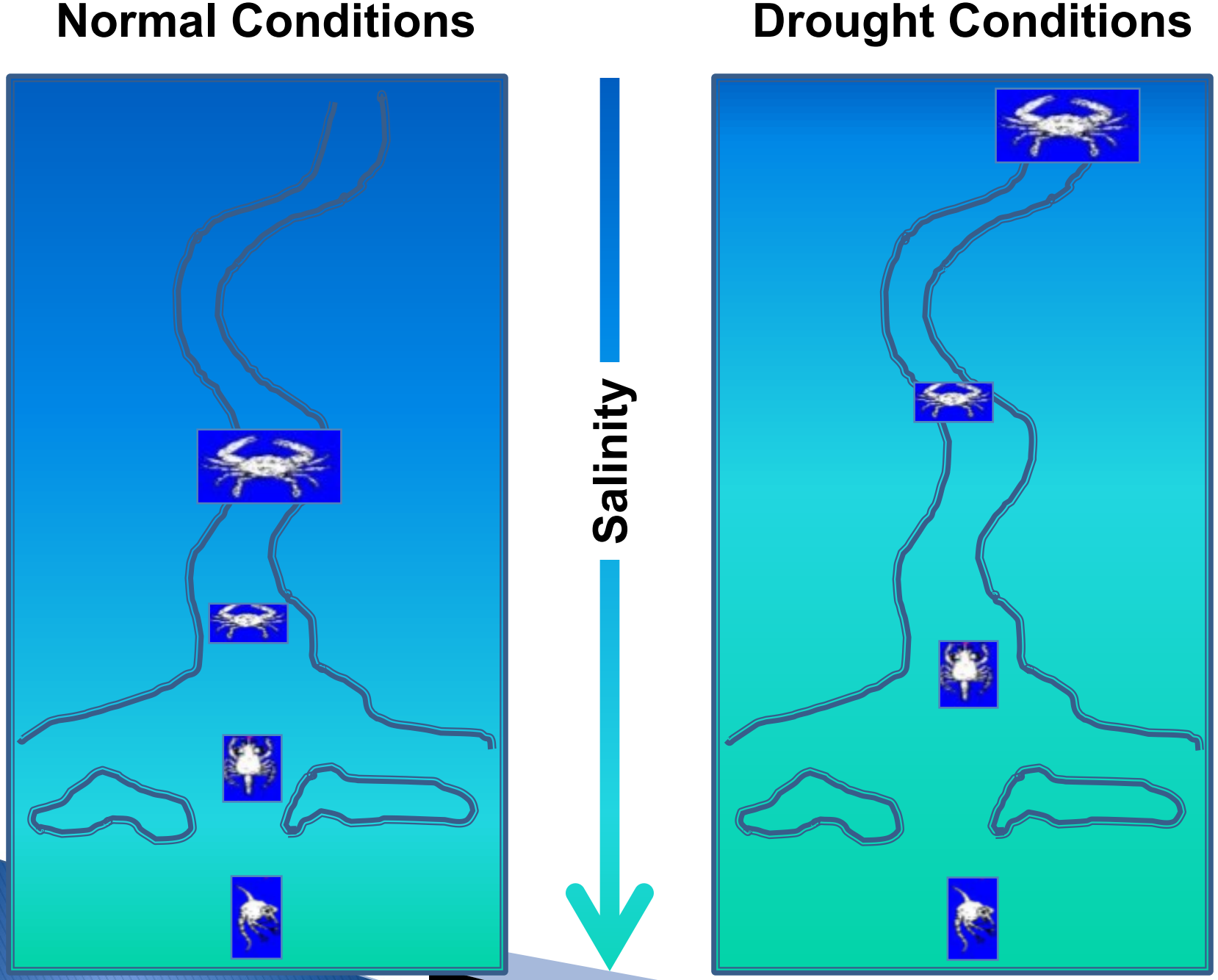


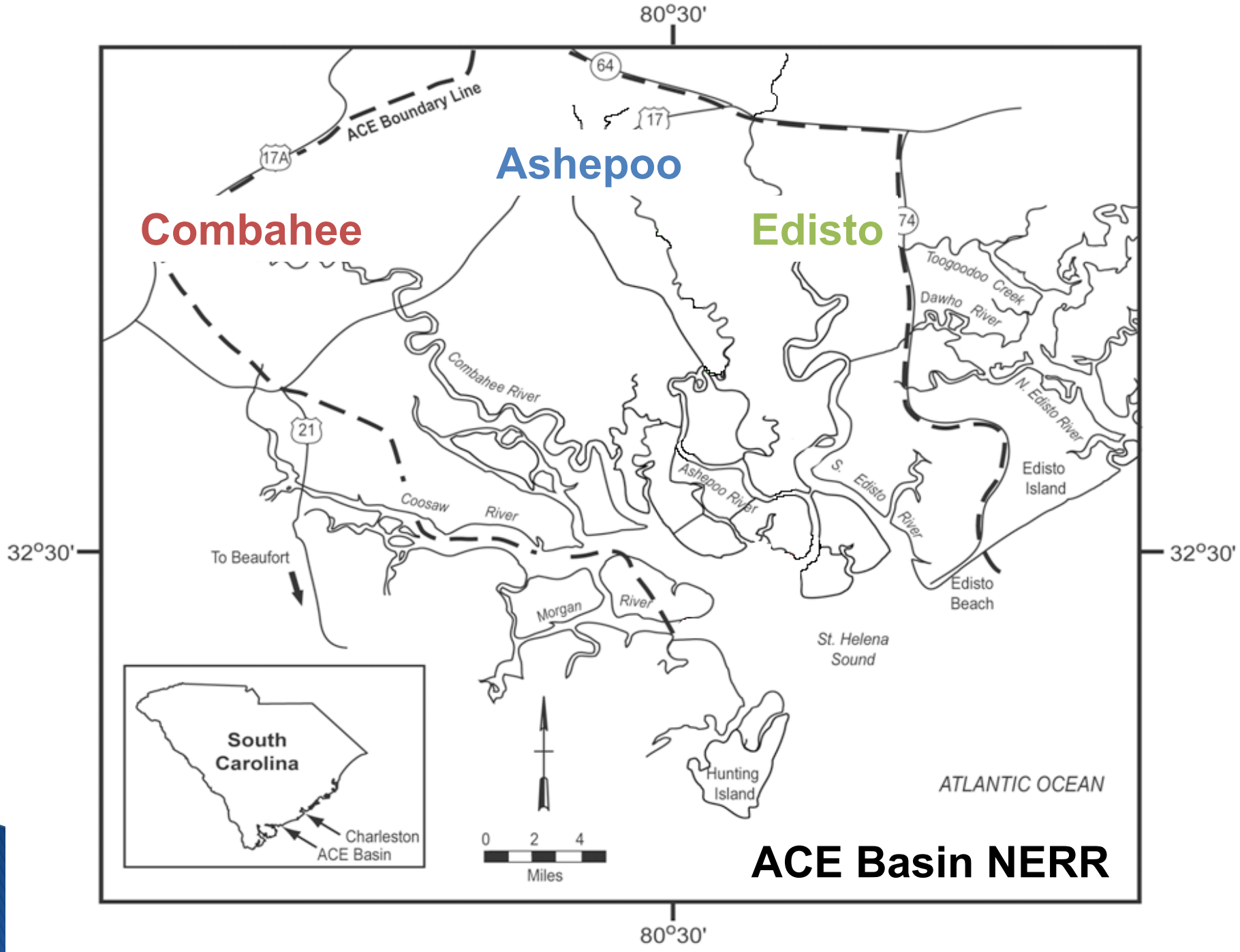
How does drought affect blue crabs?

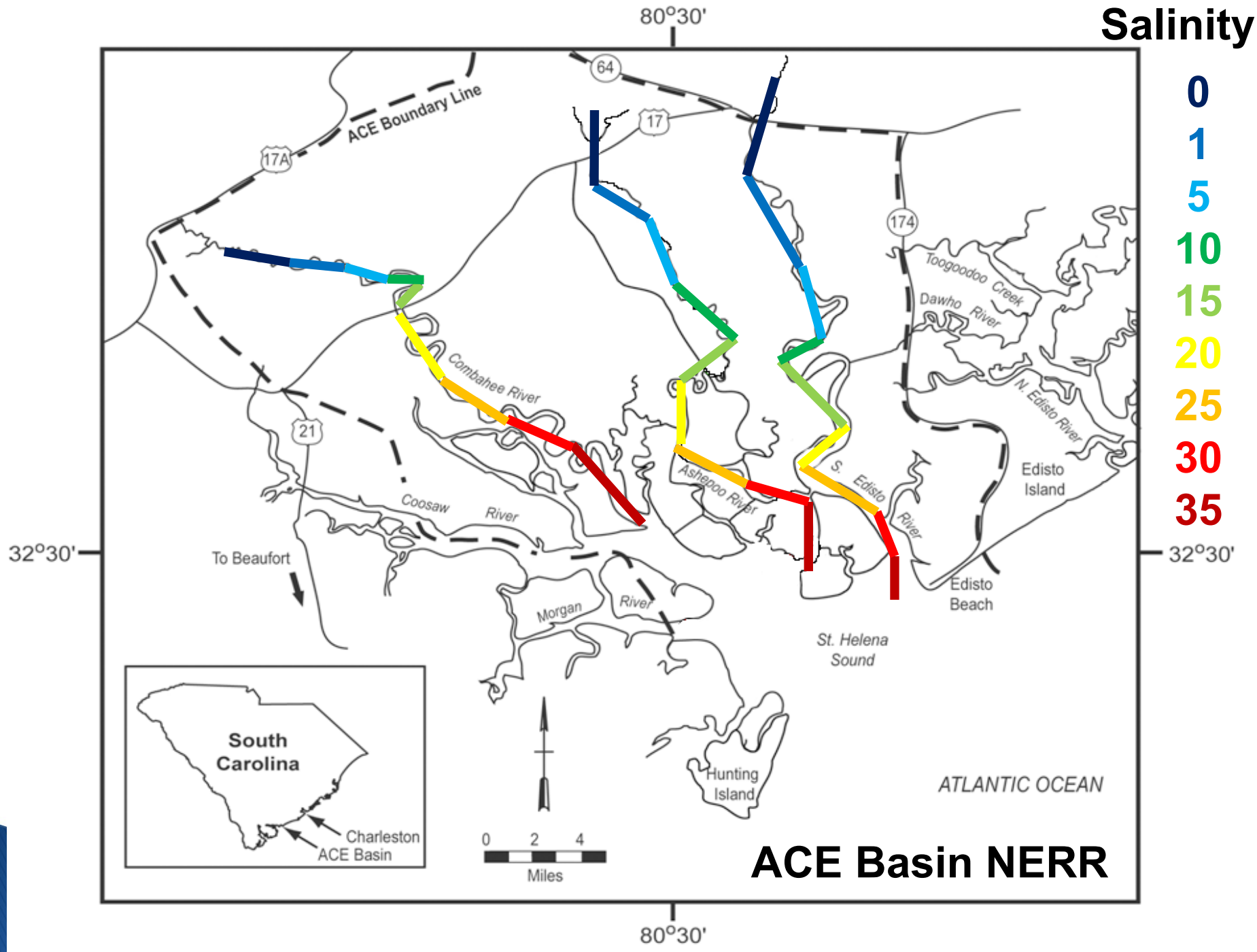
Freshwater → Saltwater



SCDNR Photos


Normal Conditions
Drought Conditions
Salinity


80°30'
ACE Boundary Line
64
17
17A
Ashepoo
Combahee
Edisto
74
Toogoodoo Creek
Dawho River
Combahee River
N. Edisto River
21
Ashepoo River
S. Edisto River
Edisto Island
Coosaw River
32°30'
To Beaufort
Morgan River
Edisto Beach
St. Helena Sound
South Carolina
Charleston
ACE Basin
0 2 4
Miles
Hunting Island
ATLANTIC OCEAN
ACE Basin NERR
80°30'


