

Oyster Metapopulation Modeling for Louisiana's Estuaries

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Louisiana developed \$132M oyster restoration plan to increase oyster density, improve oyster resource resilience, develop and protect spawning reefs



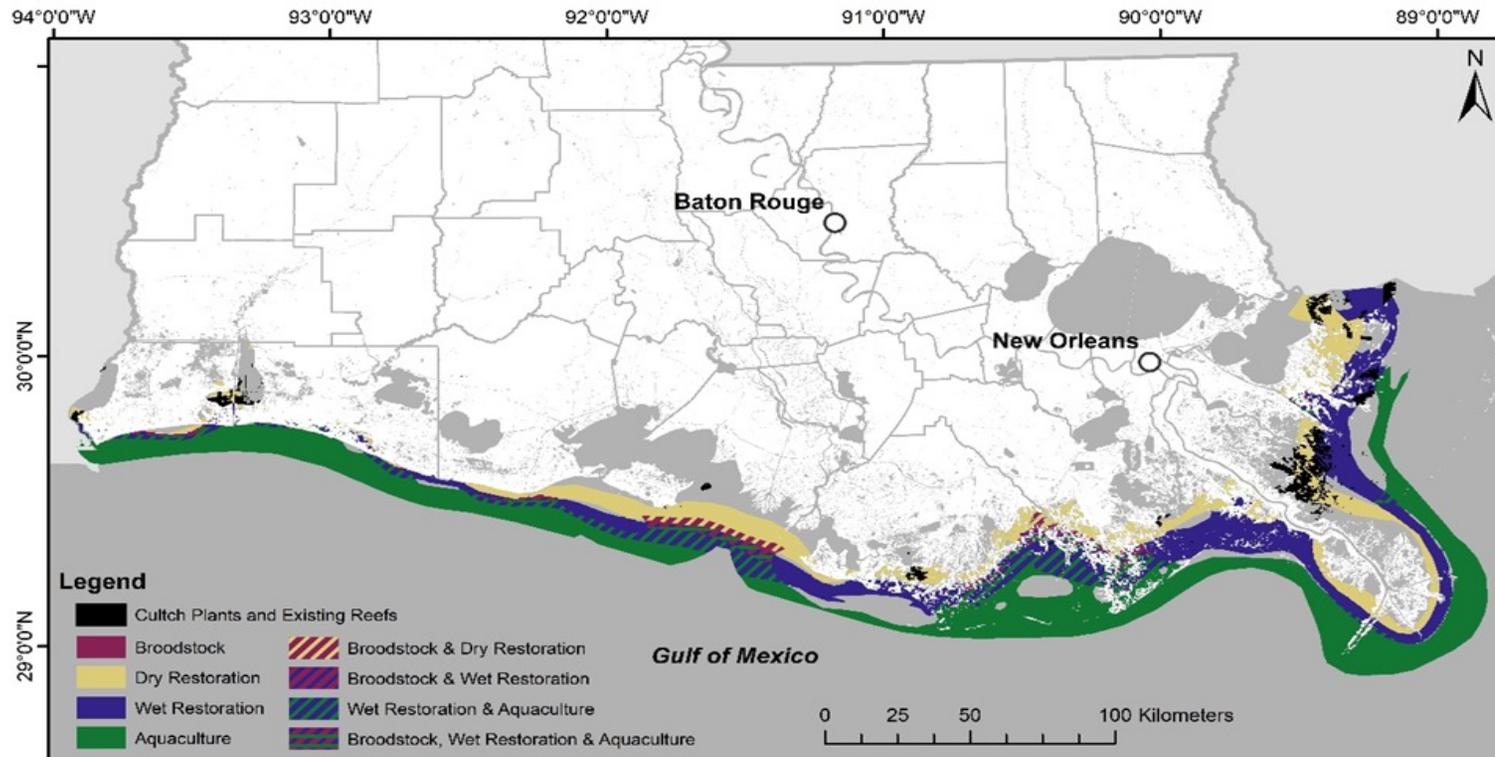
<https://www.wlf.louisiana.gov/assets/Resources/Publications/Oyster/Final-Draft---Oyster-Strategic-Plan---12.30.20.pdf>

