Comprehensive Aquatic Systems Models for Evaluating Restoration Projects in Coastal Louisiana

Shaye Sable and Kate Shepard Watkins

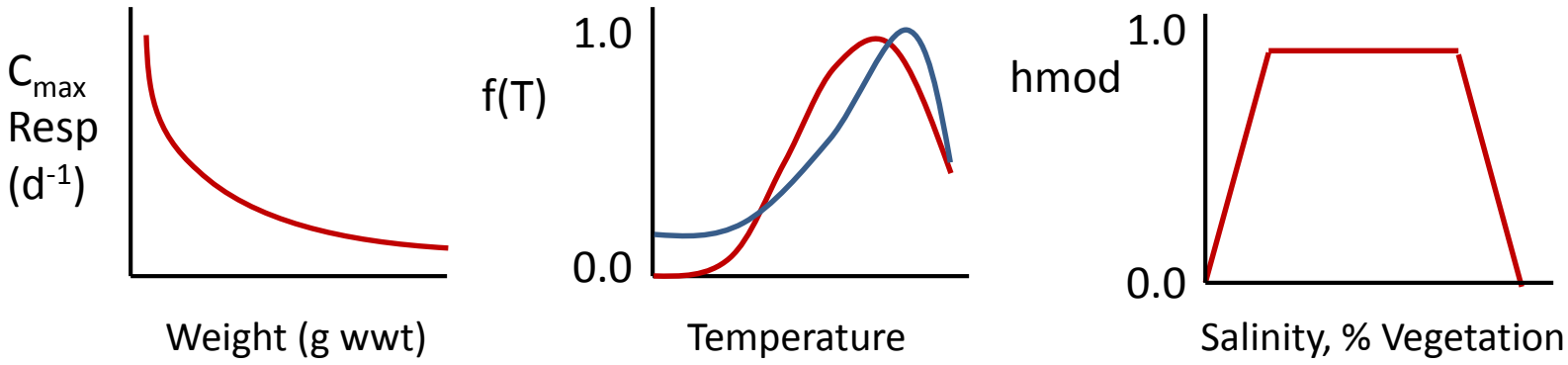
Dynamic Solutions, LLC

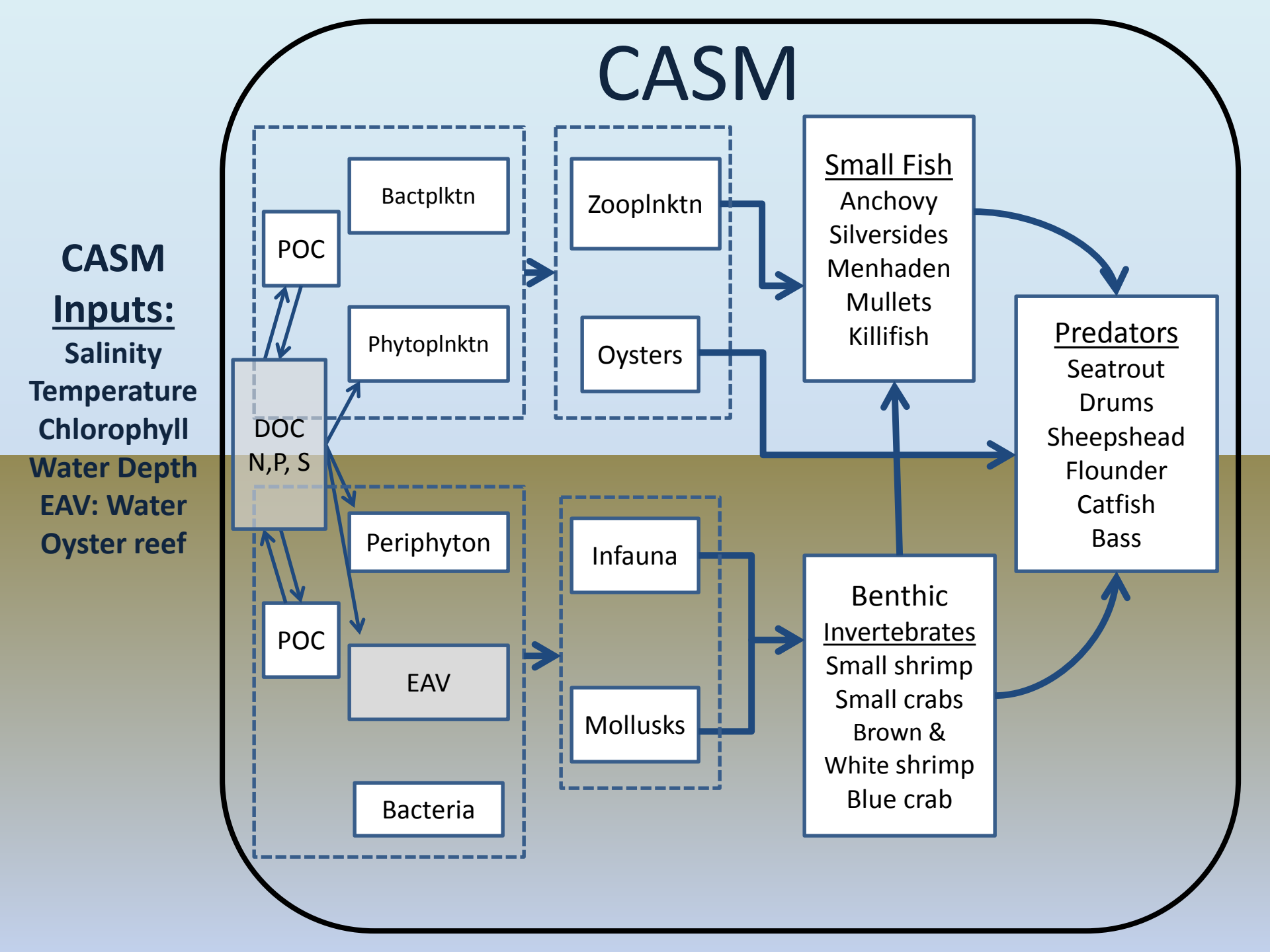
Dynamic Solutions LLC

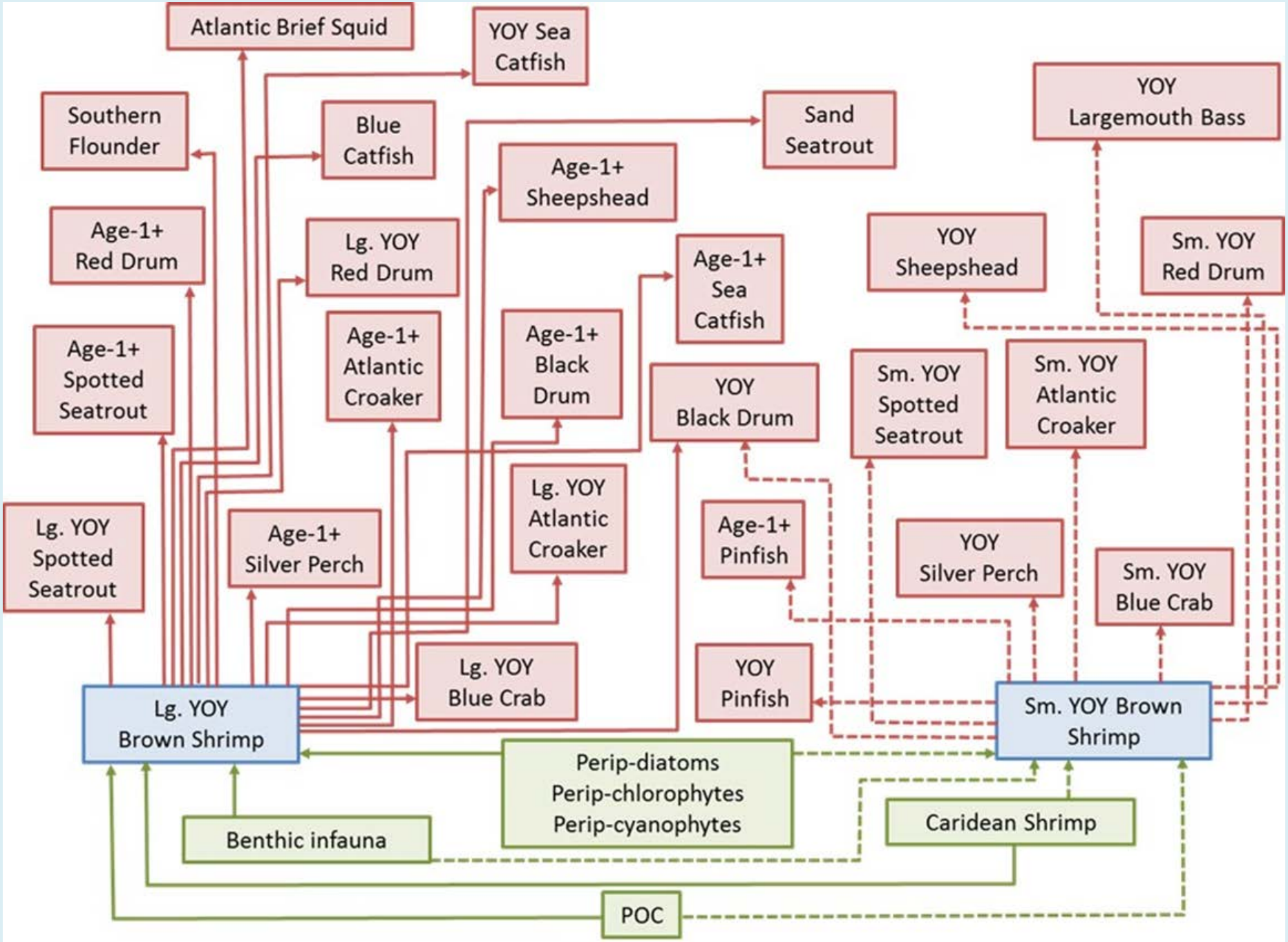
COASTAL PROTECTION AND RESTORATION AUTHORITY
CPRA

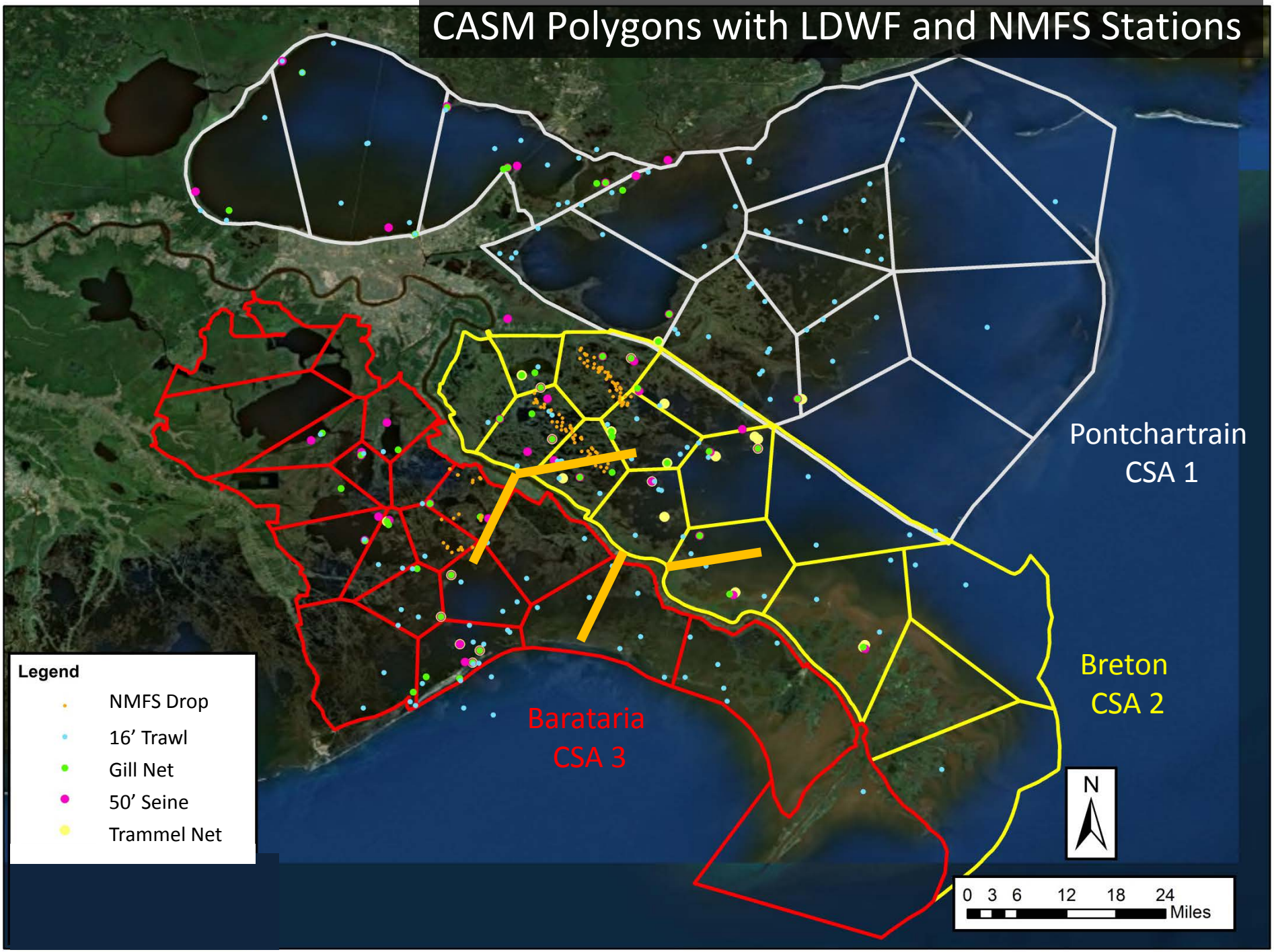
CASM

- Model development and calibration in poster on Tuesday
- Bioenergetics-based growth in an aquatic food web
- Consumers: *dB/Bdt* = [{Consumption - (Egest+Excrete+SDA) – Respiration – Mortality – Predation} + flux]*hmod
- Consumption and respiration depend on size, temperature; Consumption on prey and predator biomasses
- Growth modified by salinity, proportion of vegetation