Salinity
0
1
5
10
15
20
25
30
35
80°30'
32°30'
ACE Boundary Line
64
17
17A
174
21
Toogoodoo Creek
Dawho River
N. Edisto River
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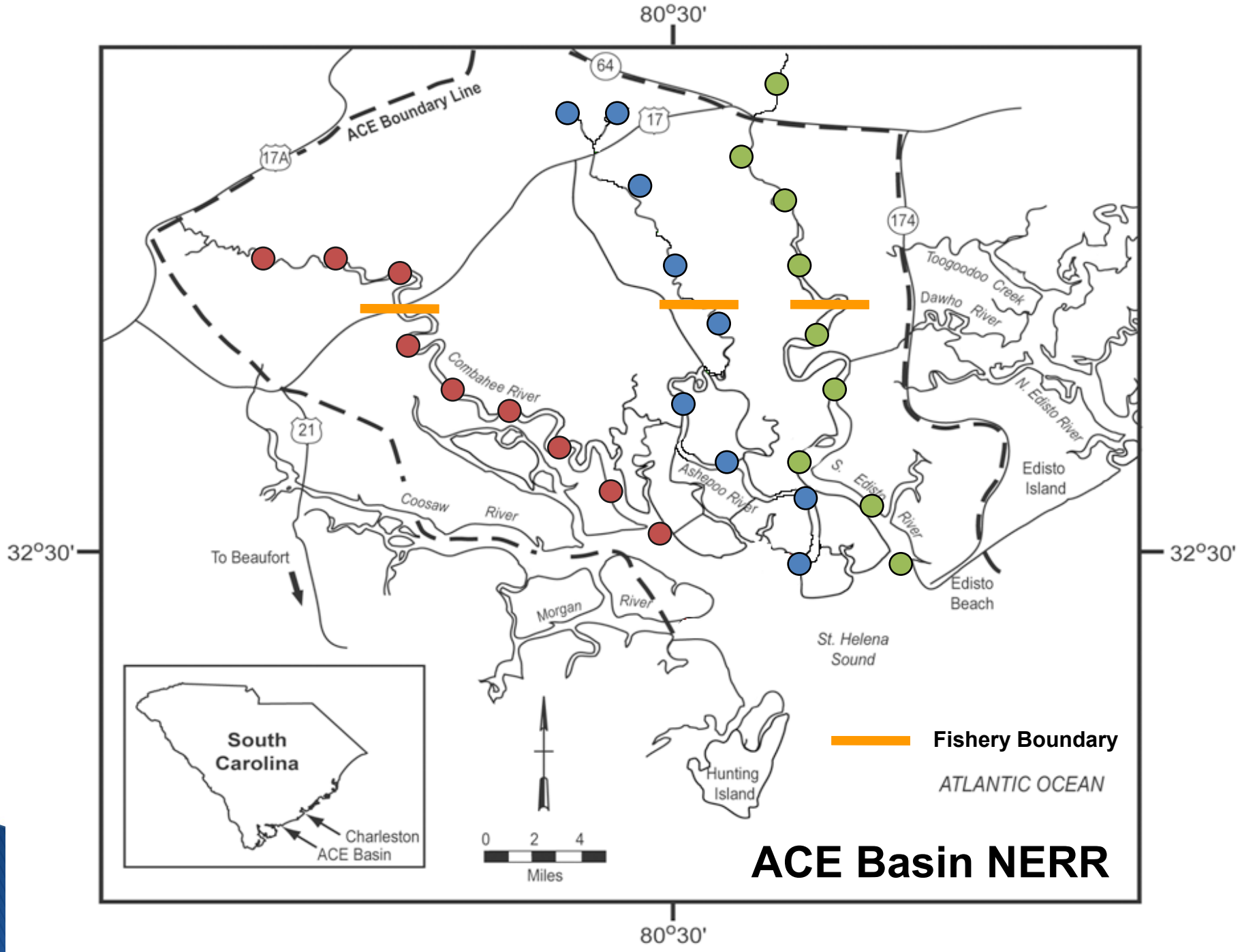
80°30'
ACE Boundary Line
64
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Toogoodoo Creek
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South Carolina
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Fishery Boundary
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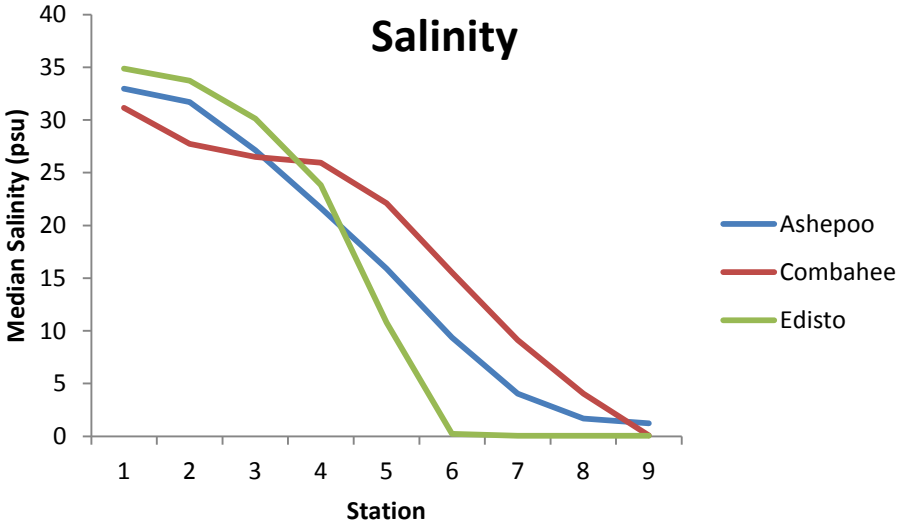
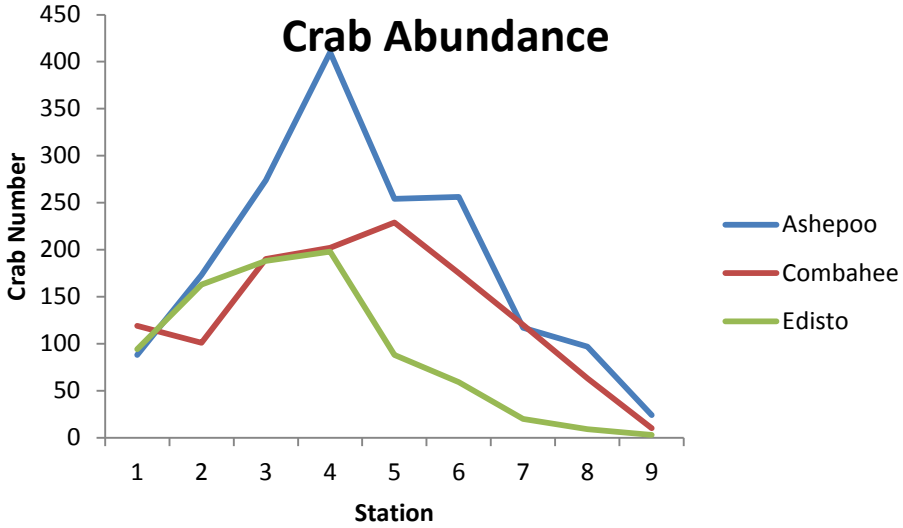
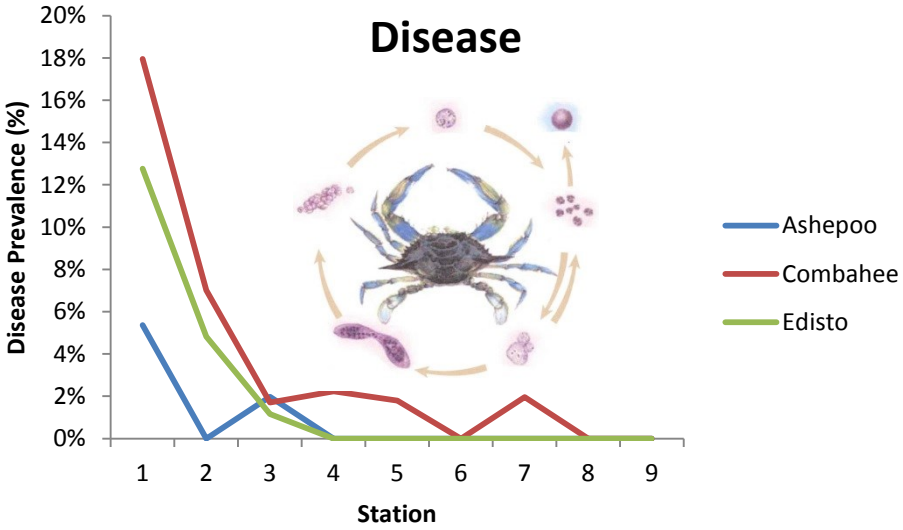
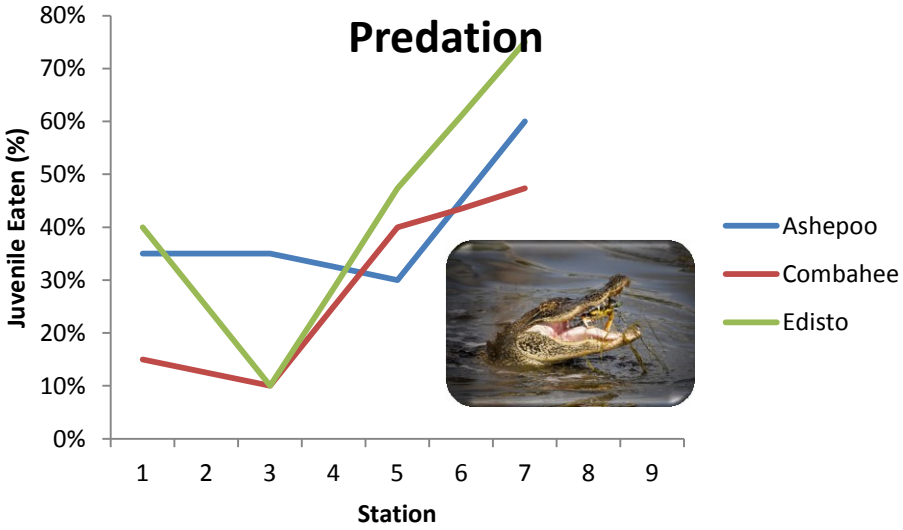
ACE Basin NERR









Crabs: $r^2 = 0.008$, $p = 0.5298$

Salinity: $r^2 = 0.277$, $p = 0.0786$

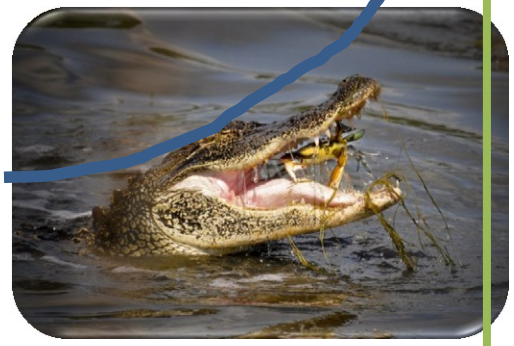
Crabs: $r^2 = 0.040$, $p = 0.5389$

Salinity: $r^2 = 0.743$, $p = 0.0003$

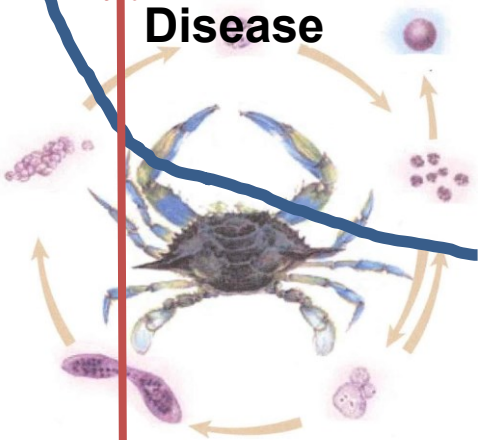
Childress & Parmenter 2012 SCWRC

Crab Abundance

Predation



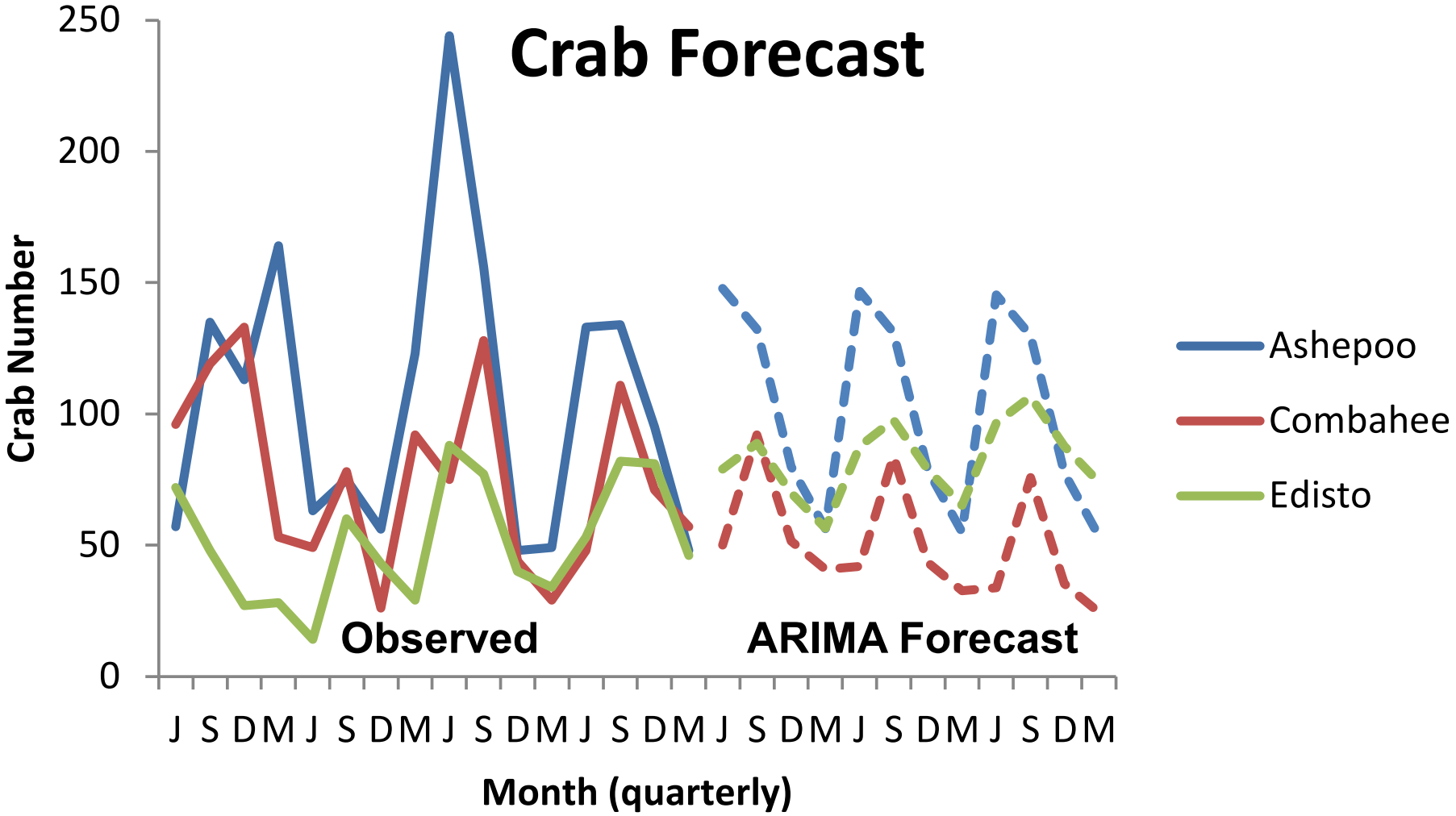
Disease



Salinity

Inflow

Parmenter et al. 2013 Estuaries & Coasts


Crab Forecast
250
200
150
100
50
0
Crab Number
Observed
ARIMA Forecast
J S D M J S D M J S D M J S D M J S D M J S D M J S D M J S D M
Month (quarterly)
Ashepoo
Combahee
Edisto