Numerous oyster restoration and construction projects enacted across the state

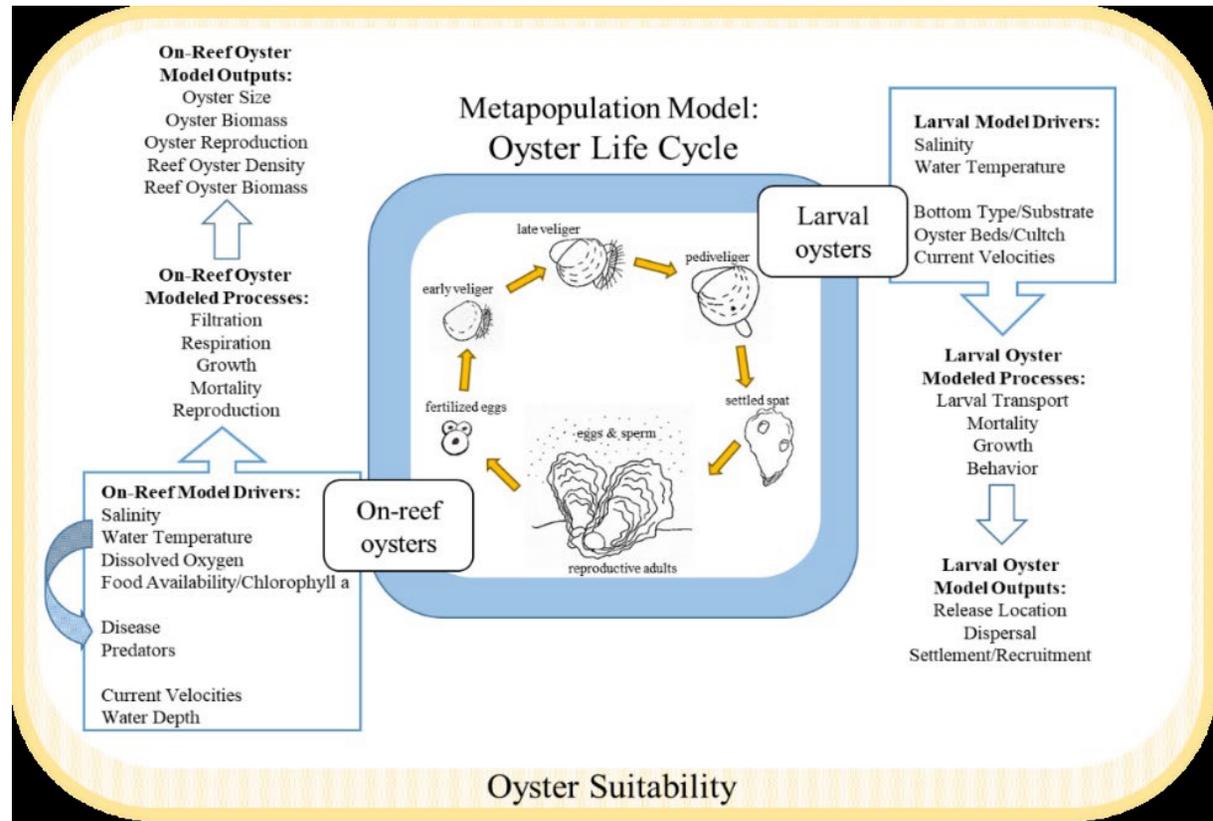
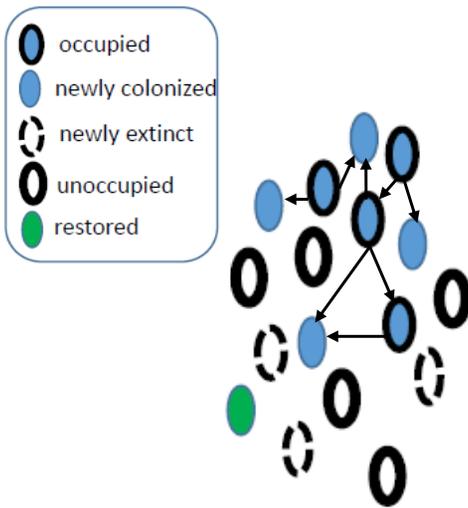
2025 Broodstock Network



Identification of suitable habitat and potential oyster zones provides some guidance, but still need to add reef connectivity



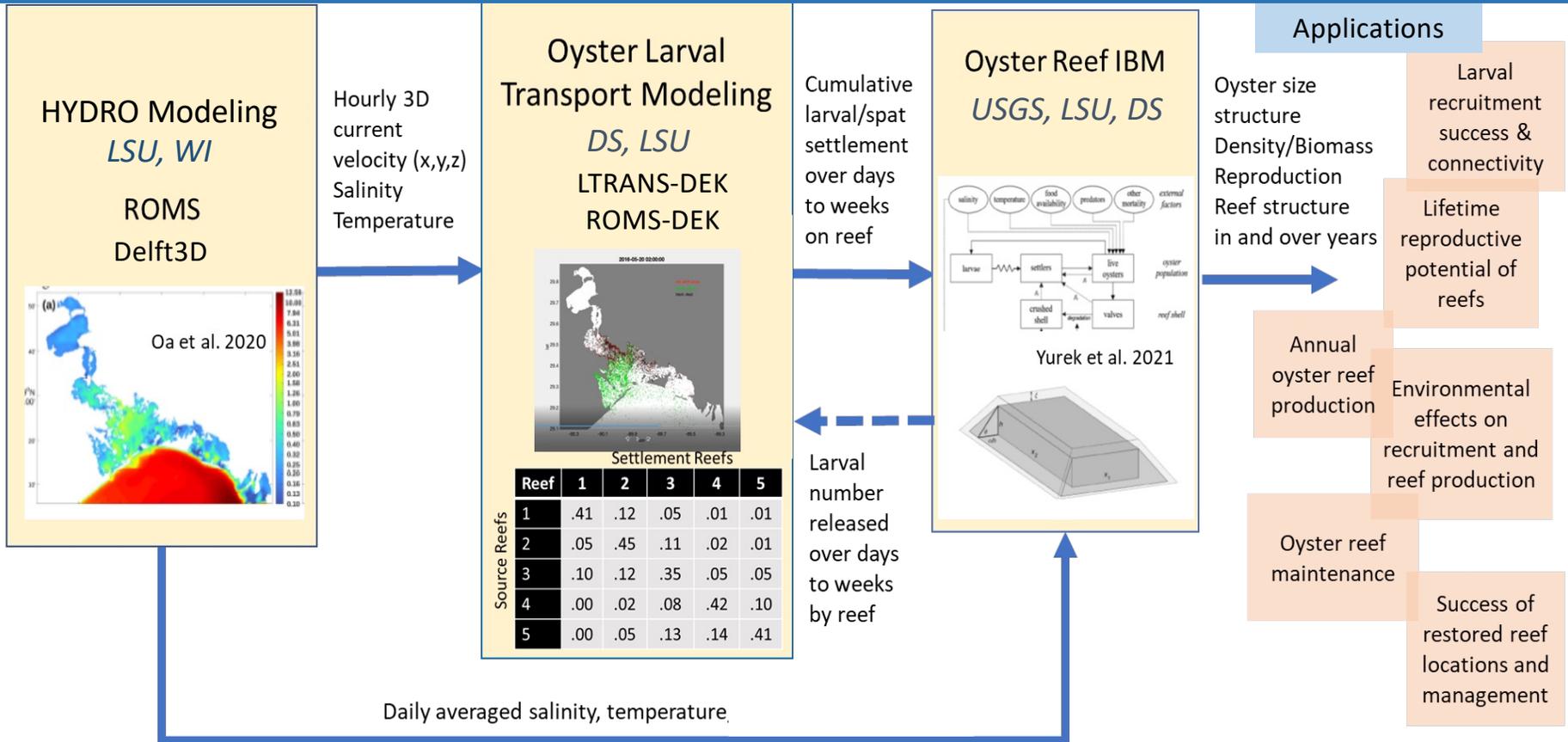
Local populations are, on their own, not stable but persist due to a balance of local extinction and colonization of patches (Van Nouhuys 2016)



