Modeling a Coastal Environment with Human Elements

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CSDMS Annual Meeting 2017

May 24, 2017

GEORGE MASON UNIVERSITY

Ecological Modeling

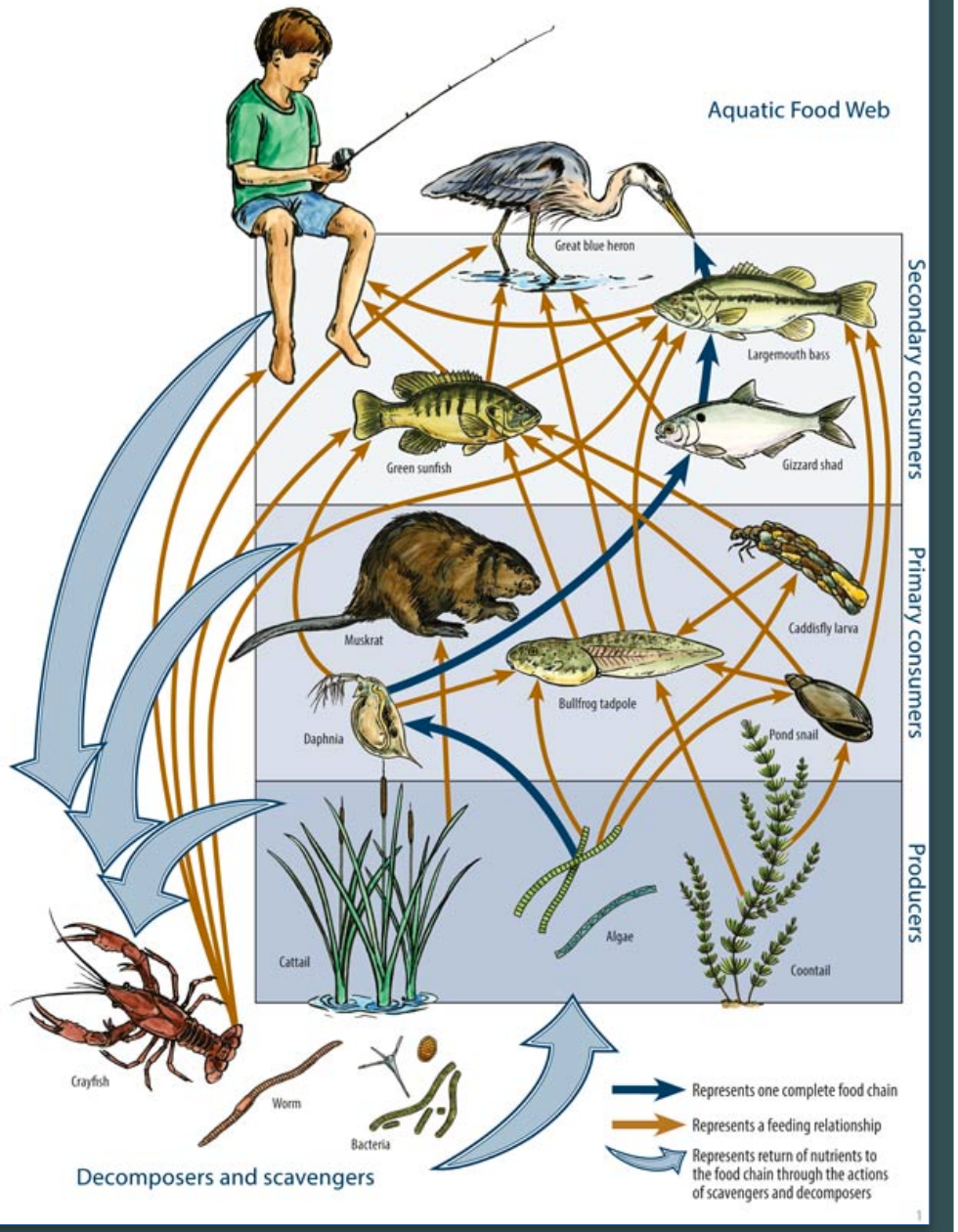
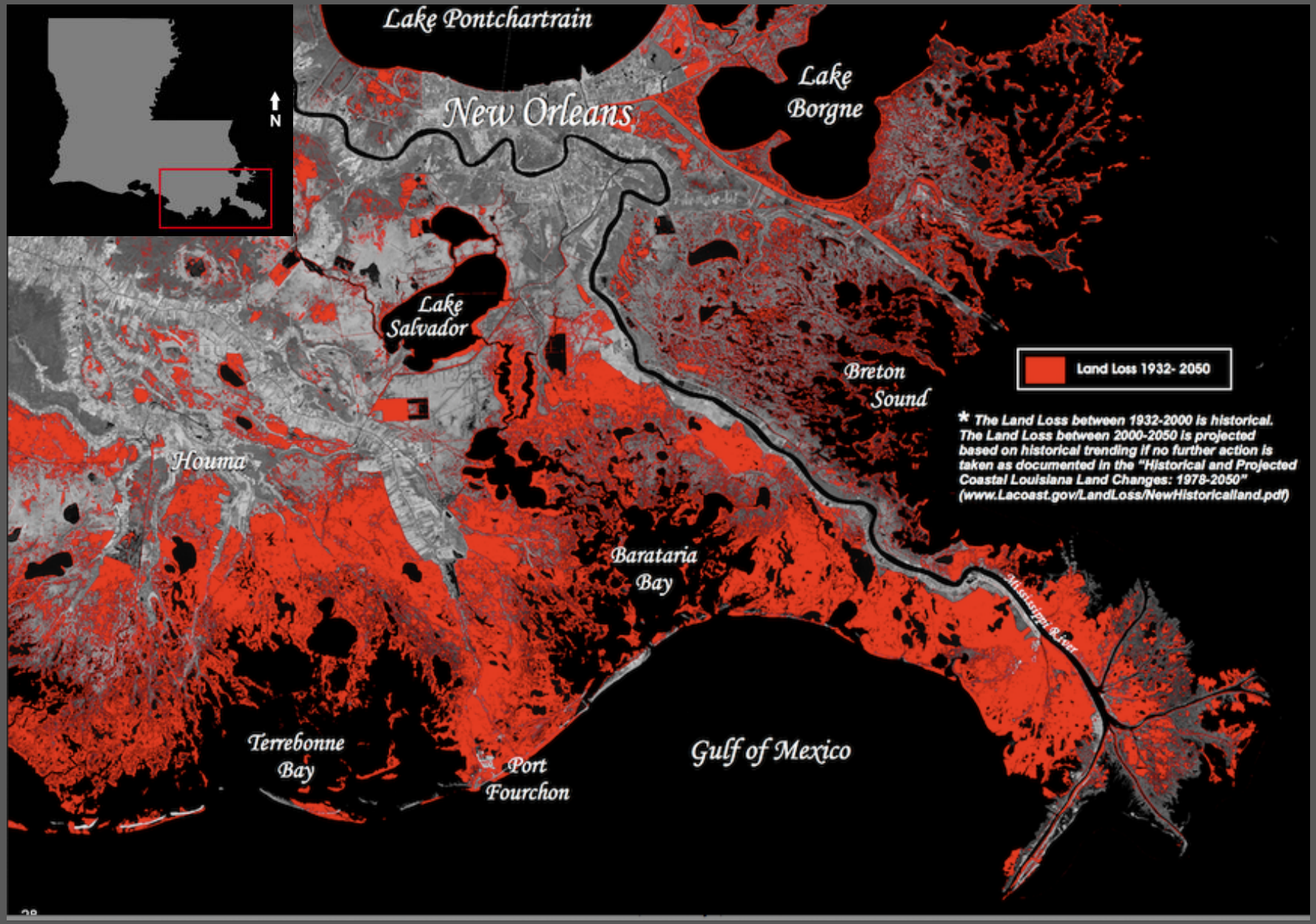


