Using Ecopath with Ecosim to explore nekton community response to freshwater diversion into a Louisiana estuary

Kim de Mutsert

Ecosystem Modeling Workshop

March 12, 2012

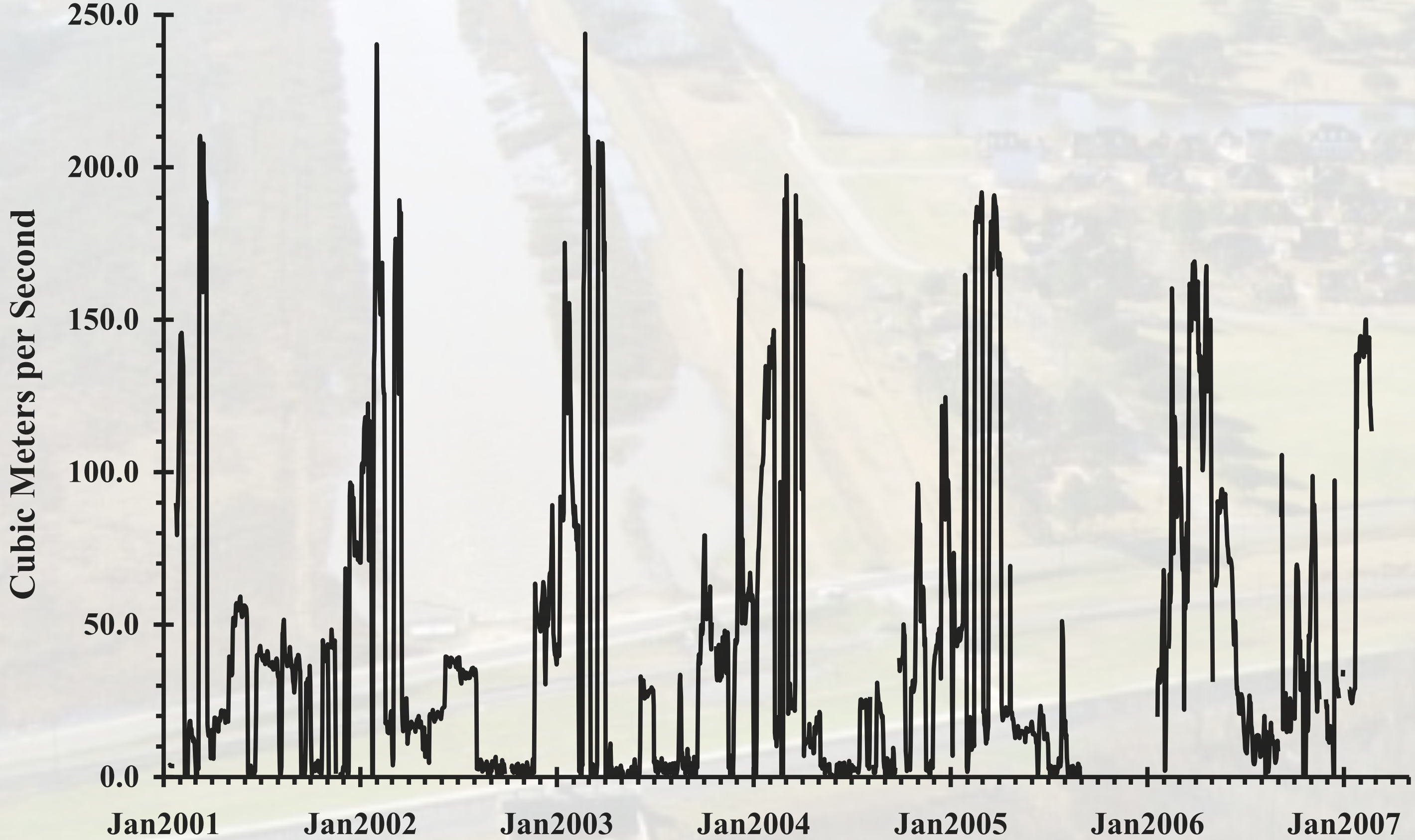
Outline

- Background research question
- Building an Ecopath model of the estuarine ecosystem
- Using Ecosim and forcing functions to address the question
- Model outcomes
- Next steps: end-to-end modeling and Ecospace


- Mississippi River
Mississippi River Diversions
Caernarvon diversion
Breton Sound
Largemouth bass
?
Brown shrimp
Spotted seatrout
?
http://visibleearth.nasa.gov

The Caernarvon Freshwater Diversion

Freshwater discharge through the CFD



sonris-www.dnr.state.la.us/www_root/sonris_portal_1.htm

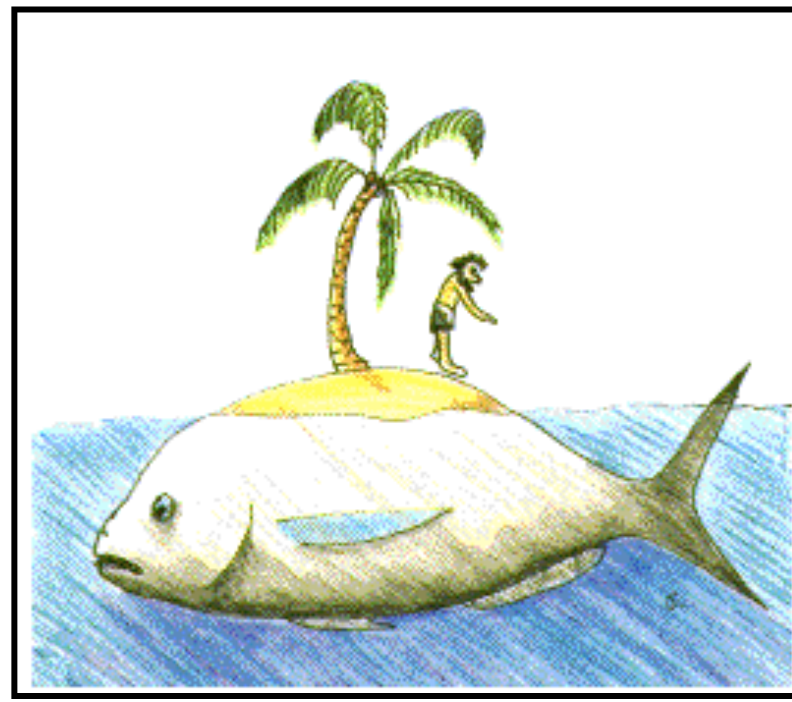
Picture: USACOE New Orleans District

Ecosystem modeling: Ecopath with Ecosim

Widely used for construction of mass-balance trophic models of ecosystems

Simulates response of fish to fishing and environmental change:

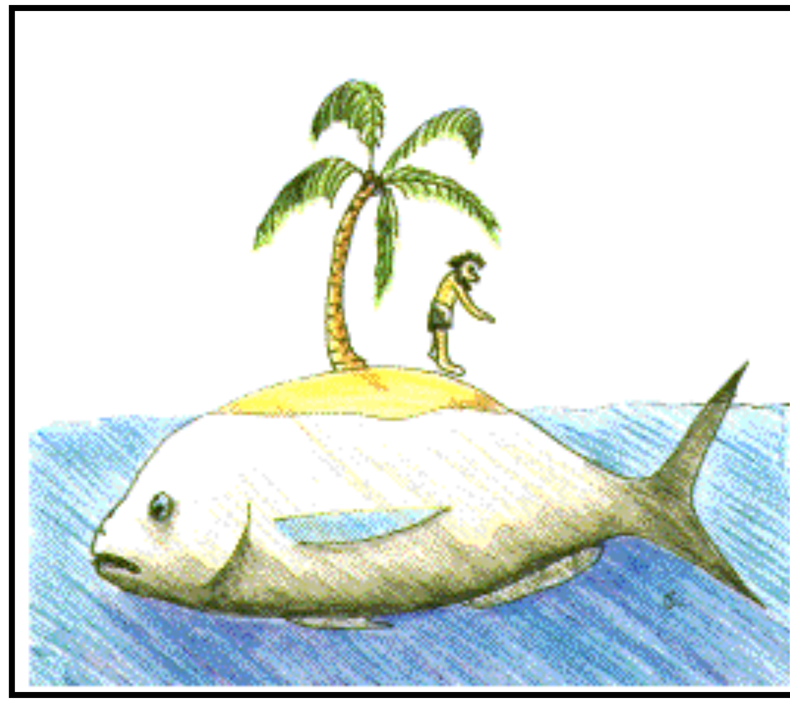
accounts for ecological interactions



Ecosystem modeling: Ecopath with Ecosim

Has three main components:

- Ecopath – a static snapshot of ecosystem trophic structure
- Ecosim – a time dynamic simulation module
- Ecospace – a spatial and temporal dynamic module



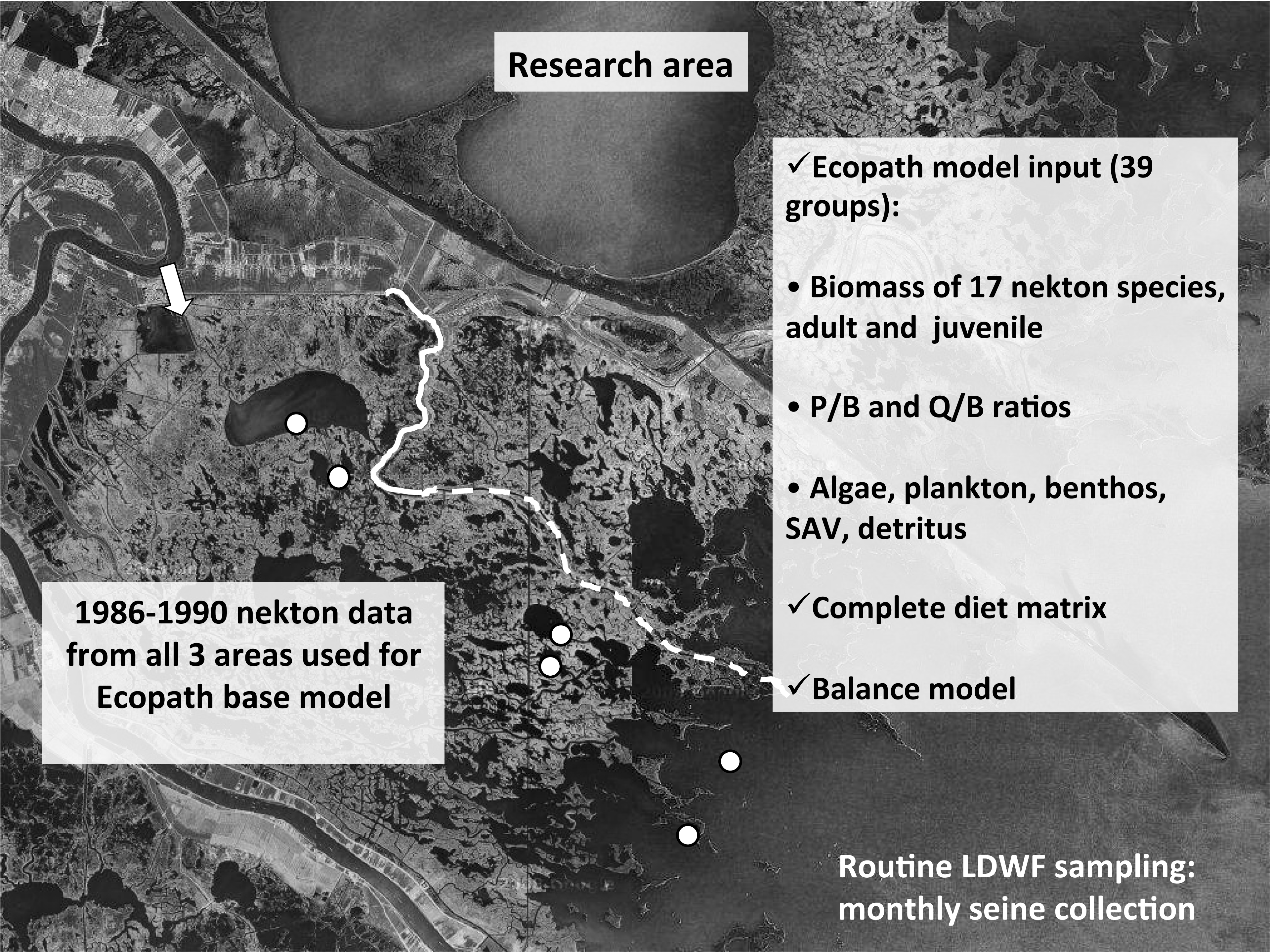
Modeling response to salinity changes

A new feature in Ecosim and Ecospace allows for fish (biomass) response to environmental forcing functions:

- Include species-specific response curve parameters to salinity

- Include time series of the salinity forcing function

- Temperature has been added to the software as well, and thereby the option to apply two forcing functions simultaneously
- Both can be modified to represent other environmental factors


Research area
✓Ecopath model input (39 groups):
• Biomass of 17 nekton species, adult and juvenile
• P/B and Q/B ratios
• Algae, plankton, benthos, SAV, detritus
✓Complete diet matrix
✓Balance model
1986-1990 nekton data from all 3 areas used for Ecopath base model
Routine LDWF sampling: monthly seine collection

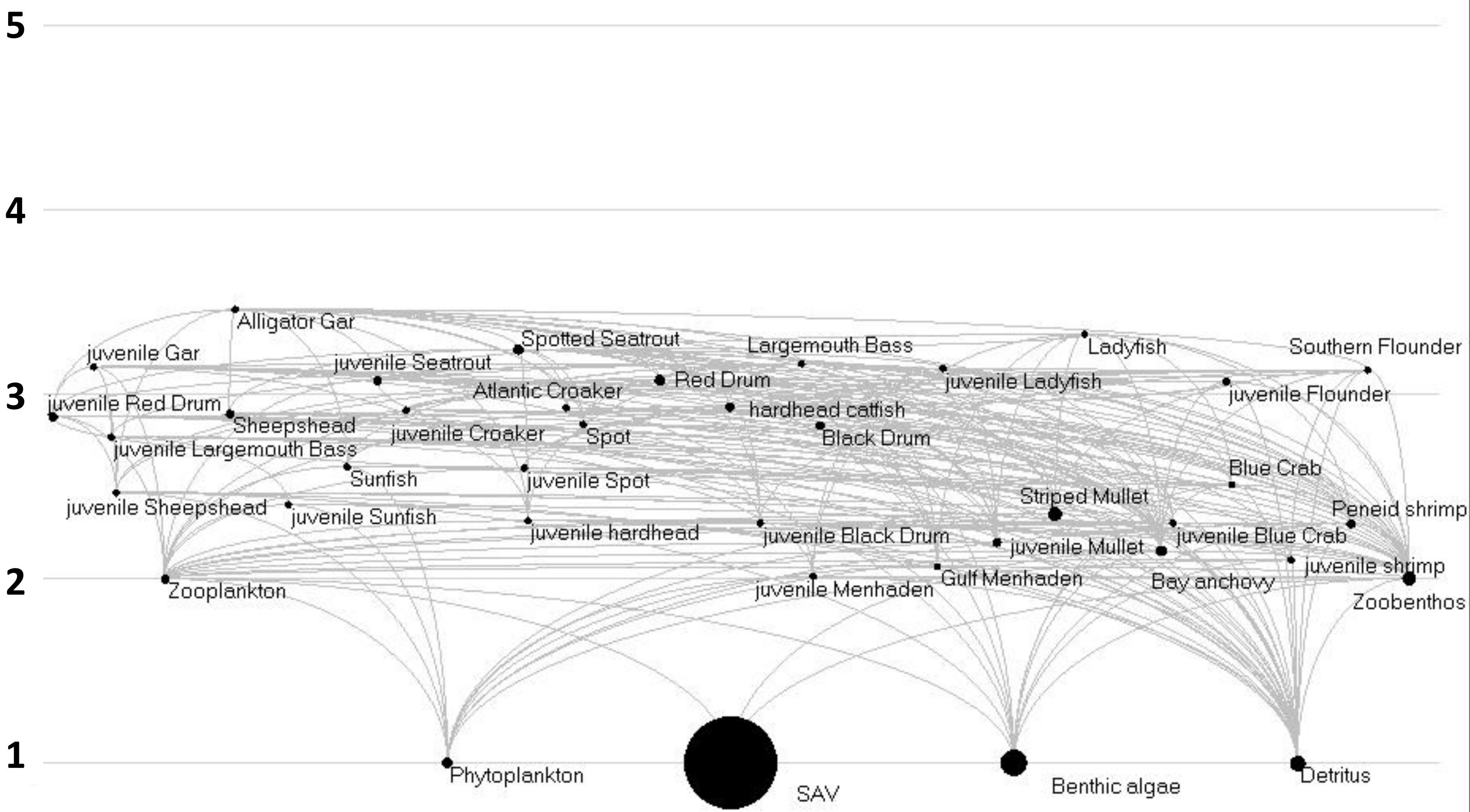
List of species/groups in the model

gar sp.	gulf menhaden
spotted seatrout	striped mullet
red drum	bay anchovy (+ small forage fish)
largemouth bass	blue crab
sheepshead	penaeid shrimp (brown,white,pink)
sunfish	zooplankton
ladyfish	zoobenthos (+ grass shrimp)
Atlantic croaker	phytoplankton
spot	macro algae/SAV
catfish sp.	benthic algae
black drum	detritus
Southern flounder	

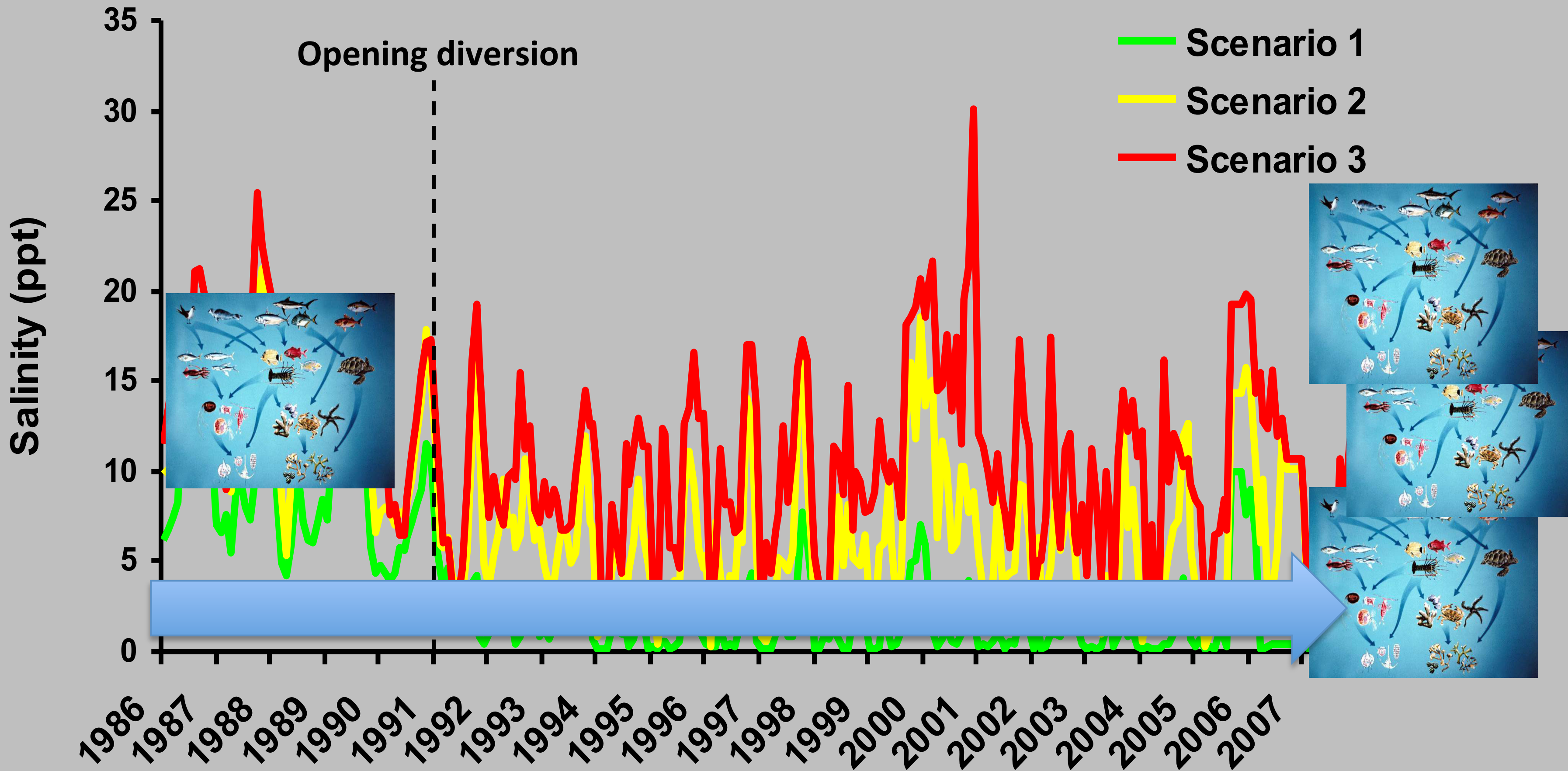
The Breton Sound Ecopath model: output

Group name	Trophic level	biomass (g/m²)	P/B	Q/B	EE	P/Q
juvenile Gar	3.147256	5.31E-05	2	9.649451	0.3336831	0.2072657
Gar	3.459231	0.0376	0.193	1.49	0	0.1295302
juvenile Seatrout	3.07791	0.5272942	3.7	6.441572	0.04098525	0.5743939
Spotted Seatrout	3.242222	1.88	0.7	1.6	0.000927416	0.4375
juvenile Red Drum	2.880879	0.2803999	2.2	4.86953	0.2484199	0.451789
Red Drum	3.075991	1.526	0.62	1.86	0.06495768	0.3333333
juvenile Largemouth Bass	2.7668	0.000209998	2	9.010589	0.8733456	0.2219611
Largemouth Bass	3.164393	0.0063	0.6	2.814	0.2964233	0.2132196
juvenile Sheepshead	2.4646	0.00356516	2	28.89982	0.8803409	0.06920458
Sheepshead	2.895	0.396	0.417	6.359	0.4075314	0.06557634
juvenile Sunfish	2.4	3.61E-05	2	12.27996	0.9183455	0.1628669
Sunfish	2.6065	0.0004	0.8	4.966	0.7156363	0.1610955
juvenile Ladyfish	3.138906	0.009840218	2.8	18.14661	0.9046535	0.1542988
Ladyfish	3.324245	0.0932	1.6	6	0.8068669	0.2666667
juvenile Croaker	2.912175	0.01361376	2	20.03493	0.9407493	0.09982565
Atlantic Croaker	2.9251	0.0454	1.5	10	0.7792511	0.15