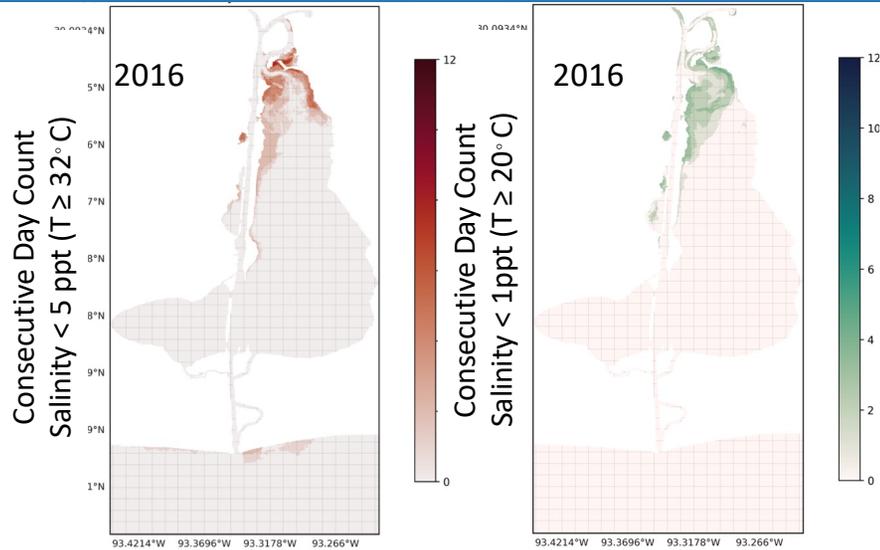
Developed an adaptable metapopulation model for Louisiana oysters to support basin-scale oyster restoration and management for sustainable populations.

- Mechanistic, adaptable and transferable metapopulation framework
- Multiple components to represent full life cycle of oysters and modifying factors:
 - Hydrodynamic and water quality models (HYDRO/WQ)
 - Oyster larval transport model
 - Oyster reef individual-based model (IBM)
- Coupled model framework to support LDWF with basin-scale oyster restoration planning and management questions

Final products include coupled oyster metapopulation models for north Pontchartrain basin (NPONT), Barataria Basin (BAR) and Calcasieu Lake (CALC)