Image: Texasaquaticscience.org

Application of Ecosystem Models

- Ecosystem-Based Management of Fisheries
- Ecosystem Restoration

Grüss et al. 2017

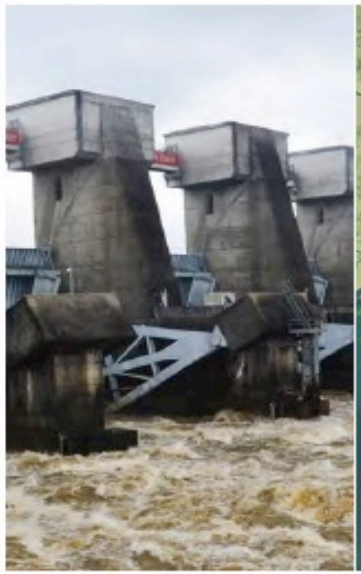
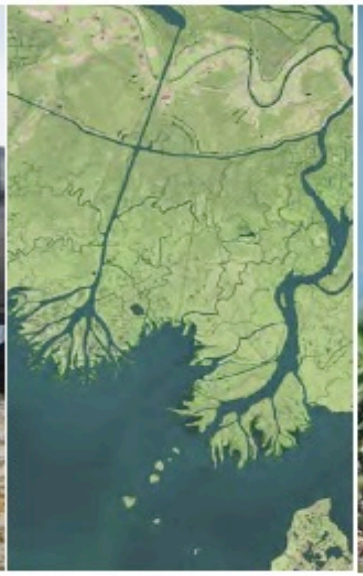

Lake Pontchartrain
New Orleans
Lake Borgne
Lake Salvador
Breton Sound
Houma
Barataria Bay
Terrebonne Bay
Port Fourchon
Gulf of Mexico
Mississippi River
N
Land Loss 1932- 2050
* The Land Loss between 1932-2000 is historical. The Land Loss between 2000-2050 is projected based on historical trending if no further action is taken as documented in the "Historical and Projected Coastal Louisiana Land Changes: 1978-2050" (www.Lacoast.gov/LandLoss/NewHistoricalland.pdf)

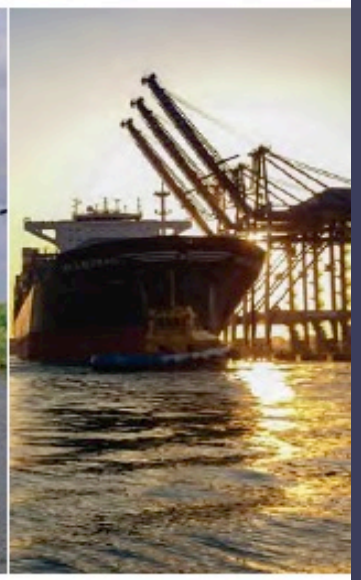
State of emergency declared for Louisiana coast by Gov. John Bel Edwards

St. Bernard Parish inside the level system near the MRGO Thursday, August 13, 2015. (Photo by David Grunfeld, NOLA.com | The Times-Picayune) *((Photo by David Grunfeld, NOLA.com |The Times-Picayune))*

