Welcome to the Mississippi Sound Coalition Science Forum

MISSISSIPPI SOUND COALITION RESEARCH FORUM

March 14 | 10-11:30 a.m.
Knight Non-Profit Center

1. Introduction of Forum Moderator, Dr. Mickle
   GERALD BLESSEY *(3 minutes)*
2. Western Sound Science Collaborative Introduction and Research Focus/Goal
   WSSC SCIENTISTS *(5 minutes)*
3. Background and Bonnet Carré Modeling Efforts
   DR. MICKLE *(10 minutes)*
4. Water Quality Modeling
   DR. WIGGERT, DR. CAMBAZOGLU, BRANDY ARMSTRONG *(10 minutes)*
5. Ecosystem Modeling
   DR. DE MUTSERT, DR. MILROY *(10 minutes)*
6. Nutrients and Harmful Algal Bloom Modeling
   DR. ALARCON AND DR. MICKLE *(10 minutes)*
7. Discussions and Questions with the Public
   WSSC SCIENTISTS *(30 to 42 minutes)*

INVITEES:

- Public
- Mississippi Sound Coalition Members
- State Legislators
- Press
- Non-Gov. Organizations
- Resource Agency Scientists
- Academic Scientists

MISSISSIPPI STATE UNIVERSITY | NORTHERN GULF INSTITUTE a NOAA cooperative institute | THE UNIVERSITY OF SOUTHERN MISSISSIPPI

EOE/F/M/VET/DISABILITY

Speakers

Dr. Paul Mickle, Moderator
Co-Director
Northern Gulf Institute
Mississippi State University

Dr. Jerry Wiggert
The University of Southern Mississippi

Dr. Kemal Cambazoglu
The University of Southern Mississippi

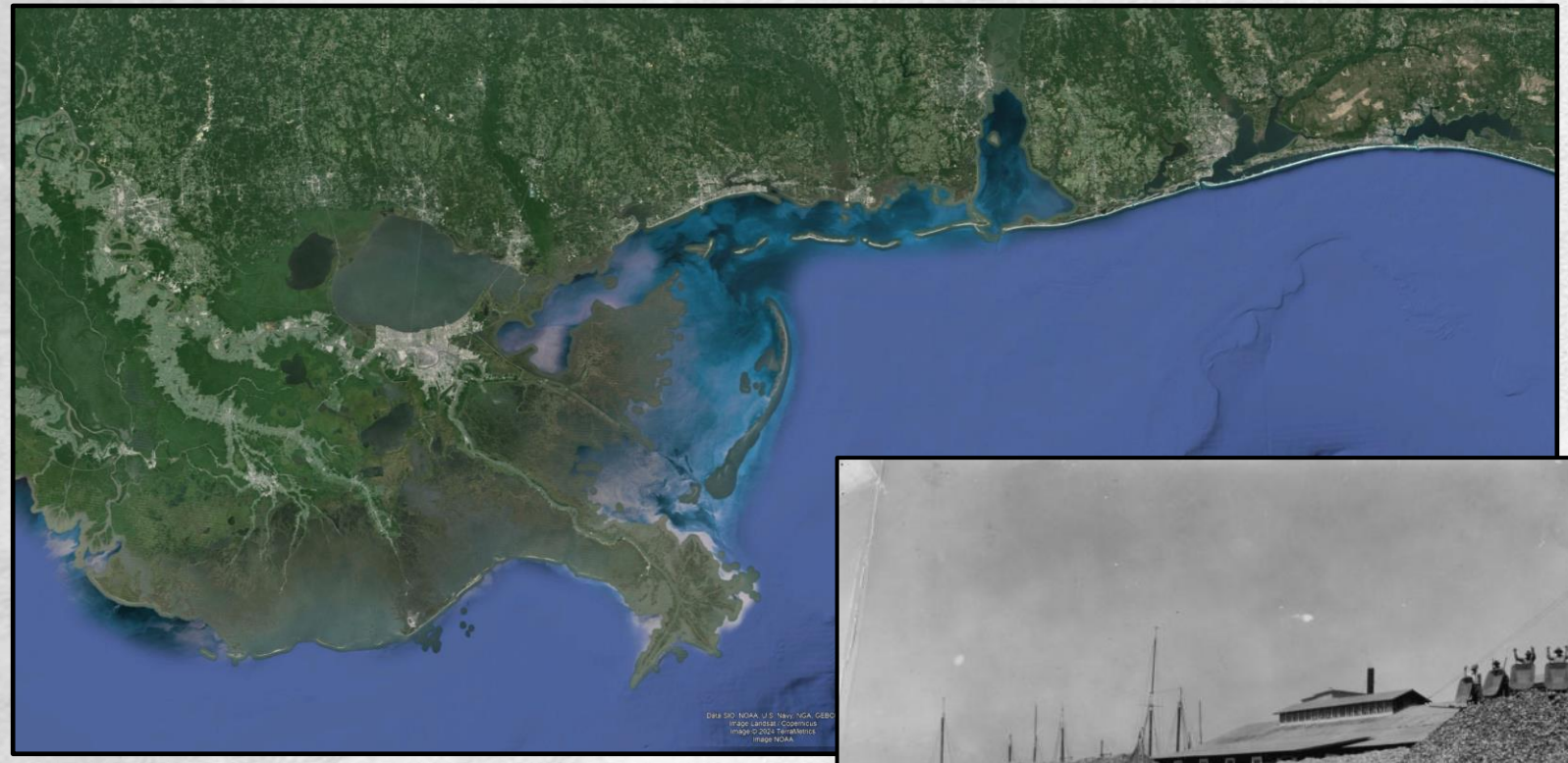
Brandy Armstrong
The University of Southern Mississippi

Dr. Kim de Mutsert
The University of Southern Mississippi

Dr. Scott Milroy
The University of Southern Mississippi

Dr. Vladimir Alarcon
Mississippi State University

Mississippi Sound



Google Earth Image

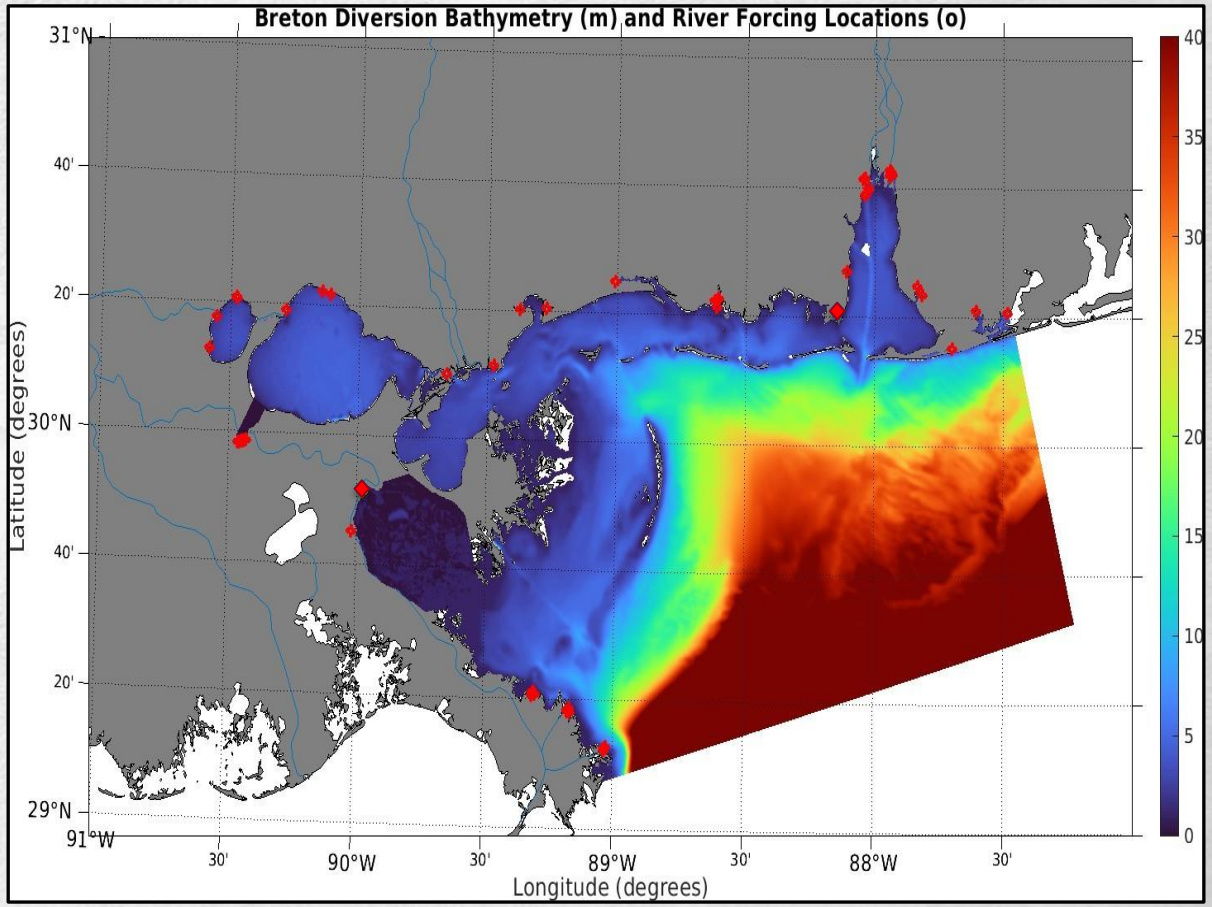
Image Provided by Mississippi Seafood Museum

- Large Estuary
- Spans into western Louisiana and Alabama
- Complex freshwater input layout
- In the 1920s identified as the seafood capital of the world

Water Quality Struggles

Drivers of Water Quality Issues

- Freshwater Diversions
- Nutrients
- Extreme wet and dry seasons
- Storms
- Erosion
- Tides
- Dredging
- Etc.…