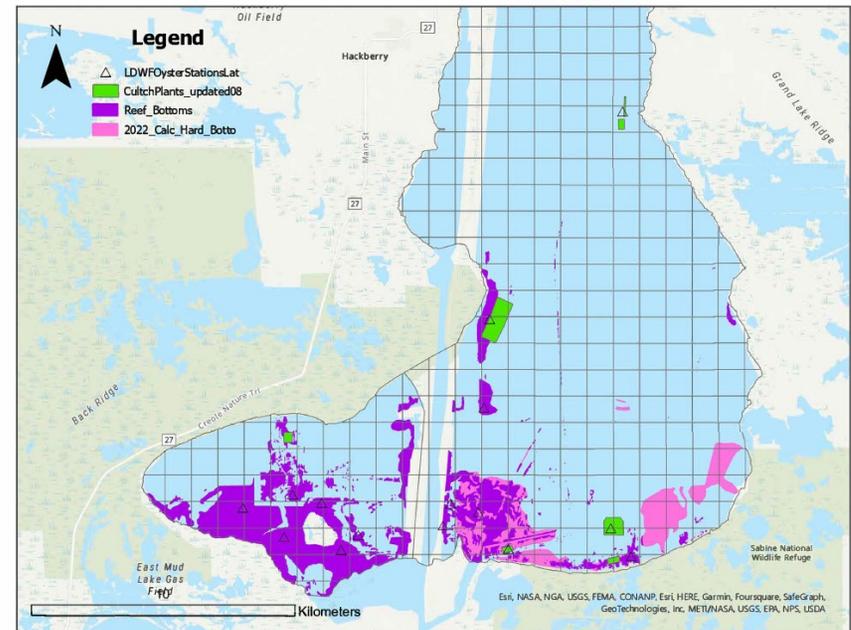


Calcasieu Lake Metapopulation Model Domain and Setup

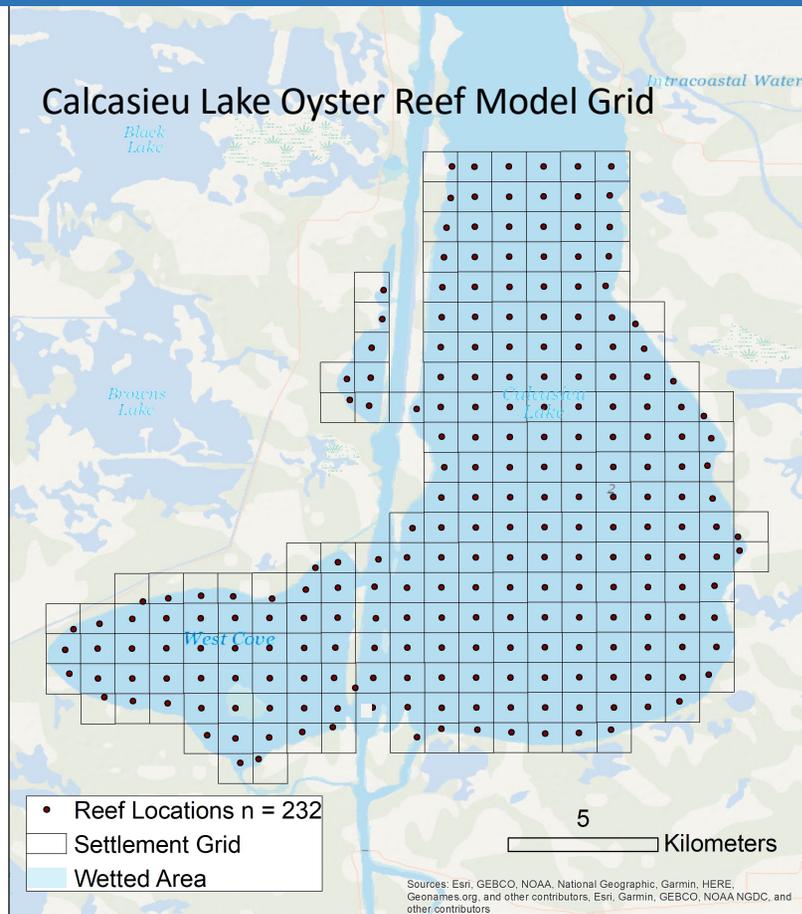


- Spatial resolution for reef IBM point models at 1-km to evaluate larval transport and connectivity among CALC oyster grounds routinely monitored by LDWF

- ROMS at 30-m resolution from 2014-2018
- The salinity thresholds barely occurred and only in the northernmost lake