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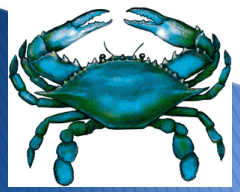
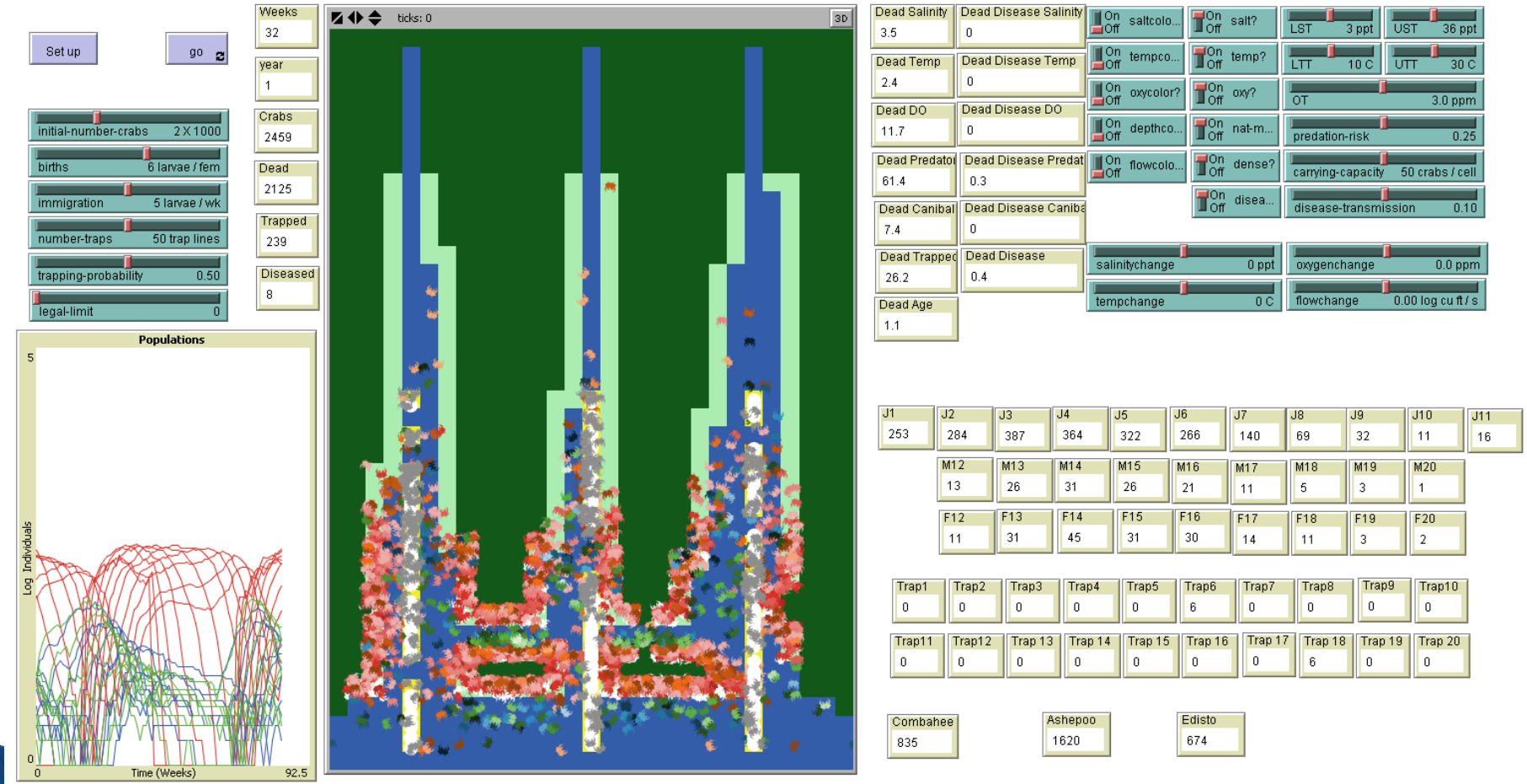
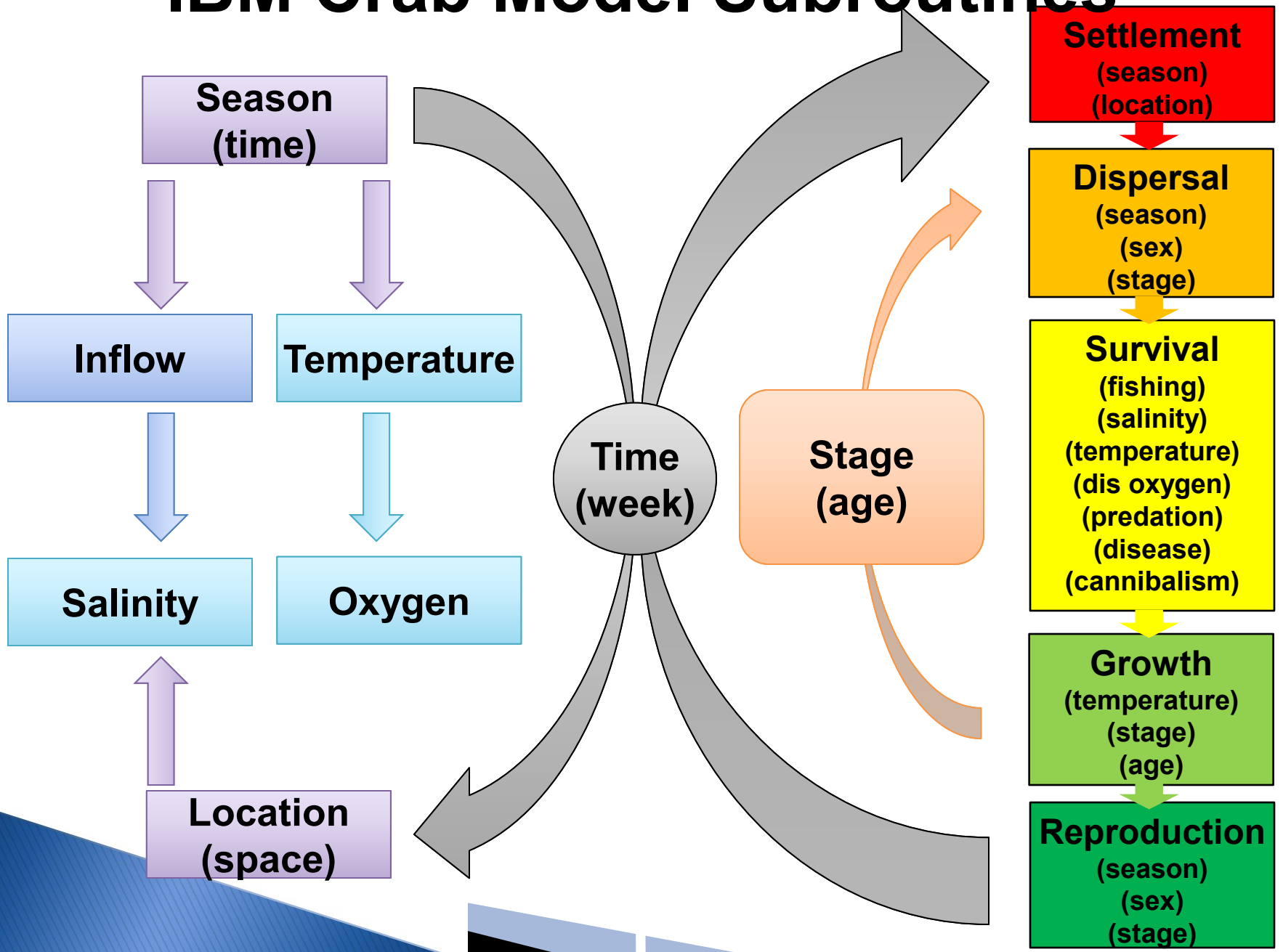


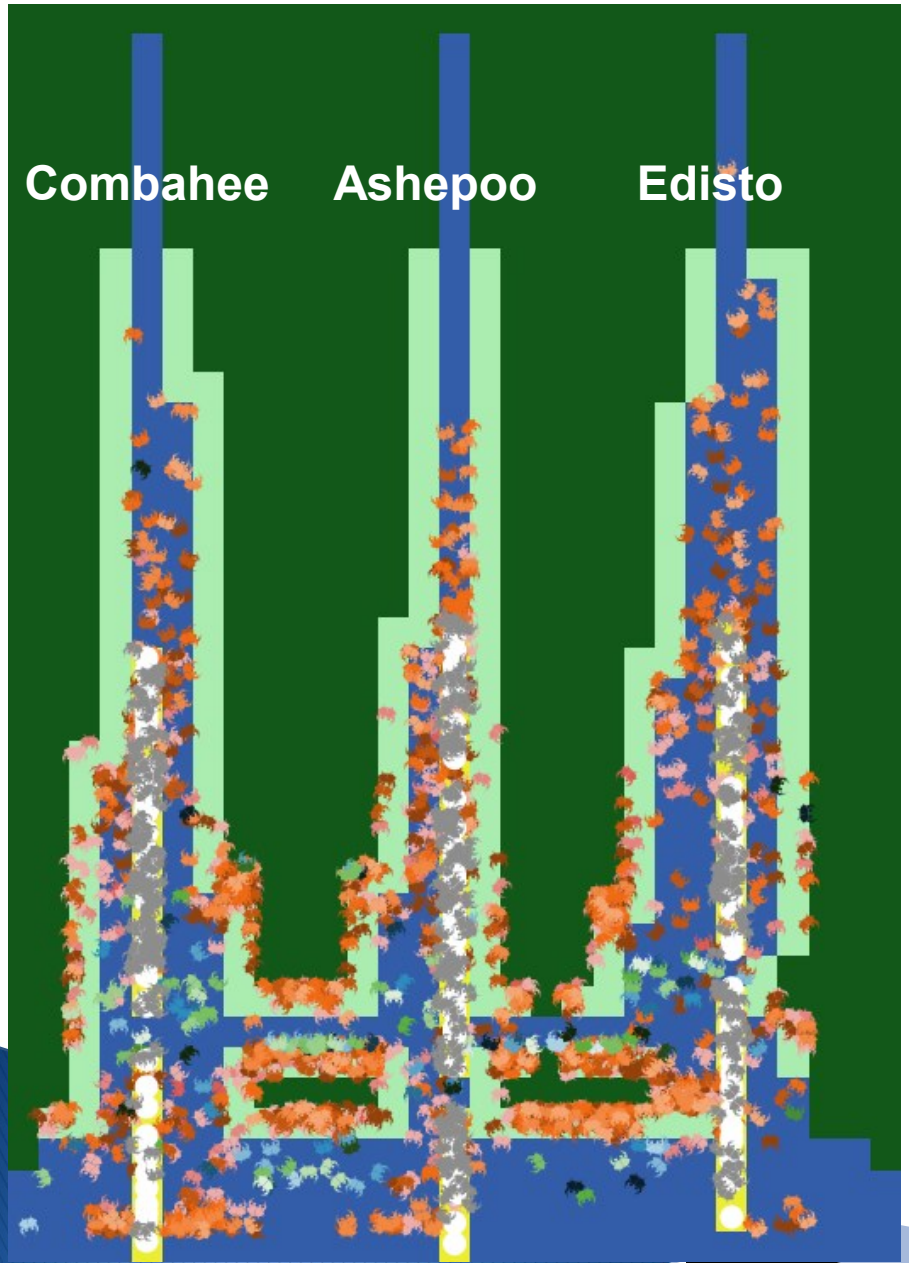
SCBCRABS model (NetLogo 4.0)

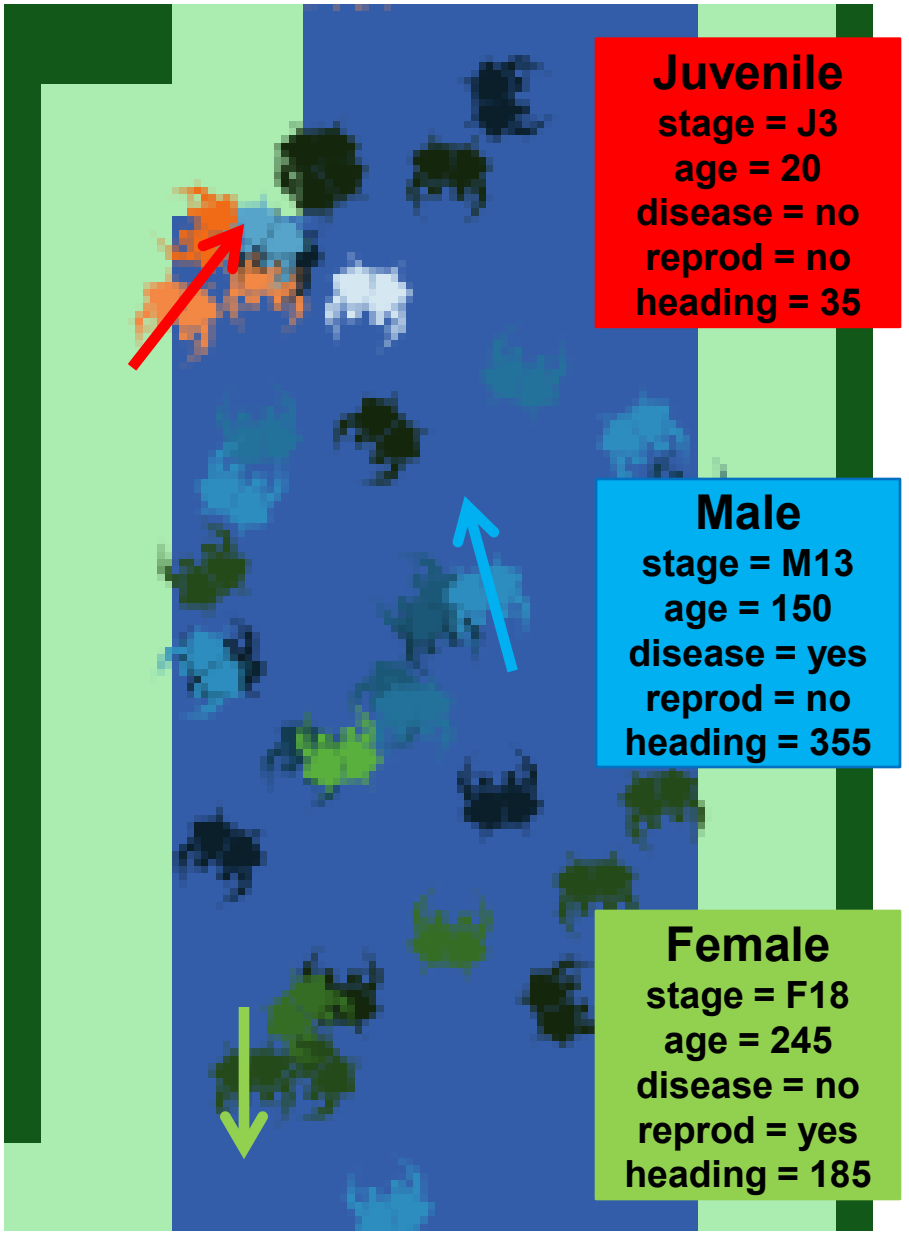


IBM Crab Model Subroutines



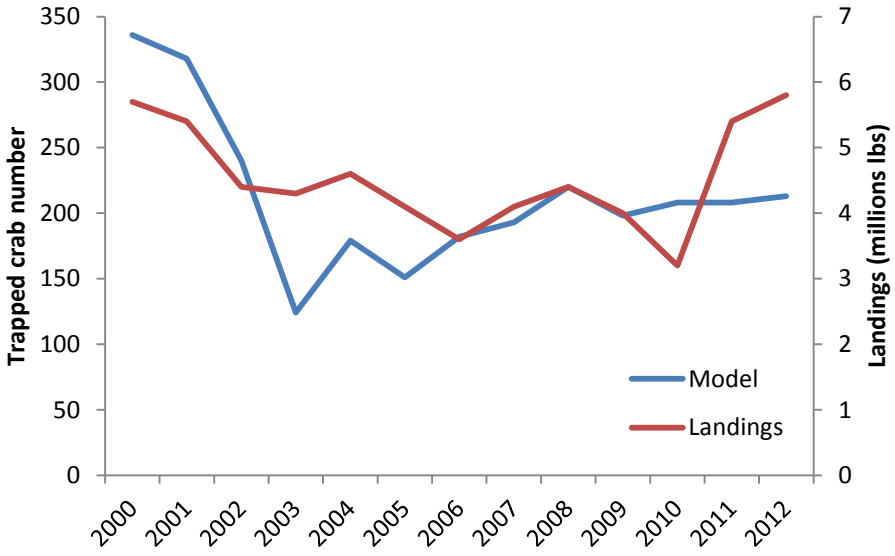
IBM Crab Model Spatial Structure

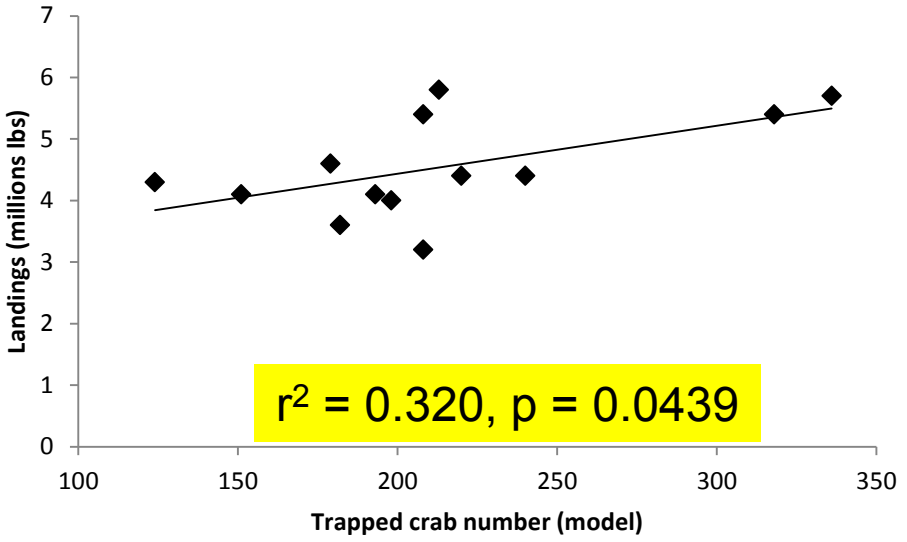


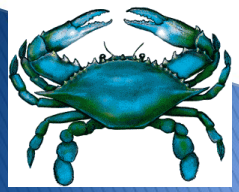


Model Landings vs. SC Landings

- Model forecasts steep decline during ’99 –’02 drought
- Model landings predict 32% of observed landing variation
- Thus, the IBM is even better at predicting crab abundance