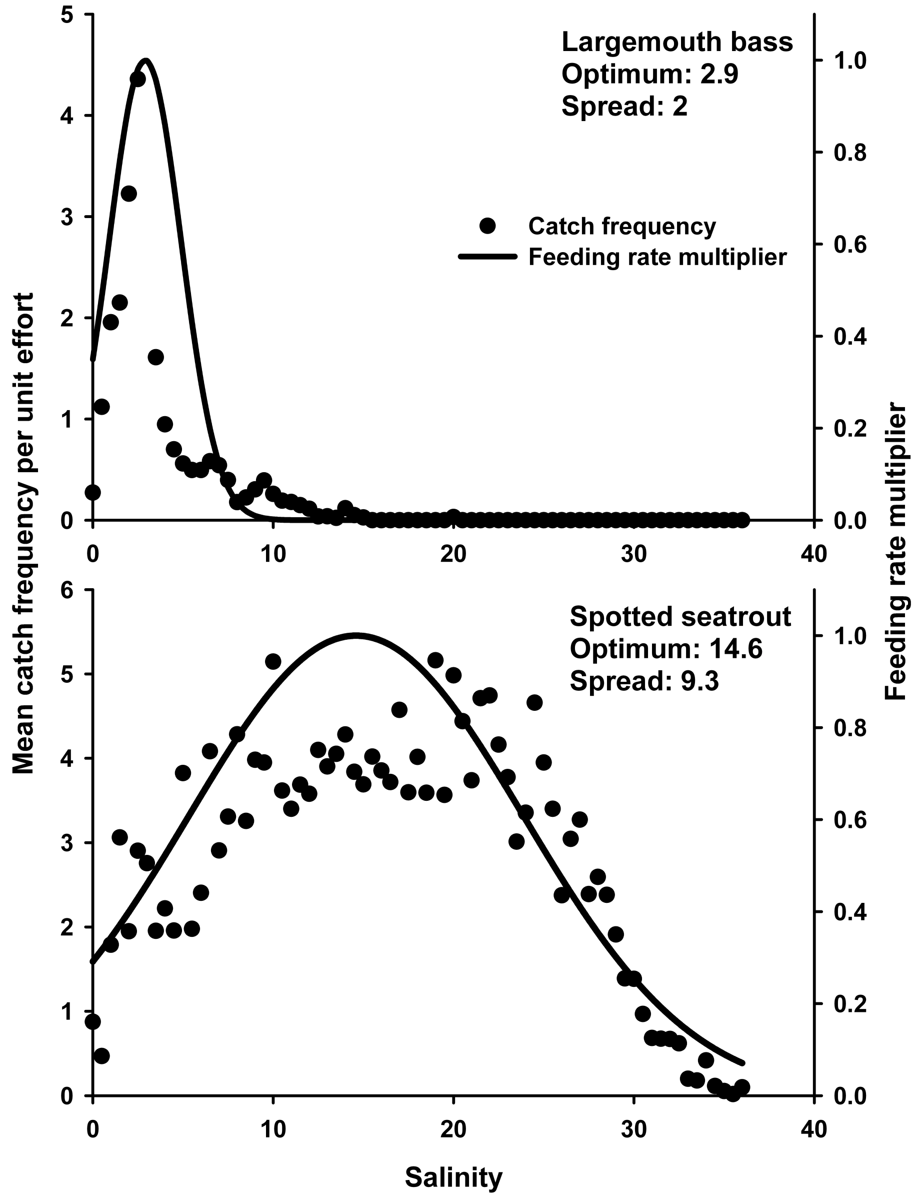
Breton Sound Ecopath model



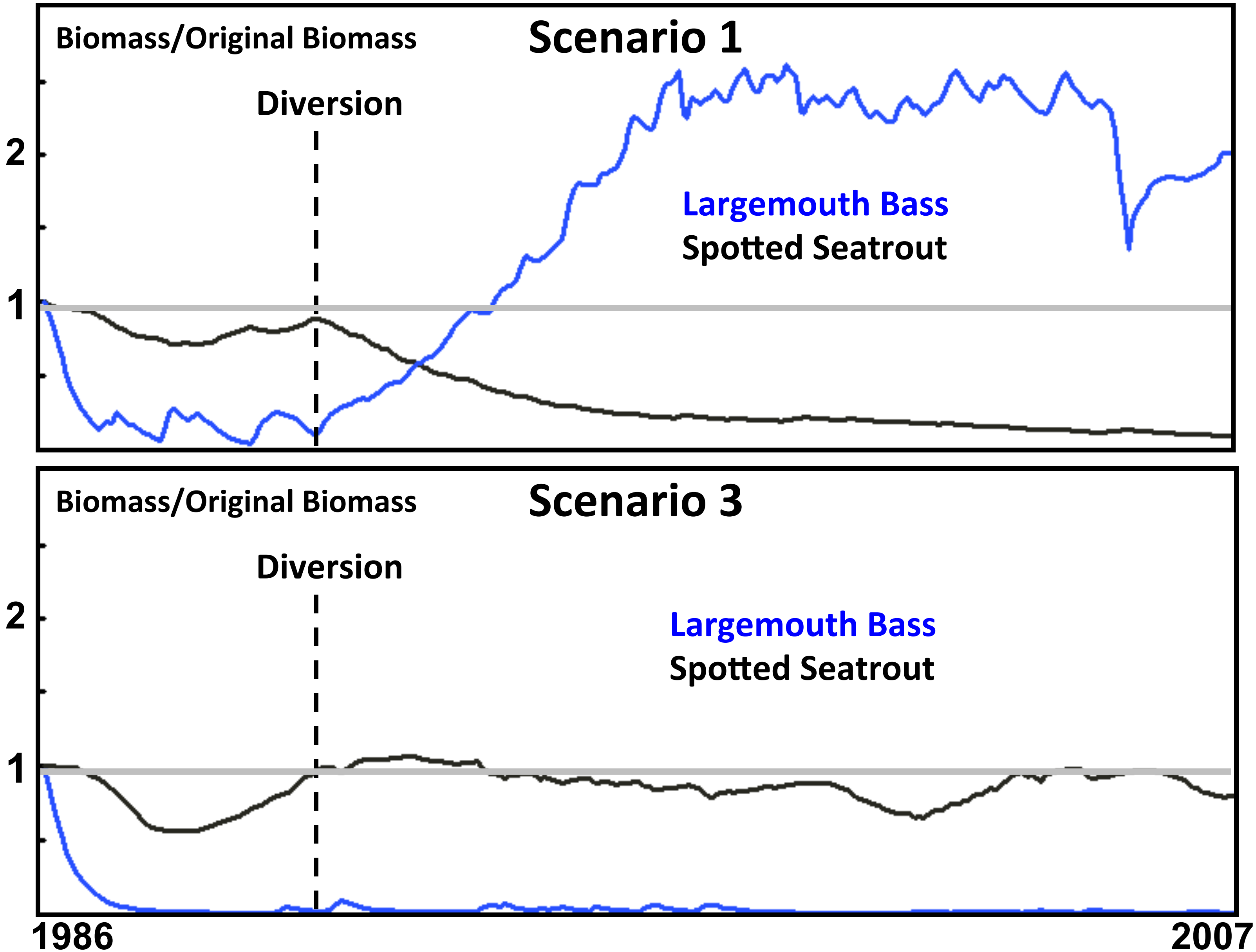
New: Ecosim can simulate nekton response to salinity changes



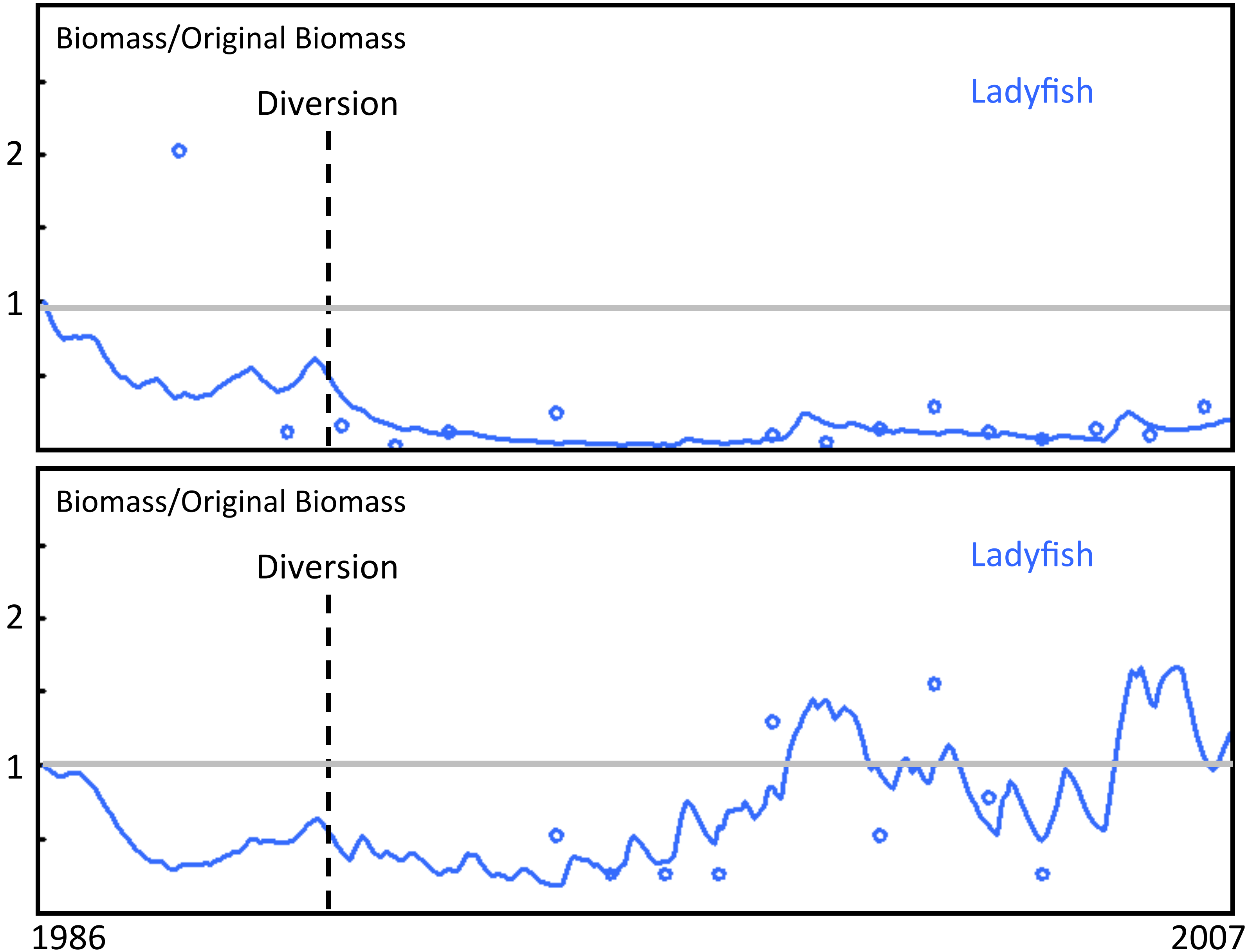
The effect of the salinity forcing function on fishes is a function of species-specific response curves