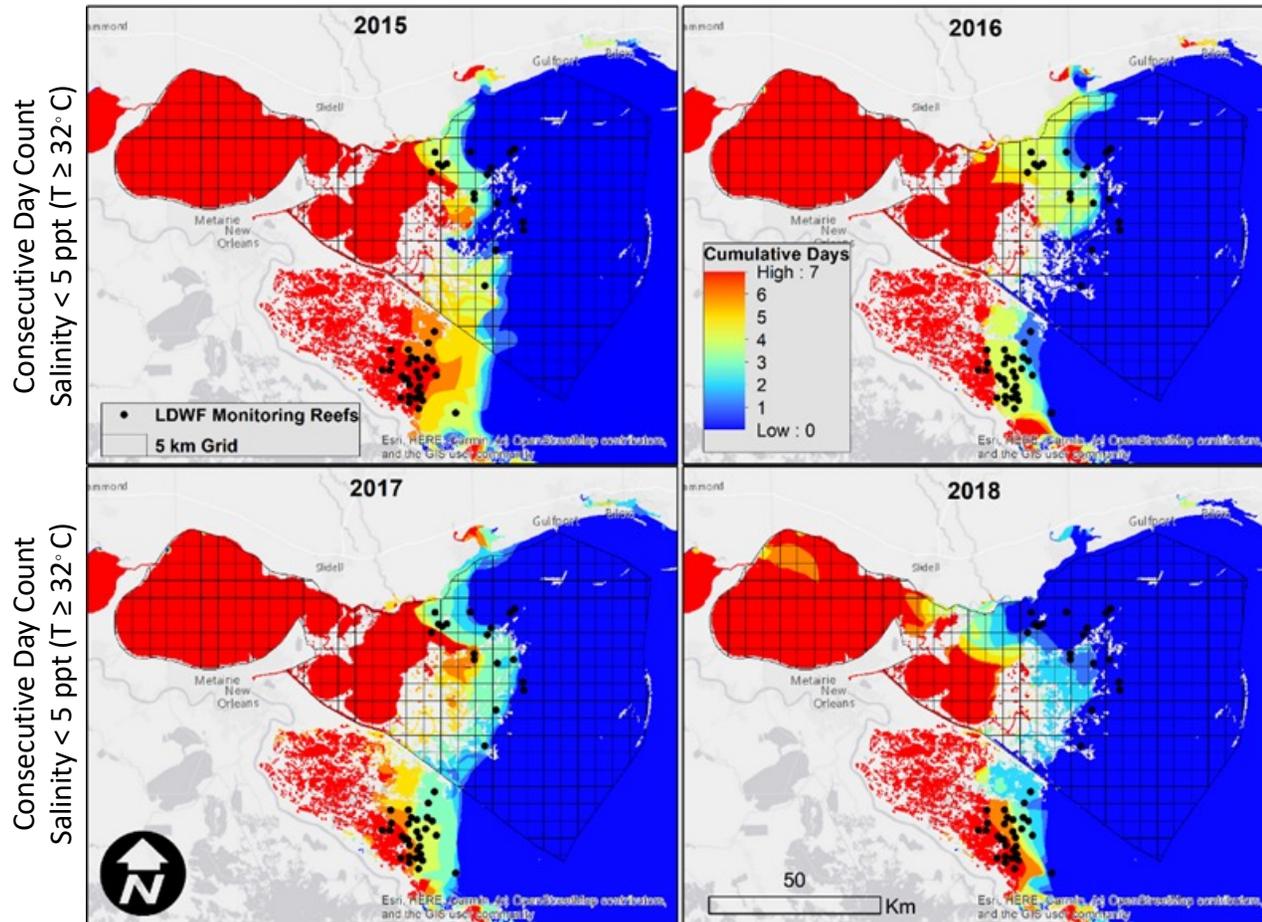


Calcasieu Lake Metapopulation Model Domain and Setup



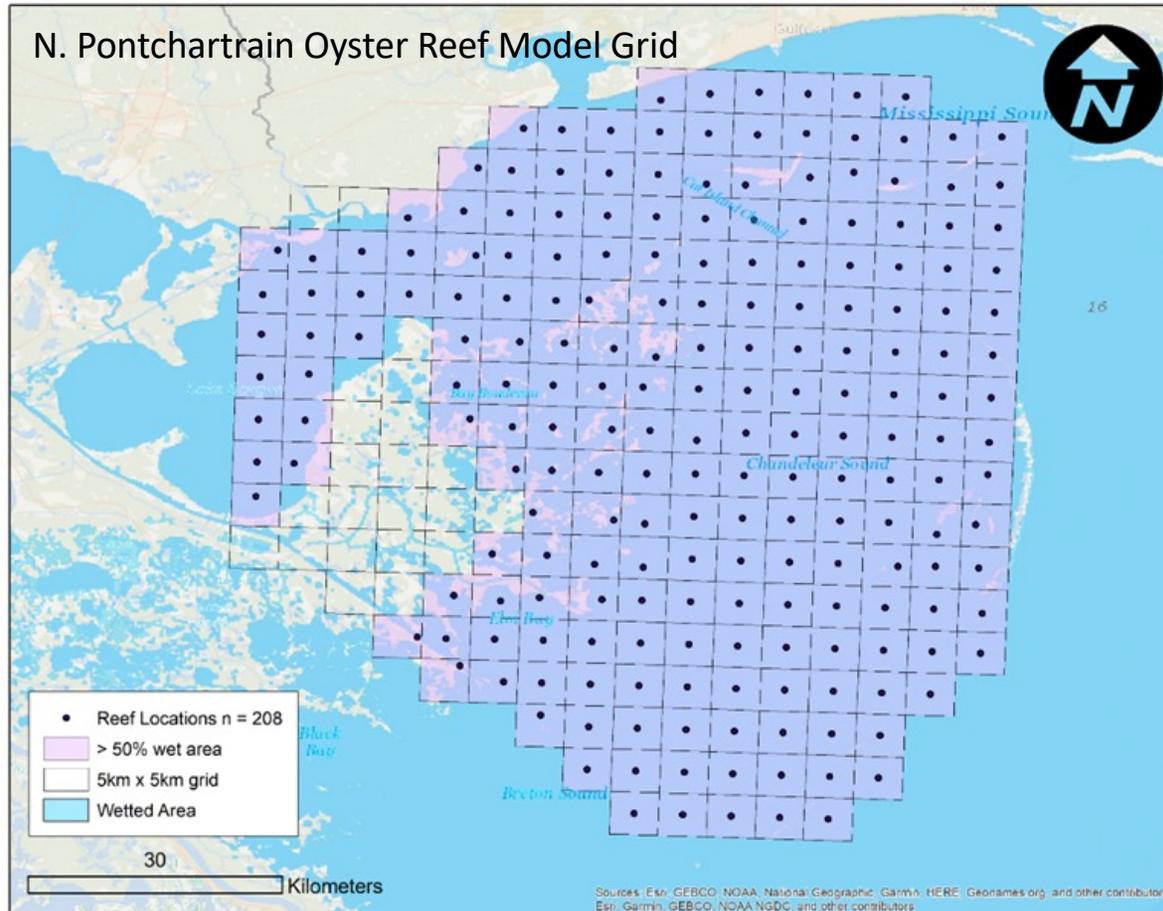
- Reef point models assumed uniform in water bottom area for 232 1-km grid cells
- Source and settlement reef cells for larval transport
- Larval settlement to reef point models for reef oyster population over years