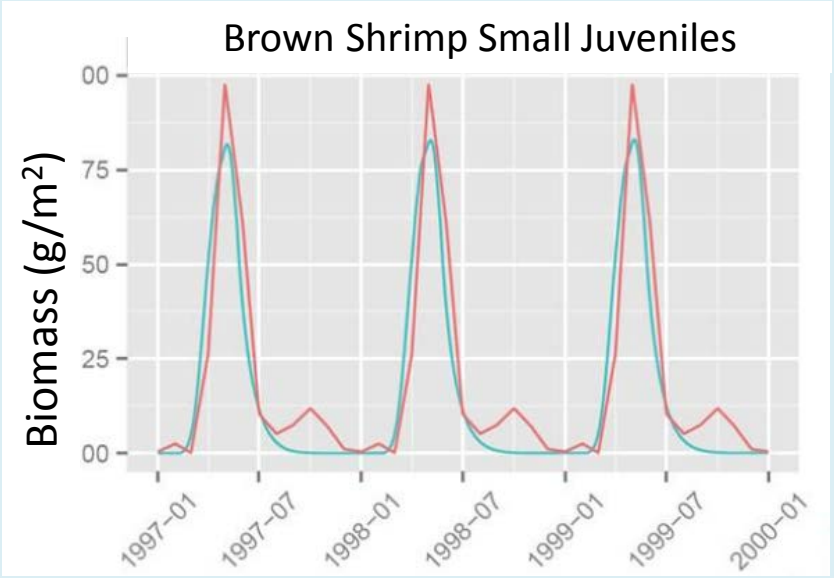

CASM
CASM Inputs:
Salinity
Temperature
Chlorophyll
Water Depth
EAV: Water
Oyster reef
Bactplktn
POC
Phytoplnktn
DOC
N,P, S
ZoopInktn
Oysters
Small Fish
Anchovy
Silversides
Menhaden
Mullets
Killifish
Predators
Seatrout
Drums
Sheepshead
Flounder
Catfish
Bass
Periphyton
POC
EAV
Bacteria
Infauna
Mollusks
Benthic
Invertebrates
Small shrimp
Small crabs
Brown &
White shrimp
Blue crab

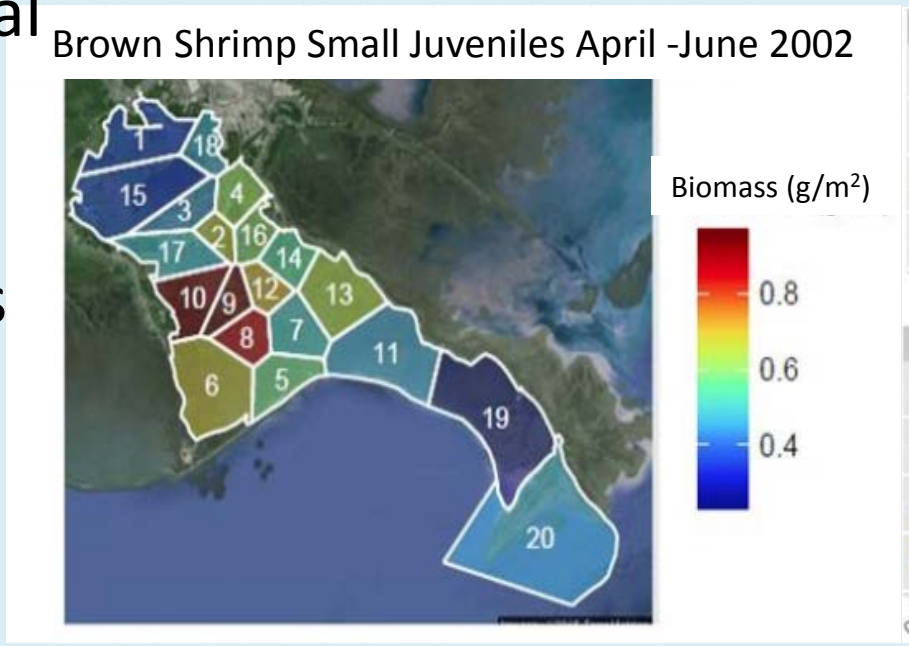

Atlantic Brief Squid
YOY Sea Catfish
Southern Flounder
Blue Catfish
Sand Seatrout
YOY Largemouth Bass
Age-1+ Sheepshead
Age-1+ Red Drum
Lg. YOY Red Drum
YOY Sheepshead
Sm. YOY Red Drum
Age-1+ Sea Catfish
Age-1+ Spotted Seatrout
Age-1+ Atlantic Croaker
Age-1+ Black Drum
YOY Black Drum
Sm. YOY Spotted Seatrout
Sm. YOY Atlantic Croaker
Lg. YOY Atlantic Croaker
Lg. YOY Spotted Seatrout
Age-1+ Silver Perch
Age-1+ Pinfish
YOY Silver Perch
Sm. YOY Blue Crab
Lg. YOY Blue Crab
YOY Pinfish
Lg. YOY Brown Shrimp
Sm. YOY Brown Shrimp
Perip-diatoms
Perip-chlorophytes
Perip-cyanophytes
Caridean Shrimp
Benthic infauna
POC

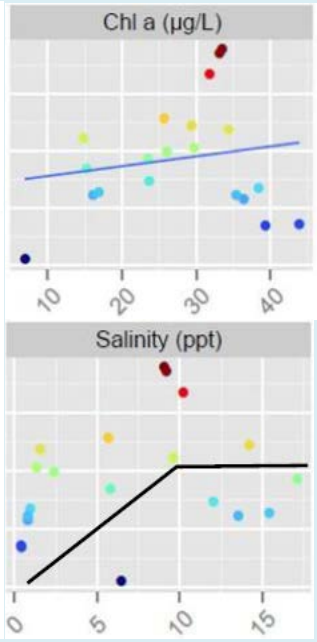

CASM Polygons with LDWF and NMFS Stations
Pontchartrain
CSA 1
Breton
CSA 2
Barataria
CSA 3
Legend
NMFS Drop
16’ Trawl
Gill Net
50’ Seine
Trammel Net
N
0 3 6 12 18 24
Miles

CASM Approach

- Calibrated, validated for 1995-2010
  - Inputs: Daily salinity, temperature, Chl a; vegetation:water
  - Calibrate seasonal biomass (g/m^2) to data
  - Validate patterns over years and spatially in years