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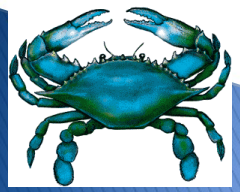
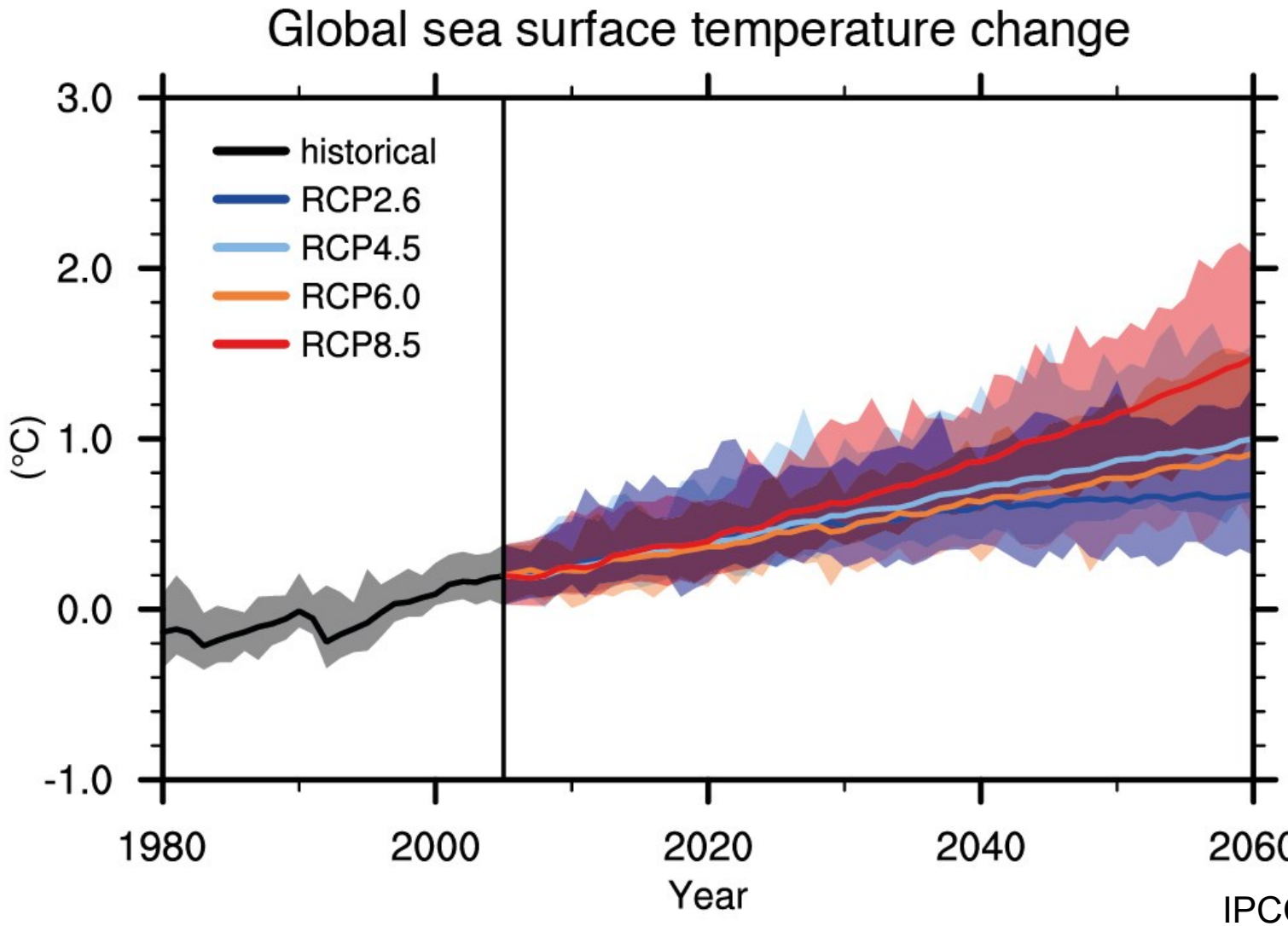
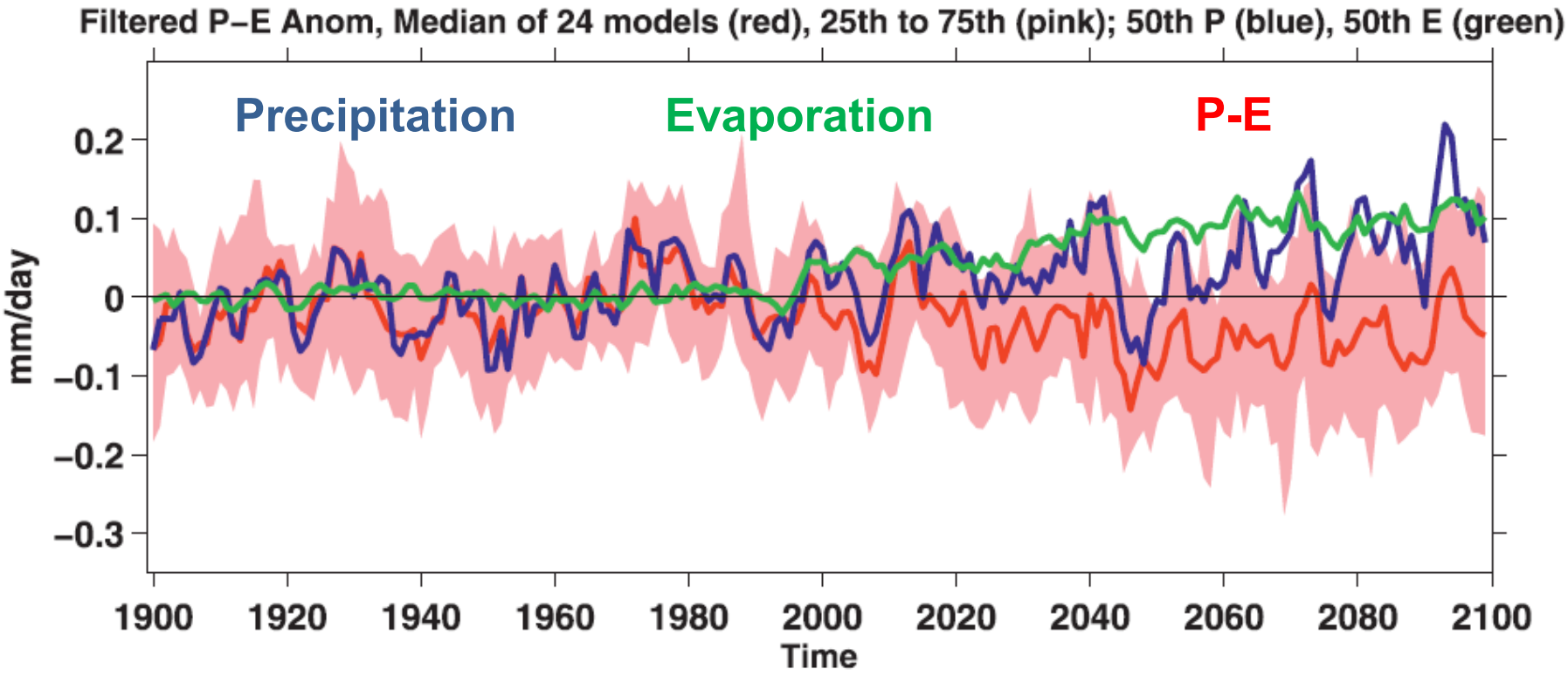