North Pontchartrain Metapopulation Model Domain and Setup



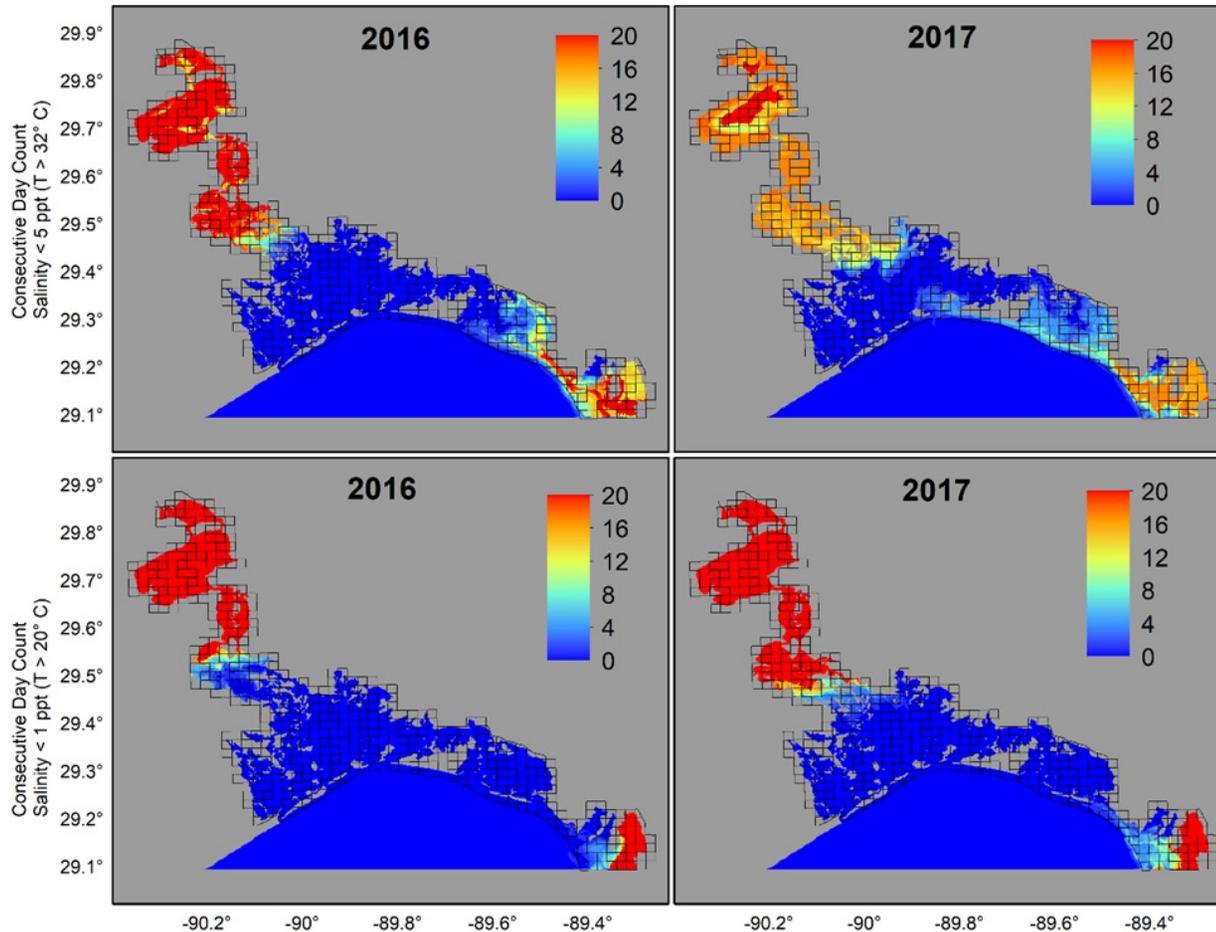
- Delft3D-FM from 2014-2018
- Spatial resolution for reef IBM point models based on number of days below seasonal salinity thresholds

North Pontchartrain Metapopulation Model Domain and Setup



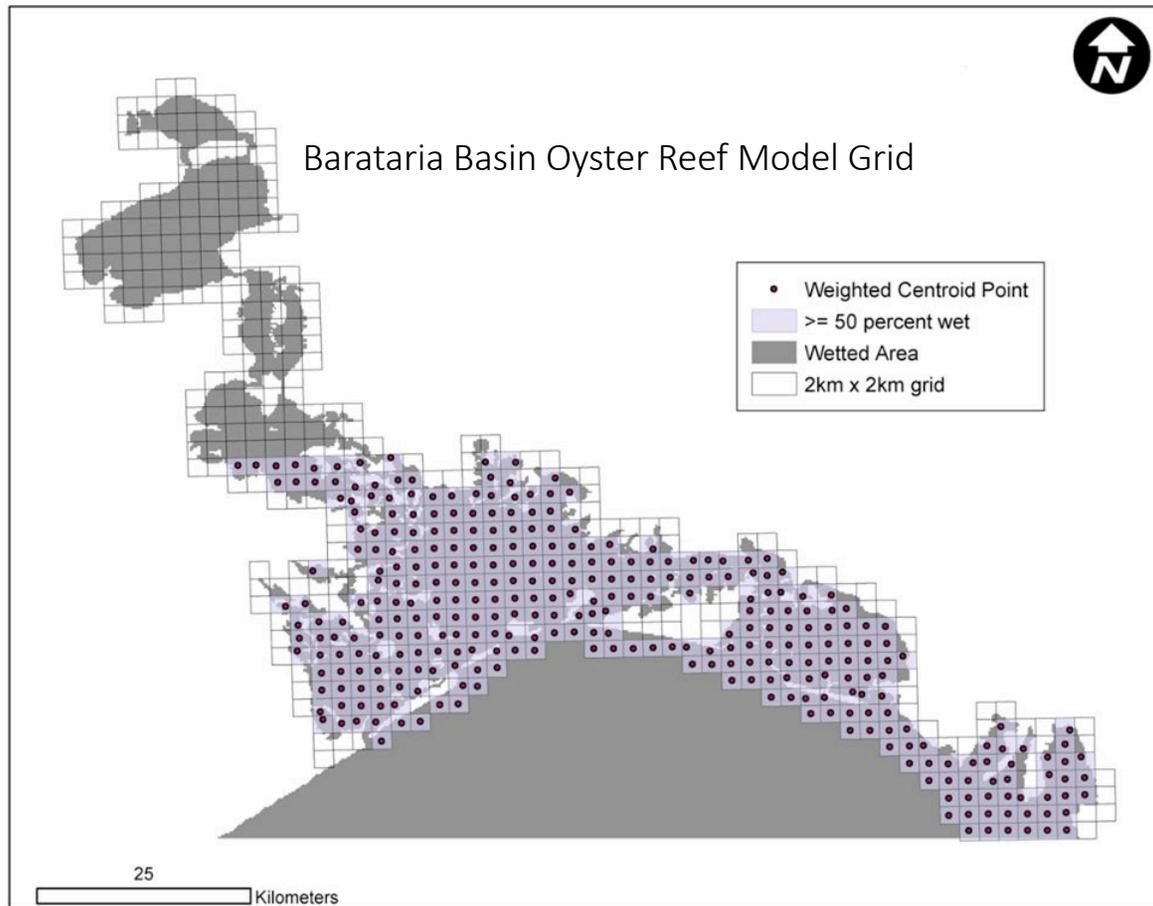
- Reef point models assumed uniform in water bottom area for 208 5-km grid cells
- Source and settlement reef cells for larval transport
- Larval settlement to reef point models for reef oyster population over years