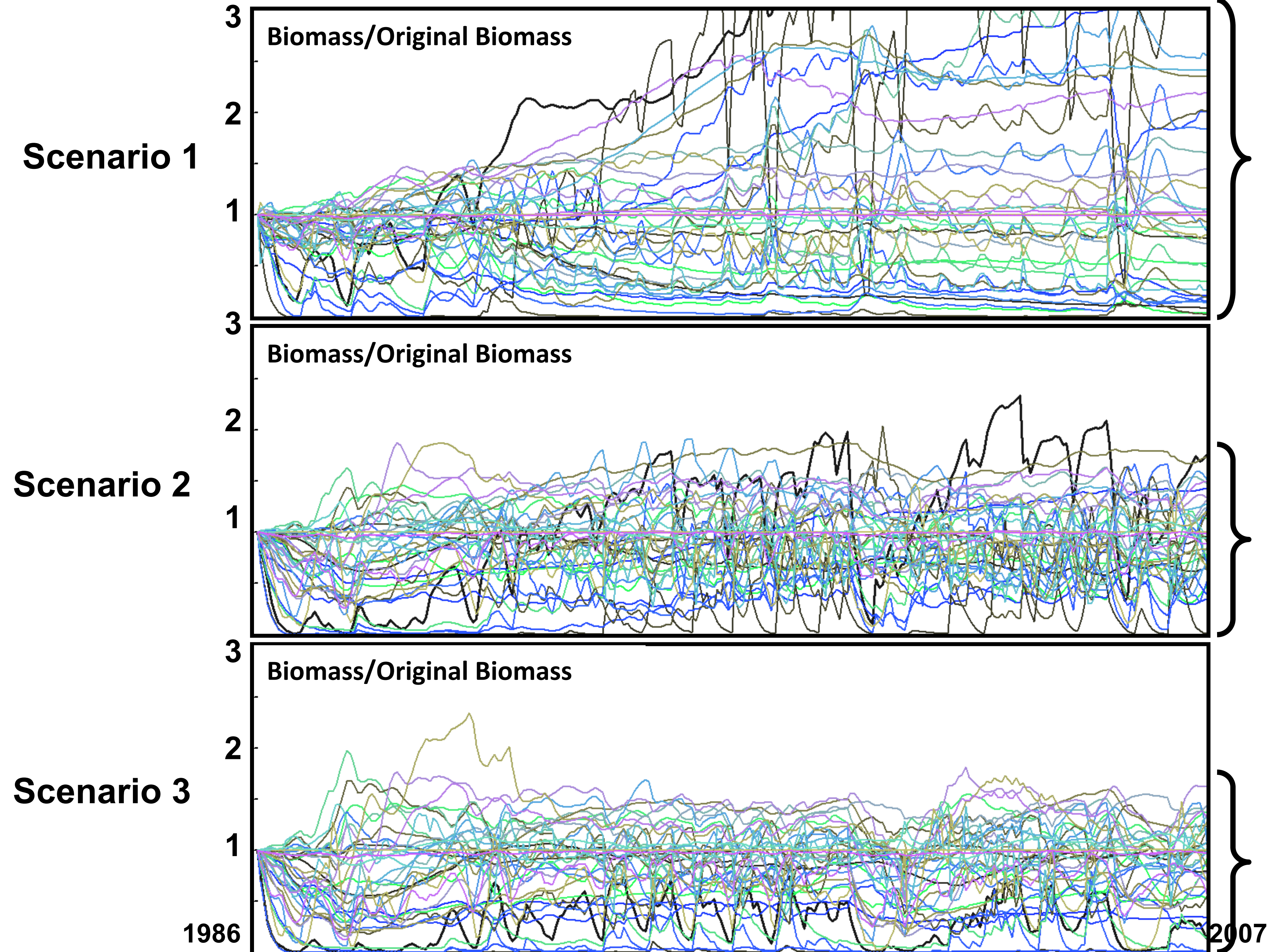


Output largemouth bass and spotted seatrout

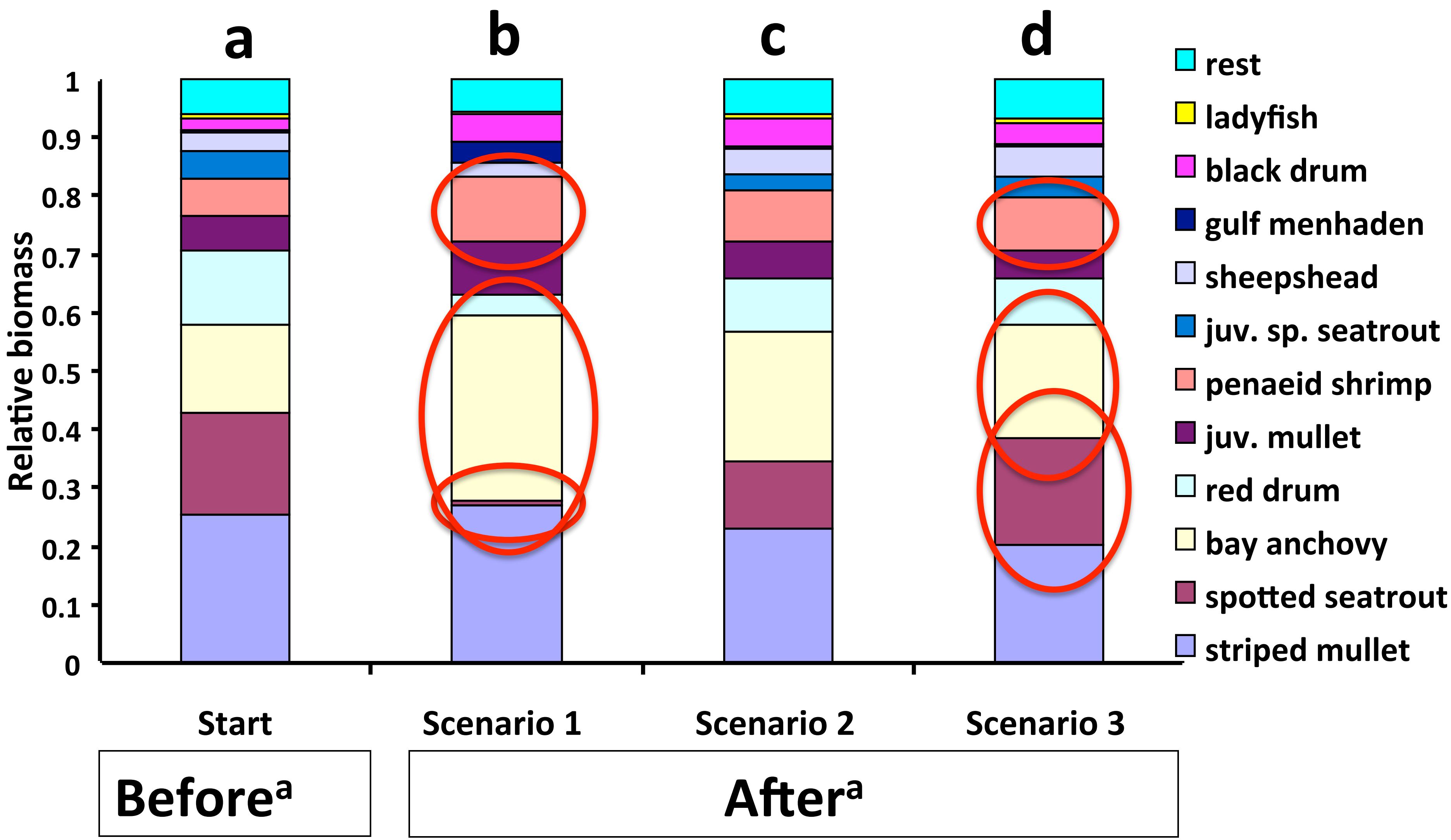


Compare Ecosim runs with time series data




Scenario 1
Scenario 2
Scenario 3
Biomass/Original Biomass
Biomass/Original Biomass
Biomass/Original Biomass
3
2
1
3
3
2
1
3
2
1
1986
2007

Nekton community Ecopath (start) and end of 3 Scenarios



Summary Ecopath with Ecosim simulations

- The salinity forcing function in EwE provides estuarine ecologists with an important modeling tool

- Current simulations:

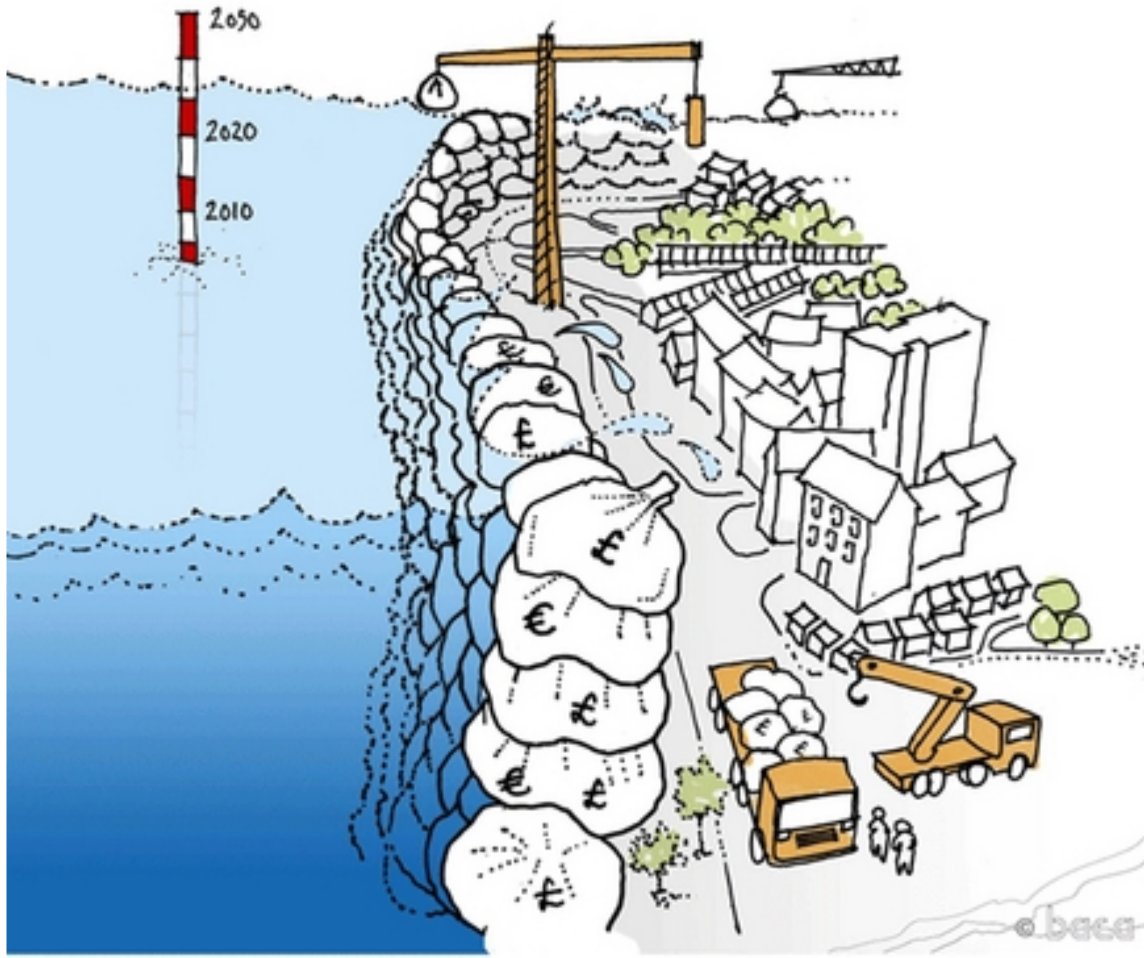
- No ecologically or recreationally important nekton species decline, some even increase in biomass

- Salinity affects the spatial distribution of species within the estuary

- Small forage species increase in low salinity due to reduced predation pressure

Should we include river diversions in coastal restoration?

It should not be discouraged because of presumed negative impacts on fish and shrimp



IS THIS THE ONLY SOLUTION?

Next steps: Forecast effect of diversion flow scenarios

- How will nekton community structure change when the diversion is open at full capacity/ is closed/ is managed with a particular flow regime?

- How will this scenario affect the biomass of a particular species of interest?

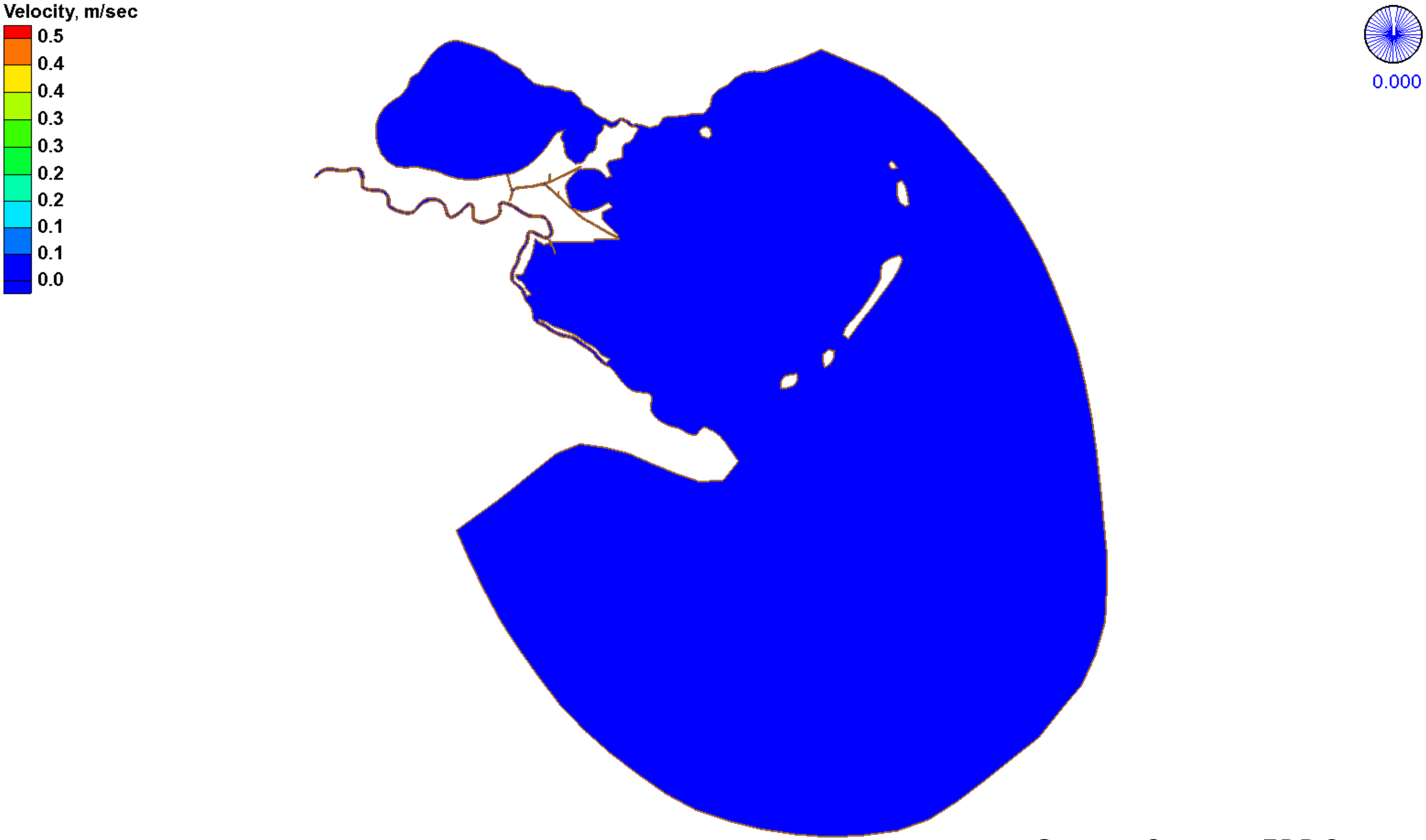
- In combination with Ecospace:

- How will scenario x affect the distribution of a species of interest?