Temperatures will rise

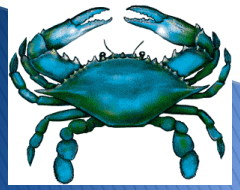


IPCC 2014

Available water (P–E) will decrease

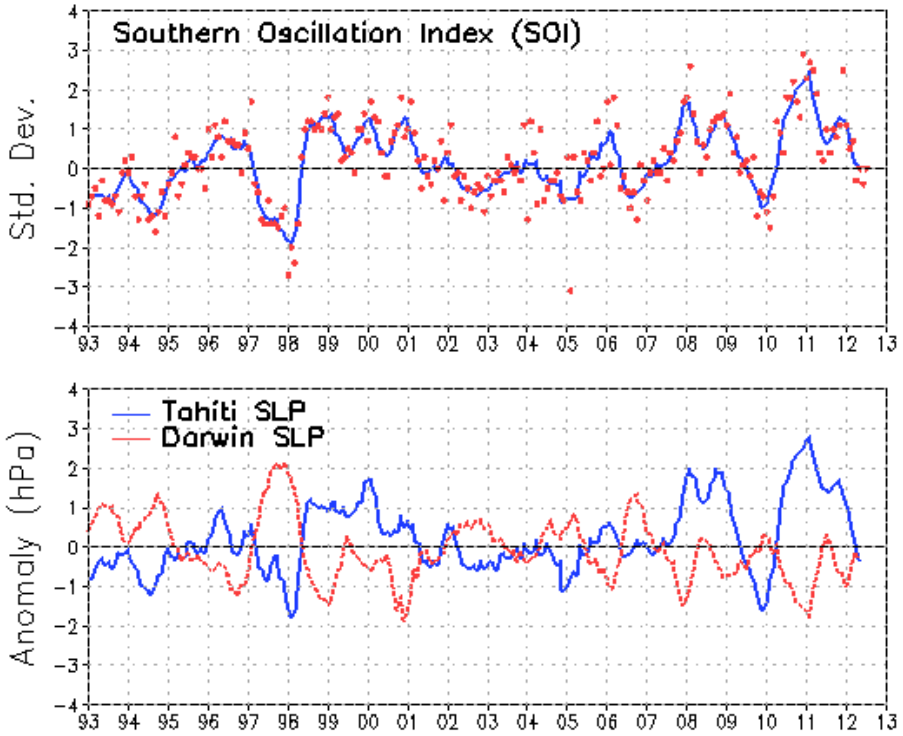


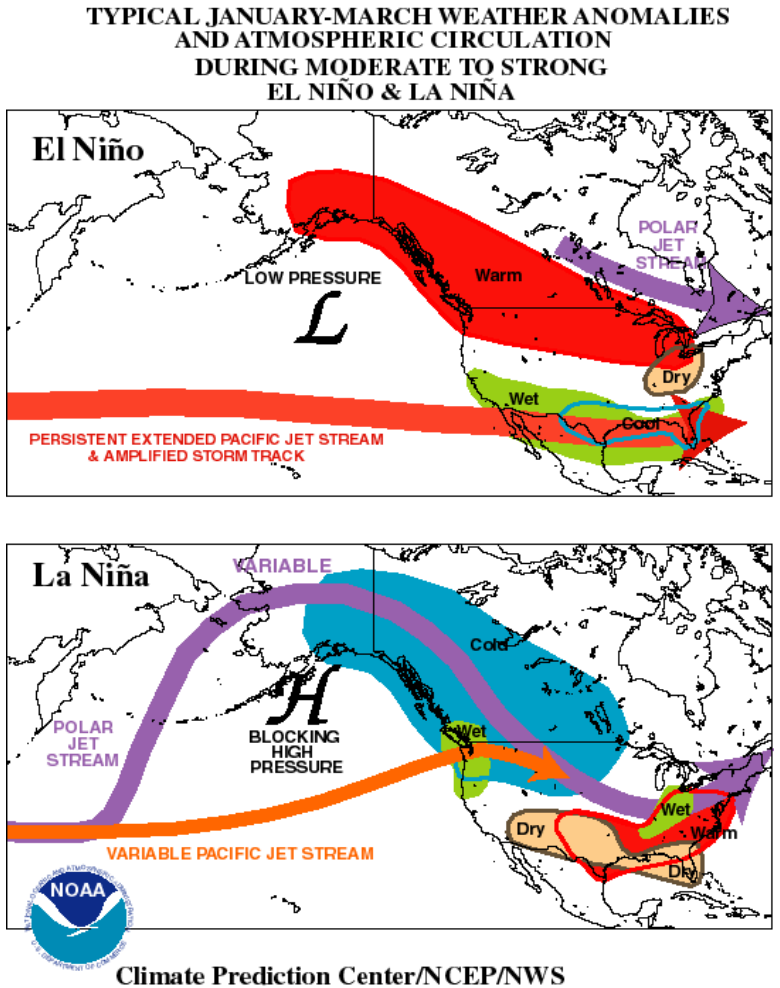
Water variability will increase

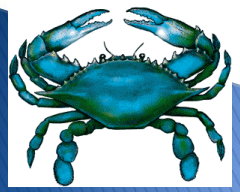


Seager et al. 2009 J Climate
Seager et al. 2012 J Climate

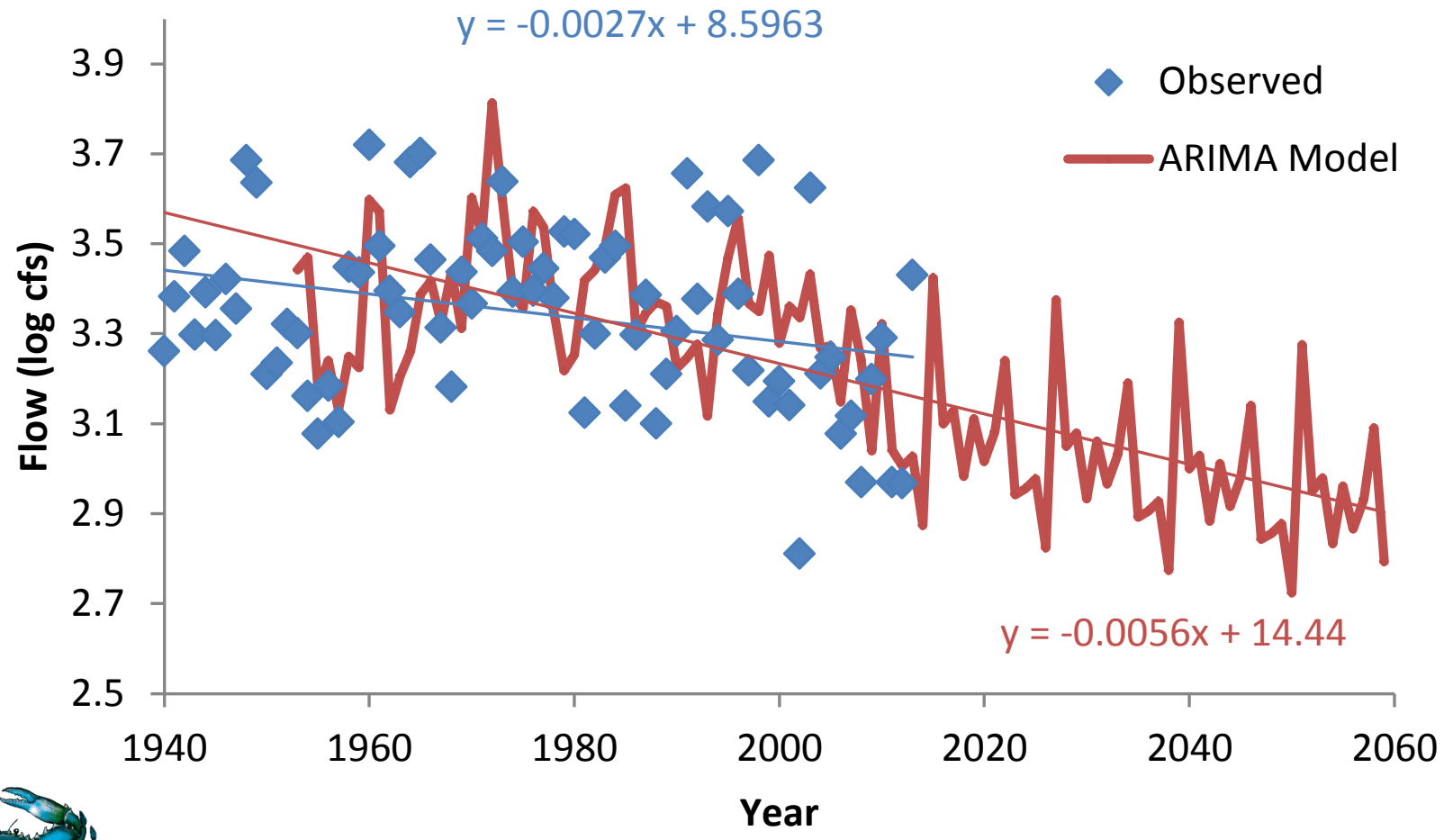
Droughts will cycle with ENSO





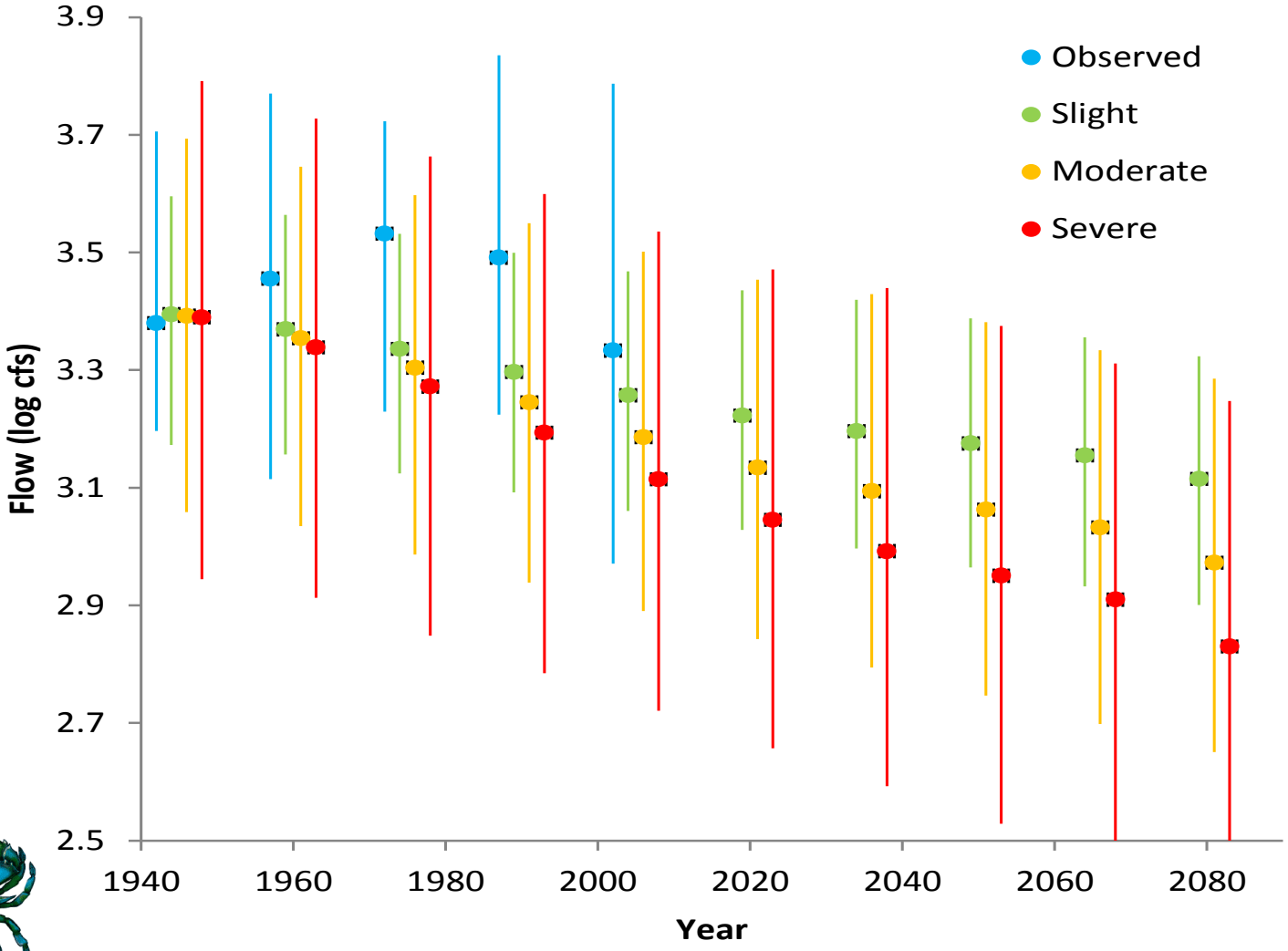


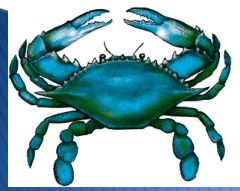
Edisto river discharge will decrease



USGS 02175000 – Edisto River near Givhans Ferry, SC

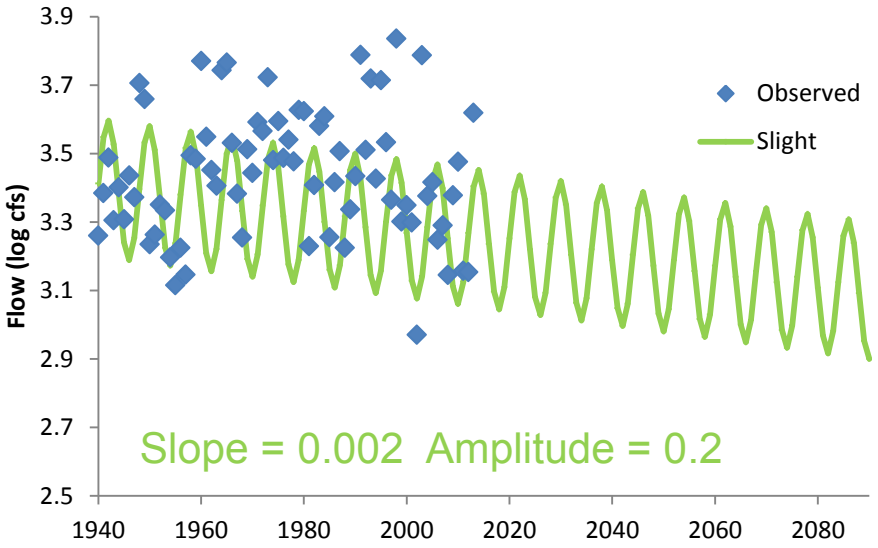
Blue Crab Landings Forecast

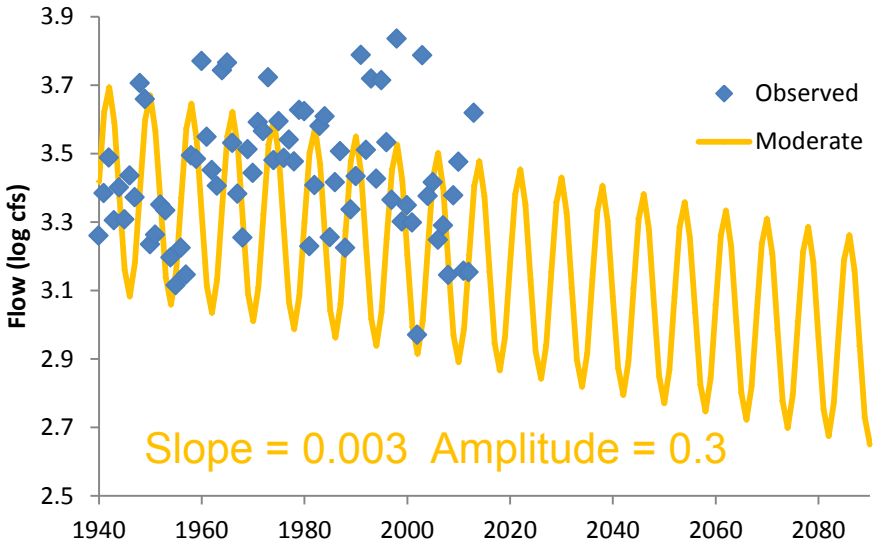


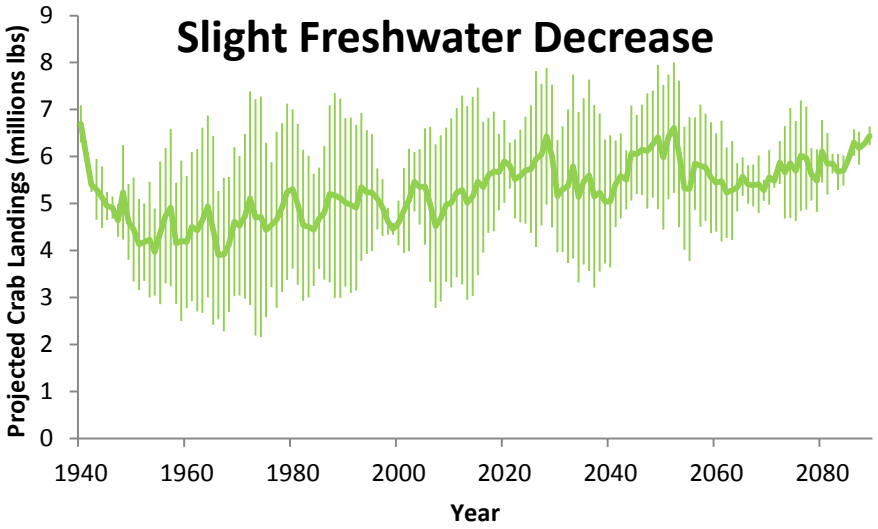


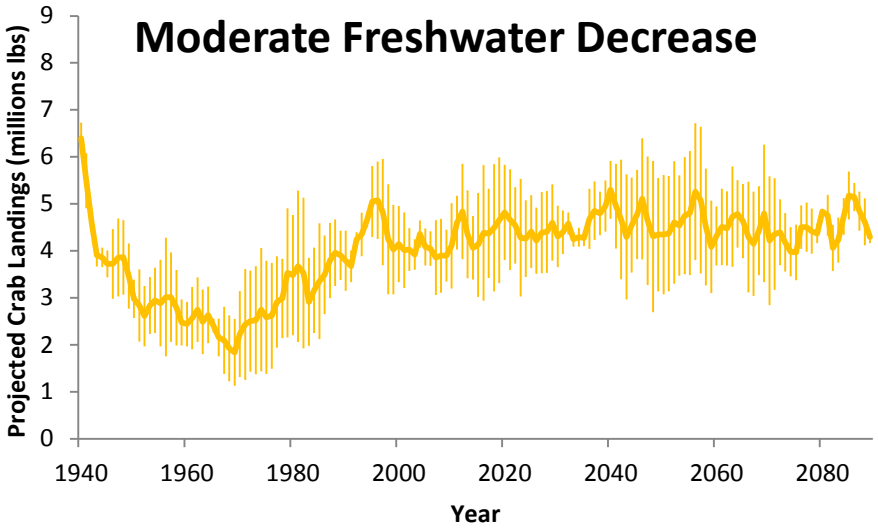
Childress 2014 SCWRC

Blue Crab Landings Forecast



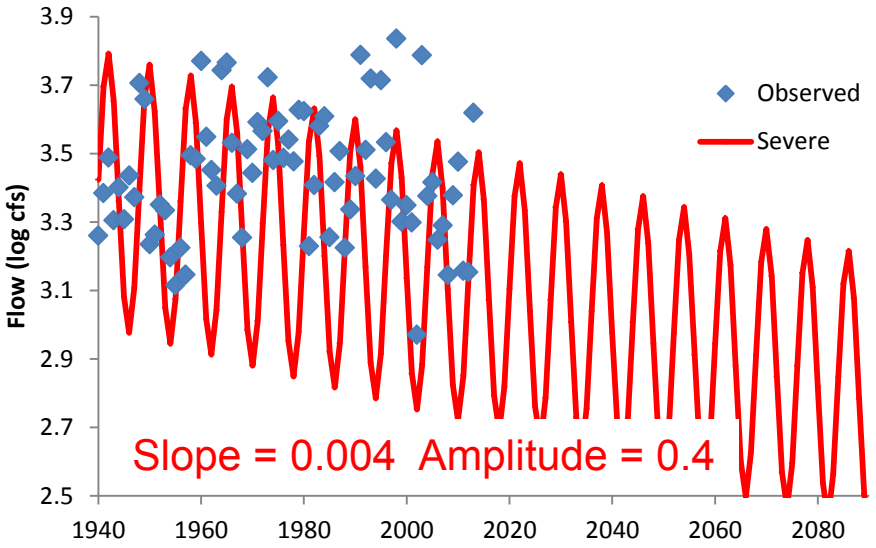


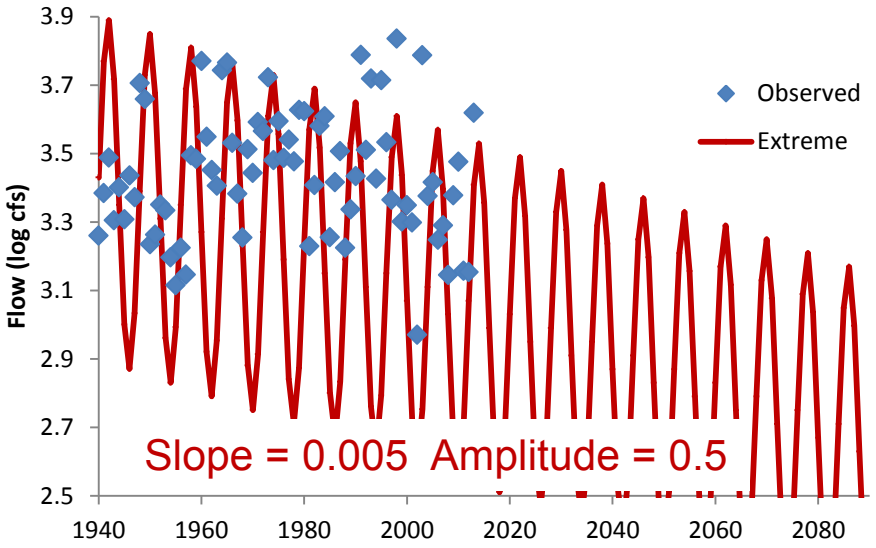


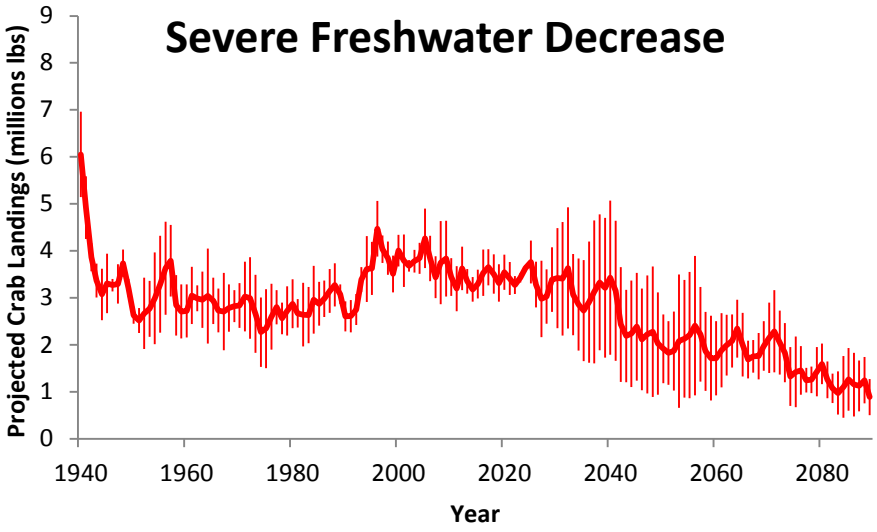


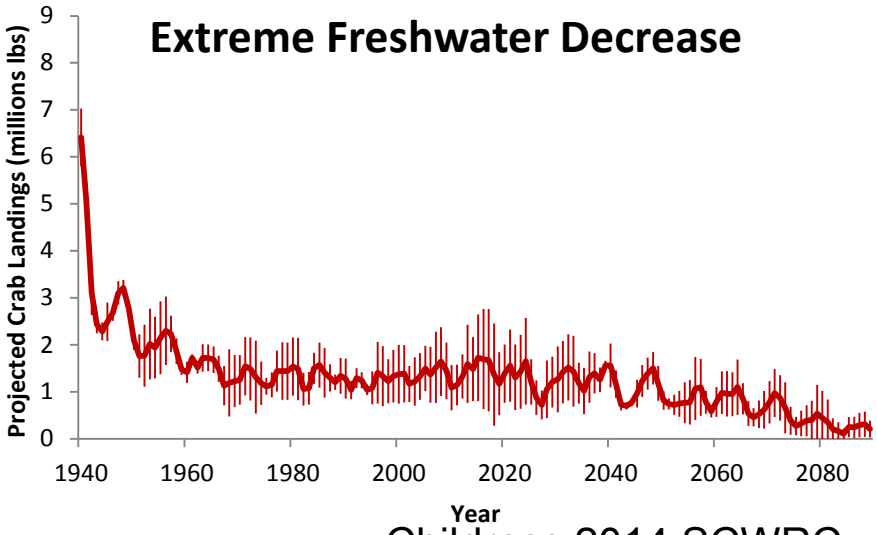
Childress 2014 SCWRC

Blue Crab Landings Forecast