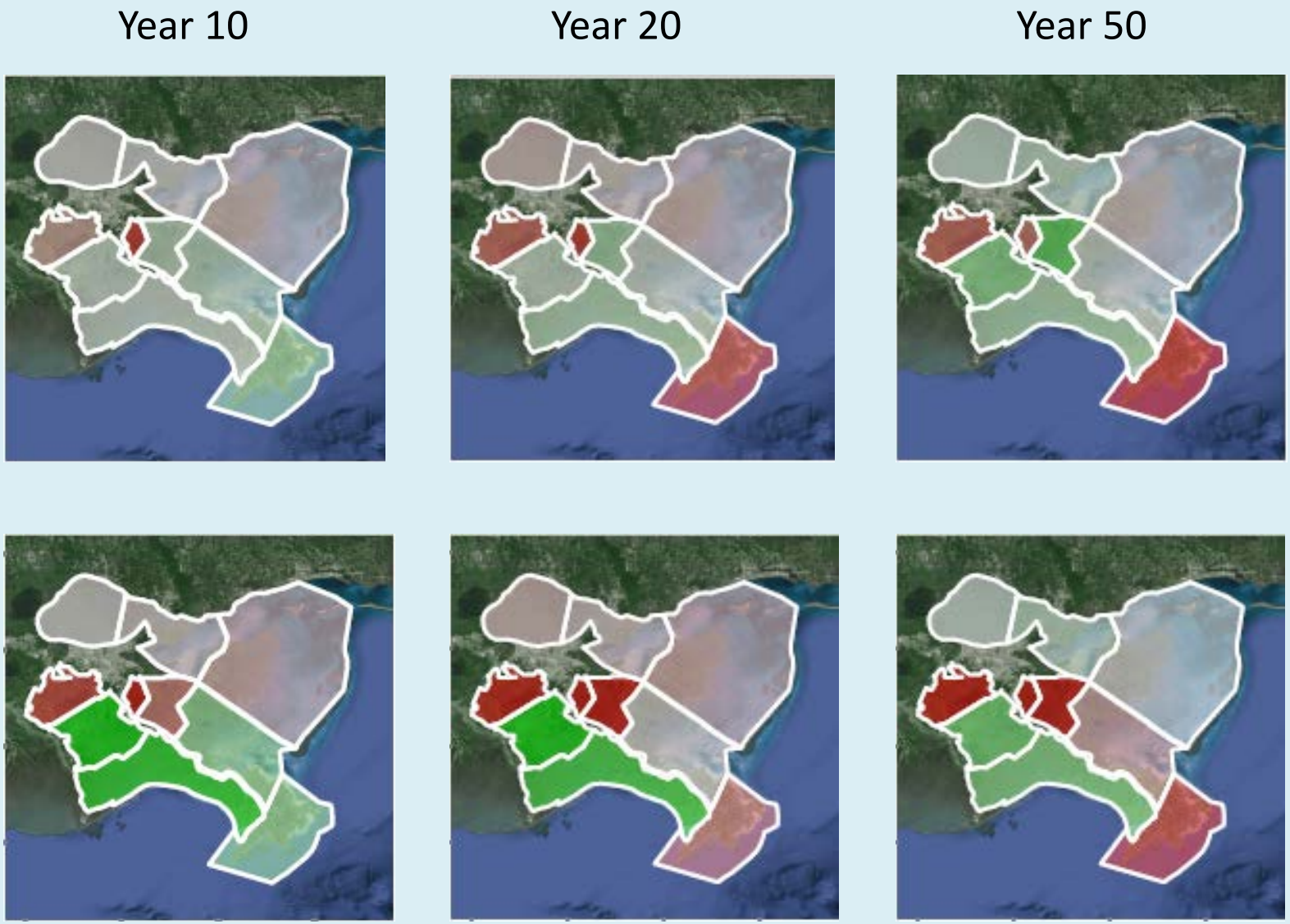




Evaluating Species Responses to Restoration Project Scenarios

- Delft-3D generated daily salinity, temperature, Chl a, vegetation:water inputs to 49 CASM polygons over 50 years
- Seven Mississippi River diversion production runs including FWOP, single river diversions, four diversions at low and aggressive operations
- Report key species responses from TY0 for first 10 years, 20 years and at 50 years
  - Gulf menhaden, bay anchovy, brown and white shrimp, blue crab, red drum, spotted seatrout
  - System-wide, basins (CSA 1, 2, 3), and sub-basins (upper, mid, lower regions in basin)