- What area of the estuary will be suitable habitat for a species of interest when the diversion is managed with flow scenario x?

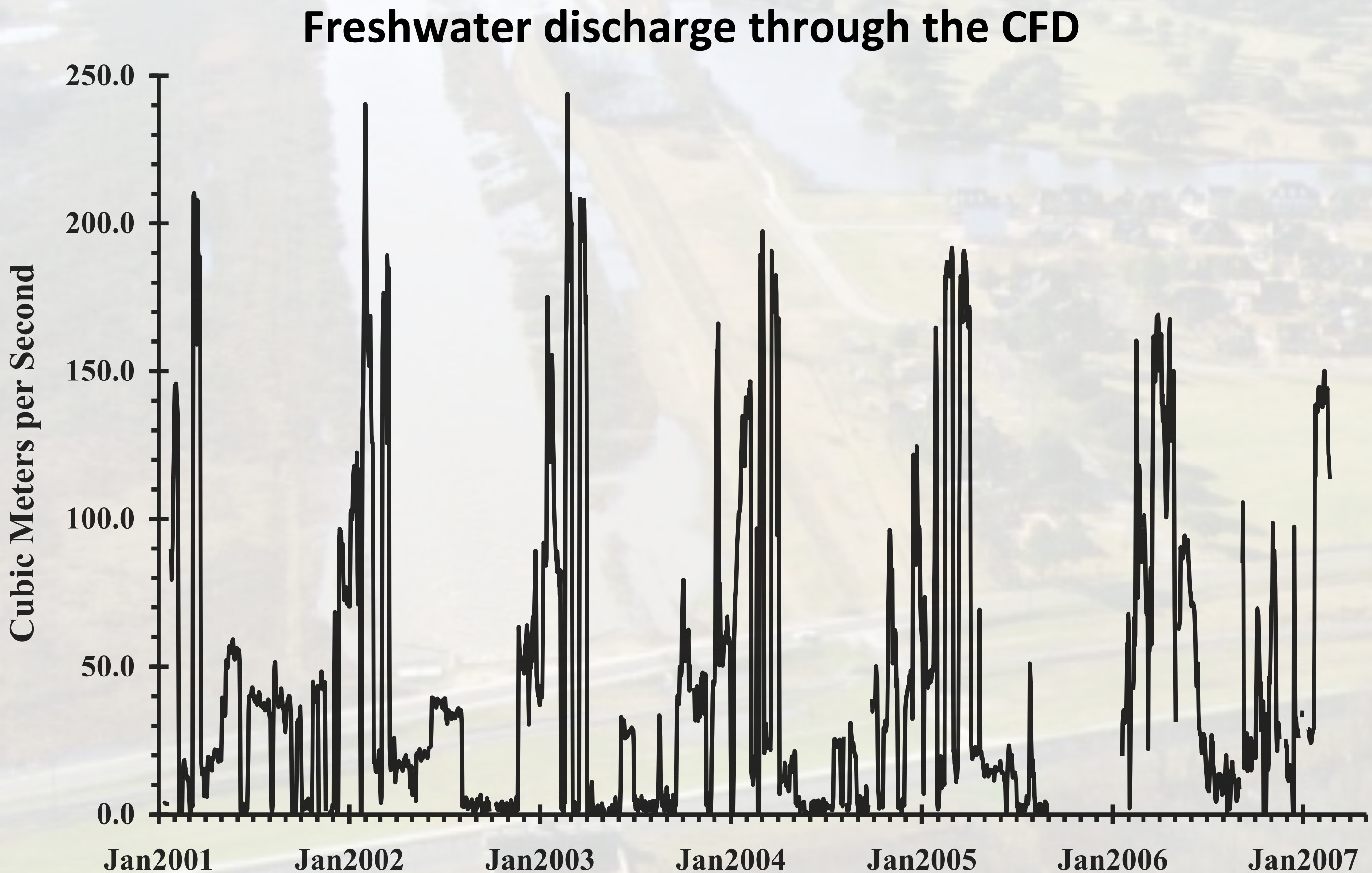
Breton Sound ADH Model

Scenario: Caernarvon diversion planned flow regime



Gaurav Savant, ERDC

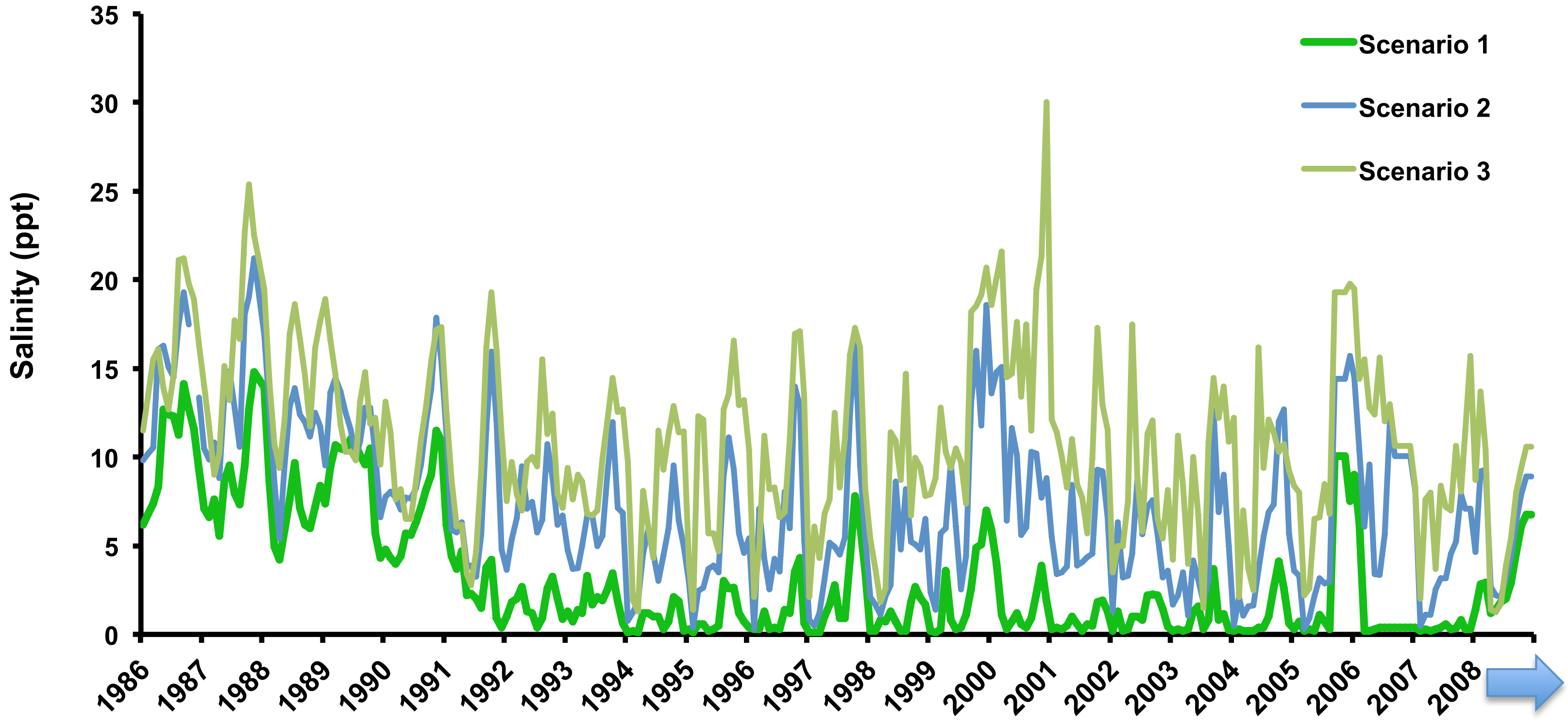
The Caernarvon Freshwater Diversion



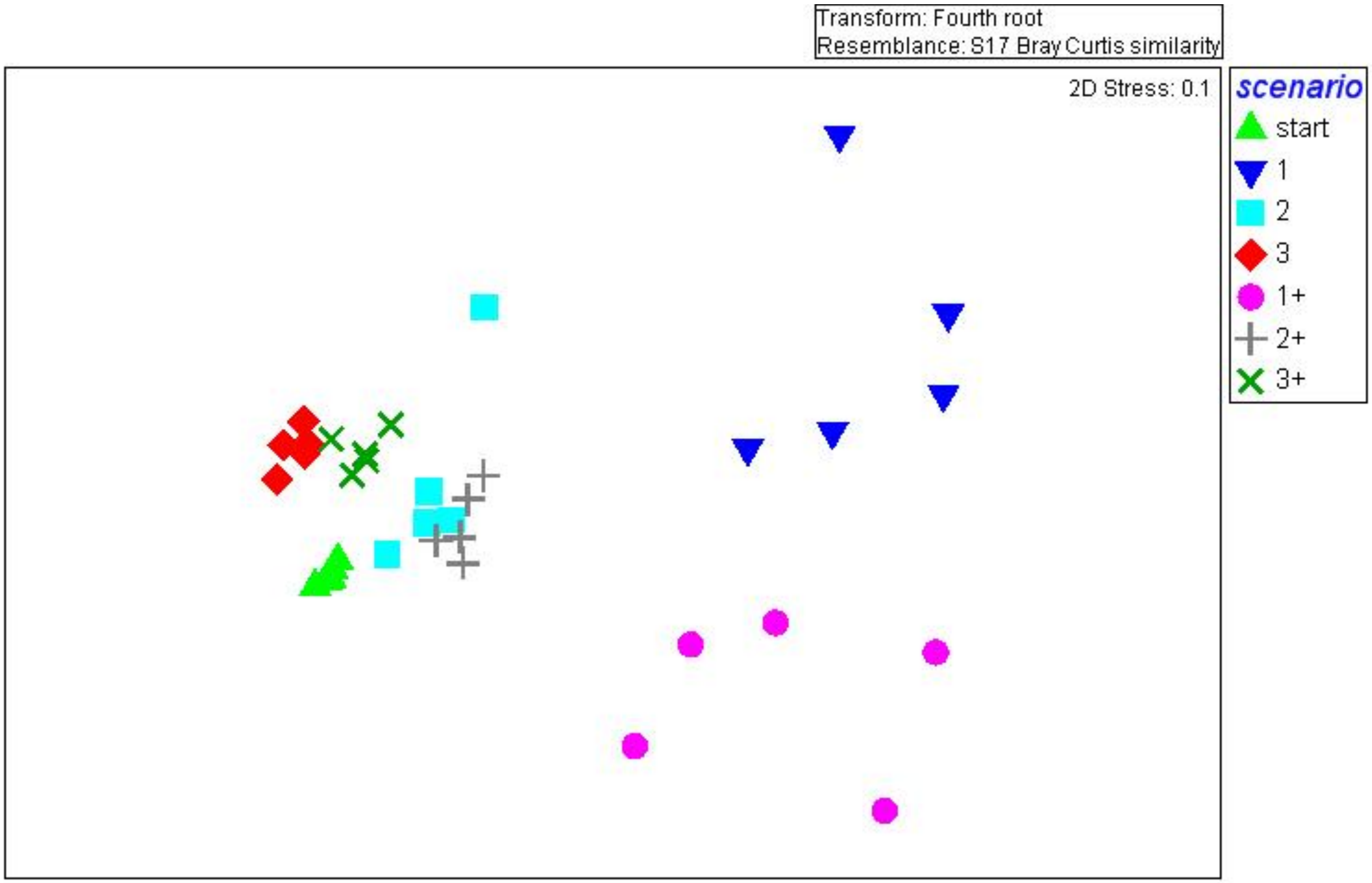
sonris-www.dnr.state.la.us/www_root/sonris_portal_1.htm