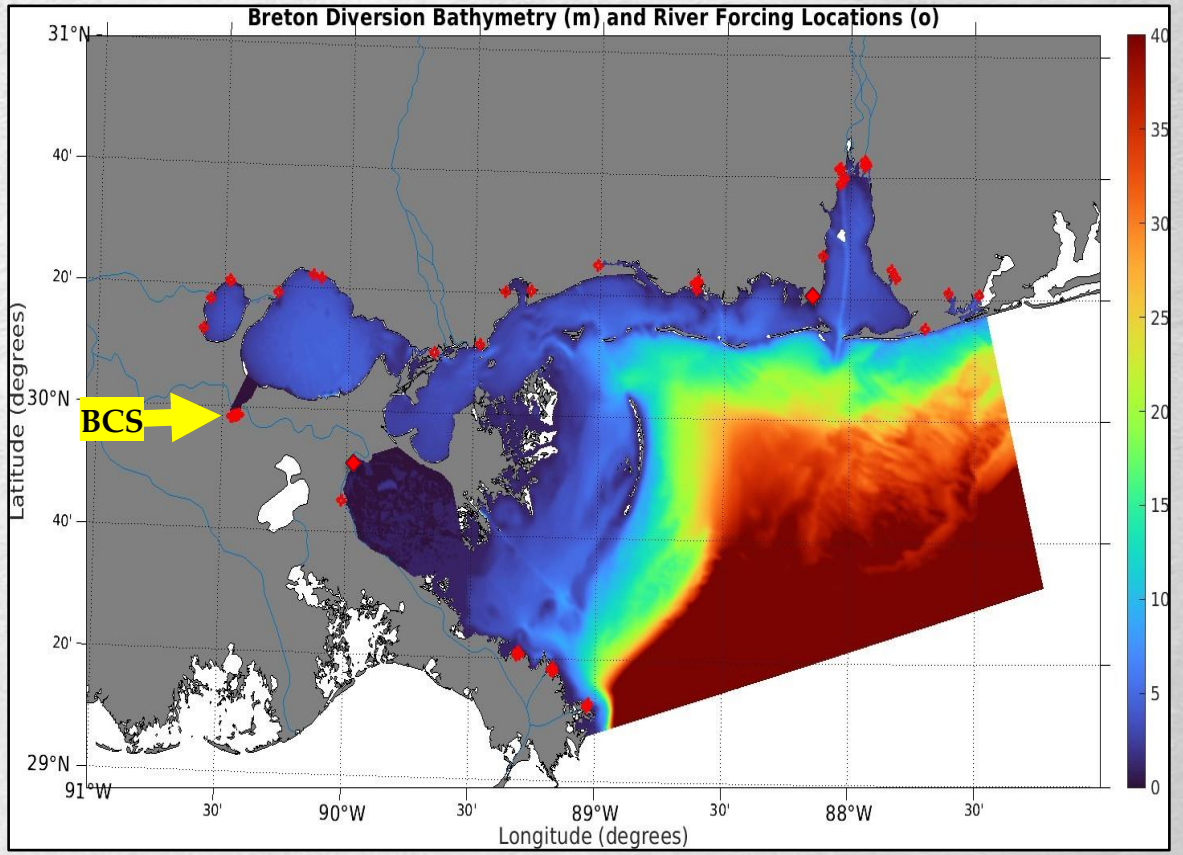


Wiggert et al. 2022

Bonnet Carré Spillway

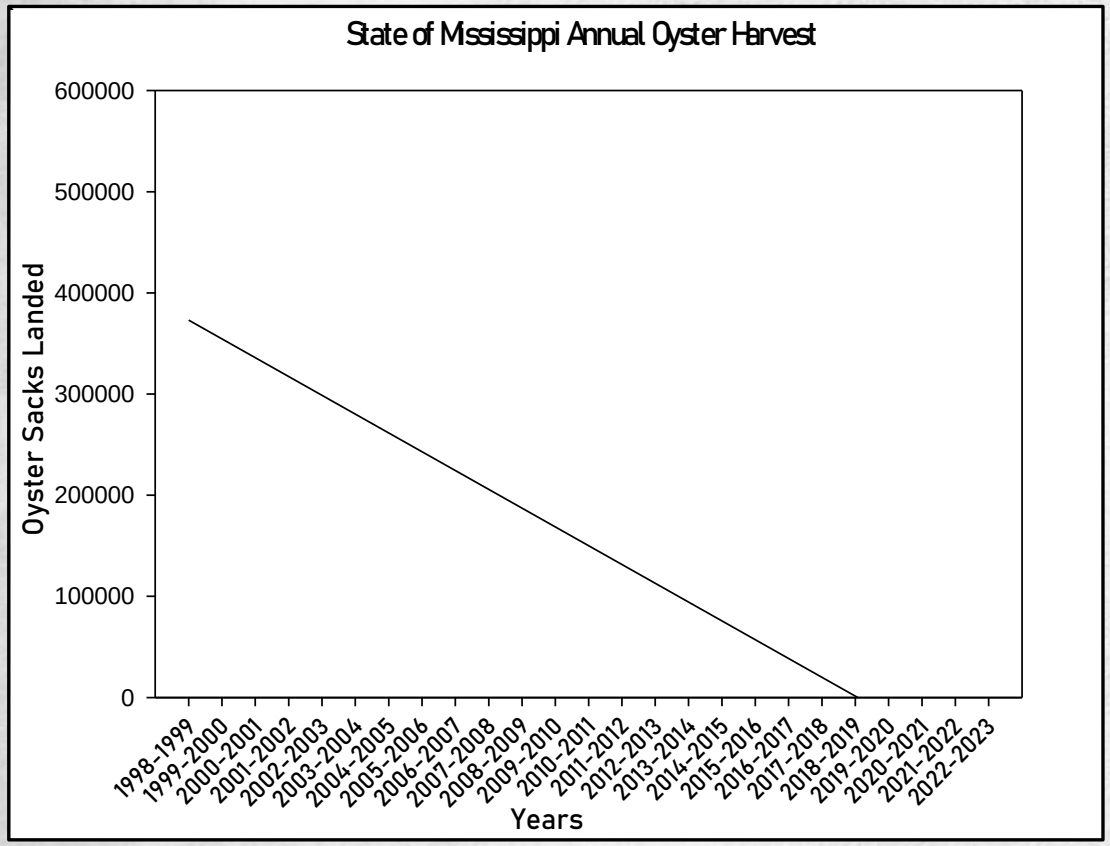
Flood Protection

Image Provided by USACE

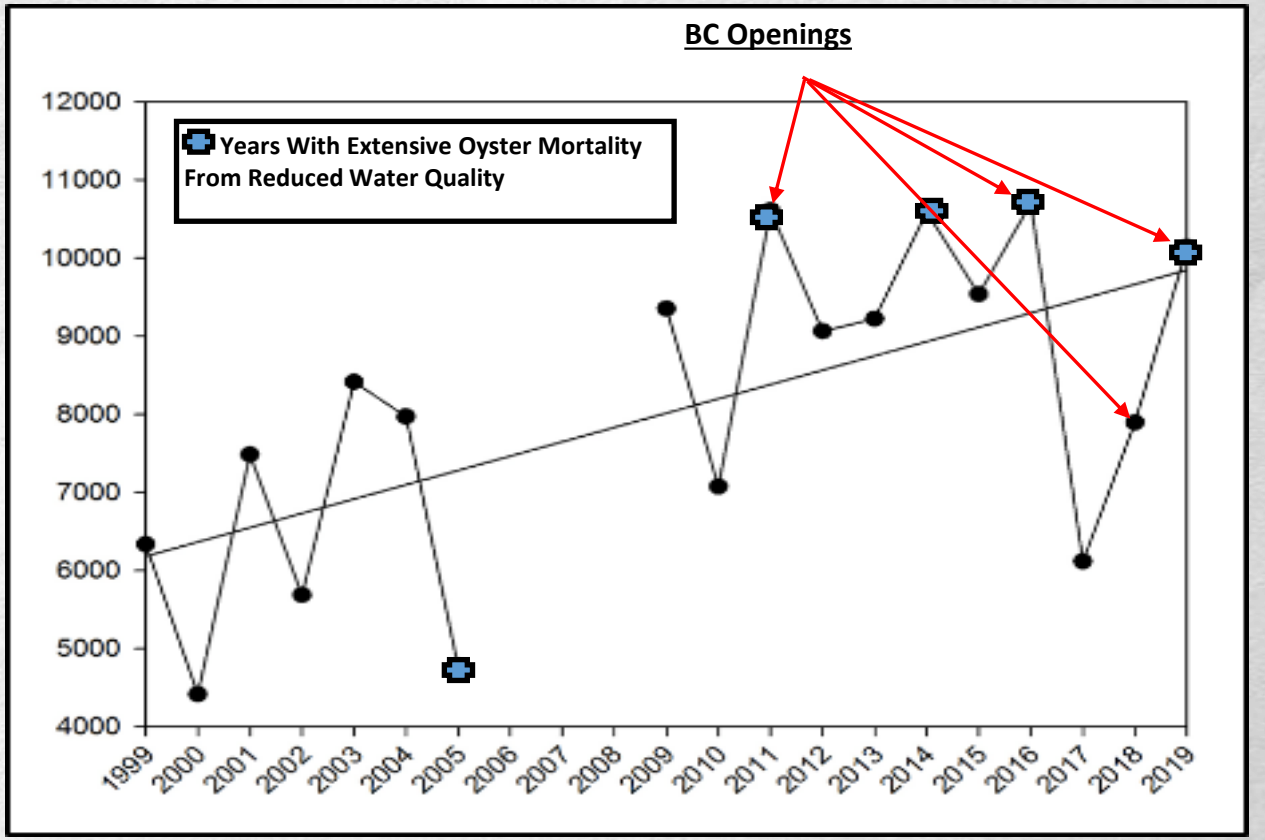


Wiggert et al. 2022

Water Quality Impacts



Data provided by MDMR



Mickle et al. 2024

Water Quality Impacts

Image Provided by MSU College of Veterinary Medicine

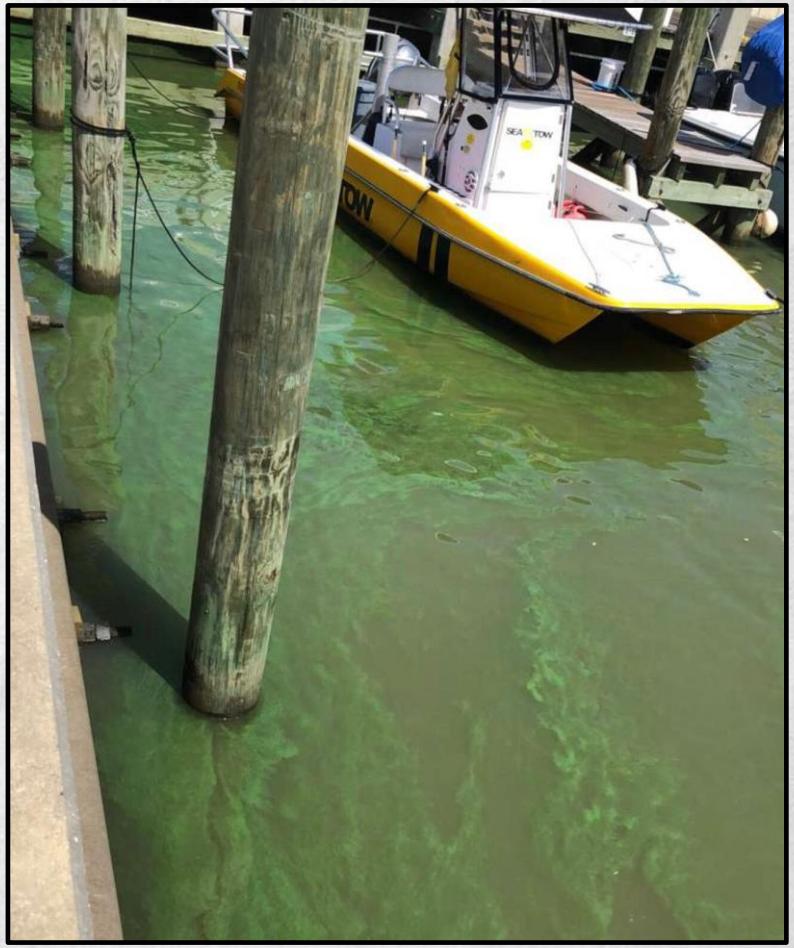
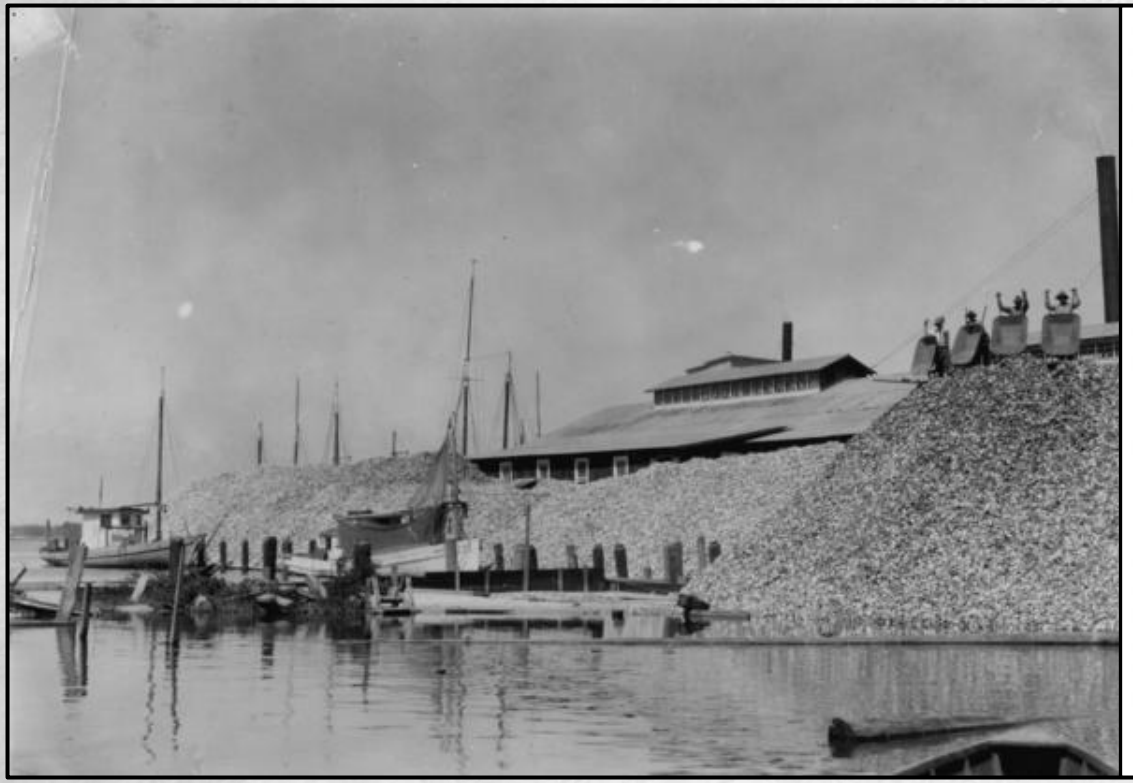
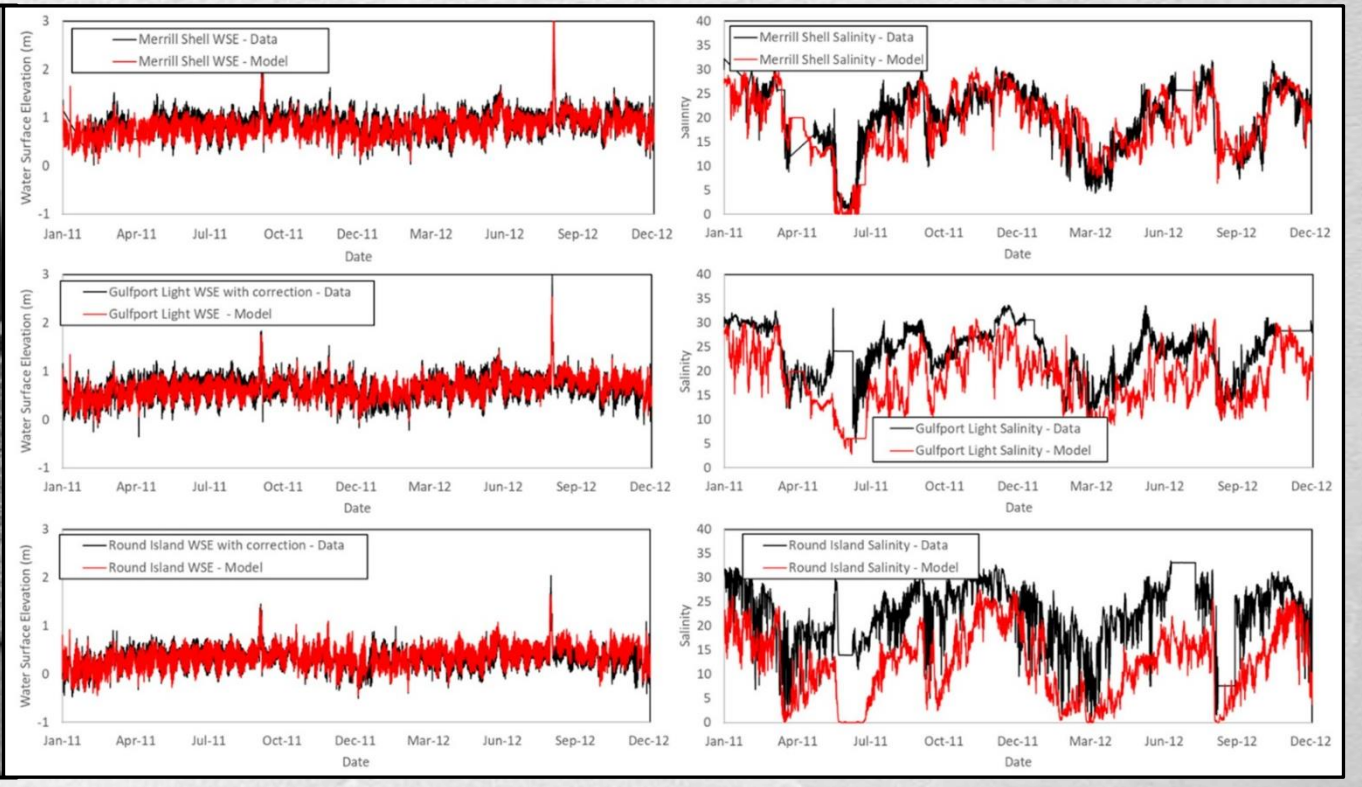