Louisiana's Comprehensive Master Plan for a Sustainable Coast

committed to our coast

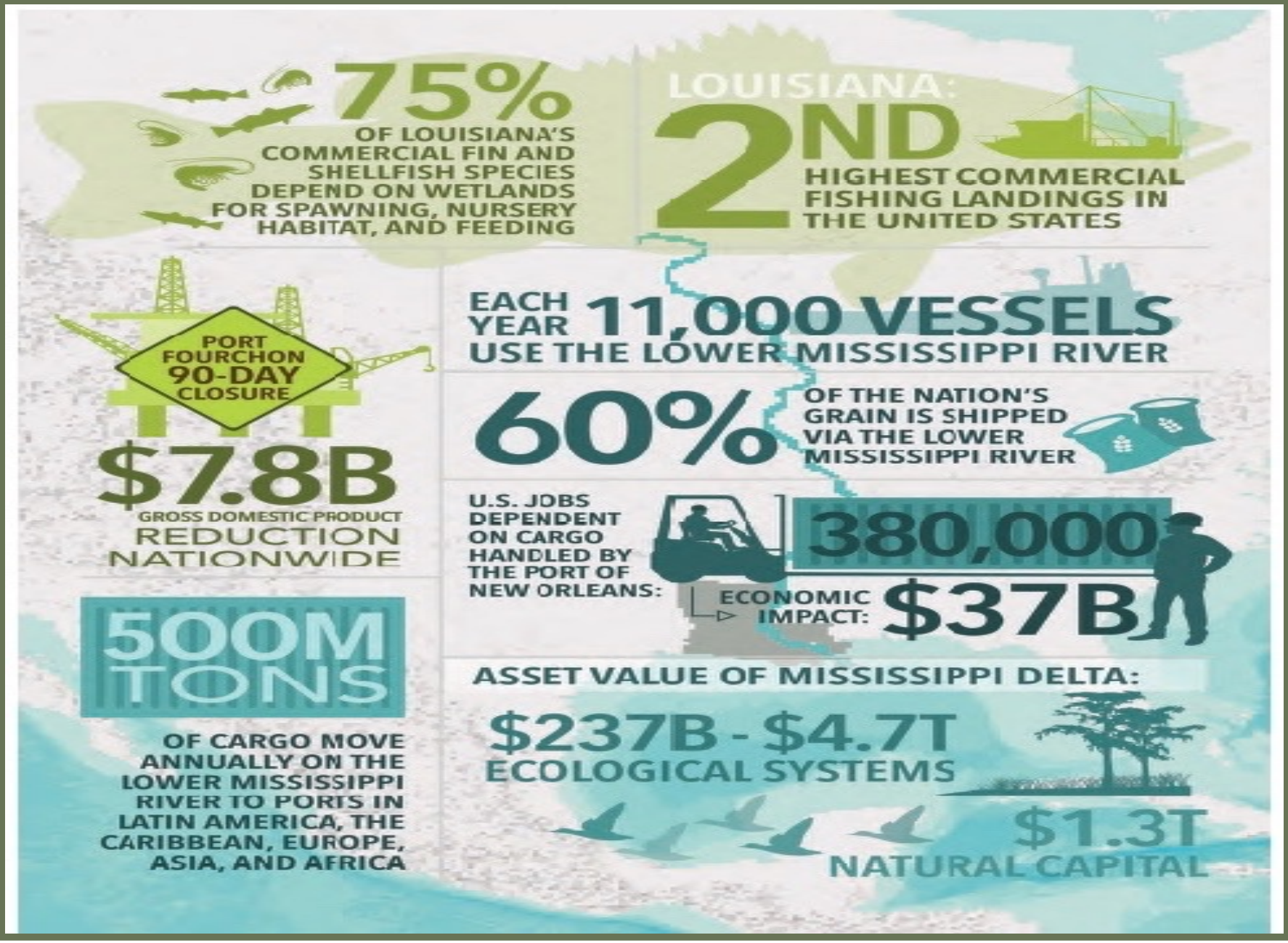


Image: 2017 Coastal Master Plan

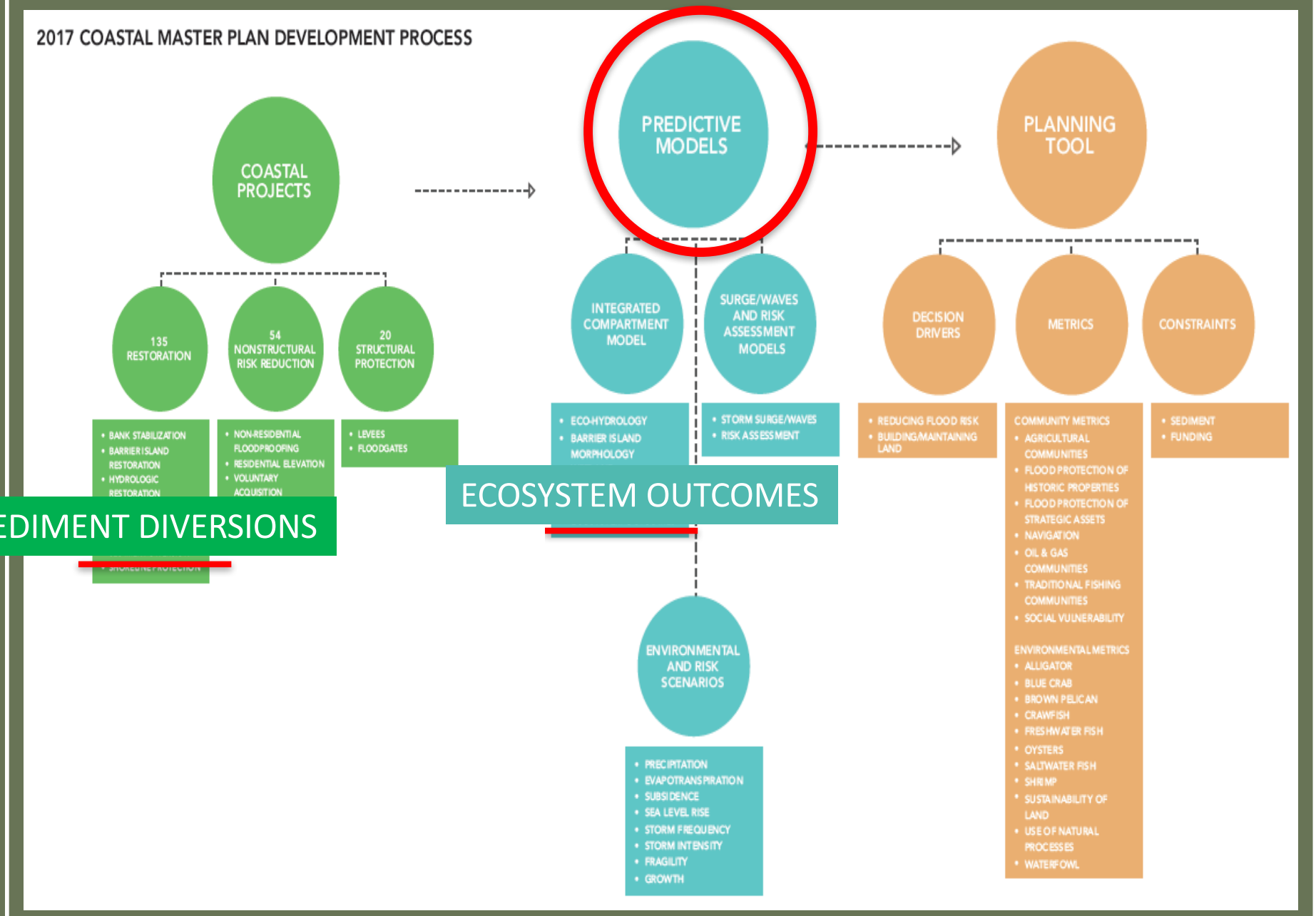
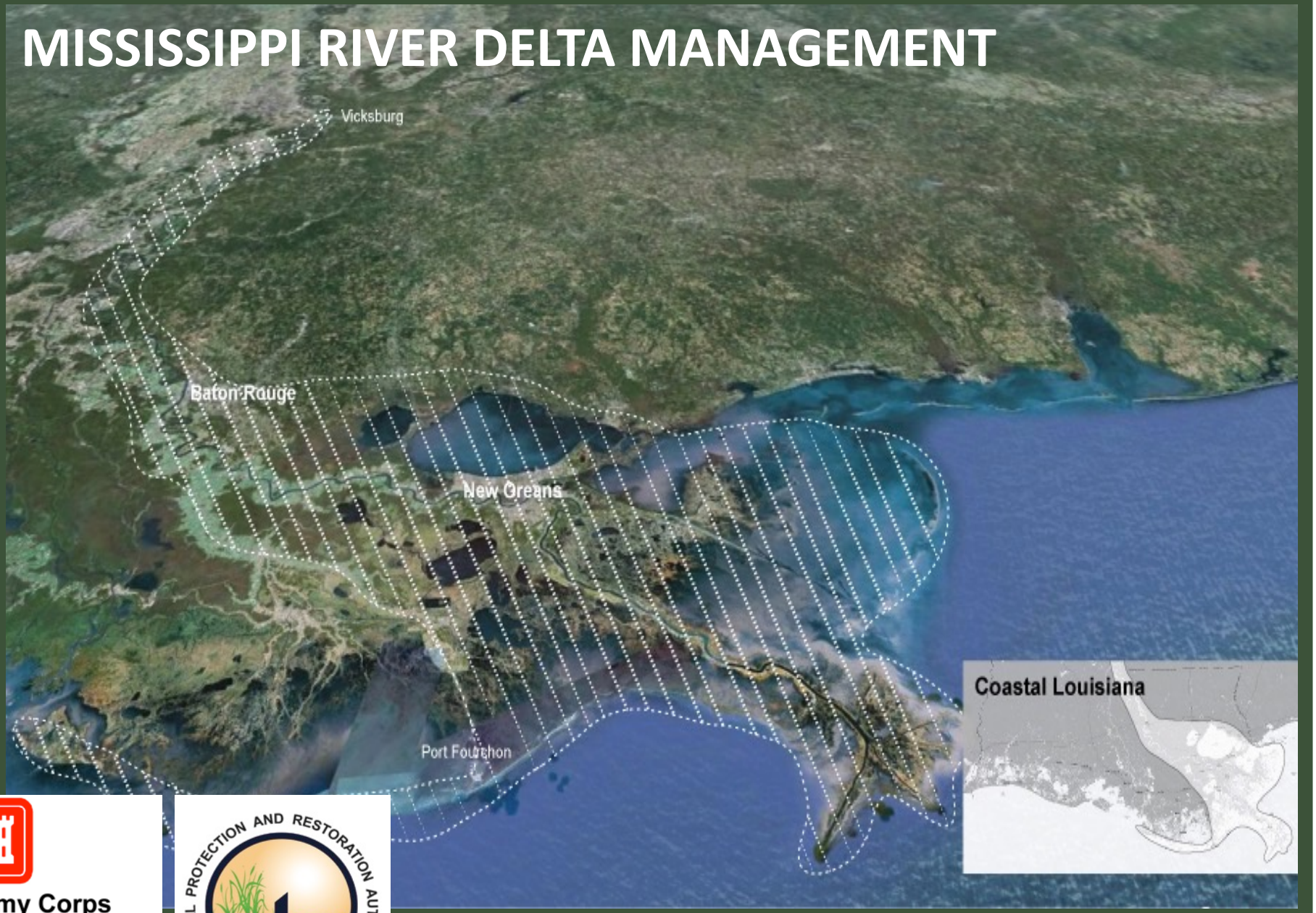