Picture: USACOE New Orleans District

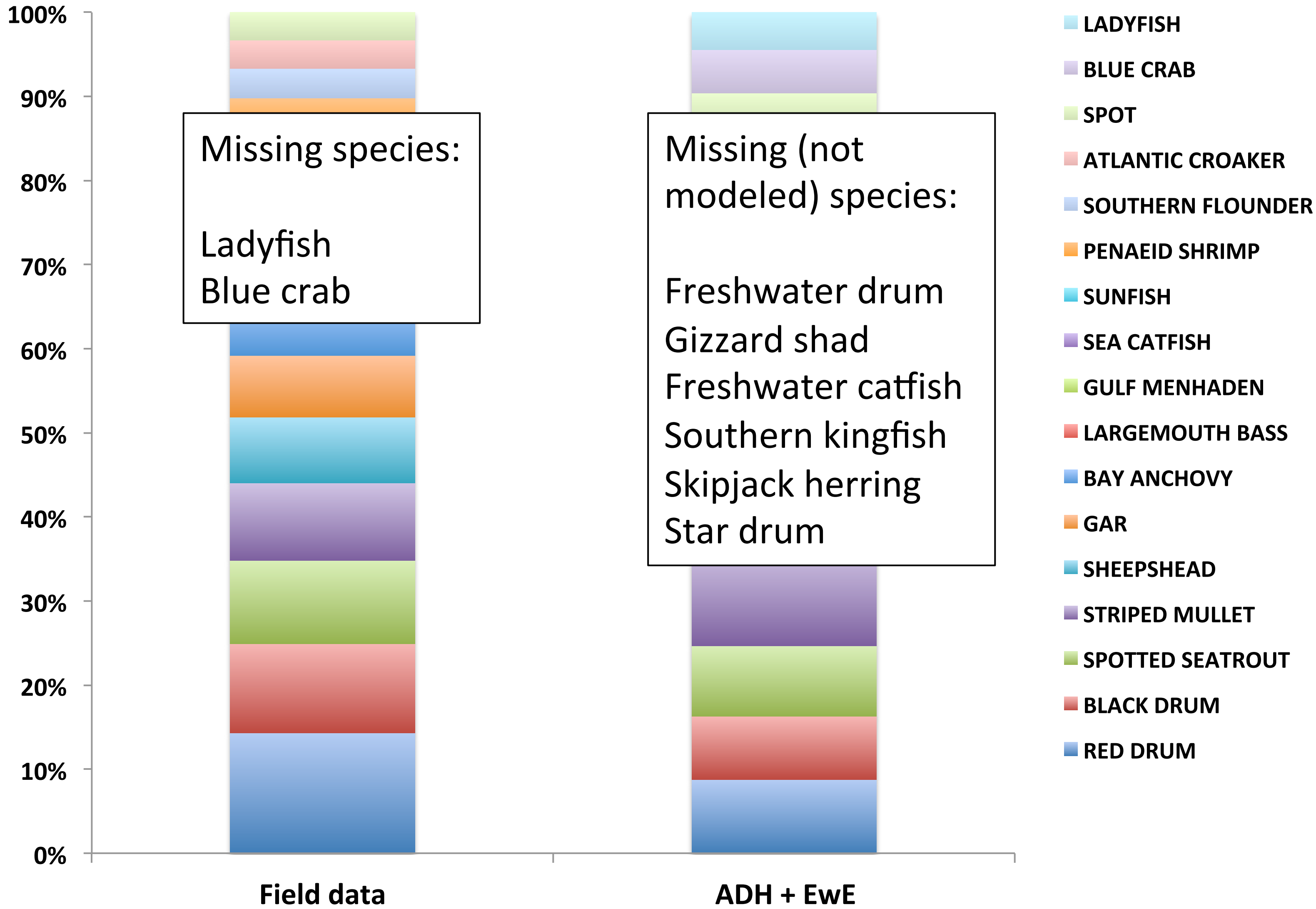
First output: 1-year salinity results in same three areas



MDS plot community structures of the 3 scenarios with and without 1 year ADH salinities



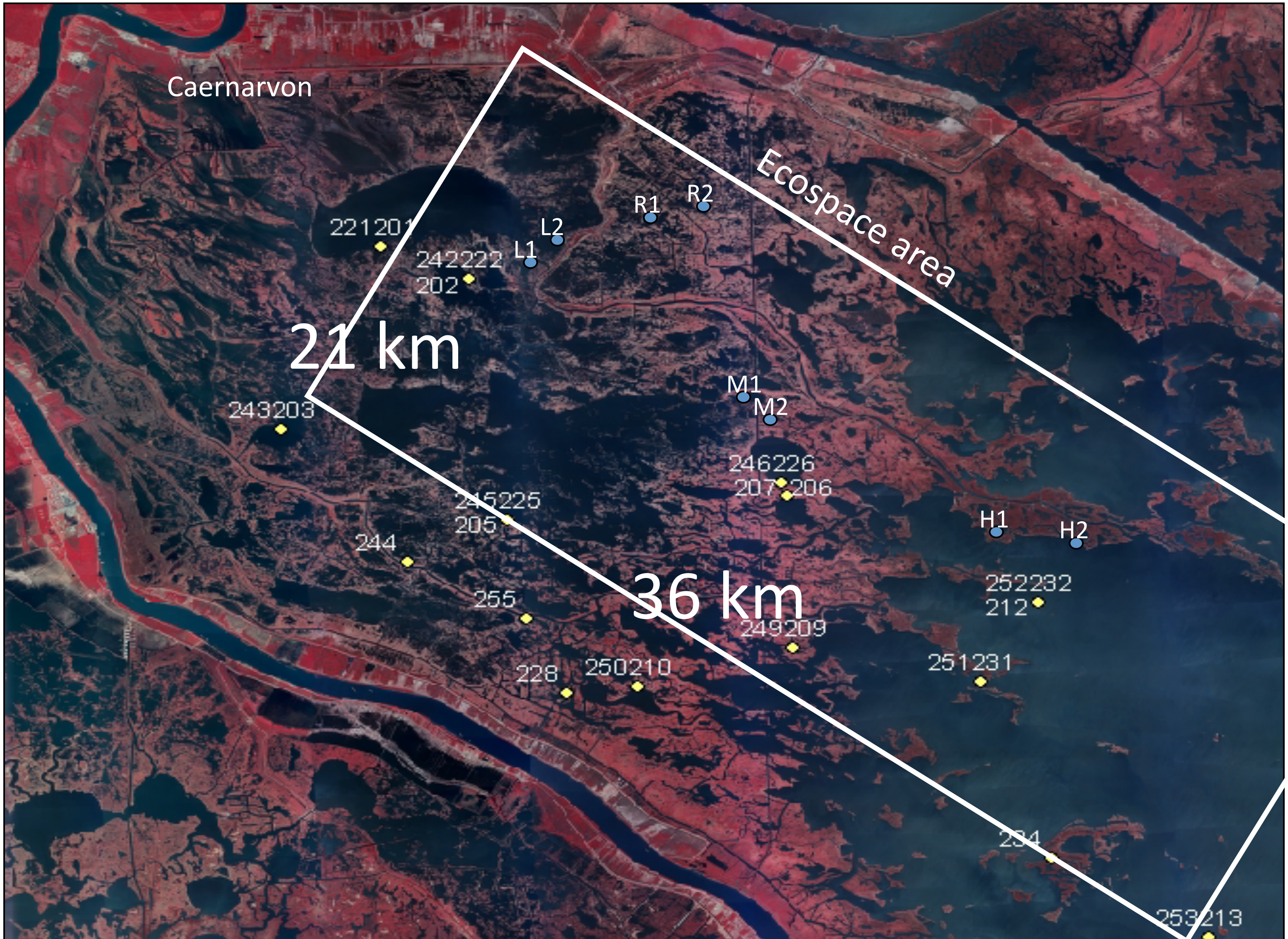
Compare ADH + EwE output with actual estuarine nekton community under similar salinity conditions as ADH scenario (2006-2008)



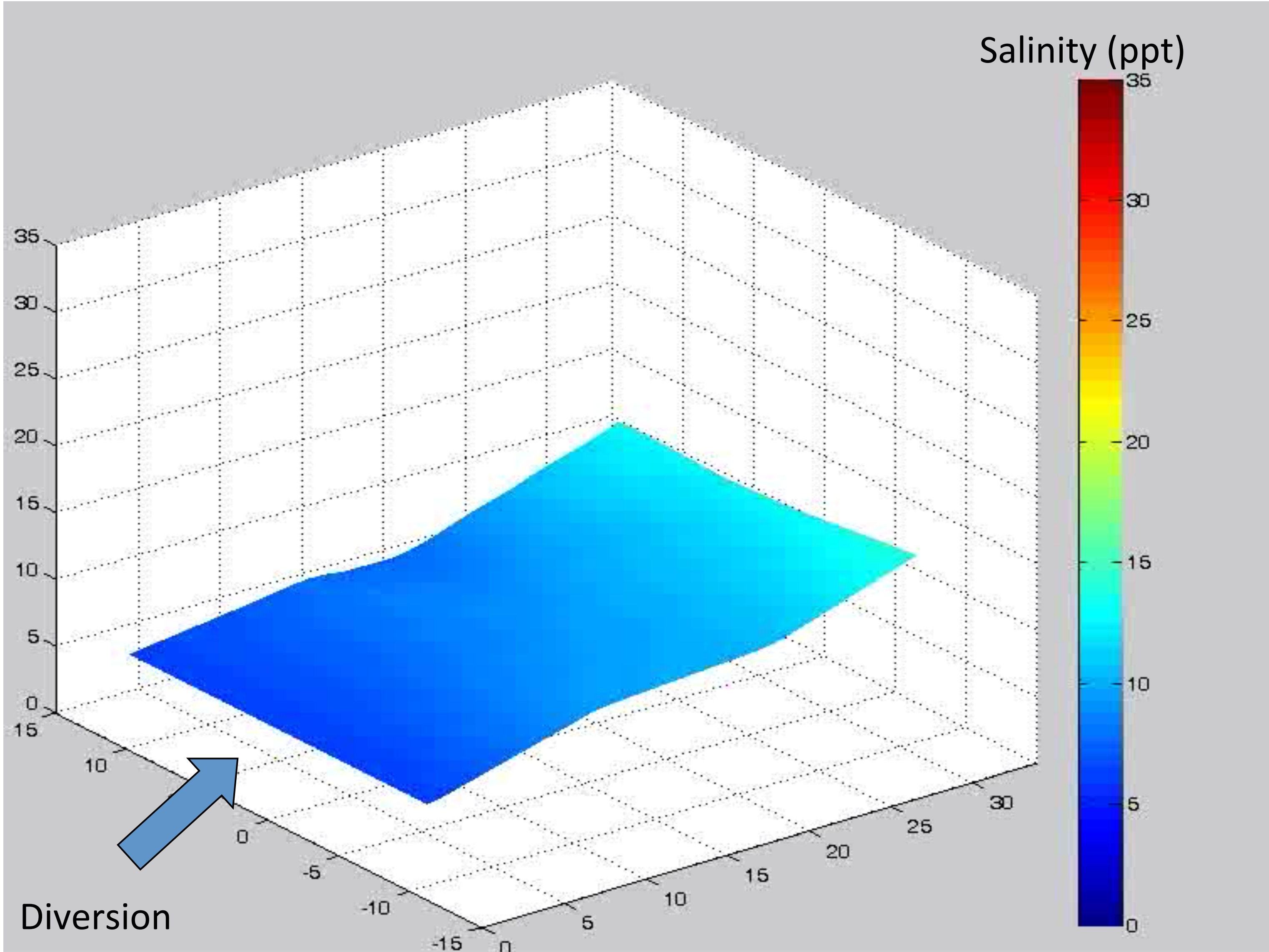
Ecospace model

- Ecospace replicates the foodweb structure in each model grid cell
- 1x1 km cells, 21x36 km grid
- Cells have habitat ‘type’ (dense marsh, open marsh, open water), species use one or more types
- Cells have time dynamic salinity
- Nekton spatial movement dependent on cell habitat type and salinity (each species can decide to stay or move)