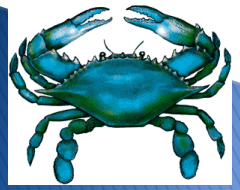




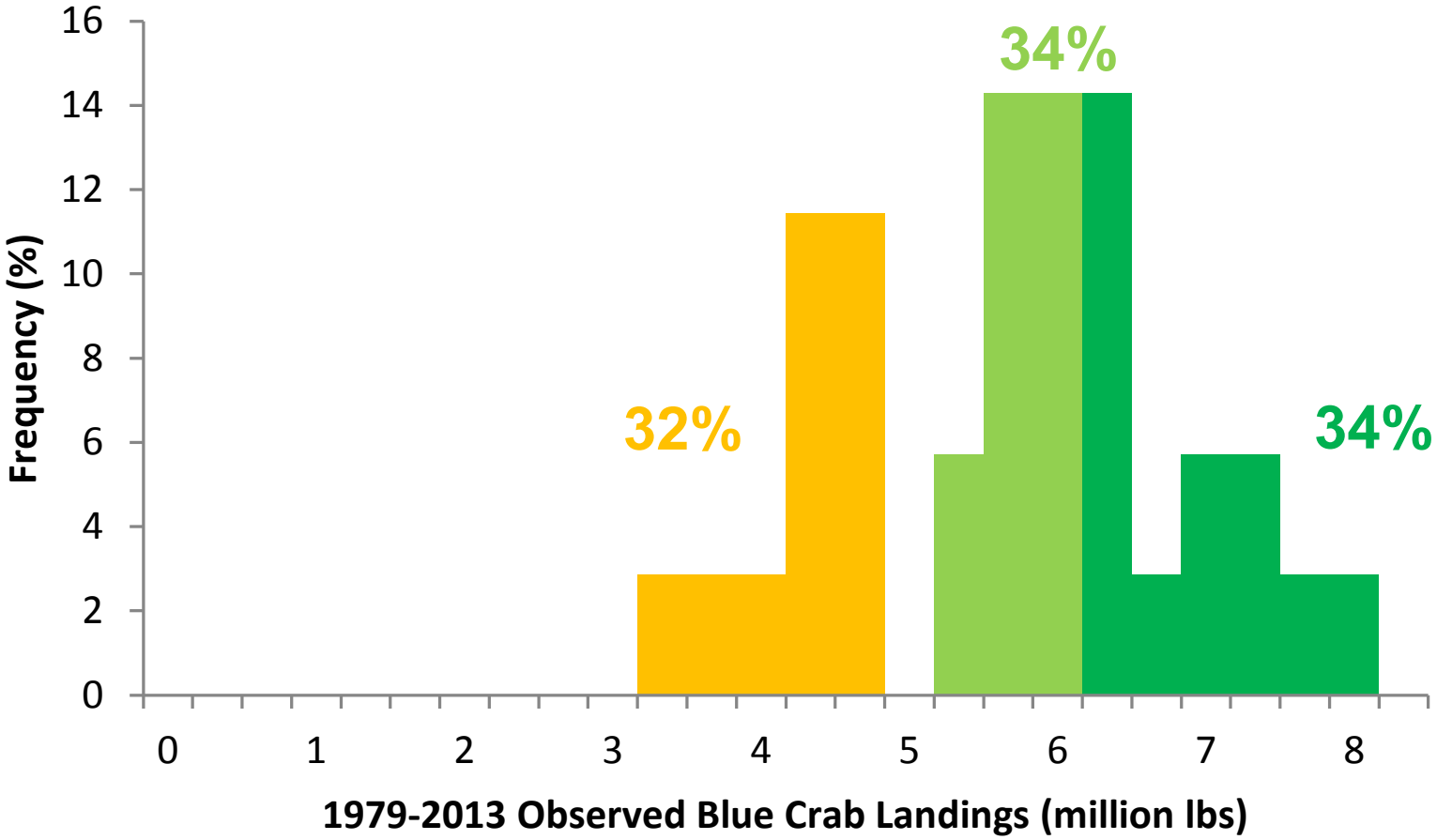
Childress 2014 SCWRC

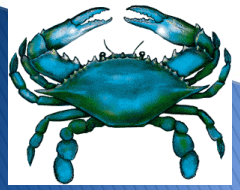
Blue Crab Landings Forecast

Year	Source	DF	F	P	r2
2015	Full	24	9.895	0.0001	.7425
	Amplitude	4	49.64	0.0001	.6512
	Slope	4	6.323	0.0003	.0811
	A X S	16	0.851	0.6248	.0101
2090	Full	24	14.54	0.0001	.8145
	Amplitude	4	34.85	0.0001	.3550
	Slope	4	44.07	0.0001	.4503
	A X S	16	2.08	0.0246	.0208

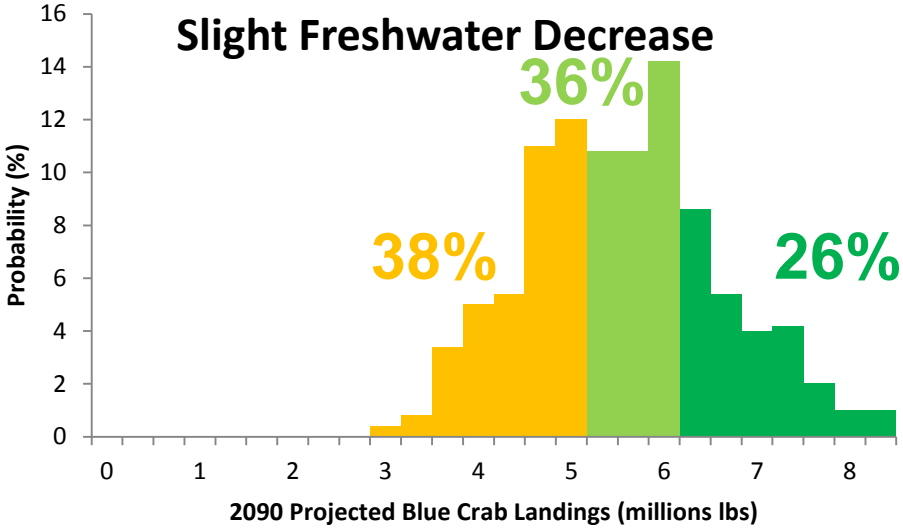


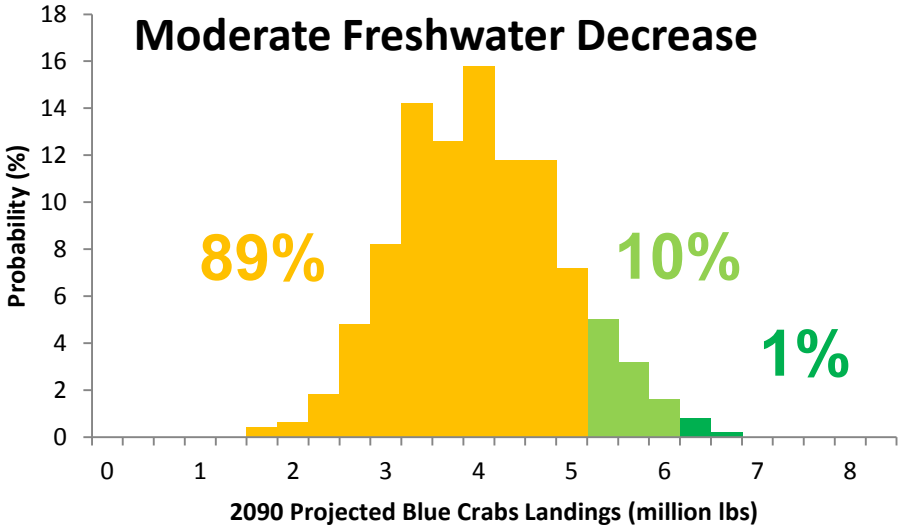
Blue Crab Landings Observed

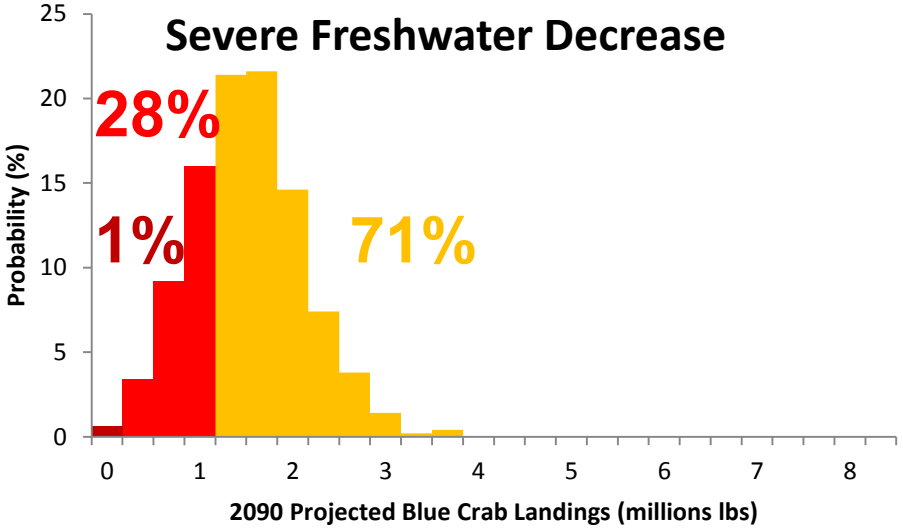


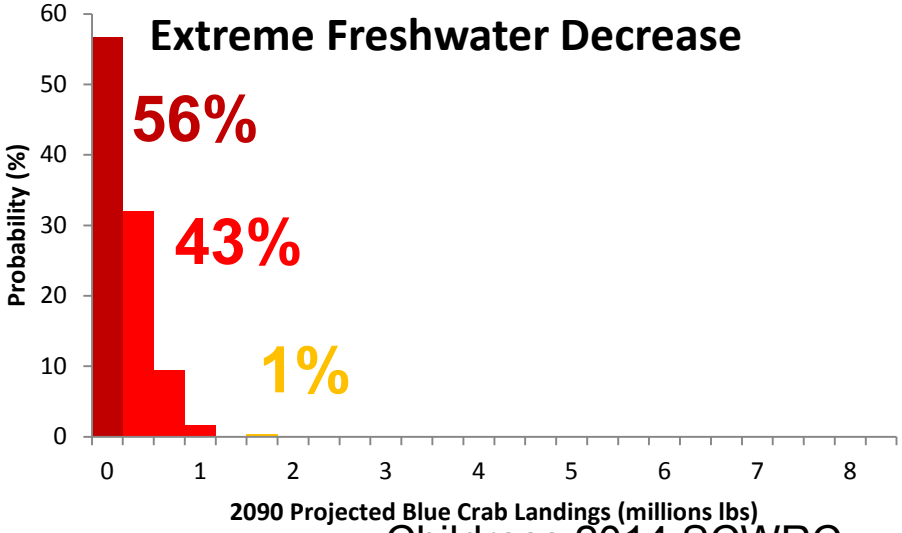


Blue Crab Landings Forecast



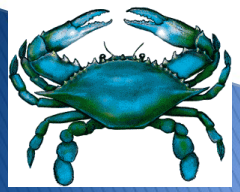




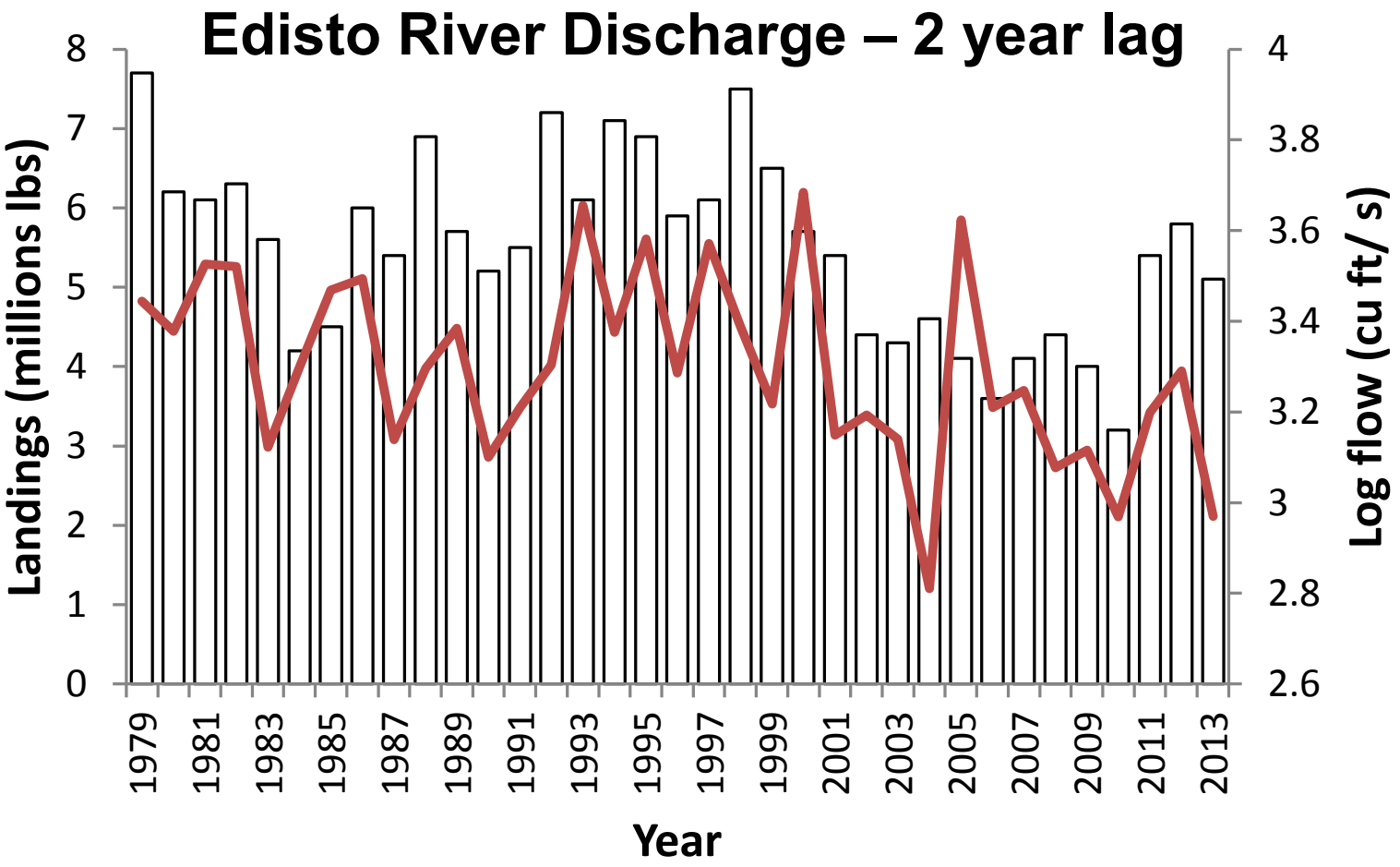


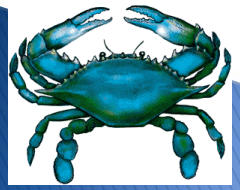
Presentation Outline

- Why are blue crabs declining?
- How does drought impact blue crabs?
- How do you model blue crabs?
- How will climate change affect crabs?
- **What is the forecast for blue crabs?**



What is the forecast for blue crabs?