Barataria Basin Metapopulation Model Domain and Setup



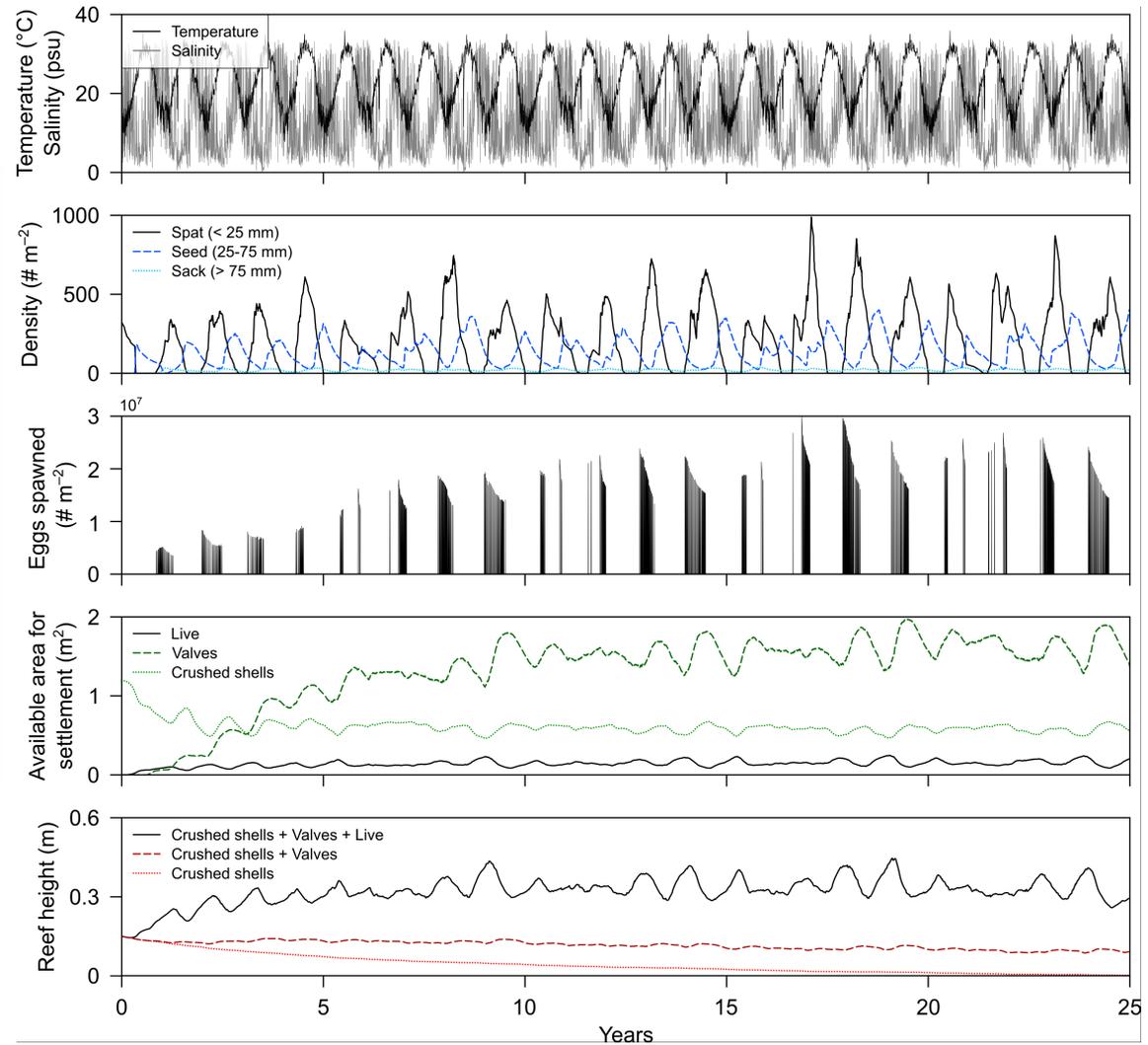
- ROMS at 200-m resolution from 2014-2018
- Spatial resolution for reef IBM point models based on number of days below seasonal salinity thresholds