Image: 2017 Coastal Master Plan

MISSISSIPPI RIVER DELTA MANAGEMENT



US Army Corps of Engineers®
Engineer Research and Development Center

COASTAL PROTECTION AND RESTORATION AUTHORITY
CPRA

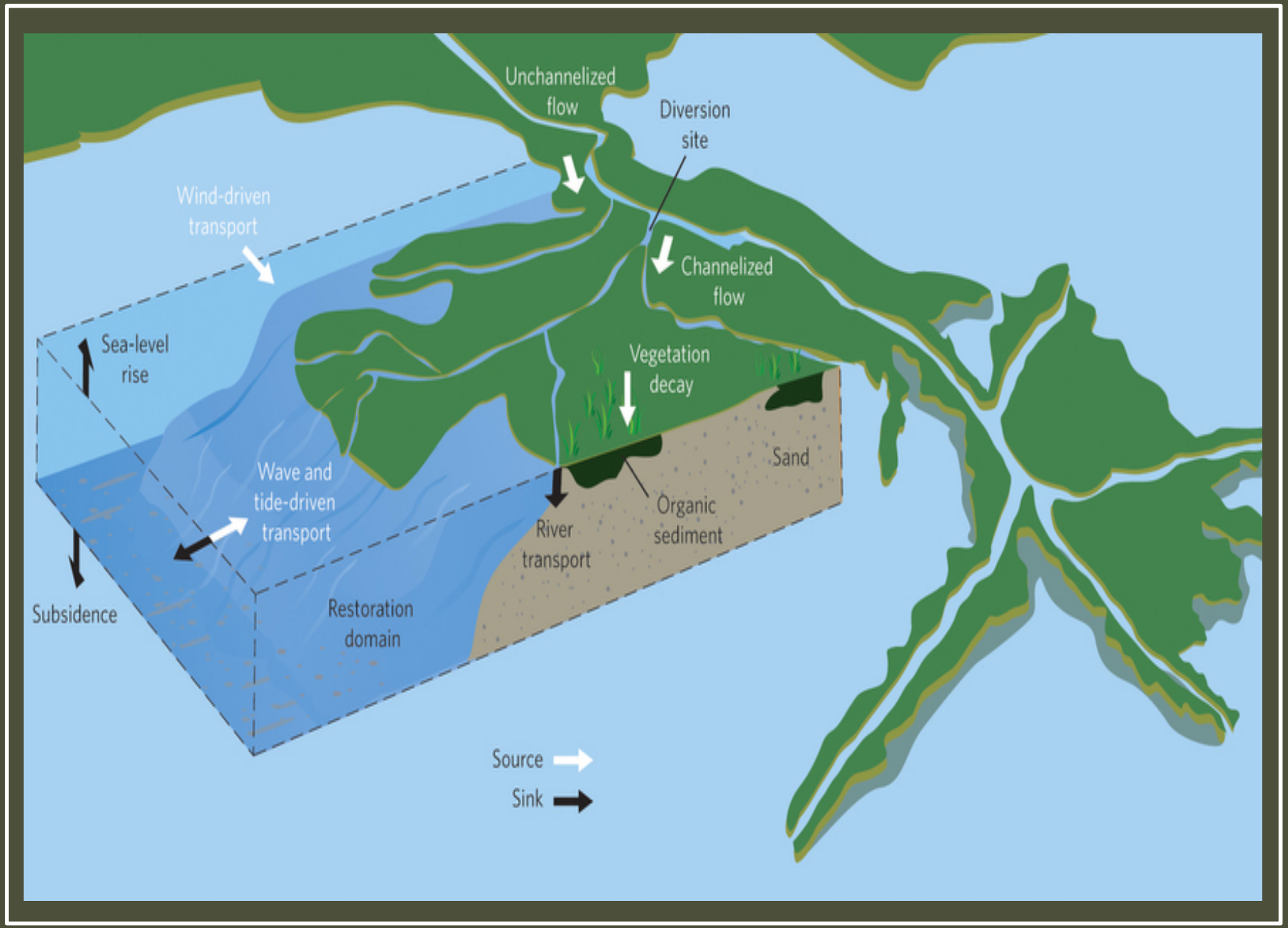


Image: Edmonds 2012

APPLIED ECOLOGICAL MODELING

Question: How do a select combination of sediment diversions affect fish and shellfish in the receiving basins?

Approach:

- Develop ecosystem model that accounts for effects of environmental changes, fishing, and predator-prey interactions
- Use output of a Delft3D hydrodynamic model as environmental drivers (Chlorophyll *a*, salinity, temperature, %wetland cover, and total suspended solids)