Image Provided by WLOX

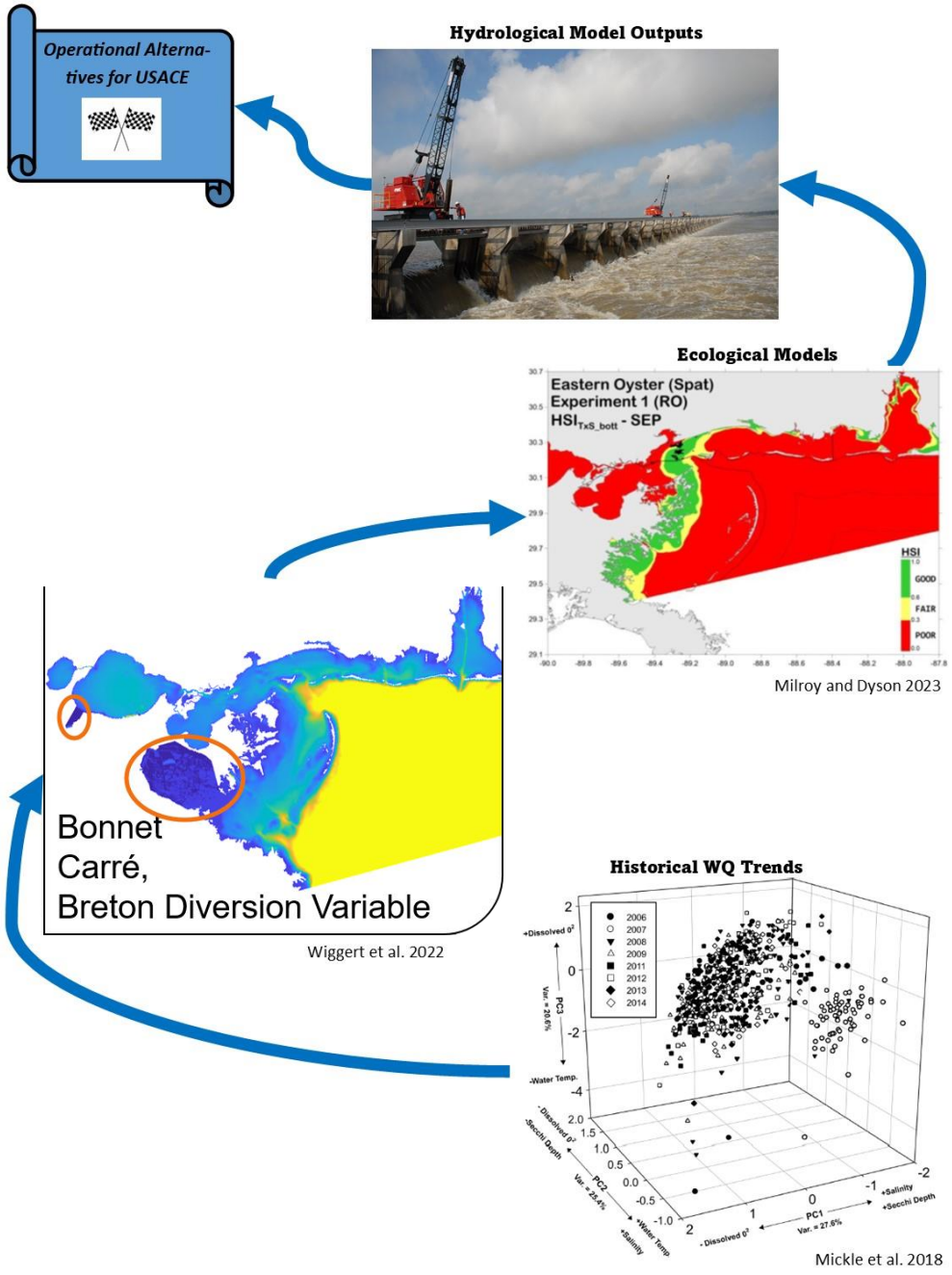
Overall Goal

Model water quality inputs needed for historical high productive conditions





Linhoss and Mickle 2023



Science to Policy

Geosystems Research Institute
Northern Gulf Institute

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Development of An Operational Alternative to the Bonnet Carré Spillway Accounting for Ecological Tipping Points in the Mississippi Sound

Jerry Wiggert
Professor
Division of Marine Science
School of Ocean Science and Engineering
The University of Southern Mississippi

Brandy Armstrong
Research Scientist
Division of Marine Science
School of Ocean Science and Engineering
The University of Southern Mississippi

Kemal Cambazoglu
Assistant Professor
Division of Marine Science
School of Ocean Science and Engineering
The University of Southern Mississippi

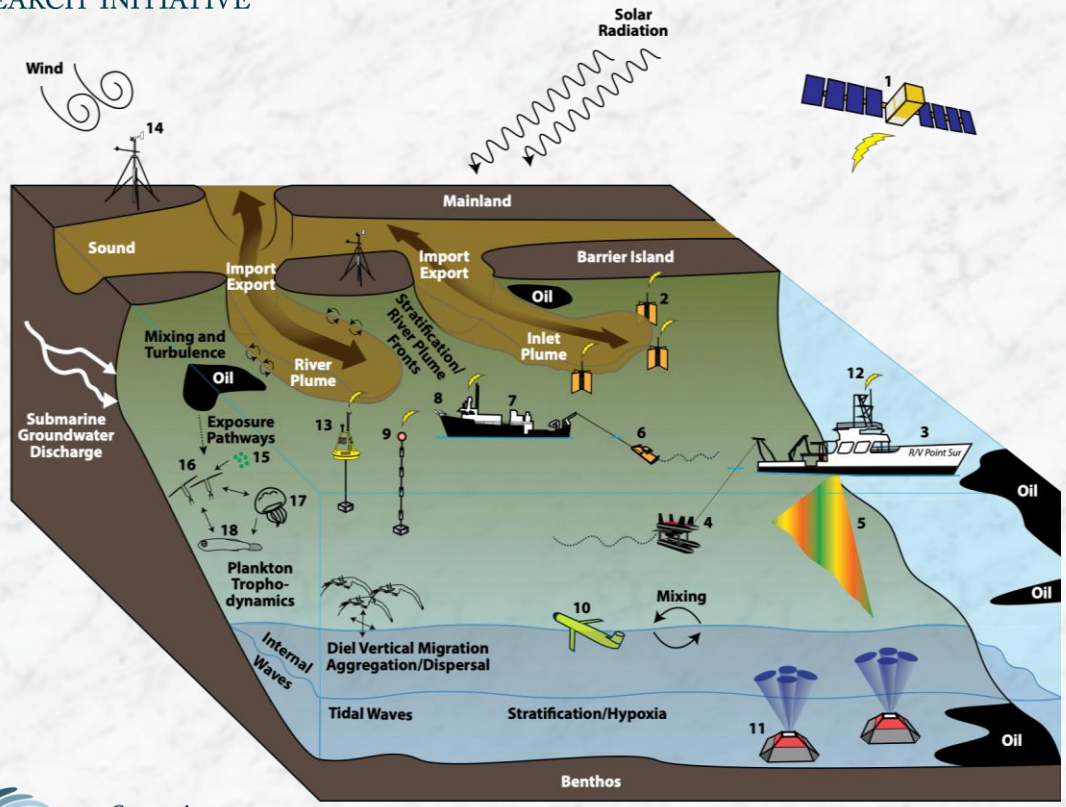
Mississippi Sound Coalition
Scientific research forum, Topic: Mississippi Sound
Knight Nonprofit Center, Gulfport, MS
March 14, 2024

SOUTHERN MISS OCEAN SCIENCE AND ENGINEERING

SOS SAVE OUR SOUND

GULF OF MEXICO RESEARCH INITIATIVE

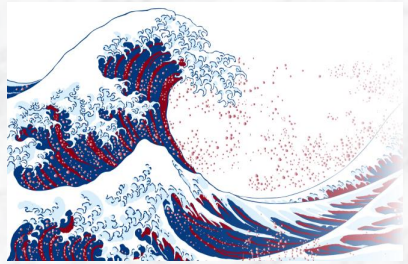
The msbCOAWST Origin Story



Consortium CONCORDE Coastal River-Dominated Ecosystems

Dynamic processes in the pulsed-river controlled Mississippi Bight that influence the distribution, transport, and exchange pathways of marine ecosystem constituents

Atmospheric Forcing (NOAA)



Gulf Boundary Forcing (NAVOCEANO)

Ocean Model (msbCOAWST)

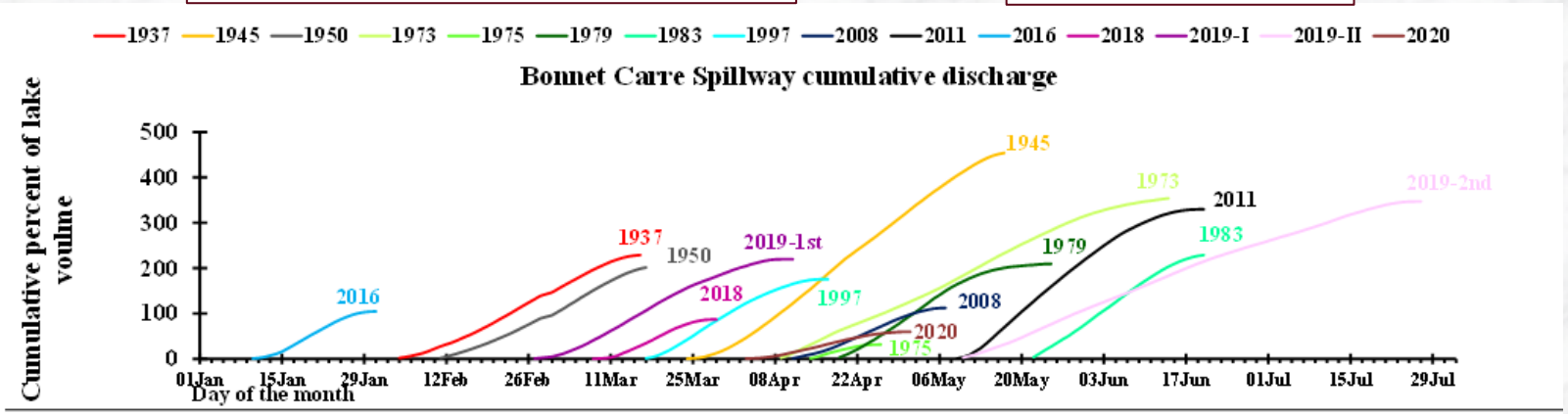
River Forcing (USGS)

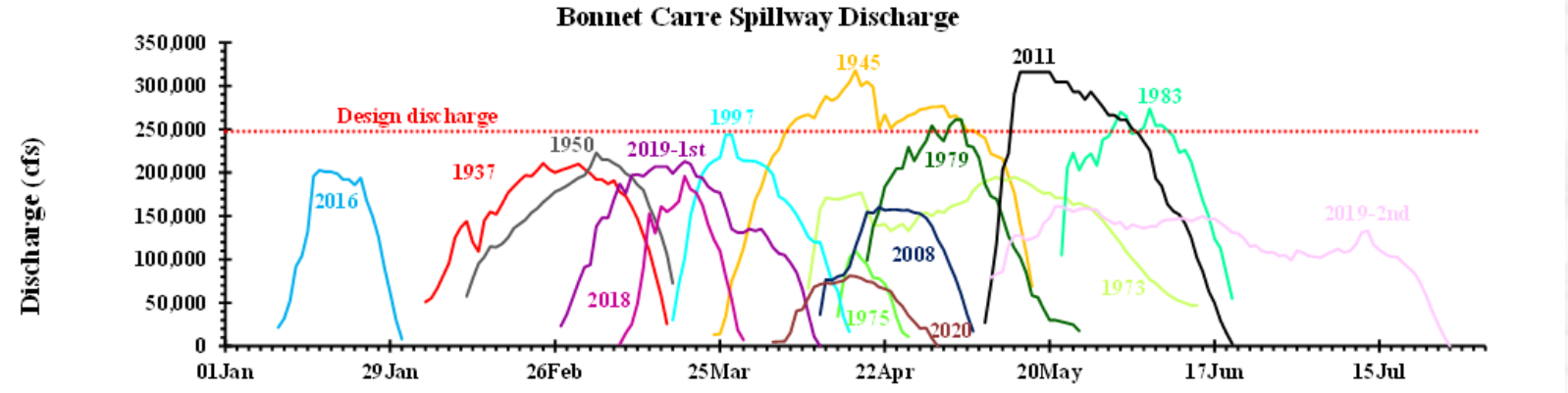
Greer et al. (2018), *Oceanography*, doi:10.5670/oceanog.2018.302.

Bonnet Carré Spillway Operations

9 operations in the first 76 years

6 operations over 10 years





Original design expectation was that the Bonnet Carré Spillway would operate every ten years

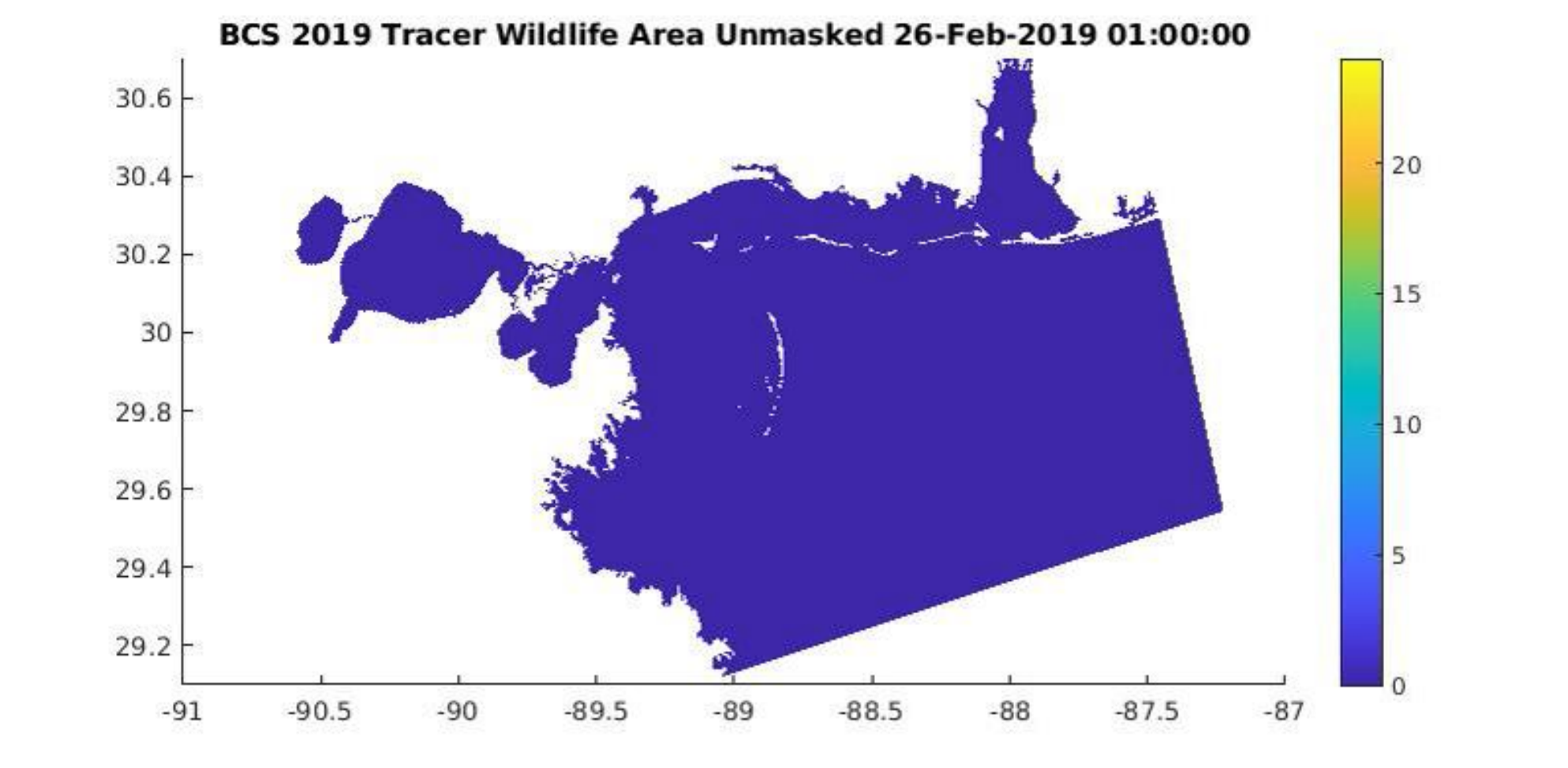
Bonnet Carré Spillway was **operated for three years in a row in 2018, 2019 and 2020 for the first time ever.**