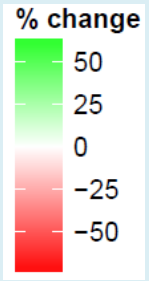
Gulf Menhaden Biomass: Change from TY 0



Brown Shrimp Biomass: Change from TY 0

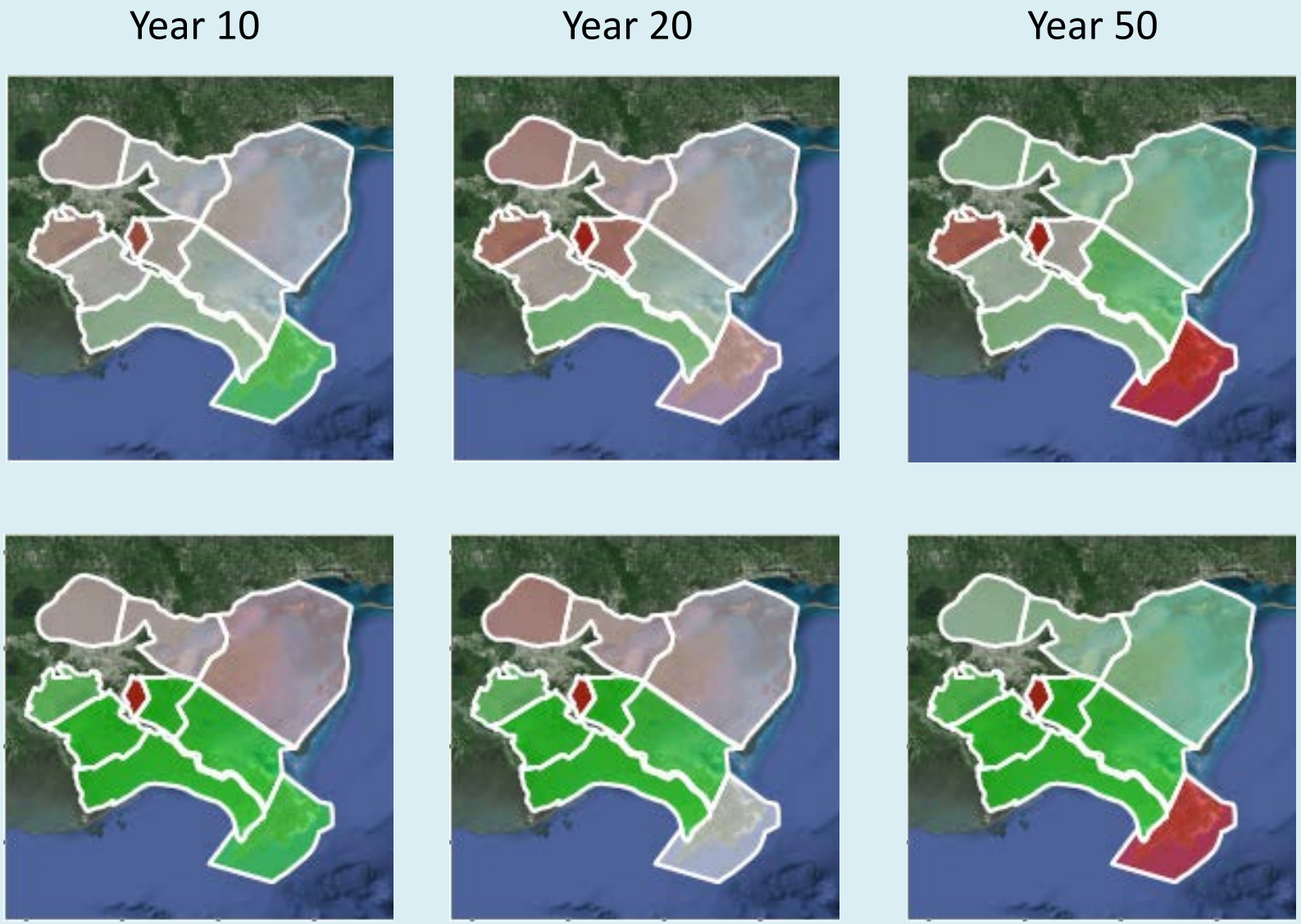
Year 10 | Year 20 | Year 50

Future Without Project (PR 2)

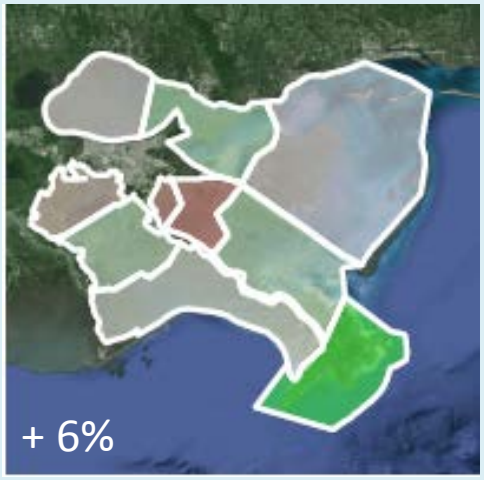
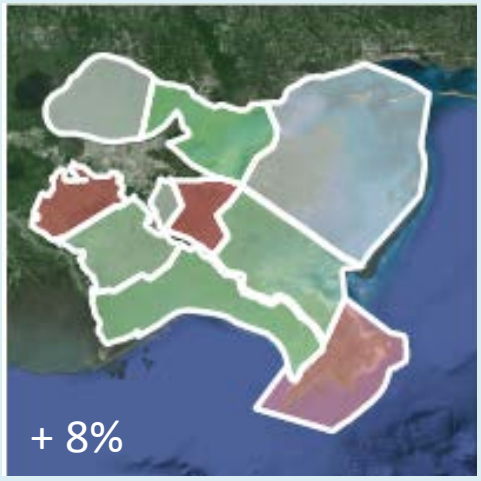
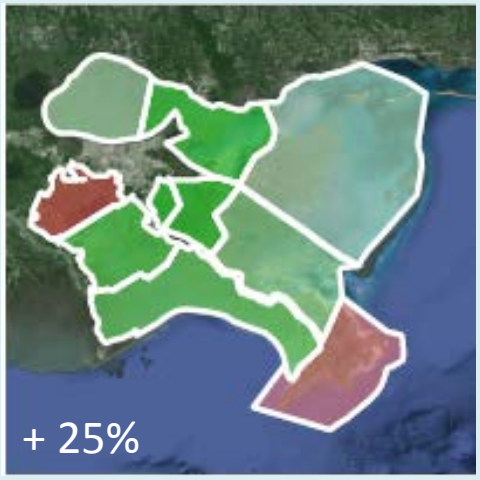
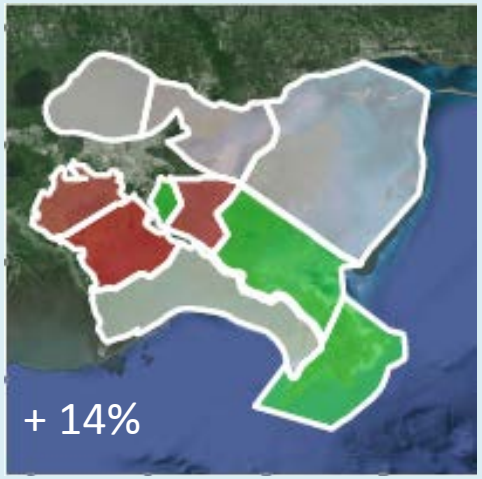
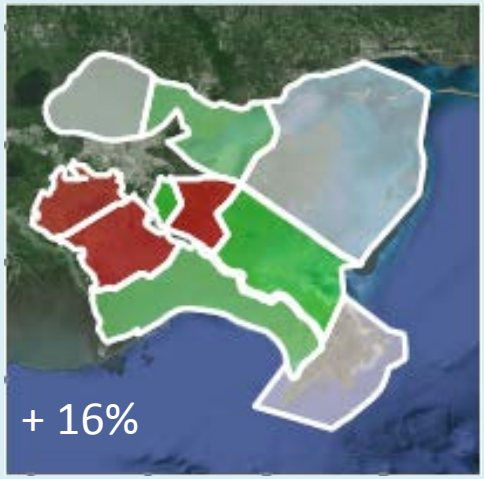
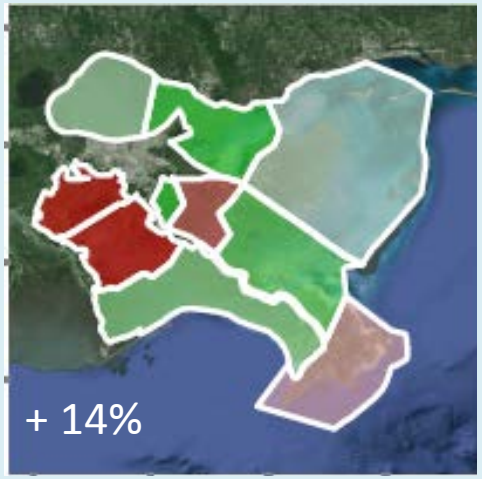


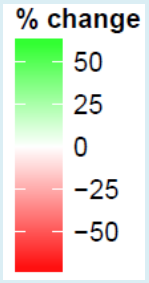
All Four Diversions Aggressive Operation (PR 7)