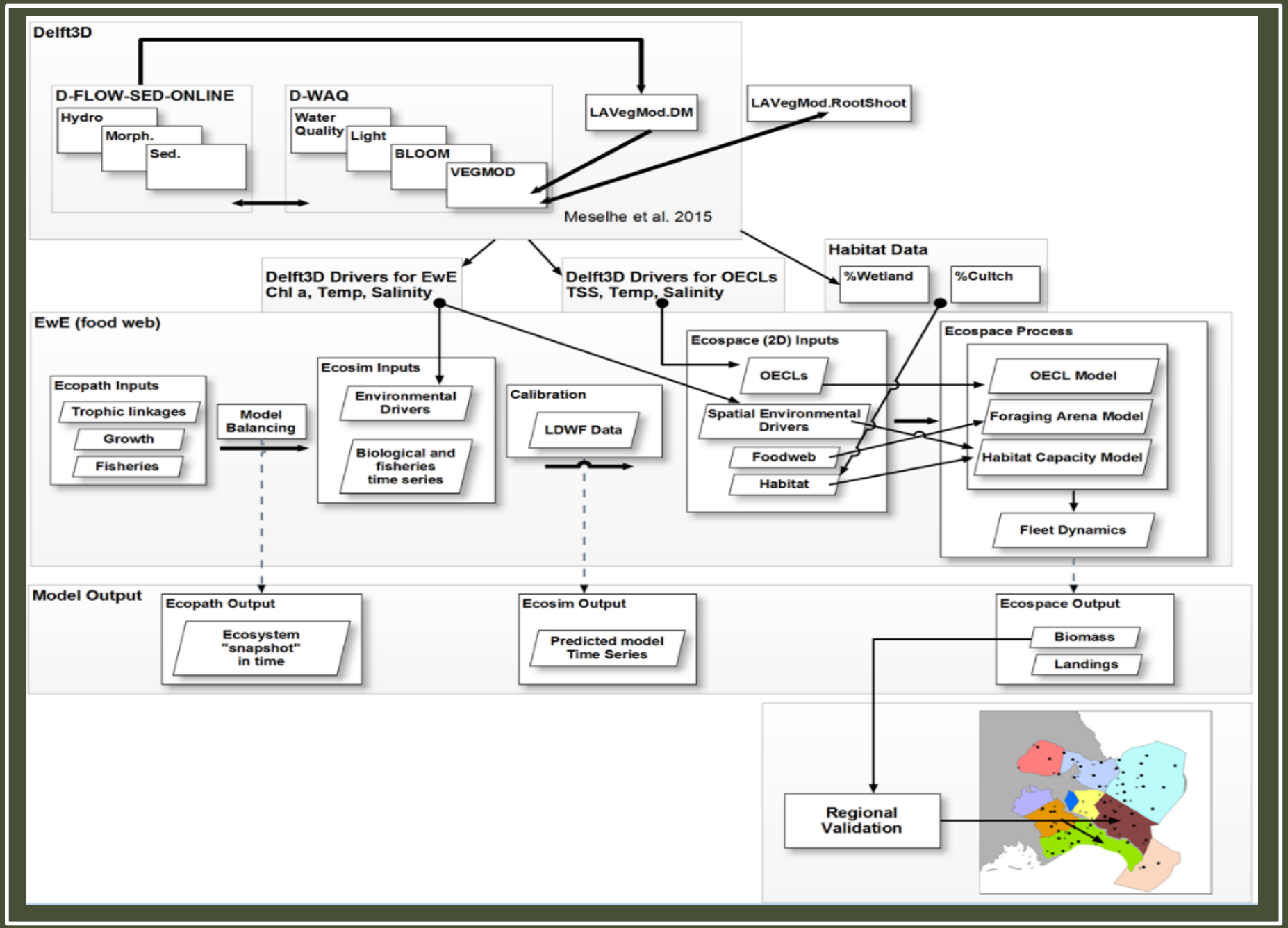
Ecopath with Ecosim and Ecospace

Ecopath: Mass-balance “snapshot” of an ecosystem (initial conditions of the model)

Ecosim: Temporal dynamic simulations (used for model calibration)

Ecospace: Spatial-temporal modeling (framework of the model)


Upper
Ponchartrain
Middle
Lower
Upper
Upper
Middle
Breton
Sound
Middle
Lower
Barataria
Bay
Lower
Birds foot
Delta
N
Lower Barataria Bay
Lower Breton Sound
Middle Barataria Bay
Middle Breton Sound
0 10 20 40 60 80
Kilometers

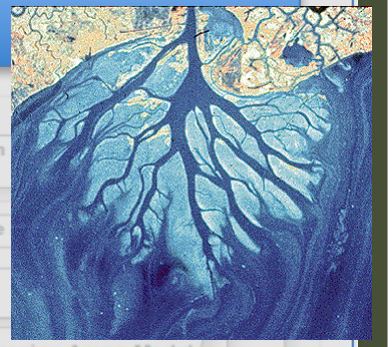


De Mutsert et al. in review

MRDM Delft 3D
Simulate sediment diversion operation plans

Output

Land gain per scenario



Daily

OECLs

Monthly env. drivers

cultch

MRDM Ecospace

Output

Fish biomass, distribution and landings

$?

Groups in the model

Fish

Atlantic Croaker[1]
Bay Anchovy[1]
Black Drum[1]
Blue Catfish[1]
Coastal sharks[1]
Gizzard Shad[1]
Grey Snapper[1]
Gulf Menhaden[1]
Gulf Sturgeon[1]
Killifishes
Largemouth Bass[1]
Pinfish[1]
Red Drum[1]
Sand Seatrout[1]
sea catfishes[1]
Sheepshead[1]

Fish

Silver Perch[1]
silversides
Southern Flounder[1]
Spot[1]
Spotted Seatrout[1]
Striped Mullet[1]
Sunfishes[1]
Threadfin Shad[1]

Invertebrates

Benthic crustaceans
Blue Crab[1]
Brown Shrimp[1]
Eastern Oyster[2]
Grass Shrimp
Mollusks

Invertebrates

Mud crabs
Other shrimp
Oyster Drill
White Shrimp[1]
Zoobenthos
Zooplankton

Primary producers

Phytoplankton
SAV[3]
Benthic algae

Other

Kemp Ridley sea turtle
Dolphins
Detritus
Seabirds

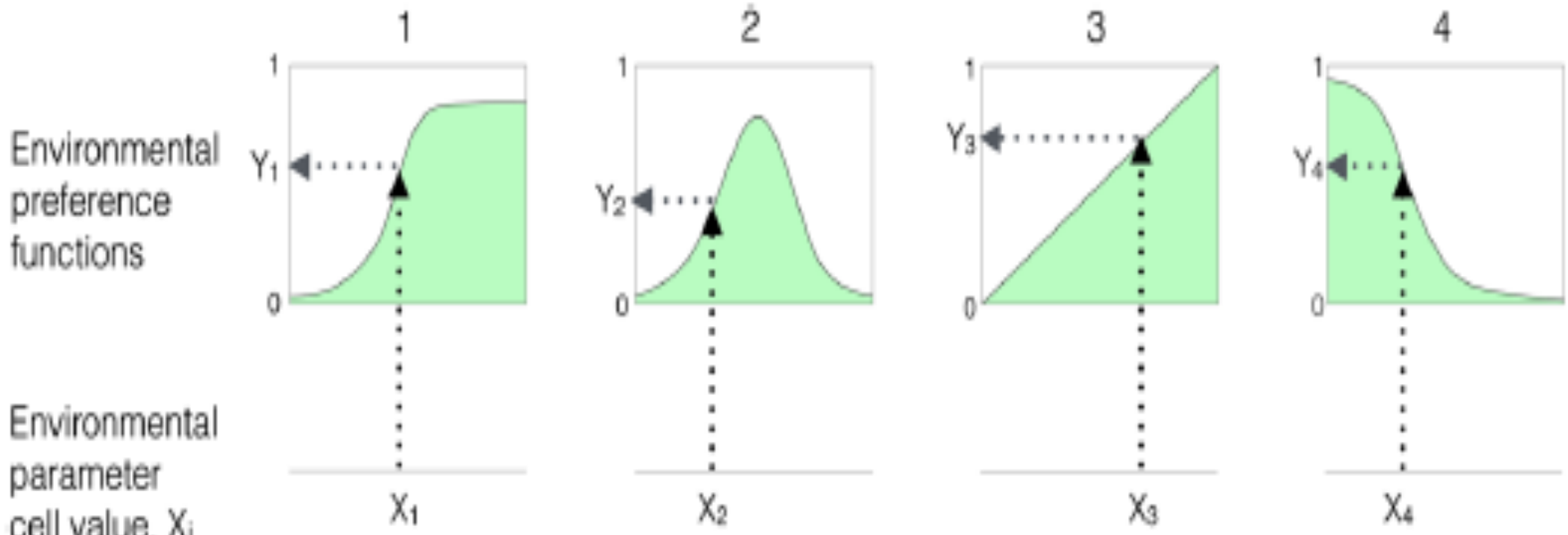
[1]Juvenile and adult, [2]spat, seed, and sack, [3]submerged aquatic vegetation