Bonnet Carré Spillway was **operated twice in the same calendar year for the first time ever in 2019.**

2019 openings combined introduced the **largest cumulative freshwater volume from the Mississippi River (~ 6 Lake**

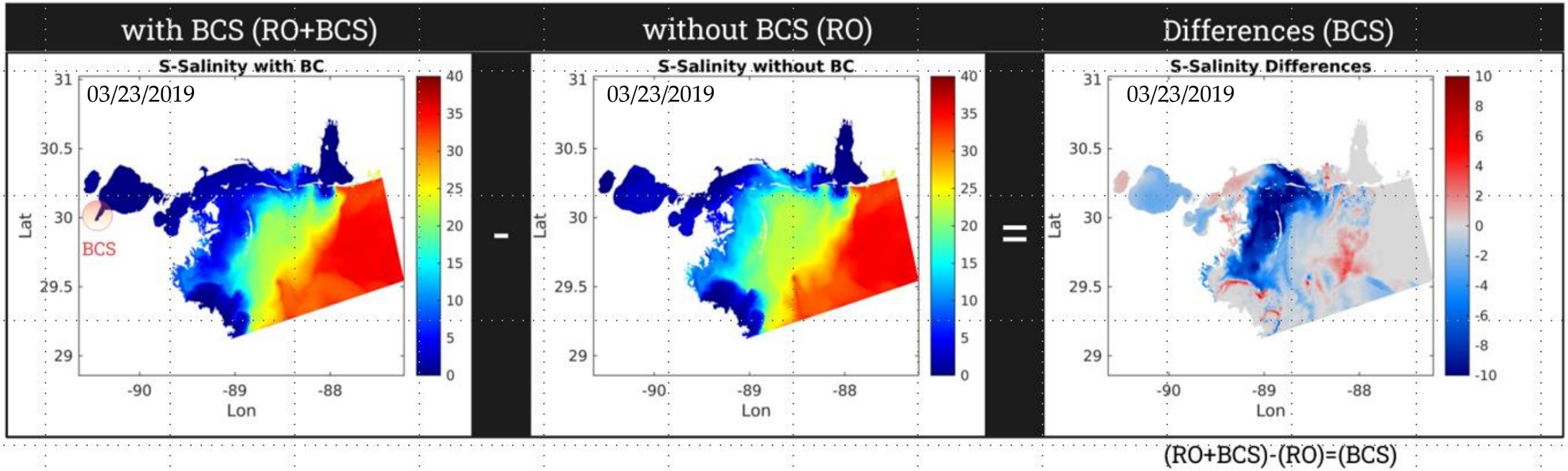
Tracking Bonnet Carré Waters

The Ocean Model (msbCOAWST) reveals the impacts of Bonnet Carré Spillway Operations on Mississippi Sound and Bight.



Dye can be released in model simulations to track how sources of freshwater (e.g., the Bonnet Carré Spillway) propagate and disperse.

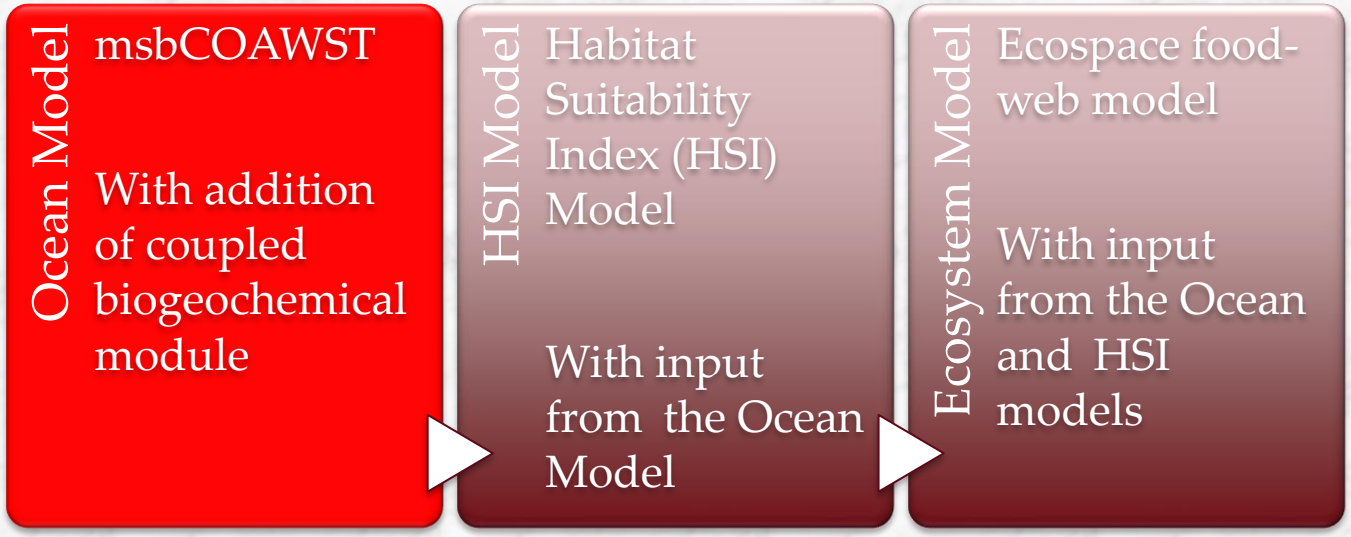
Bonnet Carré Spillway Impact on Surface Salinity (23 March 2019)



- Bonnet Carré Spillway impact isolated through twin experiment
- Difference between the two experiments shows where opening the BCS has led to increased (red) or decreased (blue) surface salinity

Tipping Points From Coupled Model Applications

Coupling Ocean Model with Habitat Suitability and Ecosystem Models



- **Tipping Point Assessments (Time-varying spatial maps)**
  - Ocean Model
    - Bottom salinity below 5 for two consecutive weeks
  - HSI Model
    - Suitability of habitat degrades to poor
  - Ecosystem Model
    - Percent mortality exceeds natural mortality

Mississippi Sound Coalition Public Forum

Habitat Suitability Index (HSI) Models

Scott P. Milroy, Ph.D.
Associate Professor of Marine Science

School of Ocean Science and Engineering
The University of Southern Mississippi
14 March 2024

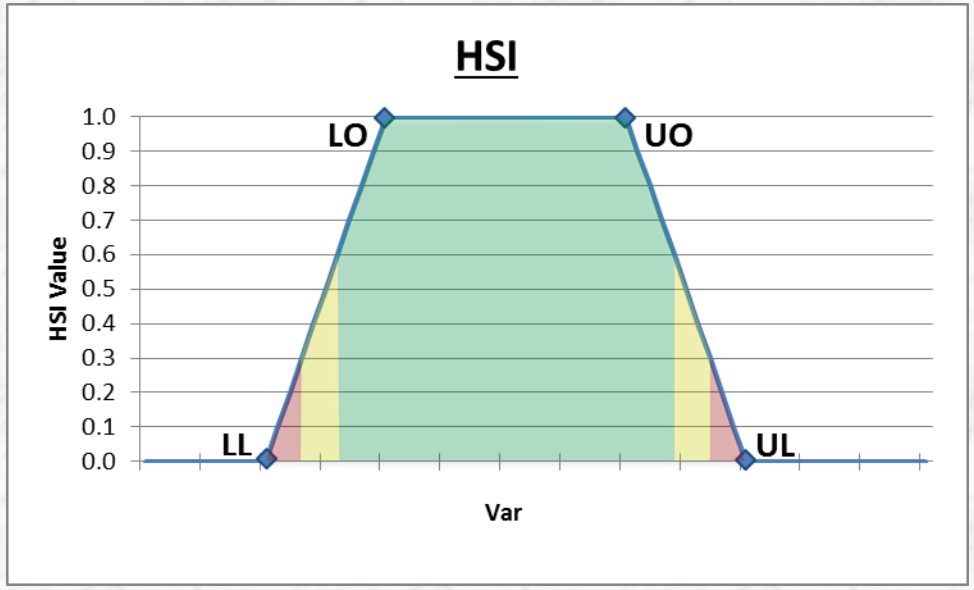
THE UNIVERSITY OF SOUTHERN MISSISSIPPI

MISSISSIPPI STATE UNIVERSITY

NORTHERN GULF INSTITUTE

Habitat Suitability Modeling

Fundamentals of the Habitat Suitability Index (HSI) Model



Trapezoid Function

- For any environmental variable (**Var**), a Habitat Suitability Index (**HSI**) value can be assigned to Oyster Larvae, Spat, Seed, and Sack based on:

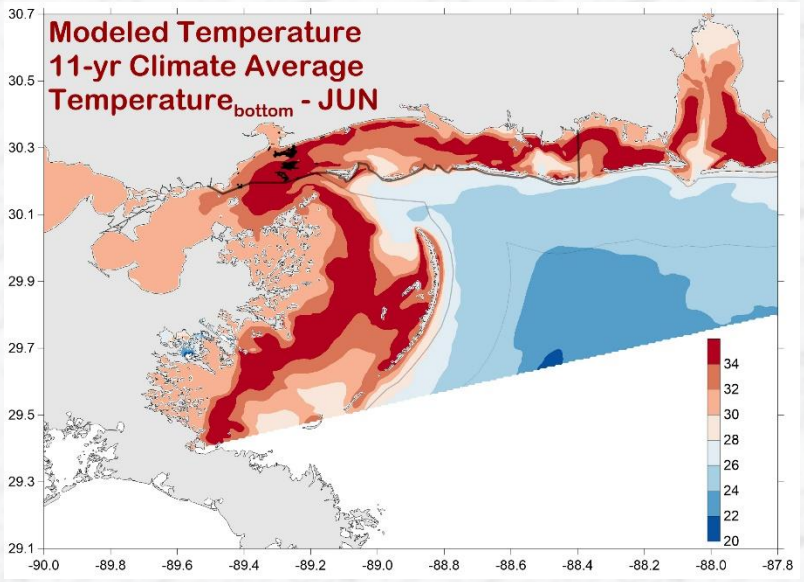
- Lower Limit (**LL**) of Survivability
- Lower Optimal (**LO**) Threshold
- Upper Optimal (**UO**) Threshold
- Upper Limit (**UL**) of Survivability

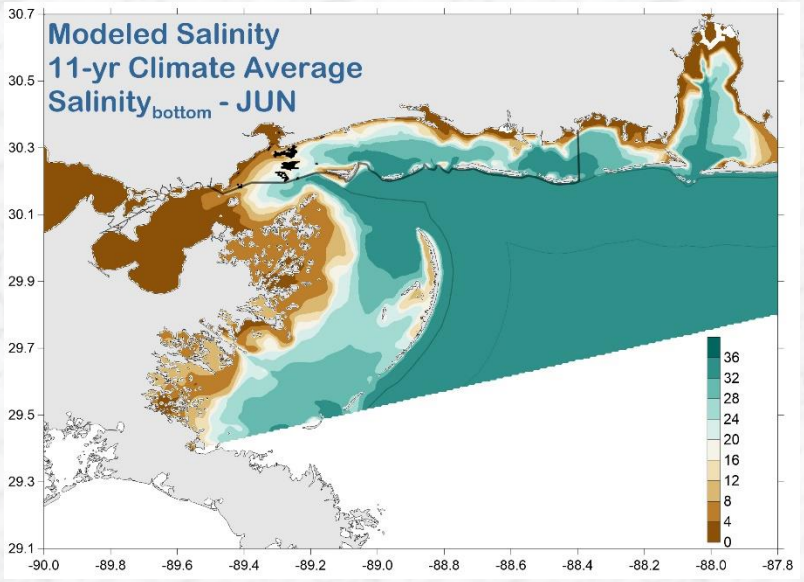
Choices of **LL**, **LO**, **UO**, **UL** for the ***Temperature*** and ***Salinity*** thresholds for each modeled age-class of oyster are informed by <u>decades</u> of peer-reviewed research, representing the best available science to-date.