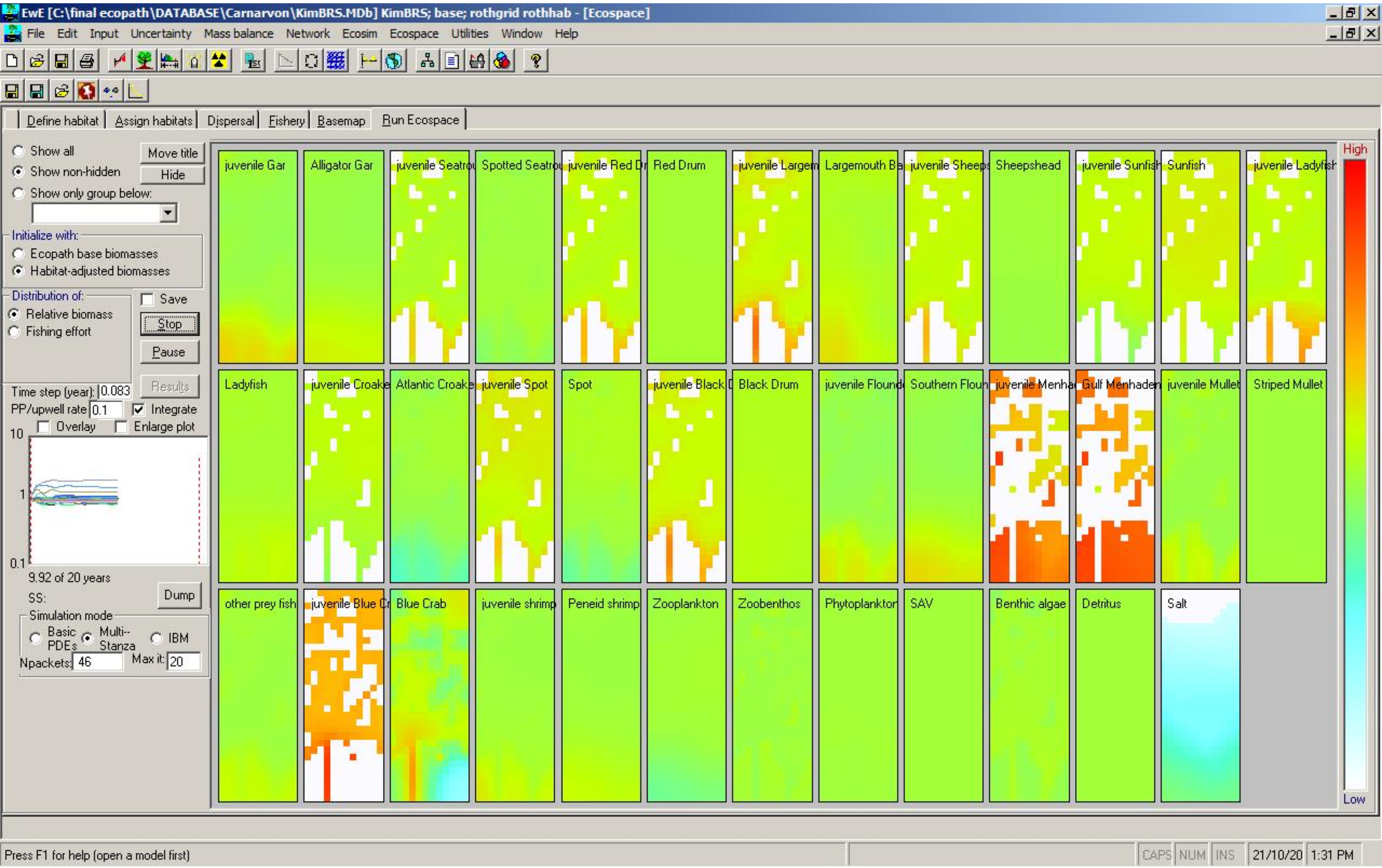
Model area


Caernarvon
Ecospace area
21 km
36 km
221201
242222
202
L1
L2
R1
R2
M1
M2
243203
246226
207
206
245225
205
244
255
H1
H2
252232
212
249209
228
250210
251231
234
253213

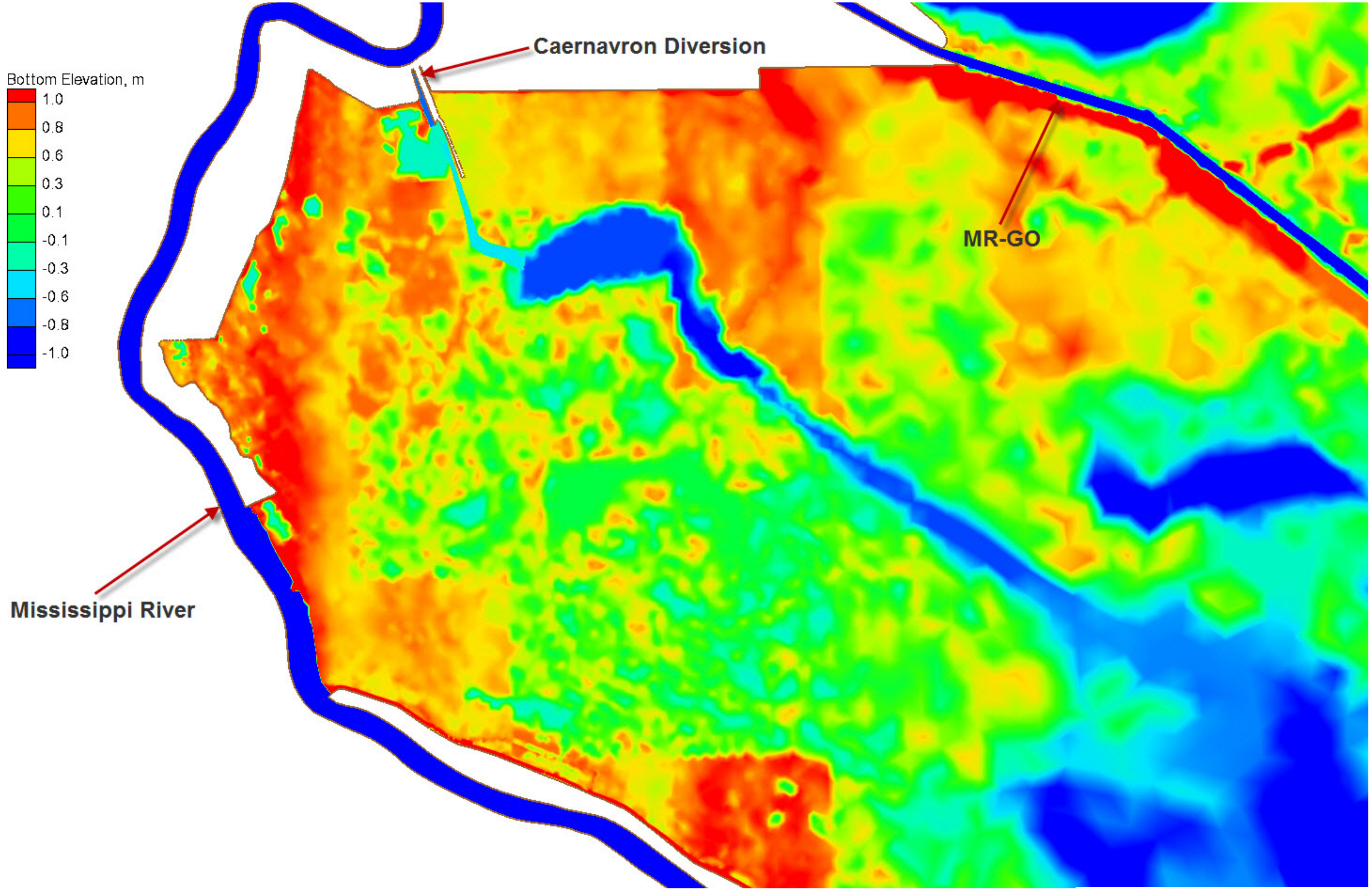
Future directions



Interface (v. 5.1)



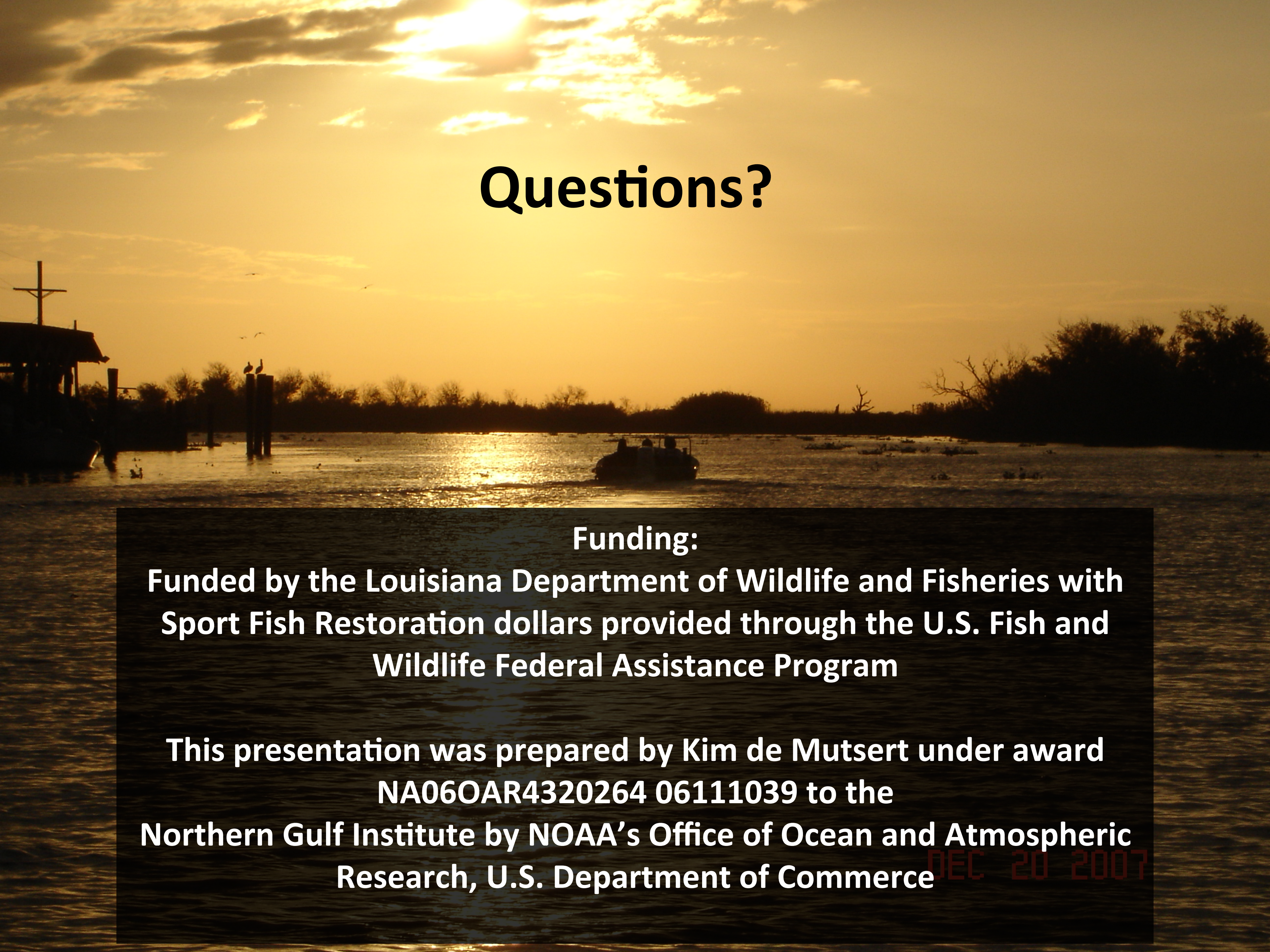
Improve habitat map (Bathymetry/GIS)



Savant, ERDC

Final notes

- This research is an example of a very ‘ecological’ use of the EwE modeling software
- The salinity forcing function adds a useful tool to the EwE software for estuarine ecologists
- The advantage of addressing these questions with an ecosystem model is that trophic interactions and indirect effects can be revealed