Groups in the model

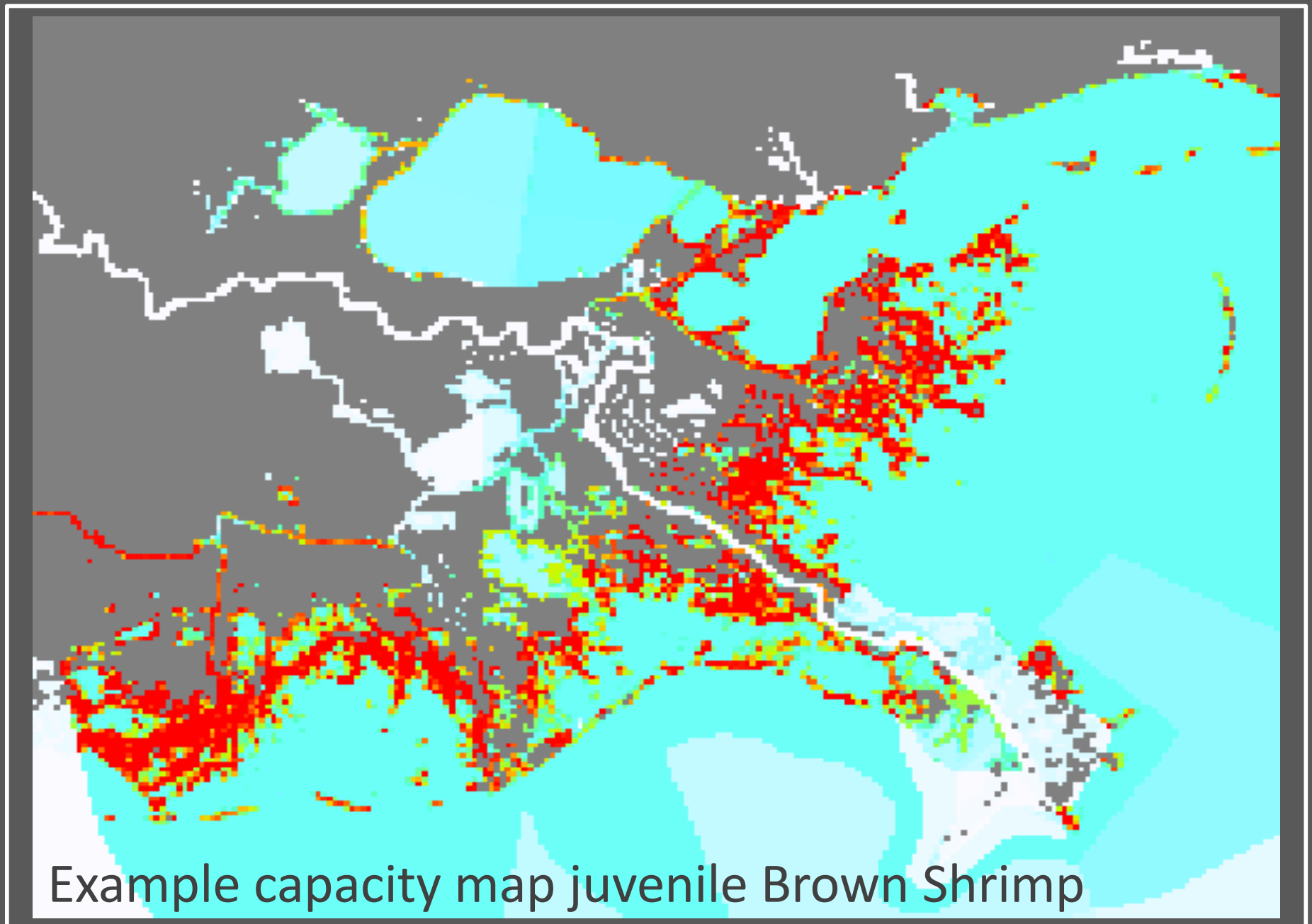
Fish	**Fish**	**Invertebrates**
Atlantic Croaker[1]	Silver Perch[1]	Mud crabs
Bay Anchovy[1]	silversides	Other shrimp
Black Drum[1]	Southern Flounder[1]	Oyster Drill
Blue Catfish[1]	Spot[1]	White Shrimp[1]
Coastal sharks[1]	**Spotted Seatrout[1]**	Zoobenthos
Gizzard Shad[1]	Striped Mullet[1]	Zooplankton
Grey Snapper[1]	Sunfishes[1]	**Primary producers**
Gulf Menhaden[1]	Threadfin Shad[1]	Phytoplankton
Gulf Sturgeon[1]	**Invertebrates**	SAV[3]
Killifishes	Benthic crustaceans	Benthic algae
Largemouth Bass[1]	**Blue Crab[1]**	**Other**
Pinfish[1]	**Brown Shrimp[1]**	Kemp Ridley sea turtle
Red Drum[1]	Eastern Oyster[2]	Dolphins
Sand Seatrout[1]	Grass Shrimp	Detritus
sea catfishes[1]	Mollusks	Seabirds
Sheepshead[1]		