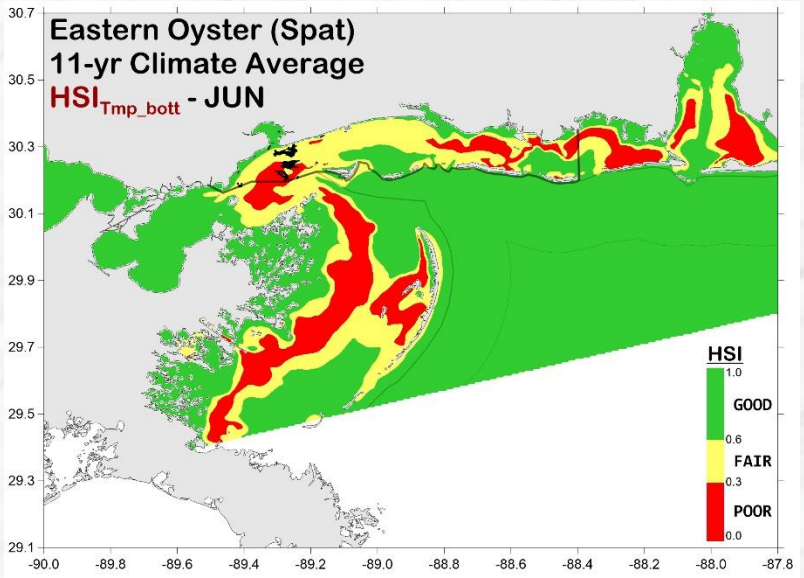
THE UNIVERSITY OF SOUTHERN MISSISSIPPI

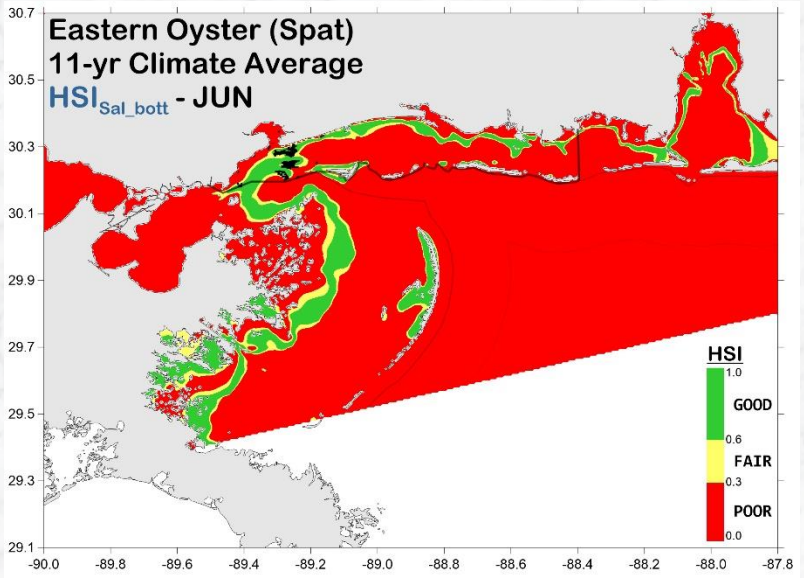
Habitat Suitability Modeling

Individual Variable (Tmp vs. Sal) HSI Models





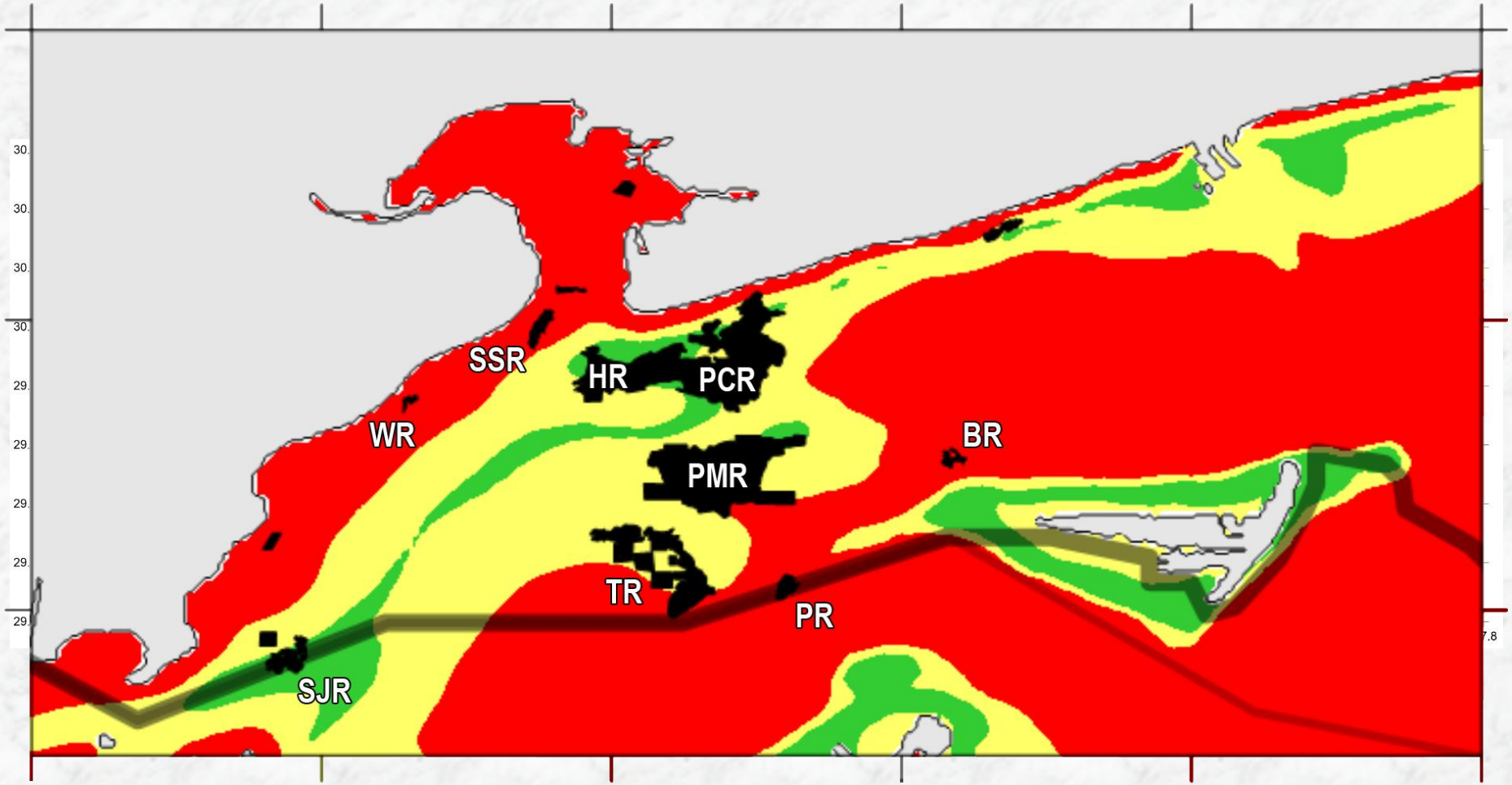




THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Habitat Suitability Modeling

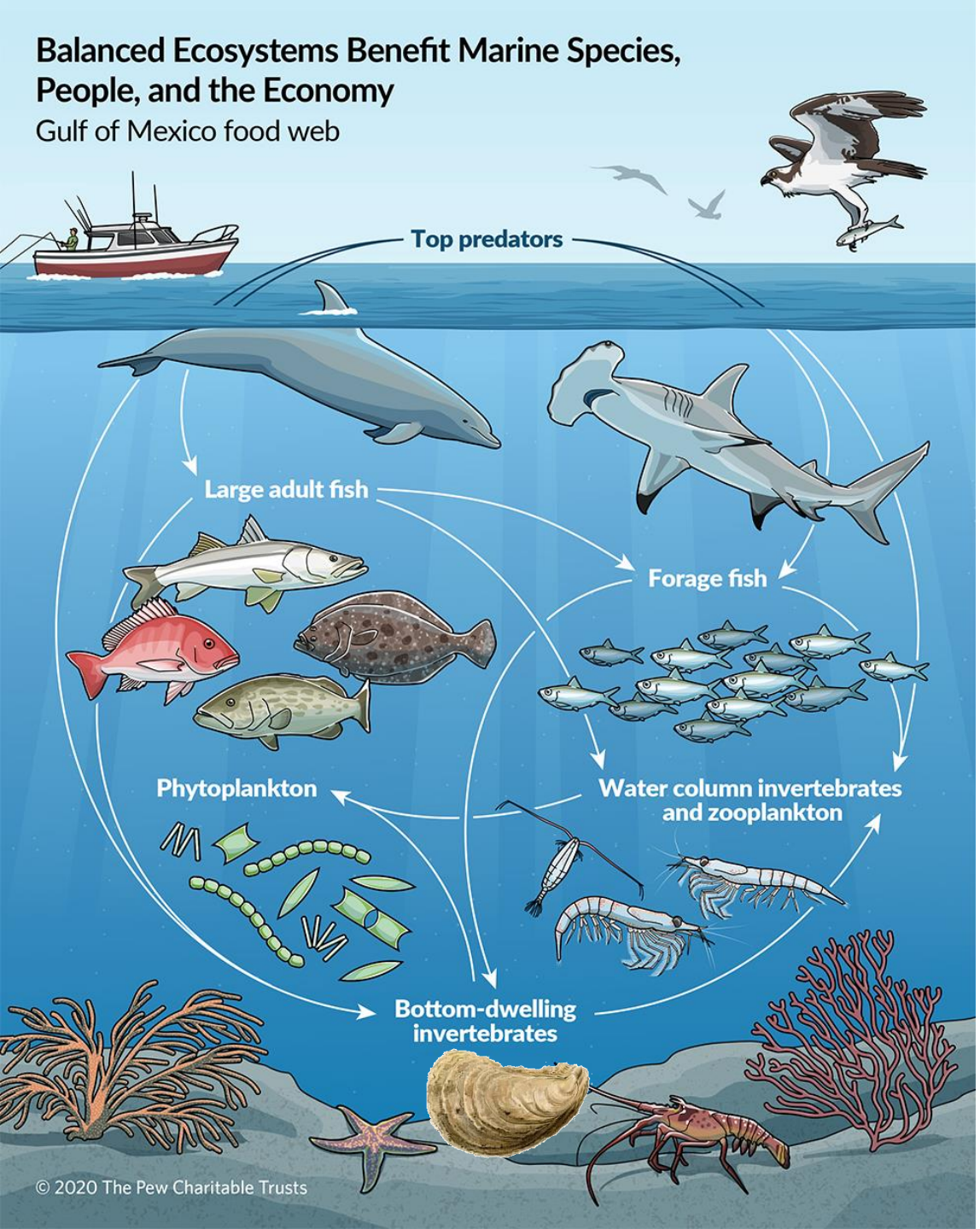
"Combined Effects" HSI Models



Determining mortality of oysters with a marine ecosystem model

Dr. Kim de Mutsert
Associate Professor, Division of Coastal Sciences
School of Ocean Science and Engineering

THE UNIVERSITY OF SOUTHERN MISSISSIPPI



What is a Marine Ecosystem Model?

- A tool to evaluate effects of changes in the environment on fish, shellfish and fisheries
- The marine fish and shellfish populations are modeled
- Predator-prey interactions are considered
- Effects of the environment and water quality on marine species are included

Research Questions

- What extent of freshwater inflow significantly increases natural mortality of eastern oysters in the Mississippi Sound?
- 2019 was a year with an unusual high amount of freshwater inflow. Would the extensive oyster mortality have been seen without the Bonnet Carré Spillway openings? What effect would the BCS openings have had under average conditions?
- At what point during the dual opening of the Bonnet Carré Spillway in 2019 was the freshening too much for the oysters?

Why we use computer models to answers these questions

It allows us to isolate cause and effect by controlling what is “on” and “off” in a computer model of the ecosystem.

Q: Did the Bonnet Carré openings cause the oyster mortality in 2019 or was higher river inflow enough?

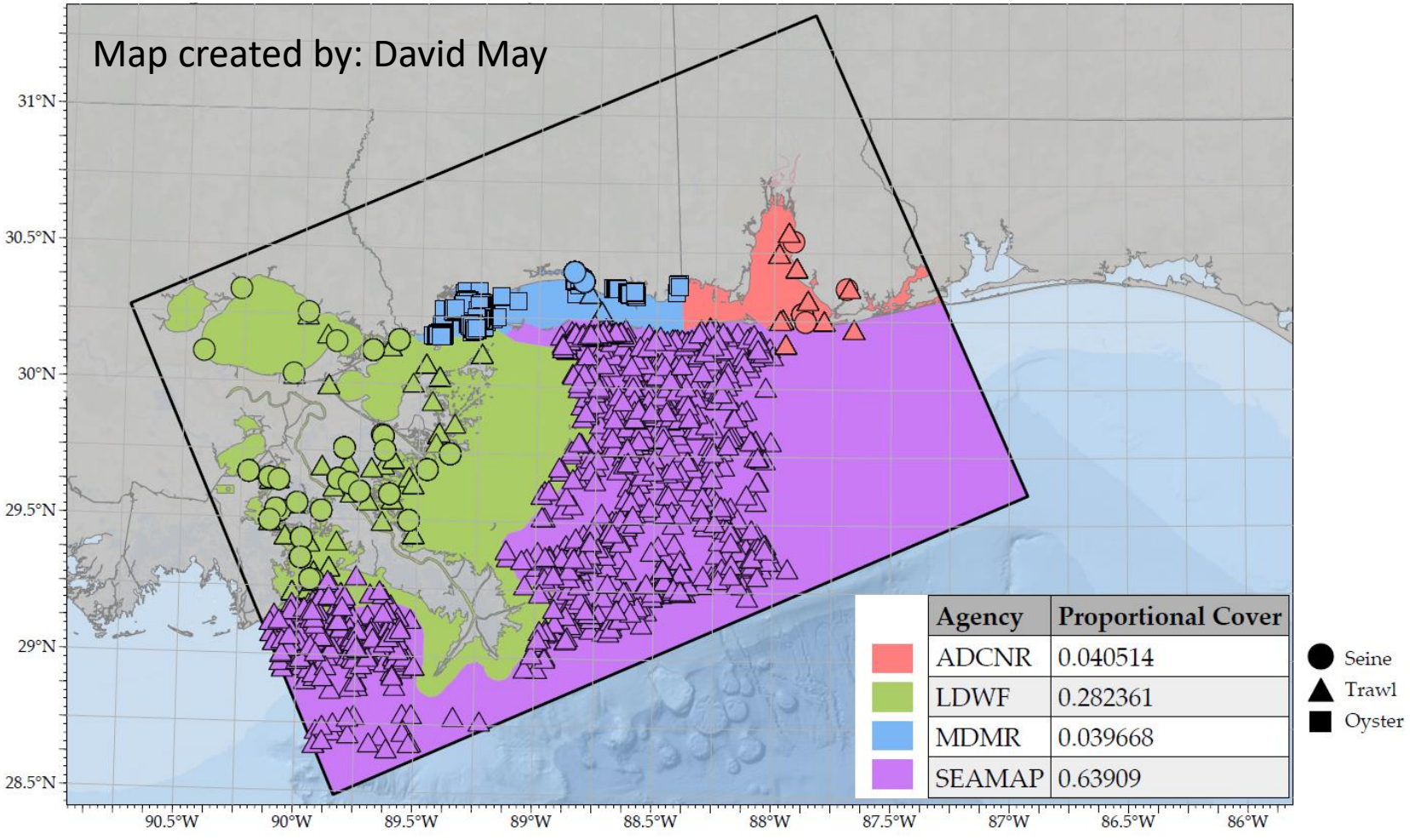
- Turn the Bonnet Carré off in the same environment and compare oyster biomass and mortality

Q: At what point was the freshwater inflow too much for the oysters?