Red Drum Biomass: Change from TY 0



Brown Shrimp Biomass: Change from TY 0

	Year 10	Year 20	Year 50
Future Without Project (PR 2)			
All Four Diversions Aggressive Operation (PR 7)			



Brown Shrimp:

System-Wide Responses Relative to TY 0

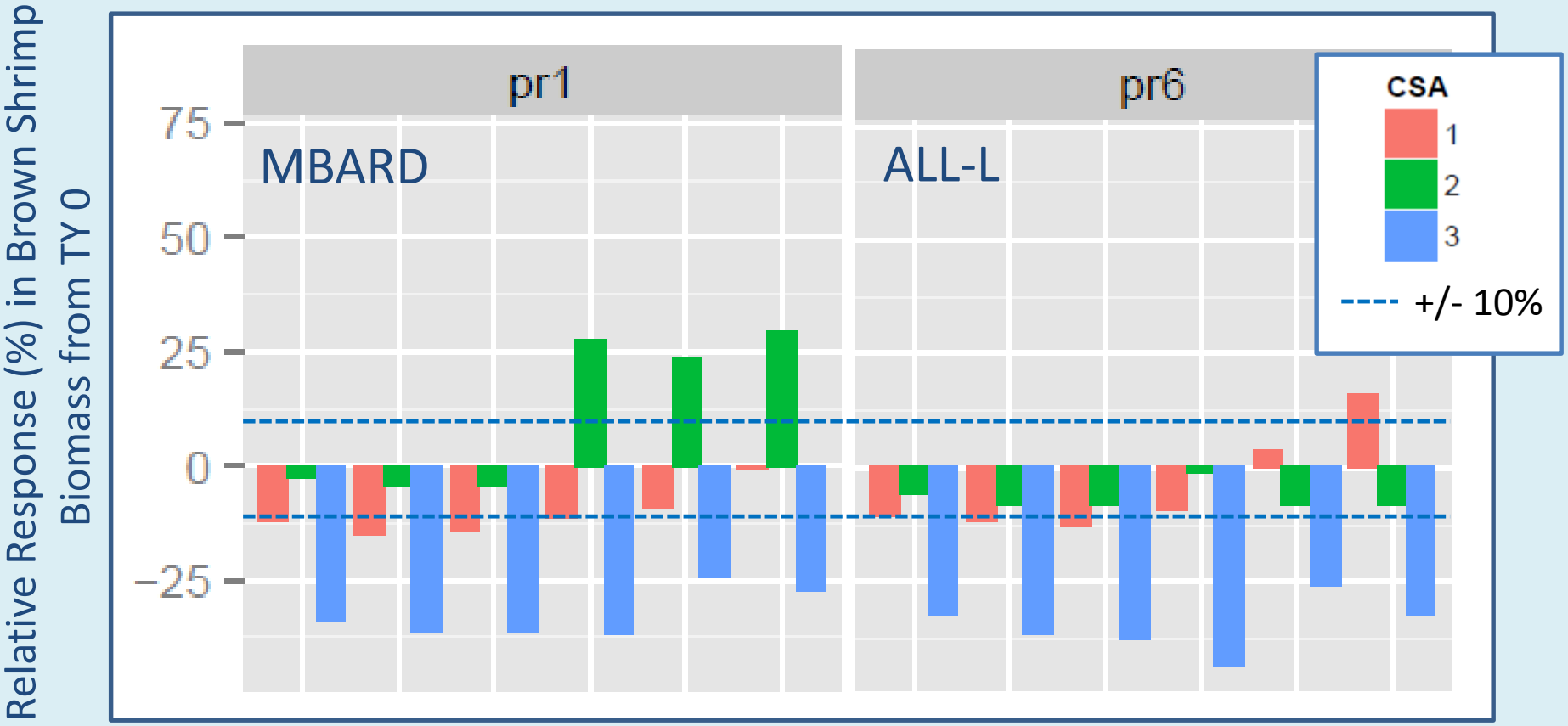
Years	MBARD PR1	FWOP PR2	MBSD PR3	LBSD PR4	LBARD PR5	ALL-L PR6	ALL-A PR7
1	-16.01	-4.18	-12.48	-5.71	-5.58	-15.59	0.32
3	-18.37	-5.61	-14.15	-7.26	-7.78	-18.11	3.77
5	-18.32	-6.05	-14.09	-7.31	-7.95	-18.71	3.38
10	-8.92	6.12	-1.60	2.35	0.01	-17.16	13.85
20	-5.11	7.87	1.82	6.18	5.50	-7.91	16.36
50	-0.87	24.64	23.98	20.95	16.26	-4.46	14.21

** Minimum threshold response +/-10% = No response due to variation and uncertainty

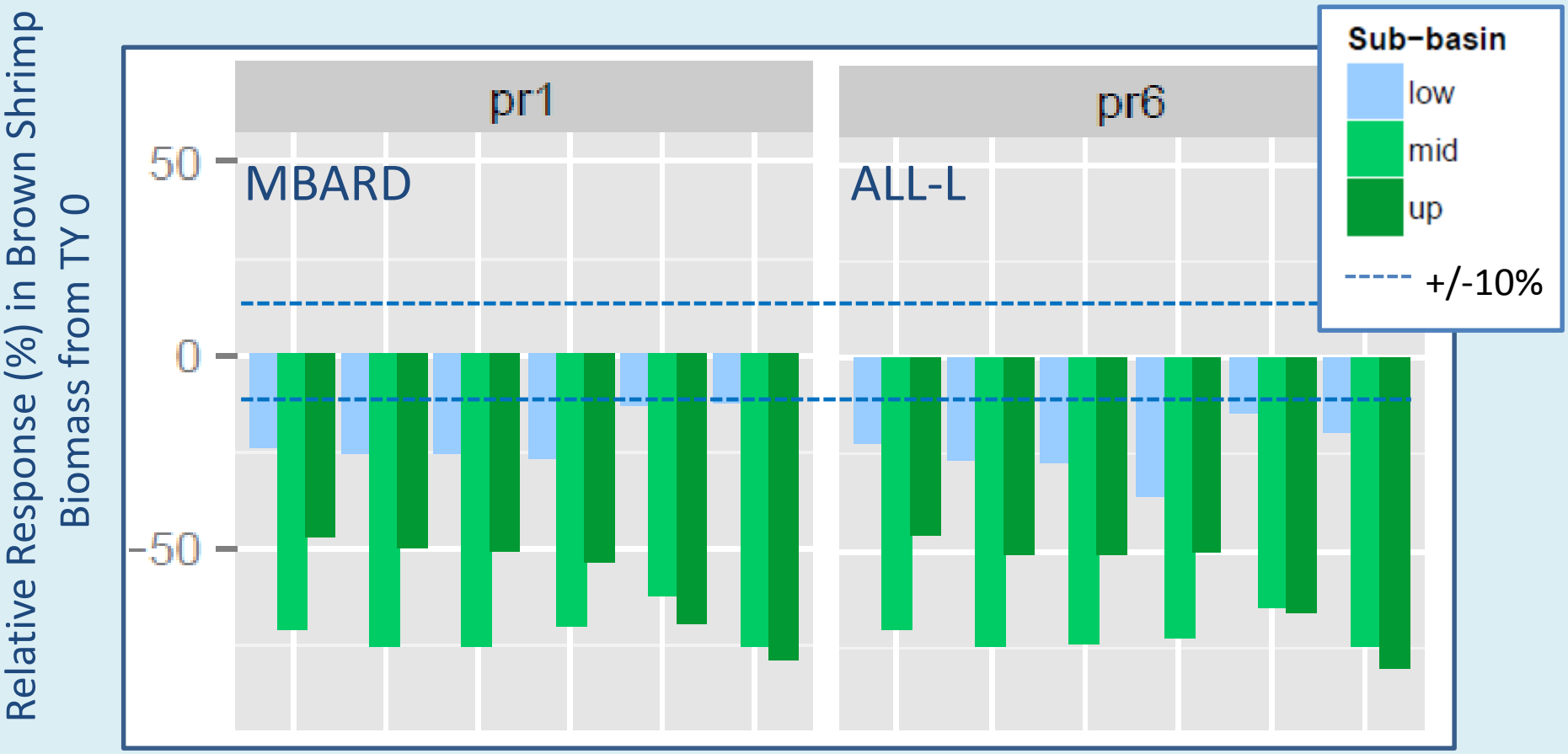
** Red more than 10% reduction; Green more than 10% increase from TY 0