[1]Juvenile and adult, [2]spat, seed, and sack, [3]submerged aquatic vegetation

Habitat Capacity in Ecospace

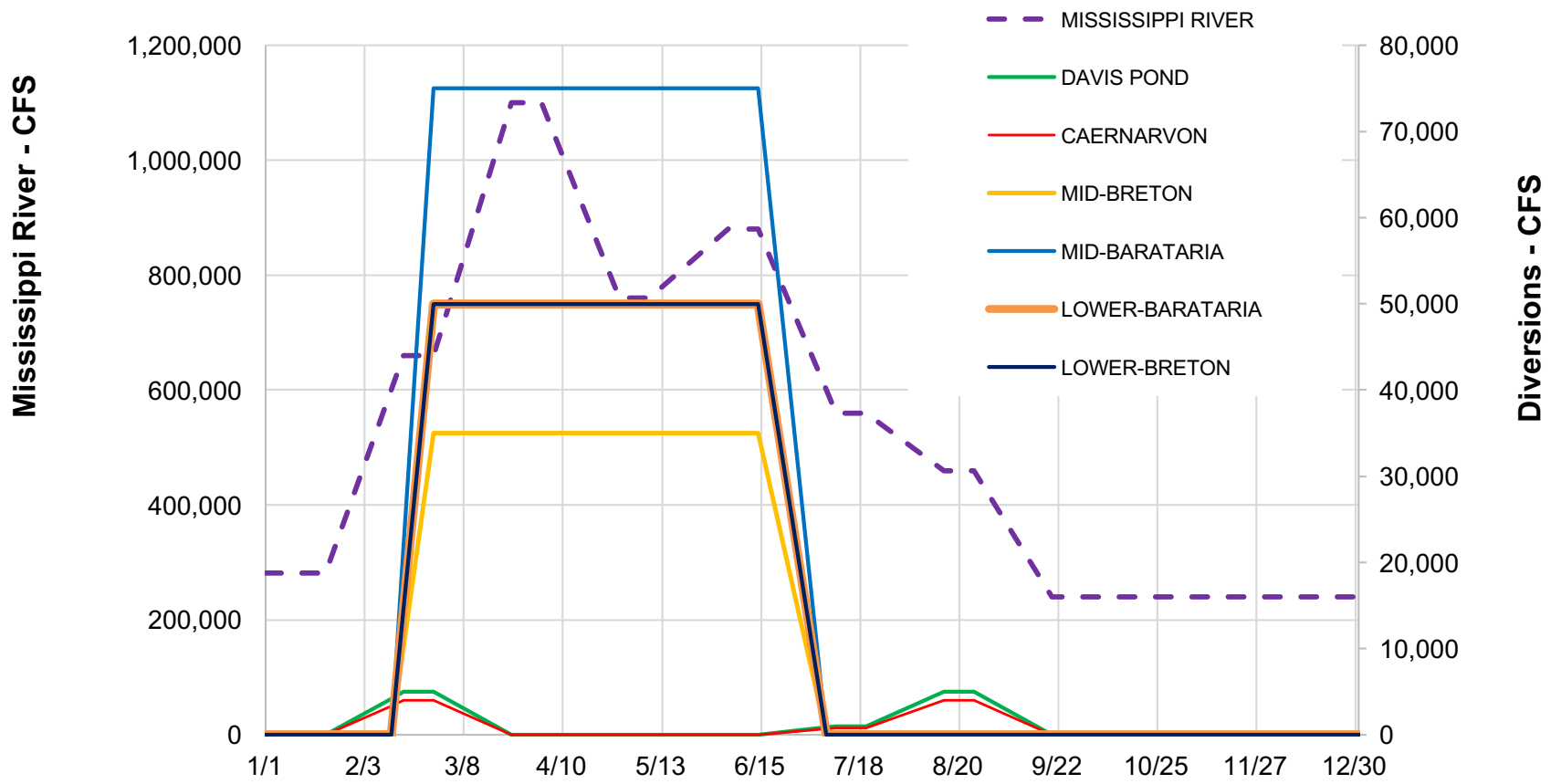


Christensen et al. 2014


Example capacity map juvenile Brown Shrimp

OPERATION PLAN:

- open four sediment diversions for 50 year (opening triggered by 600,000 CFS in the river)
- Compare with Future Without Action