- Reduce the time the Bonnet Carré was open and determine at which point mortality falls within a natural range

Data use

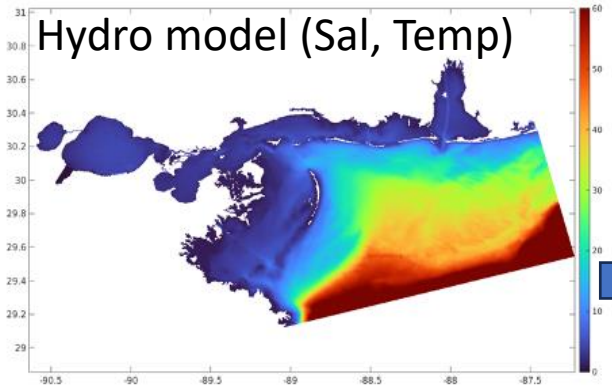
Years of data collections and research go into the marine ecosystem model so that it accurately reflects the natural environment



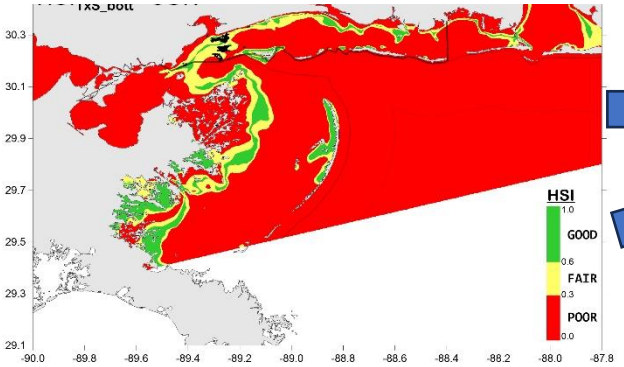
Model Coupling and Timeline

Jan-Jun 2024

Hydro model (Sal, Temp)

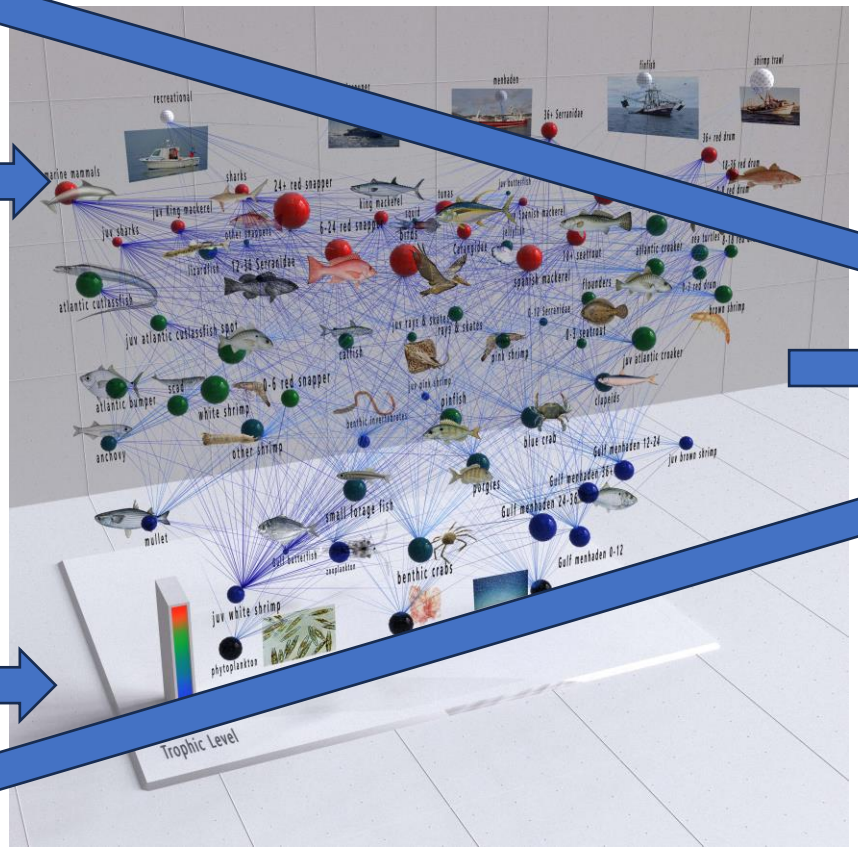


HSI model (suitability for oysters)



Jun-Aug 2024

Marine Ecosystem Model
(Oyster biomass and mortality)



Aug-Dec 2024

Jan-Jun 2025

NORTHERN GULF INSTITUTE
a NOAA cooperative institute

MISSISSIPPI STATE UNIVERSITY

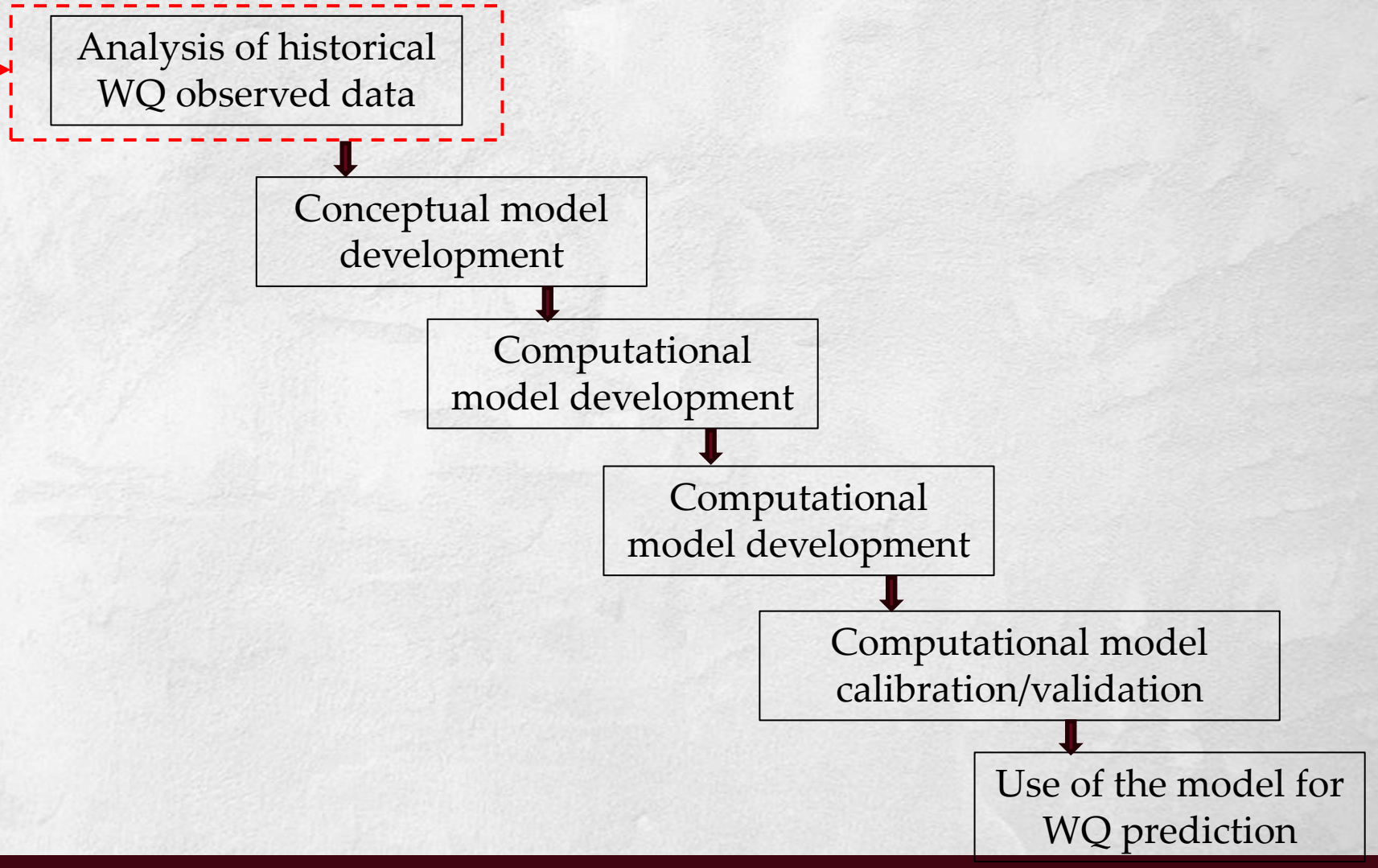
Nutrient and harmful algae blooms (HAB) modeling in the MS Sound

Paul F. Mickle, Northern Gulf Institute, NGI

Vladimir J. Alarcon, NGI-Mississippi State University

Water quality modeling overview

We are currently in this stage →



How to assess water quality?

- Eutrophication criteria for estuaries (USF, 2022):
  - Chlorophyll-a (used as an indicator of algal blooms)
    - Good: < 10 ug/L, Fair: < 20 ug/L
  - Total Phosphorus
    - Good: <0.04 mg/L, Fair: <0.07 mg/L
  - Total Nitrogen
    - Good: < 0.7 mg/L, Fair: < 1.2 mg/L

- Salinity ranges for Oysters (Gledhill et al. 2020):
  - Optimal: 14 PPT to 28 PPT
  - Tolerable: 5 PPT to 40 PPT

Trophic State Index (TSI) for lakes and estuaries

For lakes: 0-59 is good, 60-69 is fair, 70-100 is poor.
For estuaries: 0-49 is good, 50-59 is fair, 60-100 is poor.

Trophic State Index	Chlorophyll CHLA/ micrograms per liter (µg/1)	Total Phosphorus TP/ milligrams of phosphorus per liter (mgP/1)	Total Nitrogen TN/ milligrams of nitrogen per liter (mgN/1)
0	0.3	0.003	0.06
10	0.6	0.005	0.10
20	1.3	0.009	0.16
30	2.5	0.01	0.27
40	5.0	0.02	0.45
50	10.0	0.04	0.70
60	20.0	0.07	1.2
70	40	0.12	2.0
80	80	0.20	3.4
90	160	0.34	5.6
100	320	0.58	9.3

Eutrophic

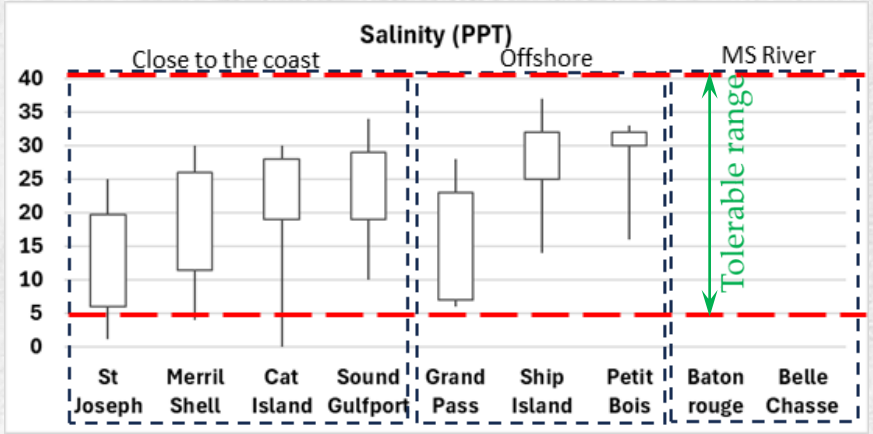
(After USF, 2022).

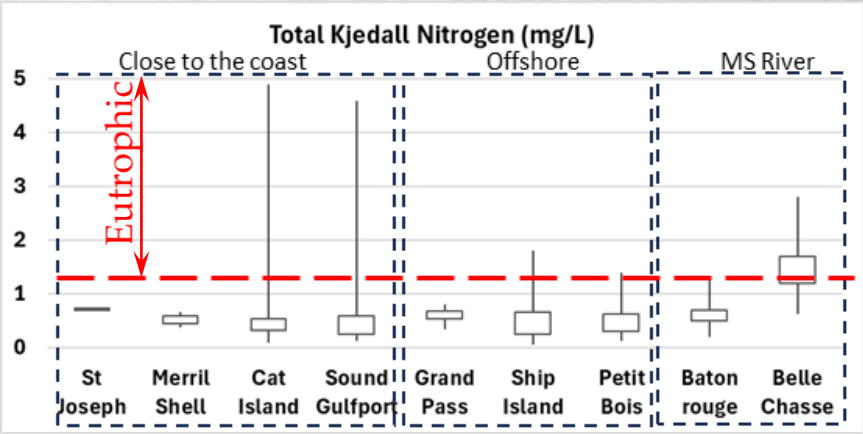
Trophic State Index	Trophic State Classification	Water Quality
0-59	Oligotrophic through Mid-Eutrophic	Good
60-69	Mid-Eutrophic through Eutrophic	Fair
70-100	Hypereutrophic	Poor

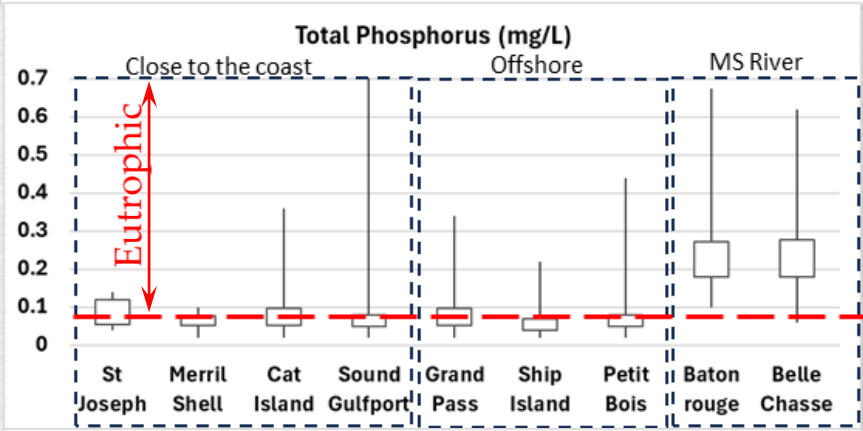
(After USF, 2022).

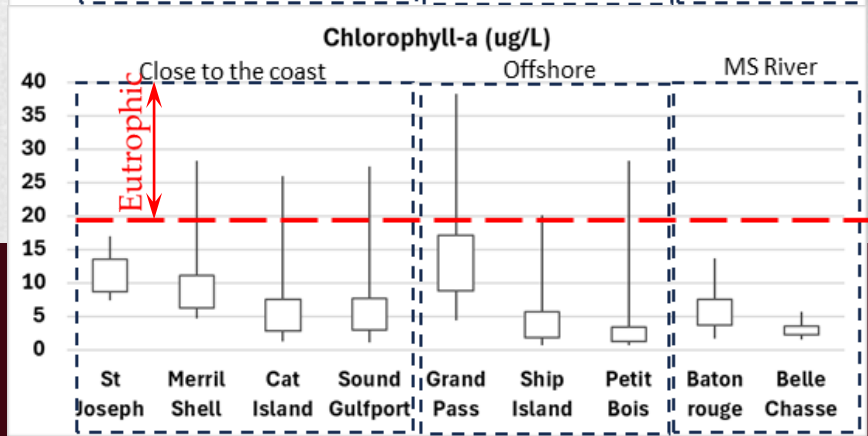
Water quality at the MS Sound (2014-2022), USGS

- Salinity increases eastwards
  - Lower salinities at eastern WQ stations
- Most of the salinity concentrations are within tolerable limits.
- Most of TKN concentrations are smaller than 2 mg/L which indicates mild eutrophication
- Most of TP concentrations are above 0.04 mg/L in the MS Sound ND above 0.15 mg/L in the Mississippi River, which indicates eutrophic conditions.
- Most of chlorophyll-a concentrations are below 20 ug/L indicating that algal biomass is not abundant.