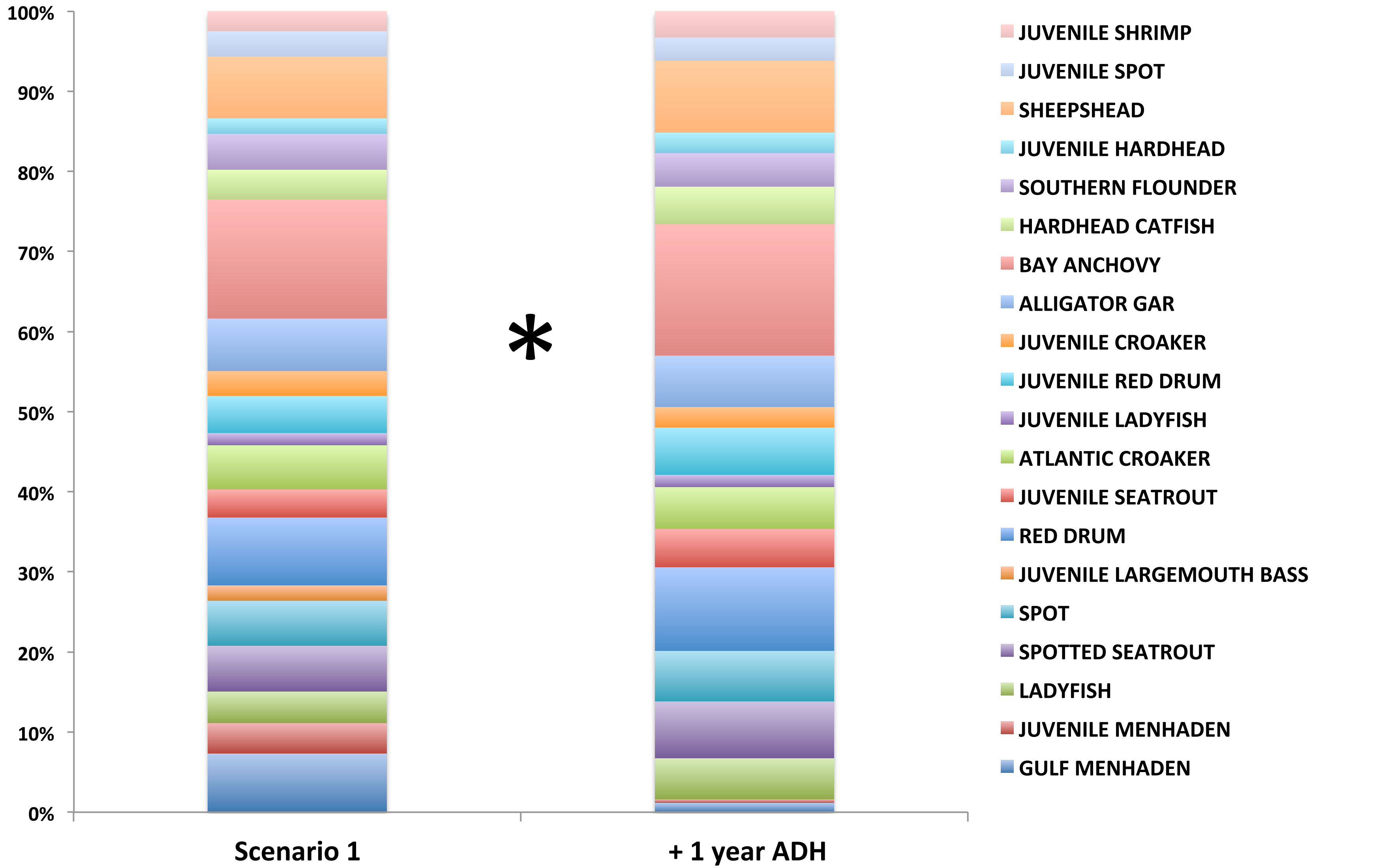


Questions?

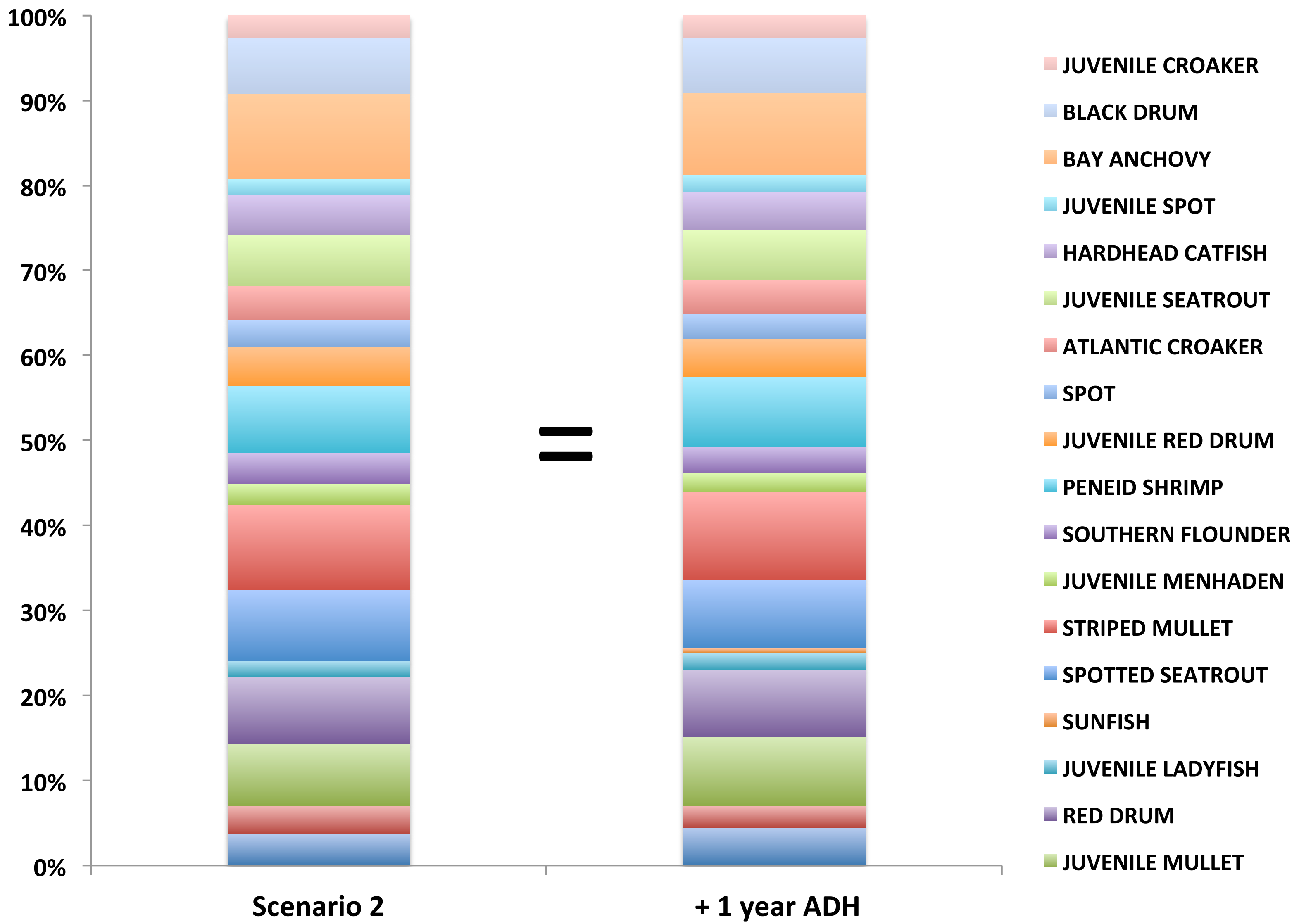
Funding:
Funded by the Louisiana Department of Wildlife and Fisheries with Sport Fish Restoration dollars provided through the U.S. Fish and Wildlife Federal Assistance Program

This presentation was prepared by Kim de Mutsert under award NA06OAR4320264 06111039 to the Northern Gulf Institute by NOAA's Office of Ocean and Atmospheric Research, U.S. Department of Commerce

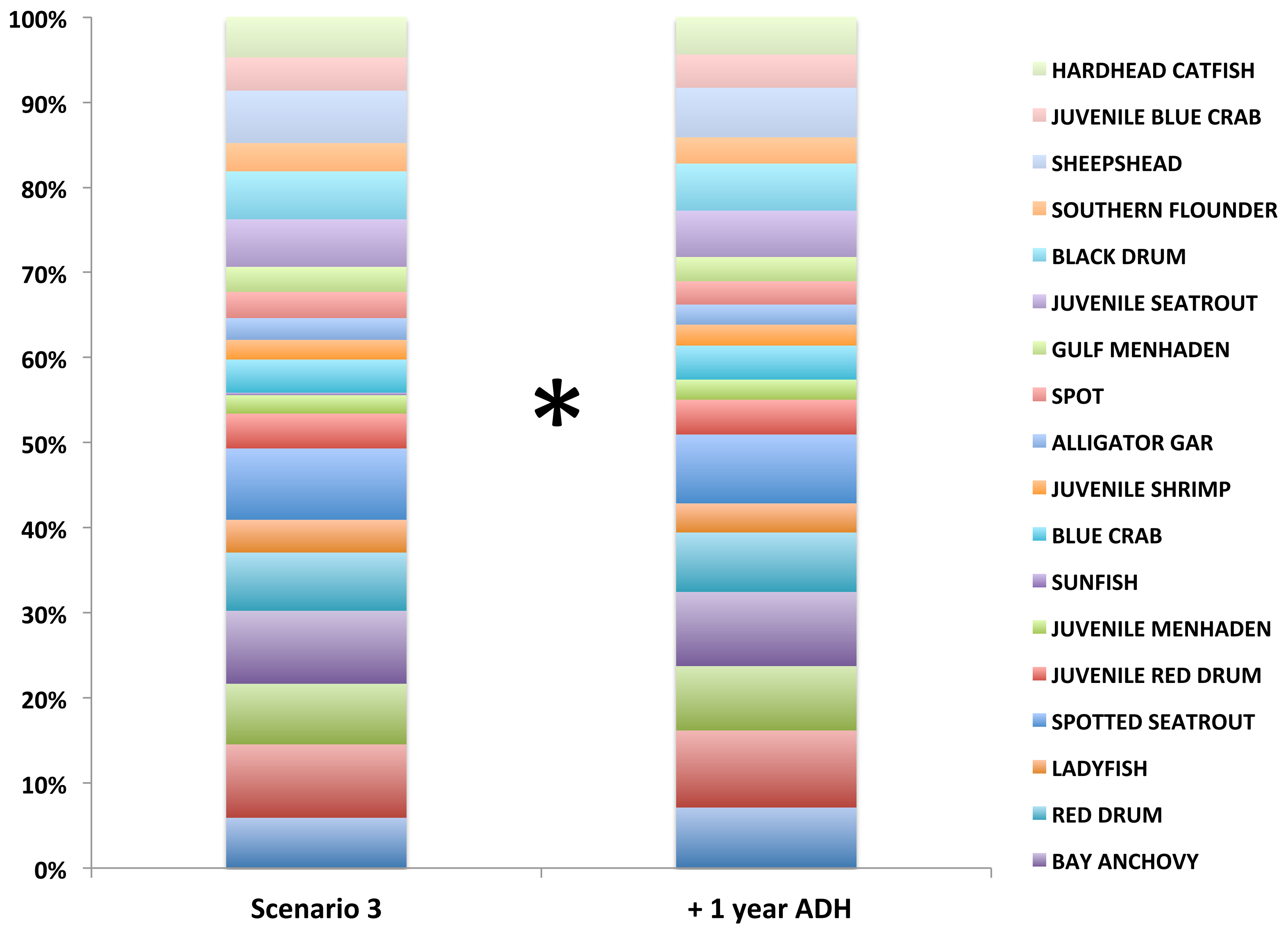
Community structure Scenario 1 before and after ADH salinity run
Species explaining 90% of dissimilarity



Community structure Scenario 2 before and after ADH salinity run
Species explaining 90% of dissimilarity



Community structure Scenario 3 before and after ADH salinity run
Species explaining 90% of dissimilarity



Community structure whole estuary before and after ADH salinity run
Species explaining 90% of dissimilarity