FWOP ~ LBSD ~ LBARD ~ MBSD ~ All-A over 50 years

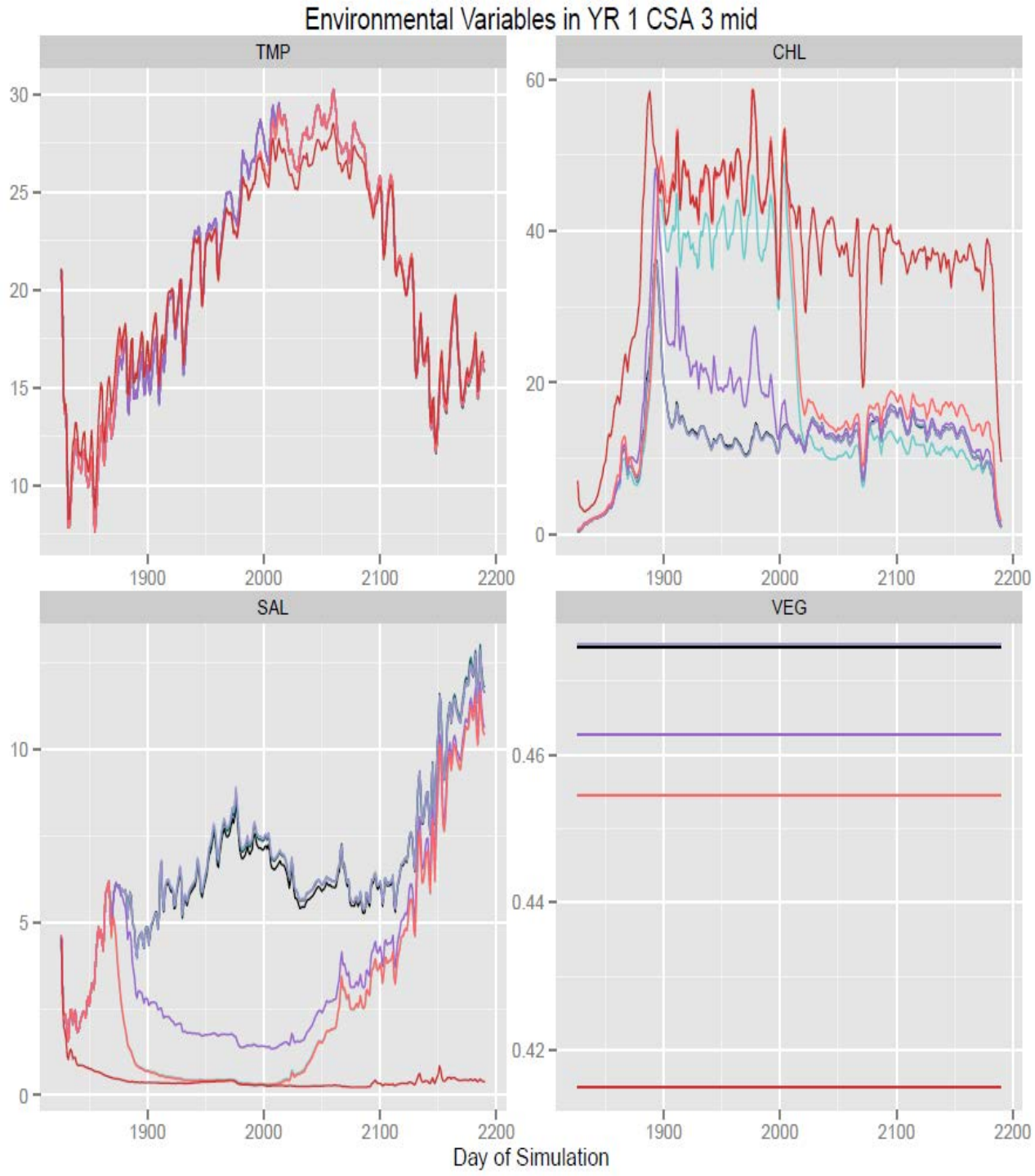
MBARD ~ All-L reduced ~ 18% early but gone by TY 20 and 50