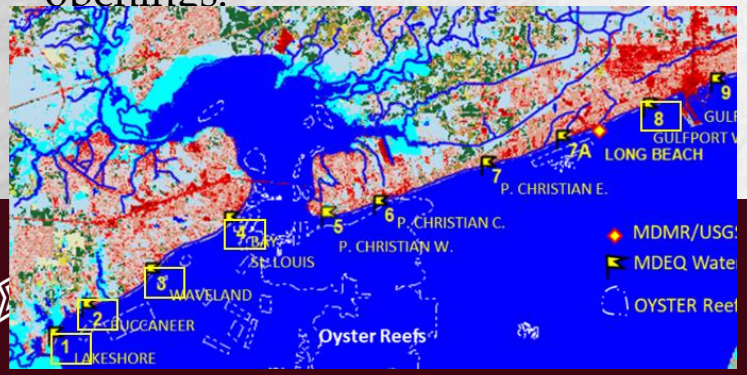




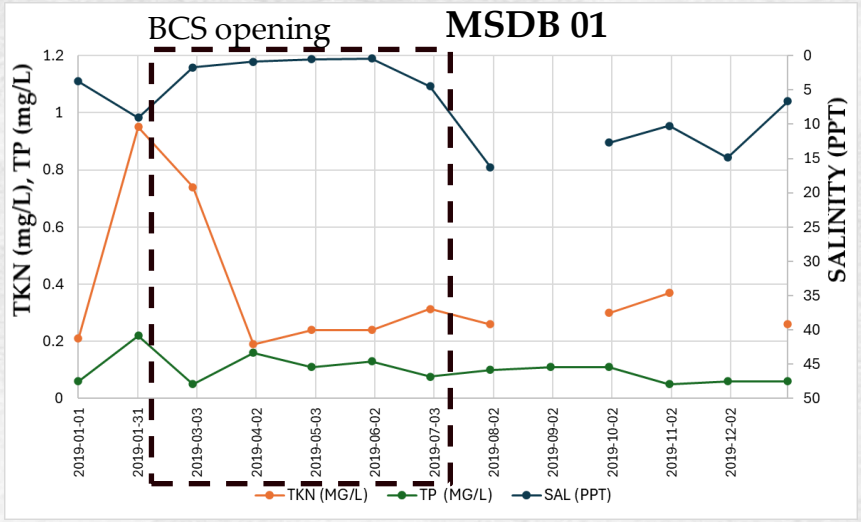


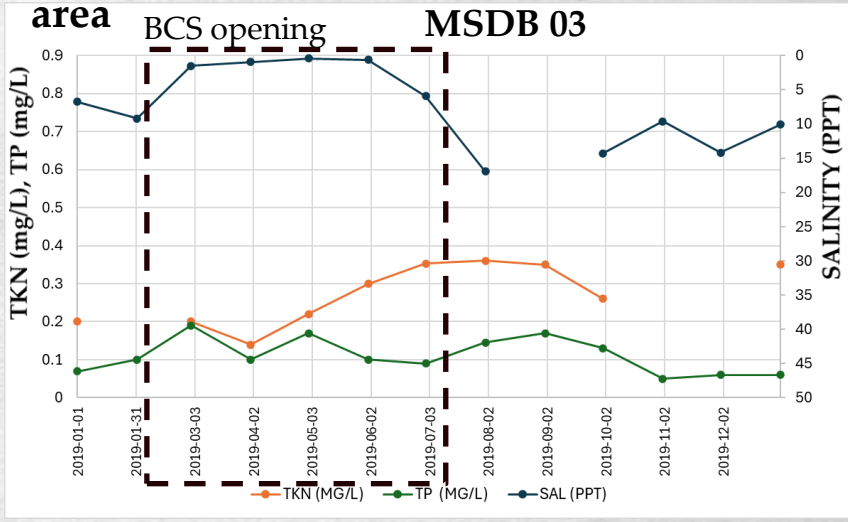
Water quality during 2019 (selected MDEQ stations)

- Salinity decreases noticeably during Bonnet Carré openings (below optimal range).
- Total Kjeldahl Nitrogen (TKN) decreases drastically during the same period at the most westward station and slightly increases in stations eastwards.
- TKN > 1.2 mg/L (mid eutrophic conditions) at Stations MSDB04 to MSDB08 after the Bonnet Carré opening event.
- Total Phosphorus (TP) is mostly above 0.07 mg/L at all stations (eutrophic conditions).
- TP trend does not seem to be related with Bonne Carré openings.

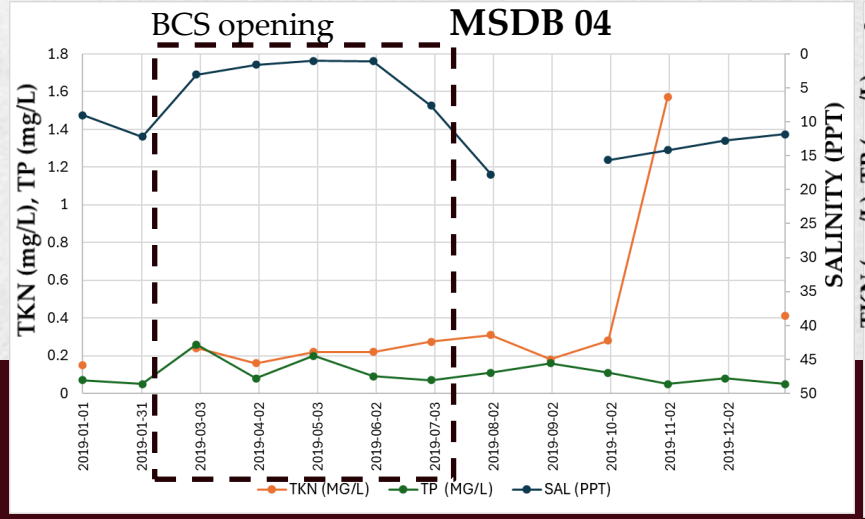


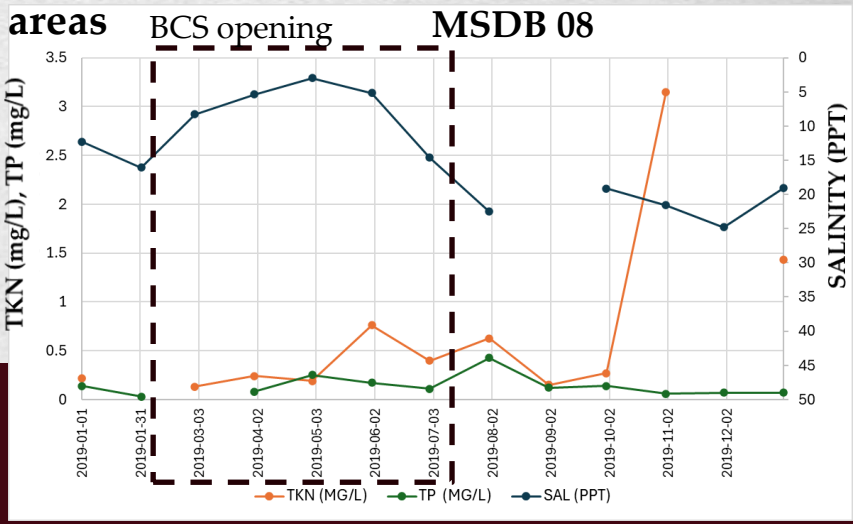
Stations at moderately urbanized coastal area





Stations at urbanized coastal areas





Final thoughts

- There is no clear relationship between BCS openings and nutrients or chlorophyll-a
- Nevertheless, a possible dilution of Total Nitrogen concentrations may be a consequence of BCS opening, similar to the observed salinity dilution.
- The effect of BCS openings on Total Phosphorus concentrations could not be detected in this preliminary data analysis.
- Water turbidity seems to increase due to BCS opening.
- Chlorophyll-a (an indicator of algal blooms) remains below 60 ug/L during BCS events (mid-eutrophic conditions)
- Episodical hyper-eutrophic conditions after the openings were detected (chl-a > 60 ug/L).
- Continuous water quality monitoring is necessary to ascertain the effect of BCS openings.
- For water quality and HAB model development, daily WQ monitoring during opening events would be ideal.

Mississippi Sound Coalition Science Forum

MISSISSIPPI SOUND COALITION RESEARCH FORUM

March 14 | 10-11:30 a.m.
Knight Non-Profit Center

1. Introduction of Forum Moderator, Dr. Mickle
   GERALD BLESSEY *(3 minutes)*
2. Western Sound Science Collaborative Introduction and Research Focus/Goal
   WSSC SCIENTISTS *(5 minutes)*
3. Background and Bonnet Carré Modeling Efforts
   DR. MICKLE *(10 minutes)*
4. Water Quality Modeling
   DR. WIGGERT, DR. CAMBAZOGLU, BRANDY ARMSTRONG *(10 minutes)*
5. Ecosystem Modeling
   DR. DE MUTSERT, DR. MILROY *(10 minutes)*
6. Nutrients and Harmful Algal Bloom Modeling
   DR. ALARCON AND DR. MICKLE *(10 minutes)*
7. Discussions and Questions with the Public
   WSSC SCIENTISTS *(30 to 42 minutes)*

INVITEES:

- Public
- Mississippi Sound Coalition Members
- State Legislators
- Press
- Non-Gov. Organizations
- Resource Agency Scientists
- Academic Scientists

MISSISSIPPI STATE UNIVERSITY
NORTHERN GULF INSTITUTE a NOAA cooperative institute
THE UNIVERSITY OF SOUTHERN MISSISSIPPI

EOE/F/M/VET/DISABILITY

Speakers

Dr. Paul Mickle, Moderator
Co-Director
Northern Gulf Institute
Mississippi State University

Dr. Jerry Wiggert
The University of Southern Mississippi

Dr. Kemal Cambazoglu
The University of Southern Mississippi

Brandy Armstrong
The University of Southern Mississippi

Dr. Kim de Mutsert
The University of Southern Mississippi

Dr. Scott Milroy
The University of Southern Mississippi

Dr. Vladimir Alarcon
Mississippi State University

Freshwater impact on Mississippi Sound

Mississippi River and more than **20 local rivers** as well as **freshwater diversion structures** directly or indirectly affect the estuarine and shelf waters.

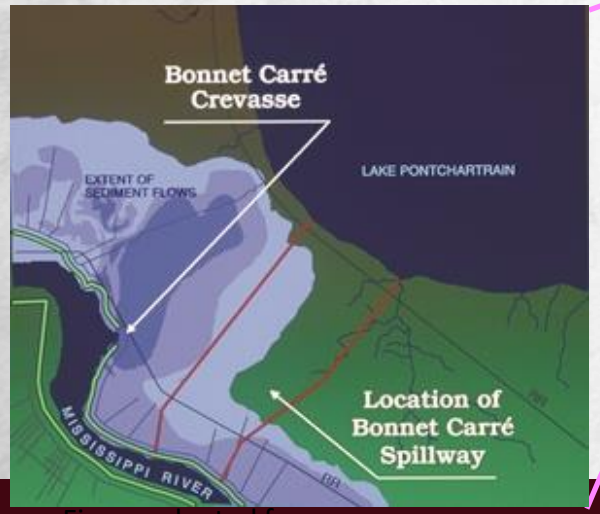
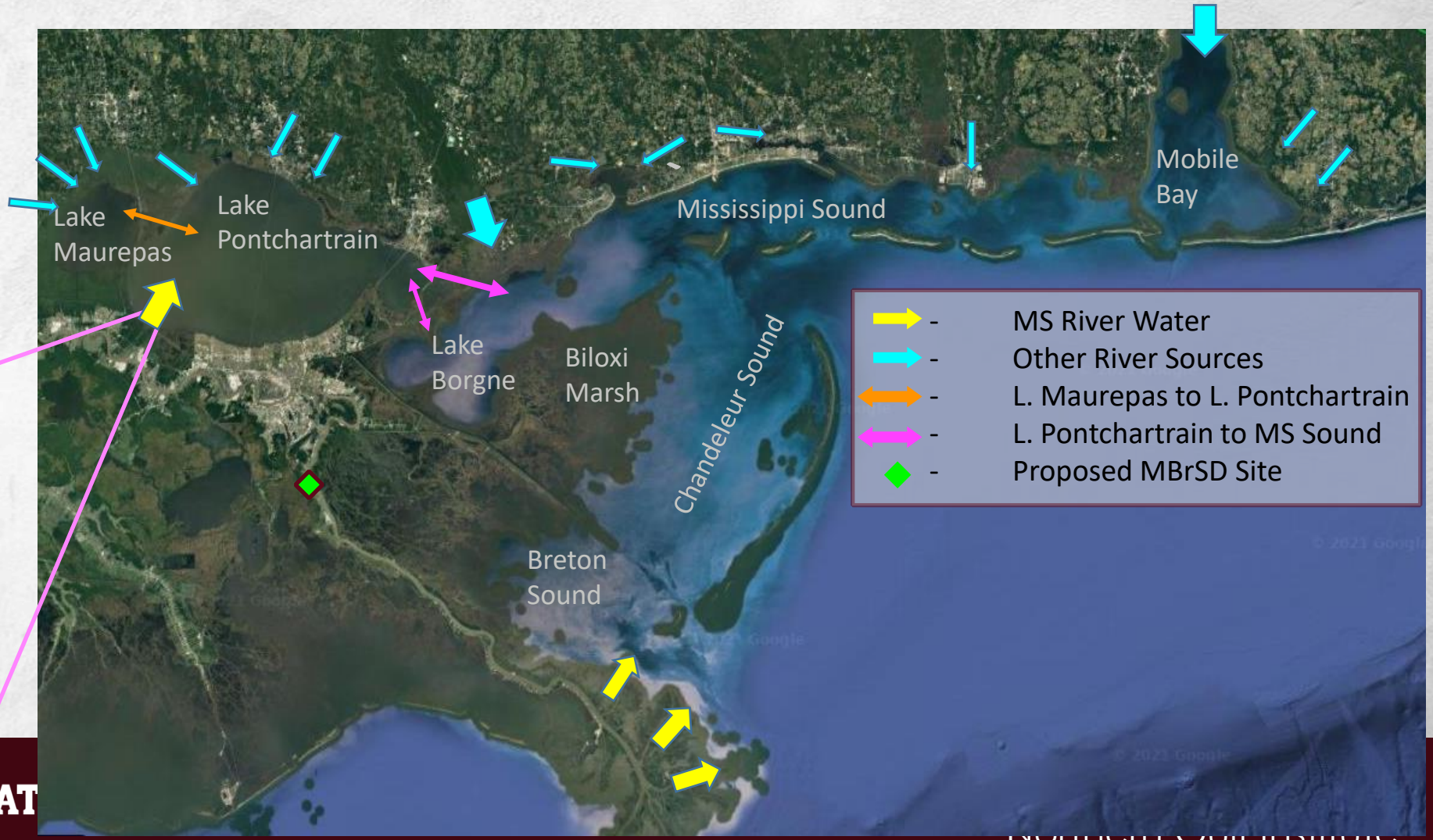
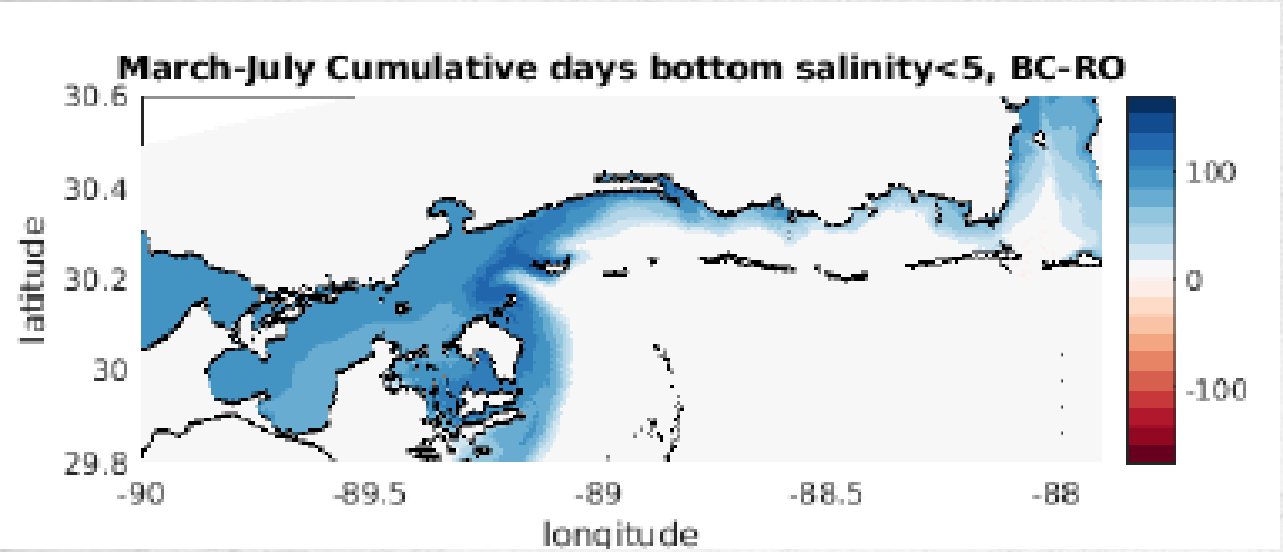