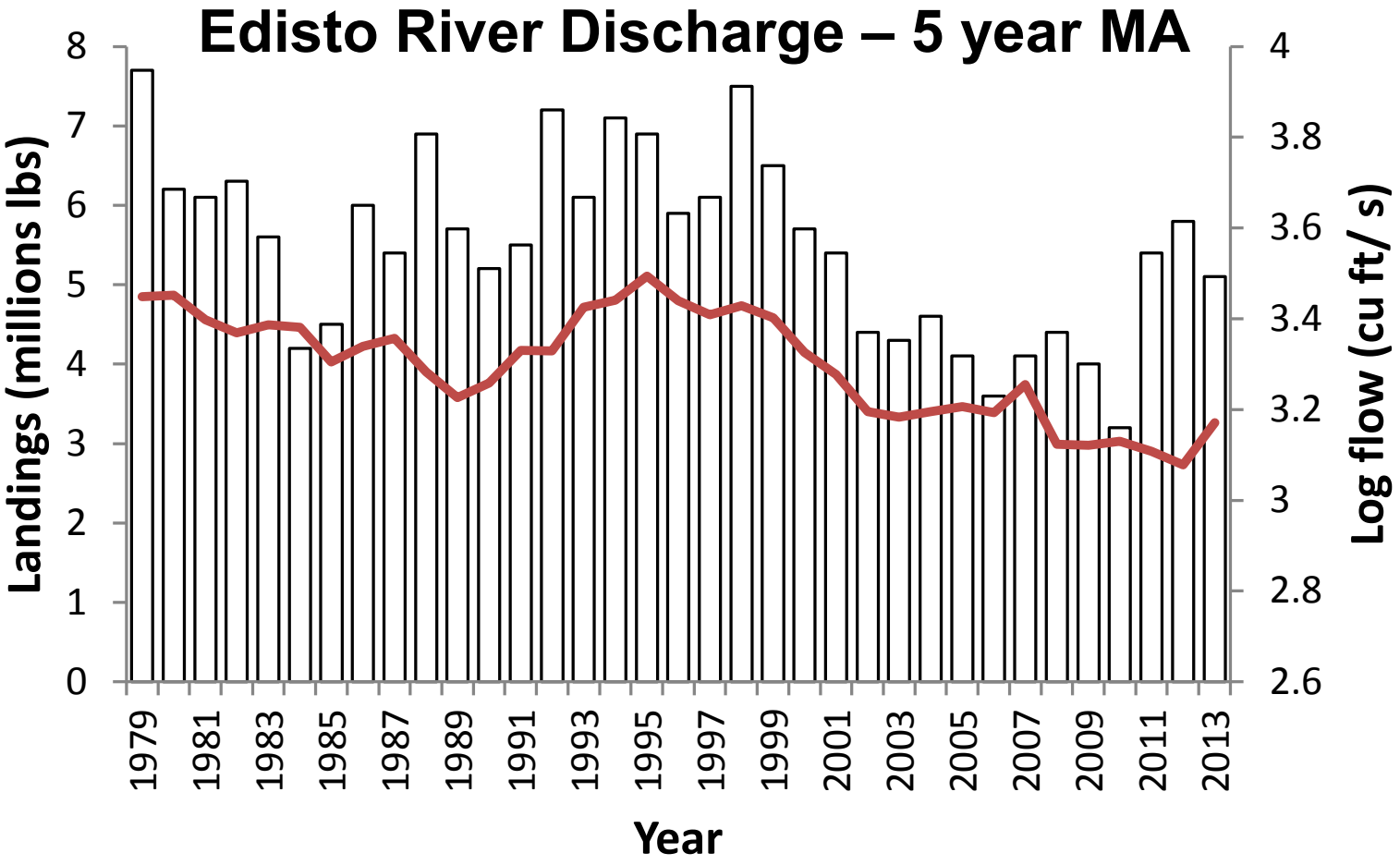


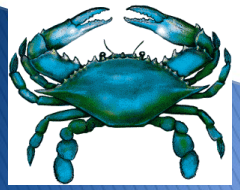


$r^2 = 0.209$, $p = 0.0056$

Childress 2014 SCWRC

What is the forecast for blue crabs?

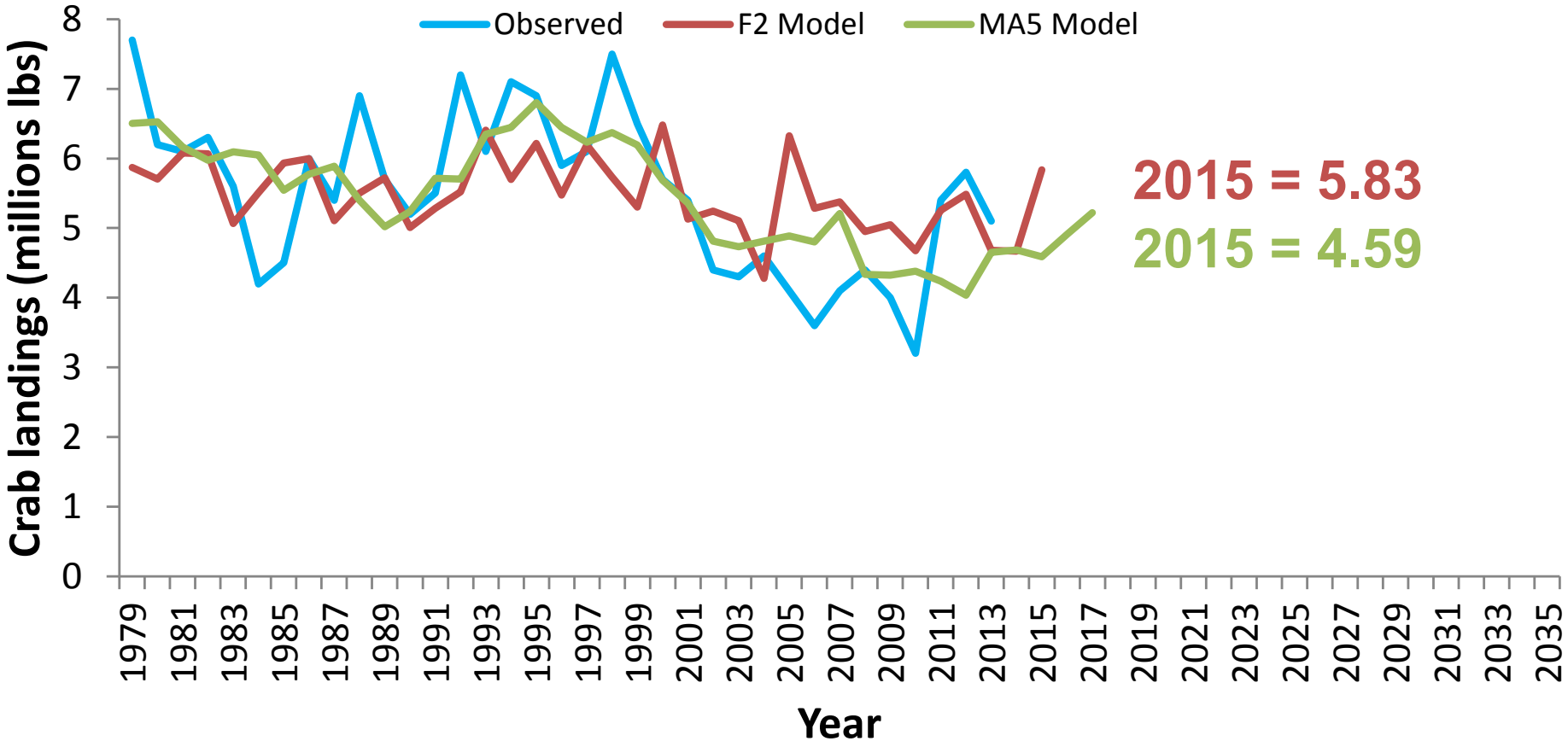


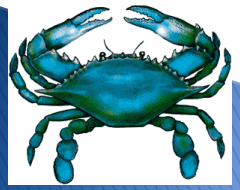


$r^2 = 0.469, p < 0.0001$

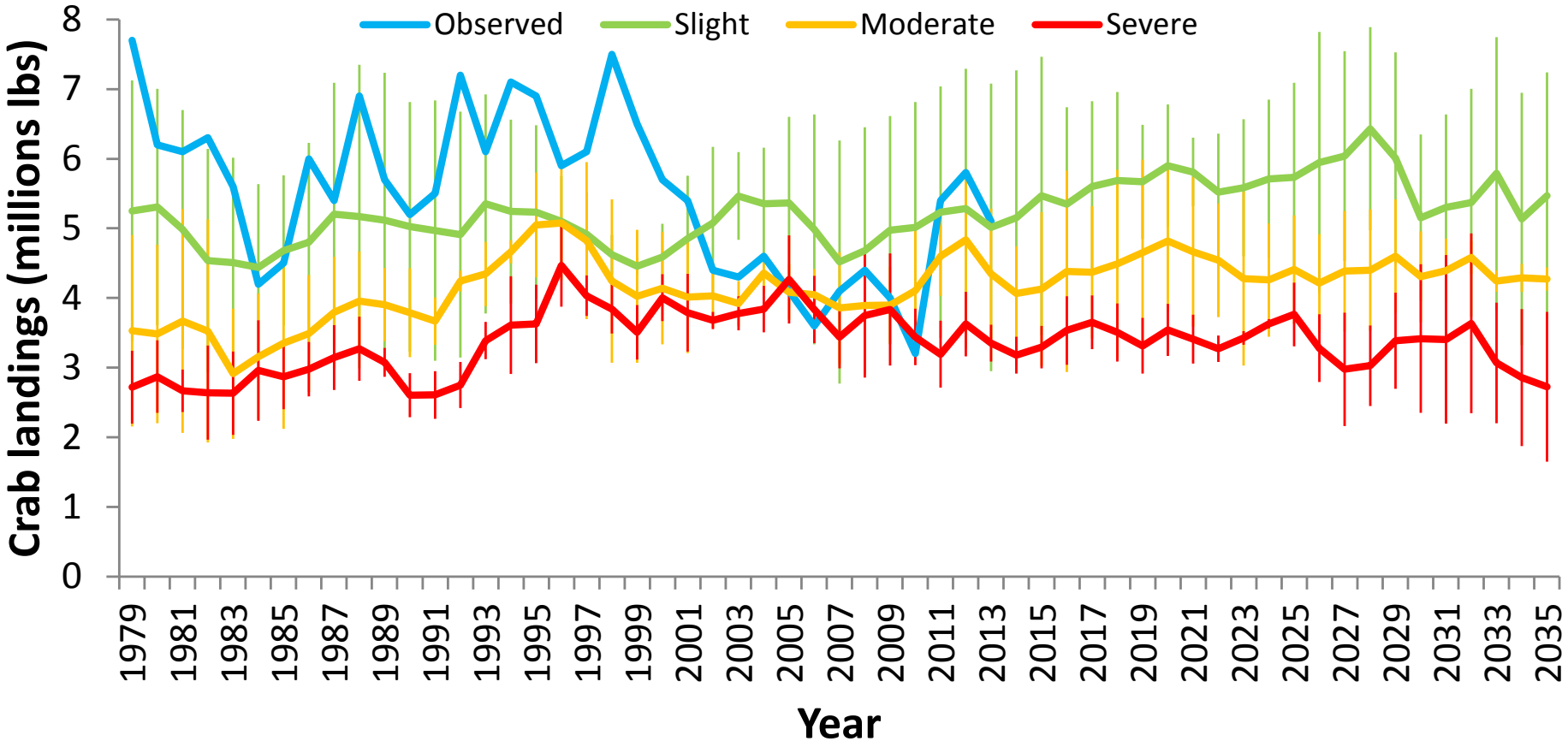
Childress 2014 SCWRC

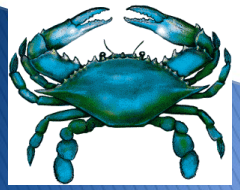
What is the forecast for blue crabs?





What is the forecast for blue crabs?

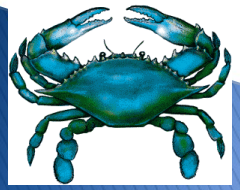




What is the forecast for blue crabs?

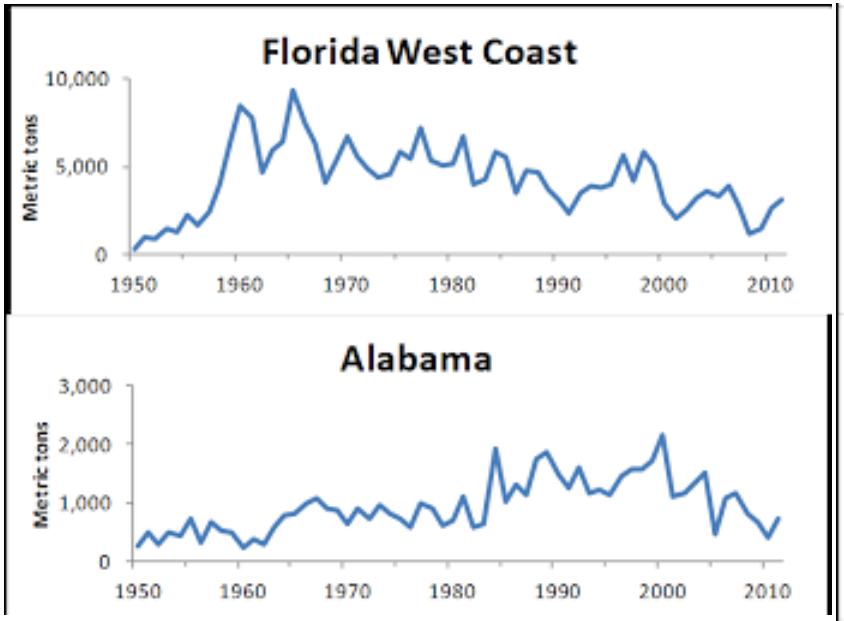
Model	2015	2035	2090
FA2 Model	5.836 (+14%)	??	??
MA5 Model	4.591 (-10%)	??	??
SCBCRABs slight	5.465 (+7%)	5.470 (+8%)	6.440 (+26)
SCBCRABS moderate	4.126 (-19%)	4.272 (-16%)	4.294 (-16%)
SCBCRABS severe	3.294 (-35%)	2.724 (-47%)	0.887 (-83%)