Juvenile Gulf Menhaden

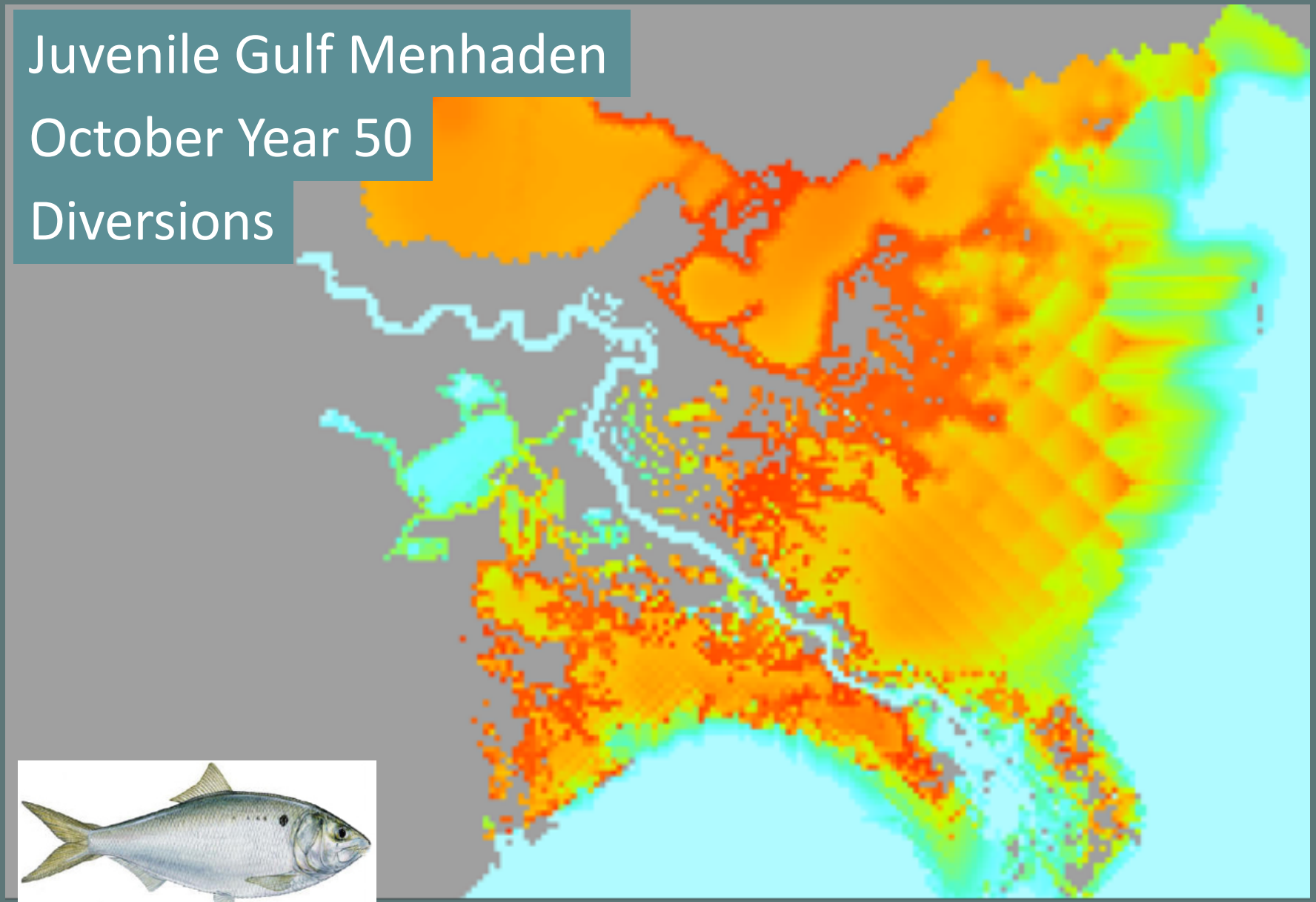
June Year 50

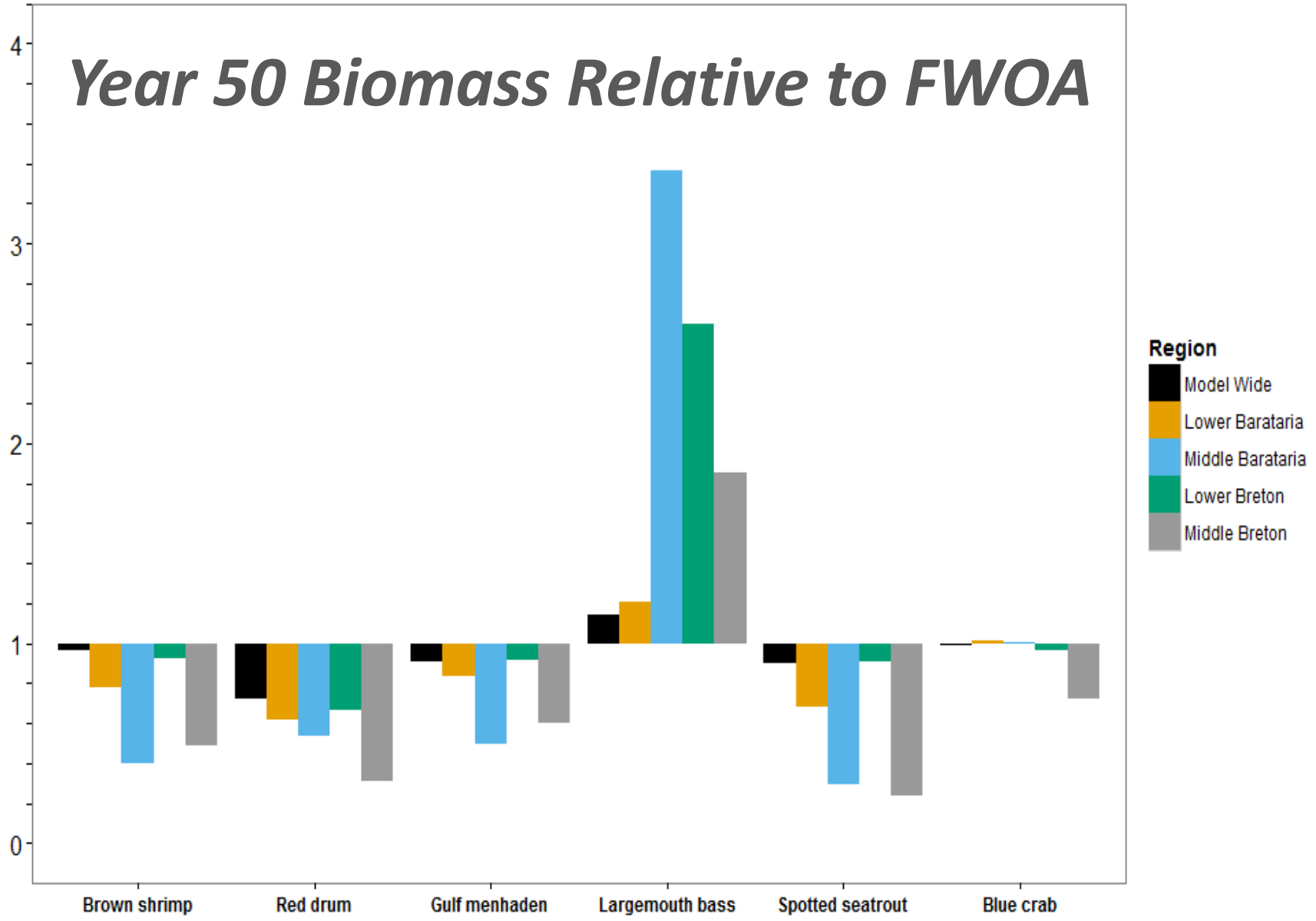
FWOA

Juvenile Gulf Menhaden
June Year 50
Diversions

Juvenile Gulf Menhaden
October Year 50
FWOA

Juvenile Gulf Menhaden
October Year 50
Diversions




Year 50 Biomass Relative to FWOA
4
3
2
1
0
Brown shrimp
Red drum
Gulf menhaden
Largemouth bass
Spotted seatrout
Blue crab
Region
Model Wide
Lower Barataria
Middle Barataria
Lower Breton
Middle Breton

Operation Plan Summary

Decreases in species that prefer higher salinities on a sub-basin level, increases in (few) species that prefer lower salinities

Magnitude of change dampened on a larger spatial scale:

- Redistribution of species
- Large *relative* change in areas with low biomass doesn't contribute much to total biomass change

Two lower diversions mostly responsible for total biomass change

Application

- Focus on two upper diversions (Mid-Barataria and Mid-Breton), lower diversions put on hold
- Land-building capacity benefits of upper diversions outweigh biomass losses
- Spatial distribution allow for estimating change in habitat use

Mid-Barataria sediment diversion is granted fast-track permitting

Figure 4. Conceptual guide levees, LA 23 bridge, rail bridge, and diversion structure

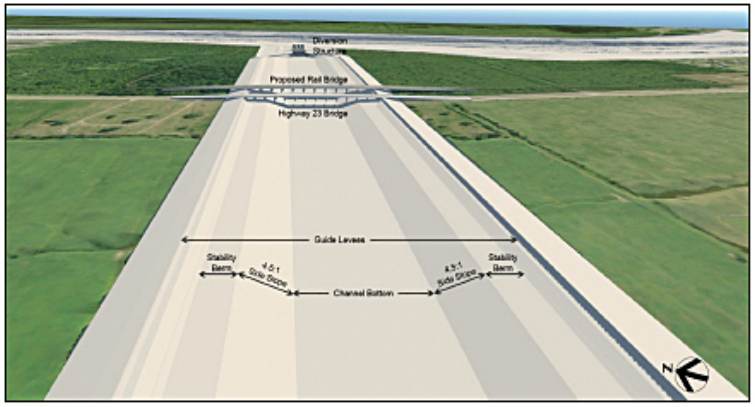
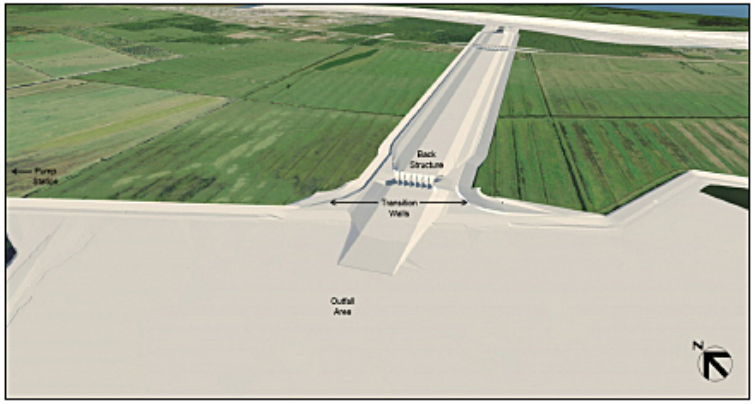


Figure 5. Conceptual outfall area, transition walls, and back structure



Conceptual views of the proposed Mid-Barataria Sediment Diversion. The upper image shows the channel of the diversion between the Mississippi River and Barataria Bay. The lower image shows the outfall area of the diversion in the bay. *(Coastal Protection and Restoration Authority)*

Permitting process will include conducting an Environmental Impact Statement

January 2017, Nola.com

Thank you!

Work presented made possible by funding from the Water Institute of the Gulf and Louisiana's Coastal Protection and Restoration Authority under grant no. CPRA-2014-T32-SB01-EM.

Data used provided by FishBase and the Louisiana Department of Wildlife and Fisheries

Photographs taken and provided by Hunter Guidry: http://www.hunterguidry.com/

I would like to thank all collaborators, co-authors, and students that worked with me on the projects presented