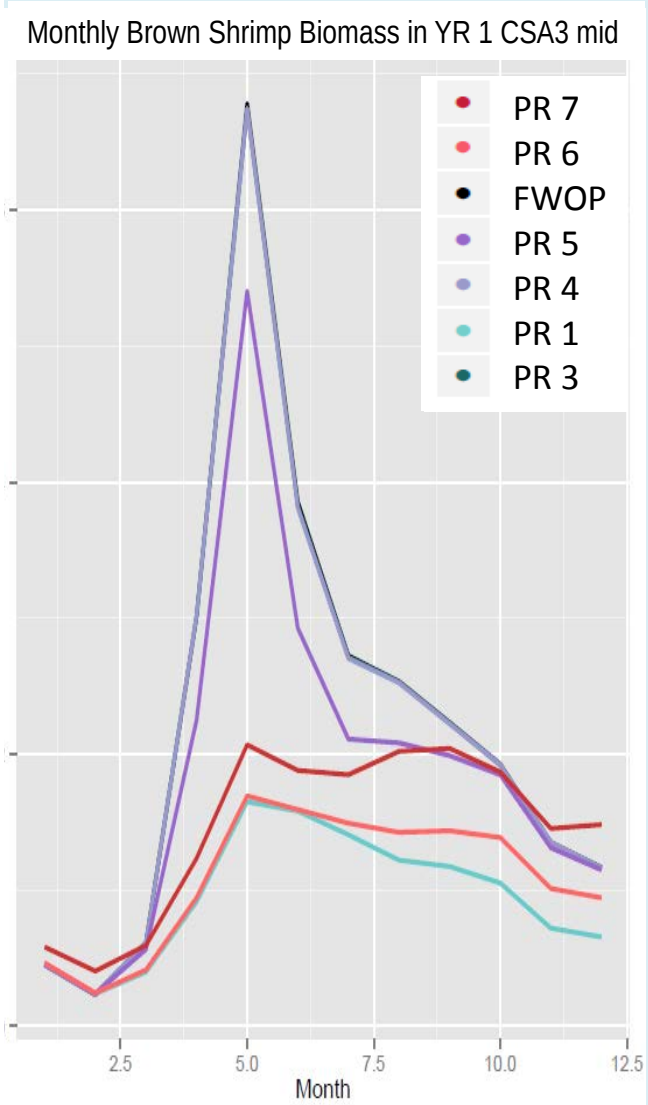


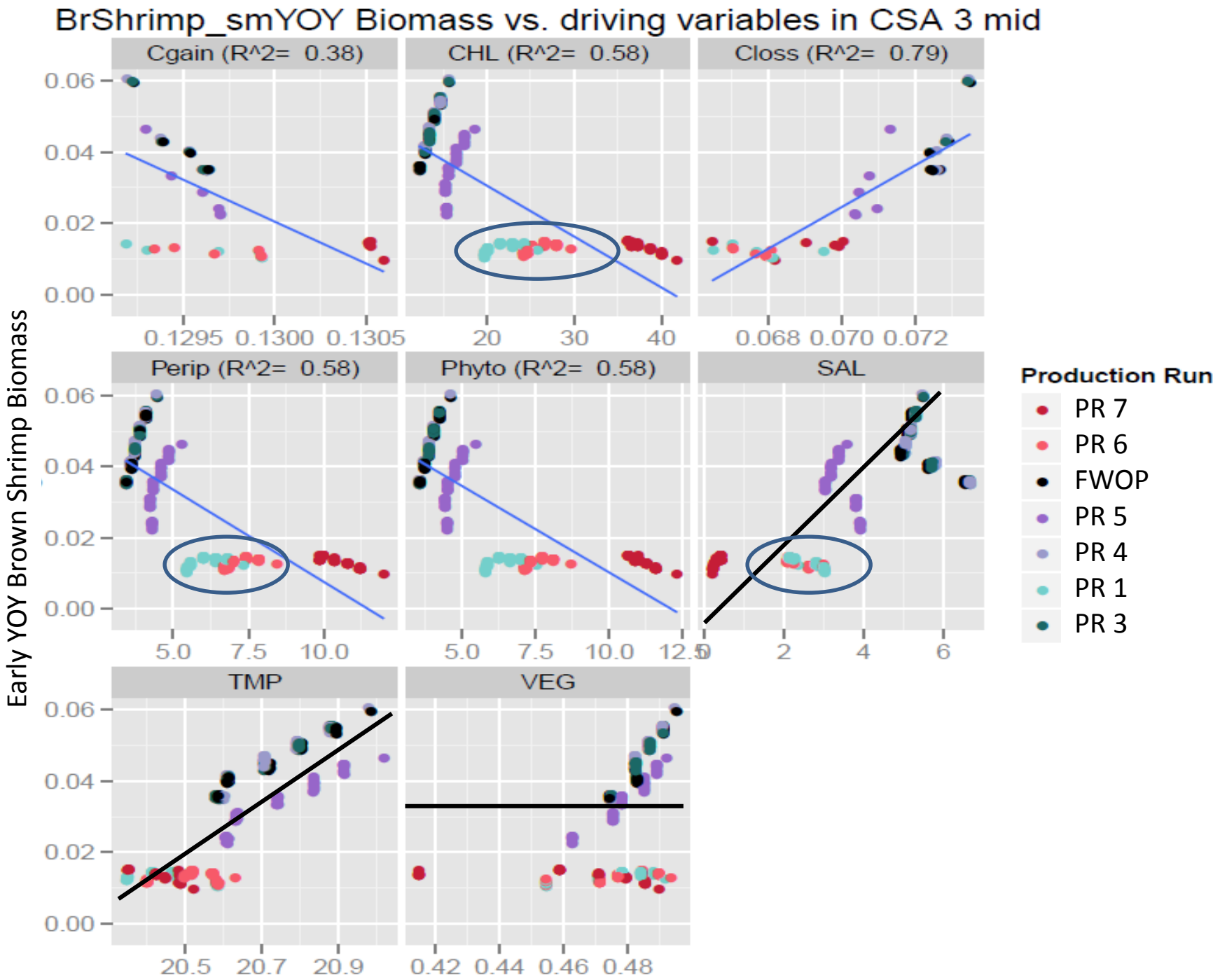
*** Supporting results for evaluating CSA 3 for lower biomasses in PR1 & PR 6



*** Relative reductions largest in upper and mid basins of PR1 & PR6 of CSA 3


Environmental Variables in YR 1 CSA 3 mid
TMP
CHL
SAL
VEG
Day of Simulation


Monthly Brown Shrimp Biomass in YR 1 CSA3 mid
PR 7
PR 6
FWOP
PR 5
PR 4
PR 1
PR 3
Month


BrShrimp_smYOY Biomass vs. driving variables in CSA 3 mid
Cgain (R^2= 0.38)
CHL (R^2= 0.58)
Closs (R^2= 0.79)
Perip (R^2= 0.58)
Phyto (R^2= 0.58)
SAL
TMP
VEG
Early YOY Brown Shrimp Biomass
0.06
0.04
0.02
0.00
0.1295 0.1300 0.1305
20 30 40
0.068 0.070 0.072
5.0 7.5 10.0
5.0 7.5 10.0 12.5
2 4 6
20.5 20.7 20.9
0.42 0.44 0.46 0.48
Production Run
PR 7
PR 6
FWOP
PR 5
PR 4
PR 1
PR 3

Evaluating Species Responses to River Diversion Scenarios

- Key species responses from initial conditions usually less than +/-10%
- Responses vary by species and are complex
  - Usually bottom-up prey (Chl-a) and salinity
  - Salinity, temperature, Chl a, vegetation:water, food web interactions differentially affect species and life stages within basins and by diversion scenarios
- Brown shrimp example how modelers, CPRA and agency scientists walked through results
- Ten key species of 32 taxa in food web were evaluated for seven restoration alternatives

CASM Conclusions and Next Steps

- Successful linking of large-scale numerical models from hydrodynamics to fish
- State used fish modeling results to support their diversion choice
- Caught between simplicity and generality vs. realism and detail, complexity of food web model
- Simplify food web with feeding guilds
- Compare single years to regenerating over time
- Compare habitat affecting prey v. modifying all