2013 SC blue crab landings = 5.098

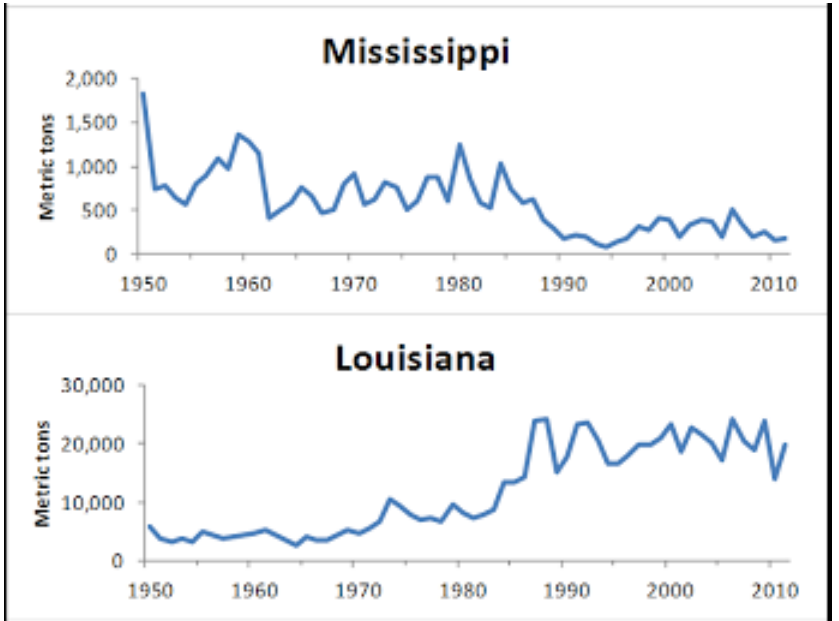


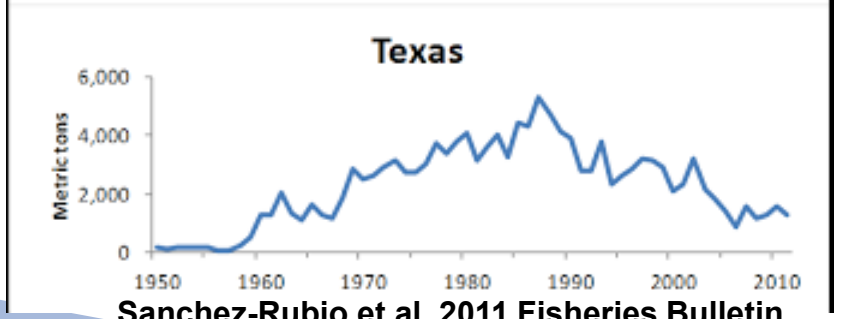
Conclusions

- Why are blue crabs declining?
  - Decreasing freshwater input to estuary

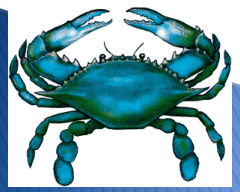


Wilber 1994 Fisheries Bulletin



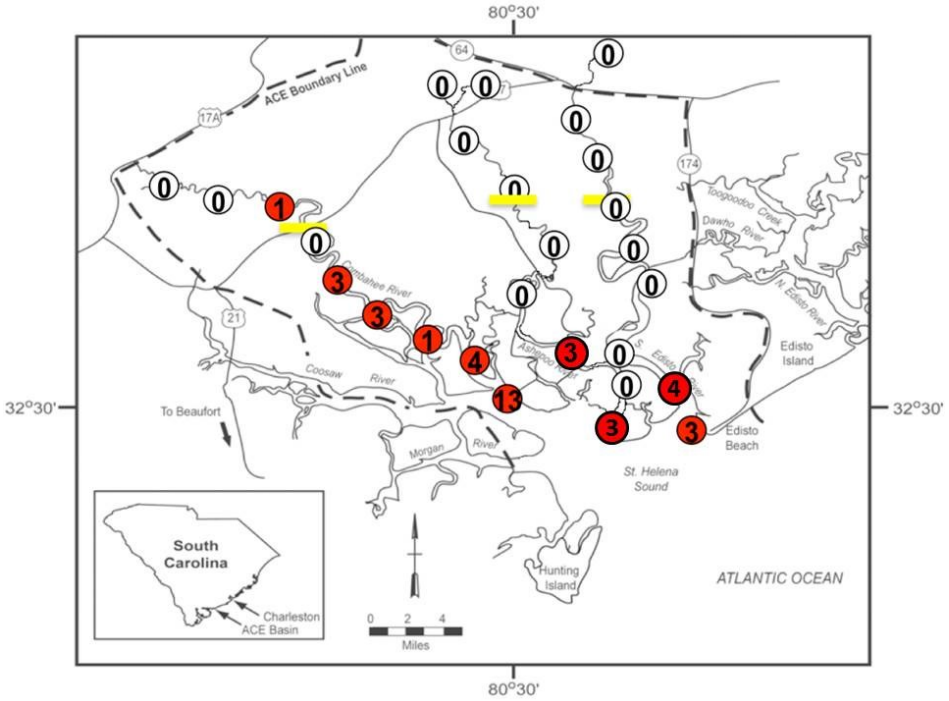


Sanchez-Rubio et al. 2011 Fisheries Bulletin

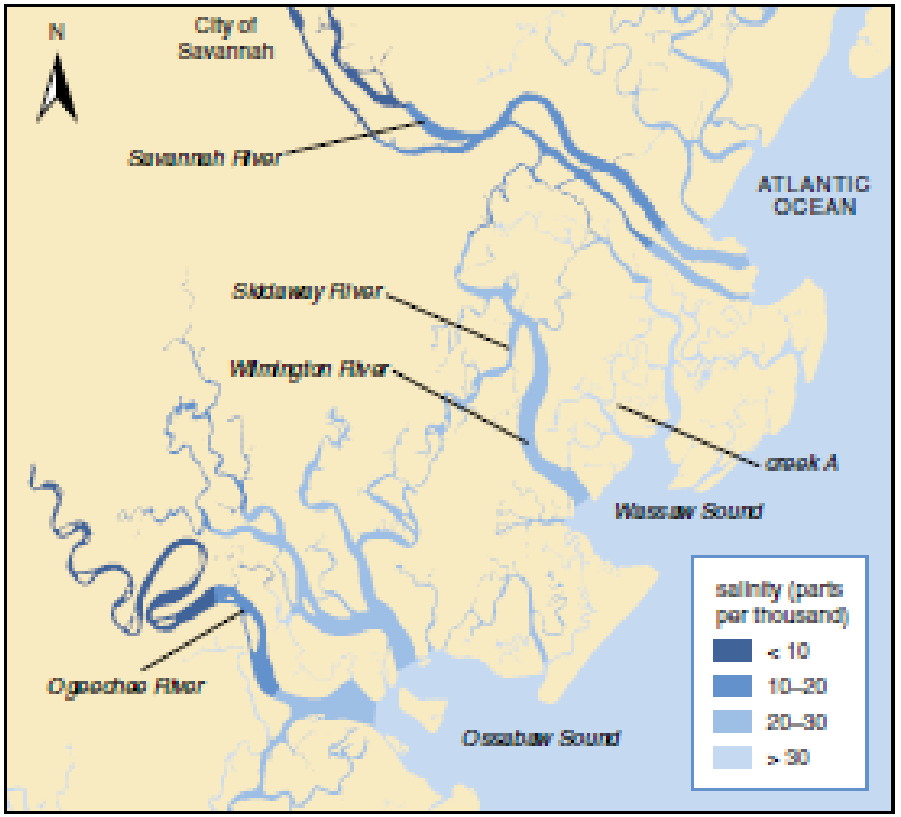


Conclusions

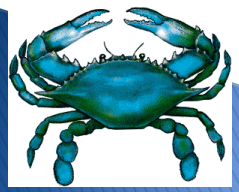
- How does drought impact blue crabs?
  - Droughts increase disease and high salinity stress



Parmenter et al. 2013 Estuaries

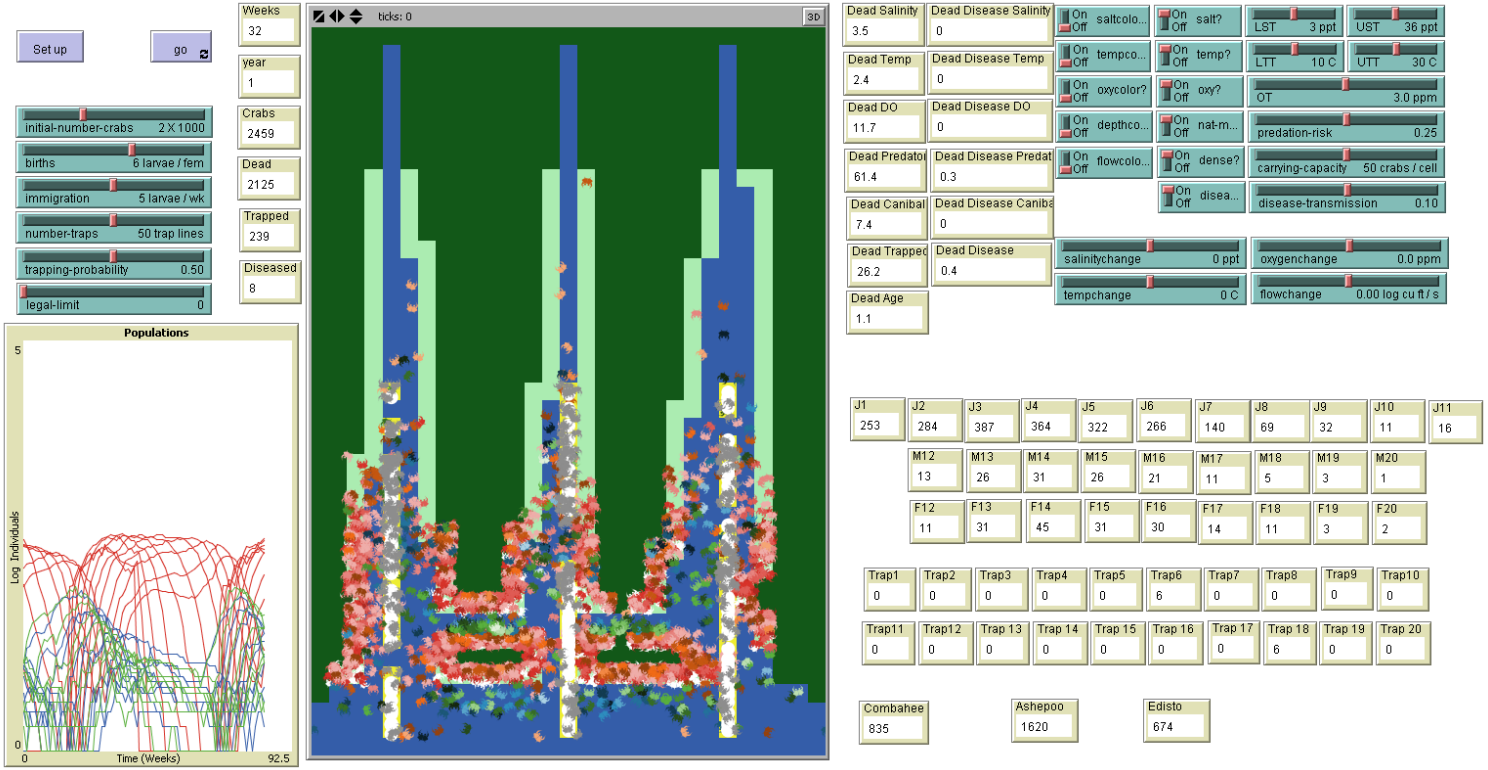


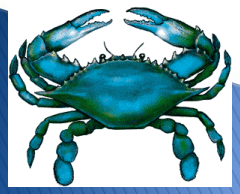
Lee & Frischer 2004 American Scientist



Conclusions

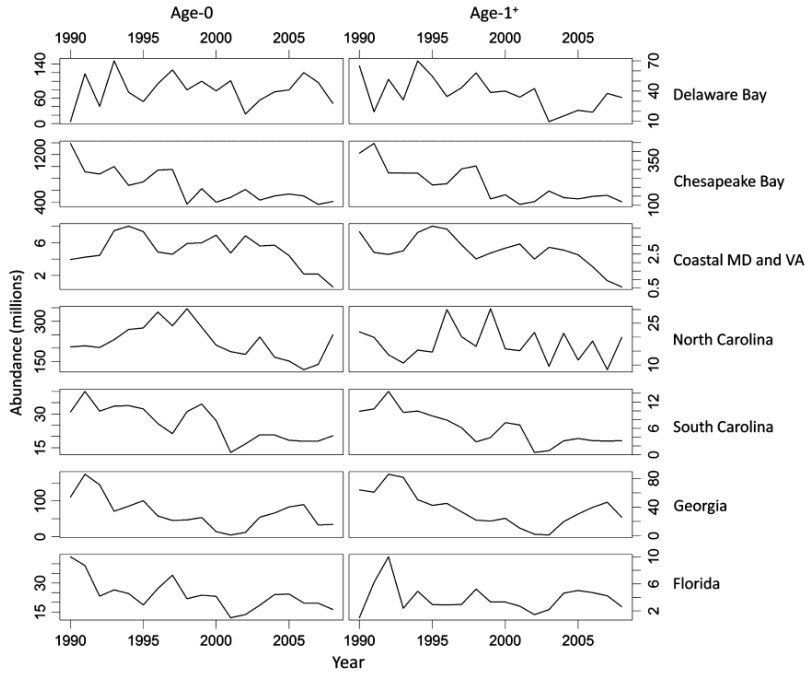
- How do you model blue crabs?
  - IBMs allow for integration of multiple effects

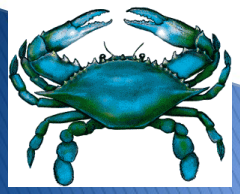




Conclusions

- How will climate change affect crabs?
  - Droughts will become more severe

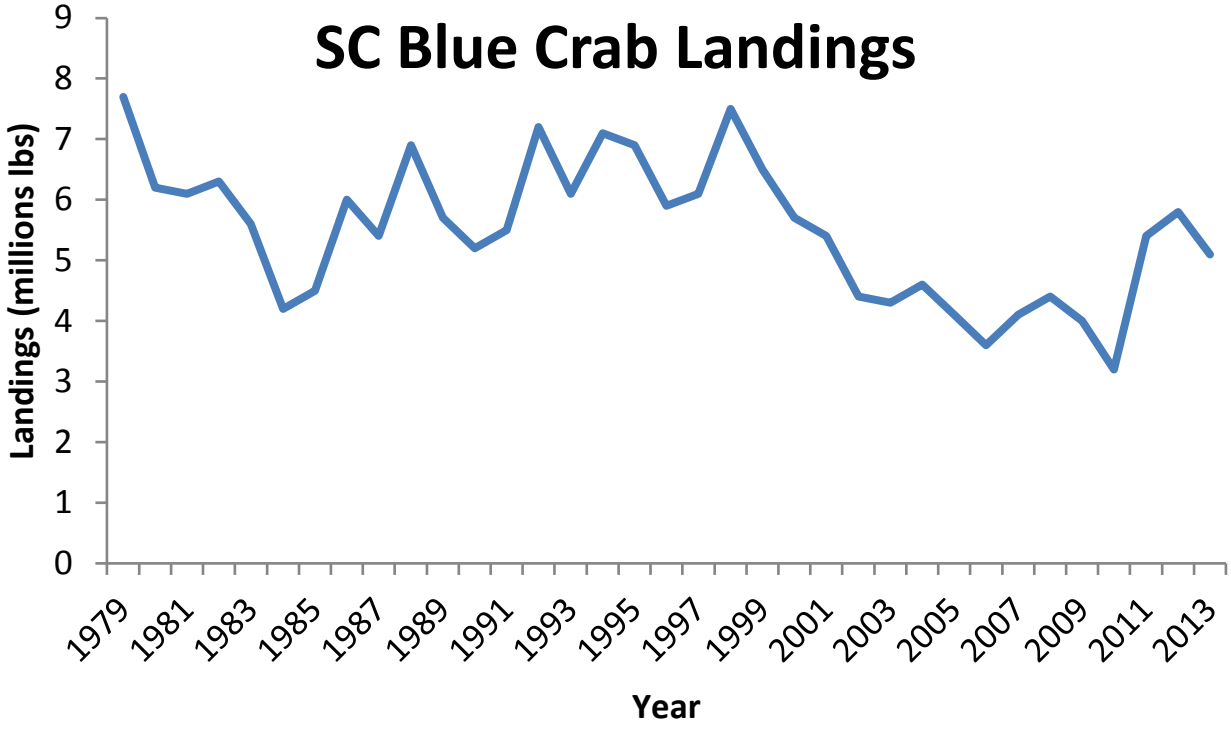


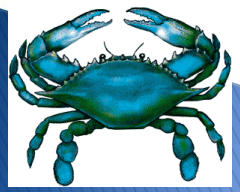


Colton et al. 2013 Fisheries & Oceanography

Conclusions

- What is the forecast for blue crabs?
  - Landings will continue to decrease if rate of freshwater decline continues at the present level





SCDNR Data

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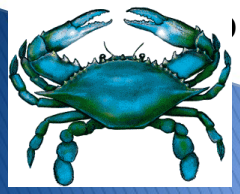
  - CISA – K Dow, D Tufford
- Field assistants
  - K Parmenter
  - K Smith
  - [illegible]nservation of Marine Resources Team



Are we stuck yet?