Figure adapted from lmvd.usace.army.mil

Freshwater Flows and Exchange Pathways



Tipping Points From Coupled Model Applications



- Twin experiment also shows additional days of salinity below 5 in the Sound due to BCS operation
- Extended exposure to low salinity leads to oyster mortality.
- Ocean Model results could show map of tipping point (i.e., salinity below 5 for two consecutive weeks)

Coupling ocean model with habitat suitability and ecosystem models

Ocean Model
msbCOAWST

With addition of coupled biogeochemical module

HSI Model
Habitat Suitability Index (HSI) Model

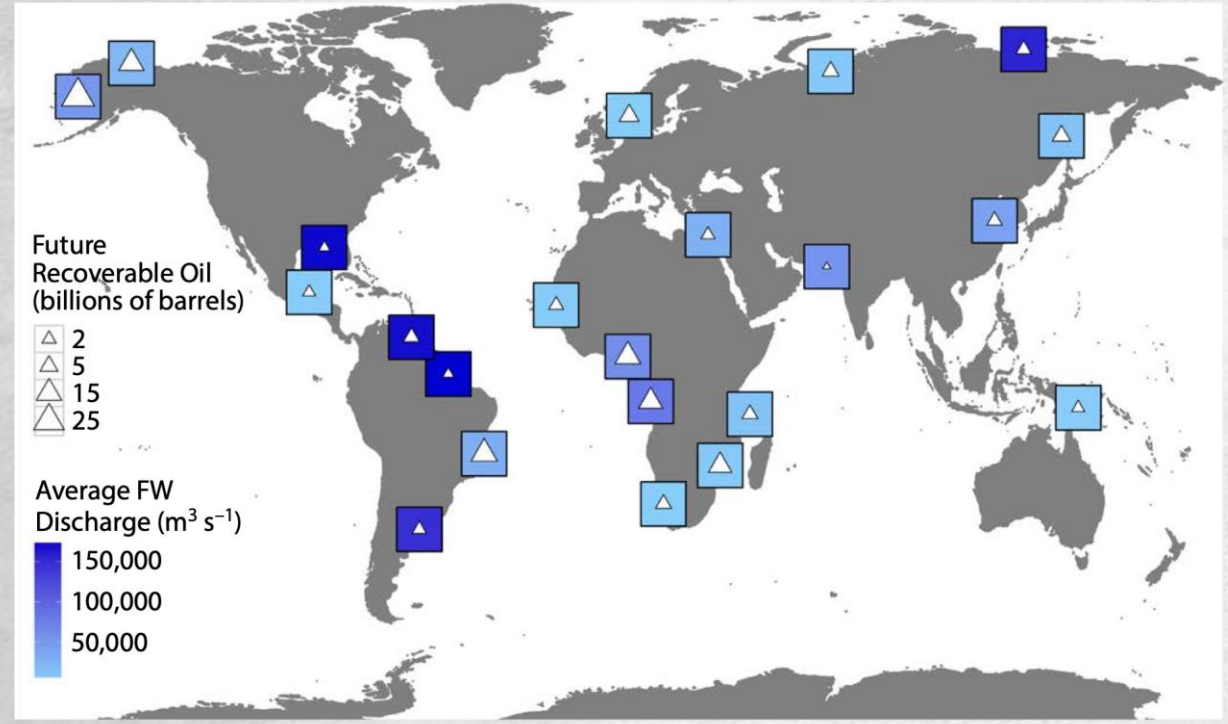
With input from the Ocean Model

Ecosystem Model
Ecospace food-web model

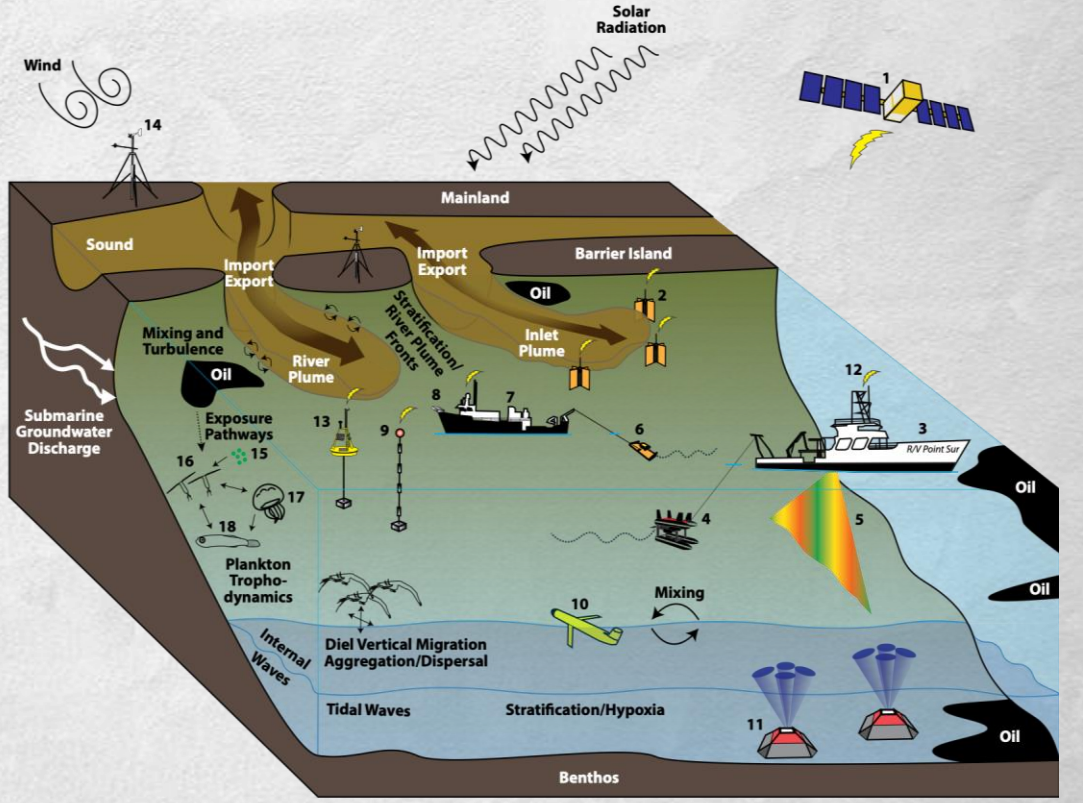
With input from the Ocean and HSI models

The msbCOAWST Origin Story

GULF OF MEXICO RESEARCH INITIATIVE



Coastal river-dominated ecosystems around the world with nearby oil extraction activities that are similar to those found within the CONCORDE domain



Dynamic processes in the pulsed-river controlled Mississippi Bight that influence the distribution, transport, and exchange pathways of marine ecosystem constituents

MISSISSIPPI STATE UNIVERSITY

Geosystems Resea
Northern G

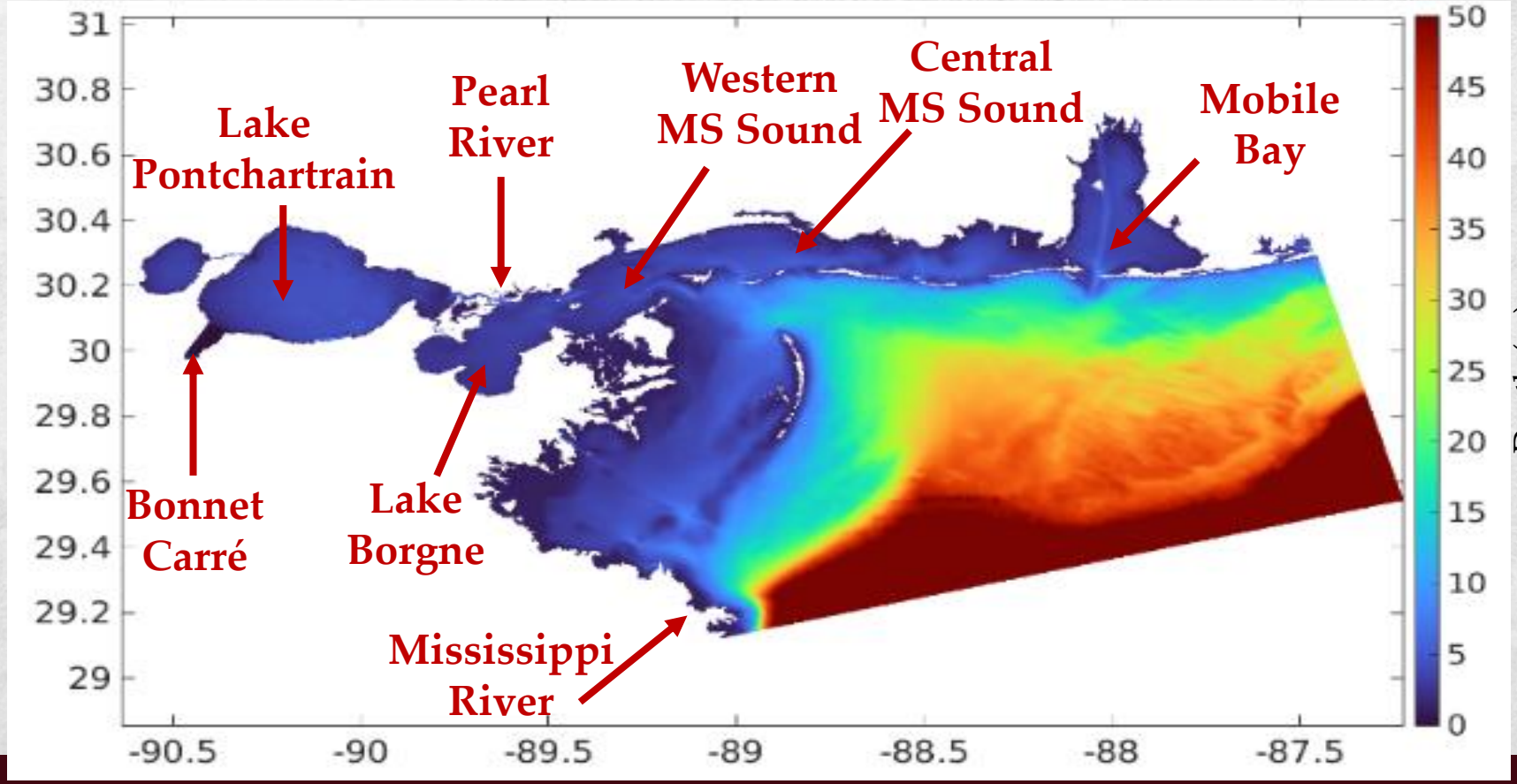
CONCORDE Consortium for Coastal River-Dominated Ecosystems

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Greer et al. (2018), *Oceanography*, doi:10.5670/oceanog.2018.302.

Modeling the Dynamics in Mississippi Sound

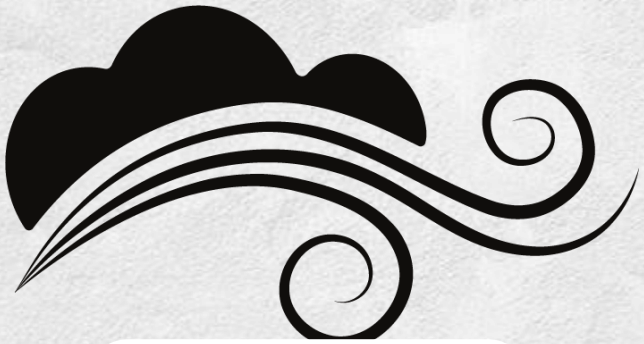
We developed an application of a modeling framework to study the **impacts of Bonnet Carré Spillway Operations on Mississippi Sound and Bight.**



The modeling system, COAWST, was originally developed by USGS Geological

Freshwater impact on Mississippi Sound

The modeling framework allows us to **predict the estuarine dynamics and variability of water quality parameters such as temperature and salinity.**



Atmospheric Forcing (NOAA)

Ocean Model

Gulf Boundary Forcing (NRL)

River Forcing (USGS)