Barataria Basin Metapopulation Model Domain and Setup



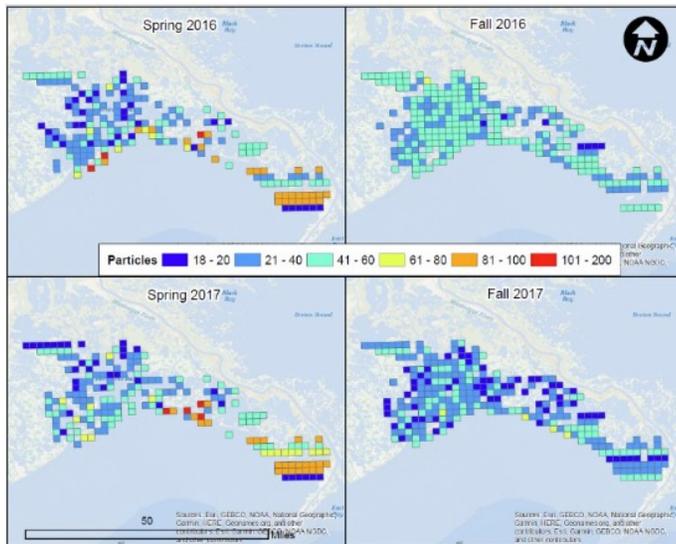
- Reef point models assumed uniform in water bottom area for 332 2-km grid cells
- Source and settlement reef cells for larval transport
- Larval settlement to reef point models for reef oyster population over years

Development of fully-coupled OMM involved validation and demonstration of seasonality to match Louisiana population field data: BAR example

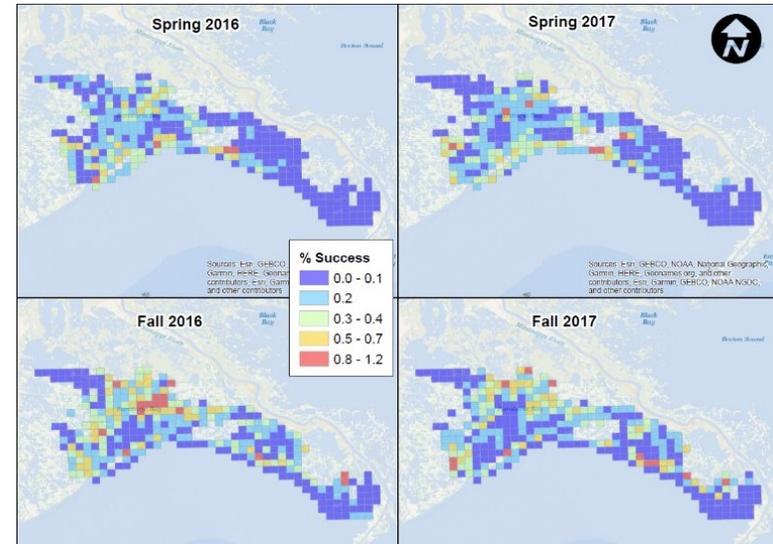


The larval transport modeling can be used to identify number of larvae released at each source reef, and the number settling at each reef.

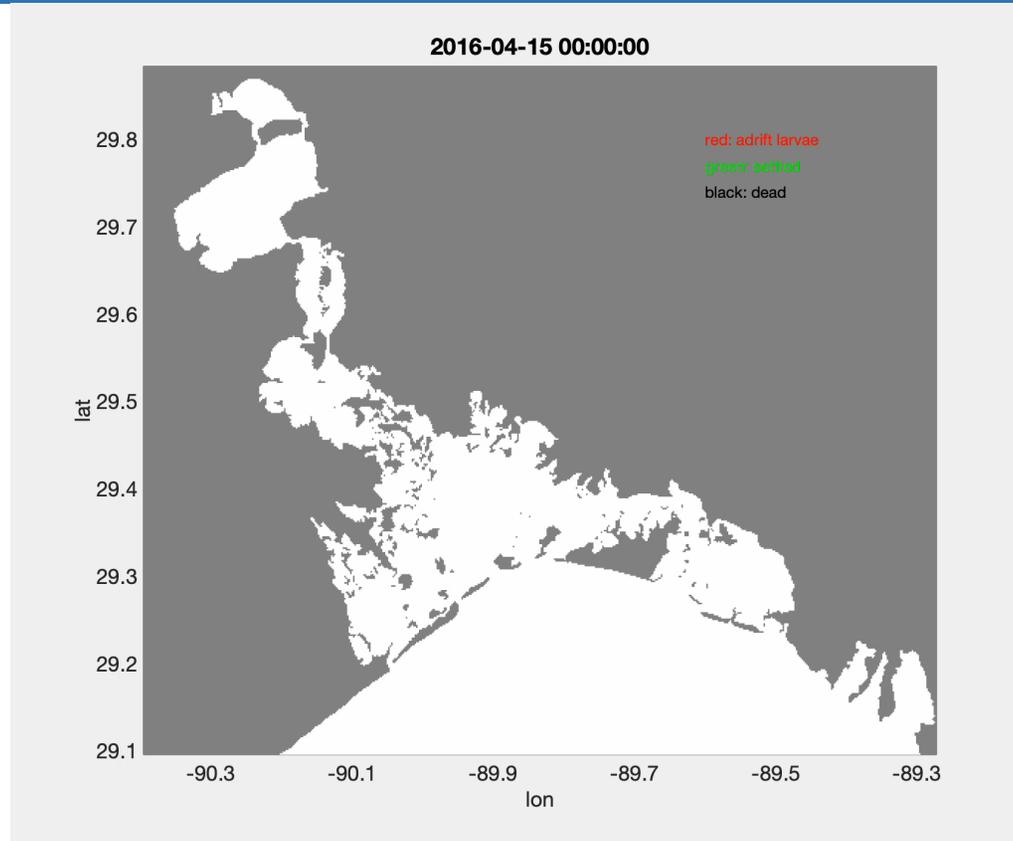
Number of Larvae Released
by Source Reef



% Settlement Success
by Settlement Reef



Animation of larval transport model showing larvae being released from source reefs, drifting for suitable locations, and eventual fate

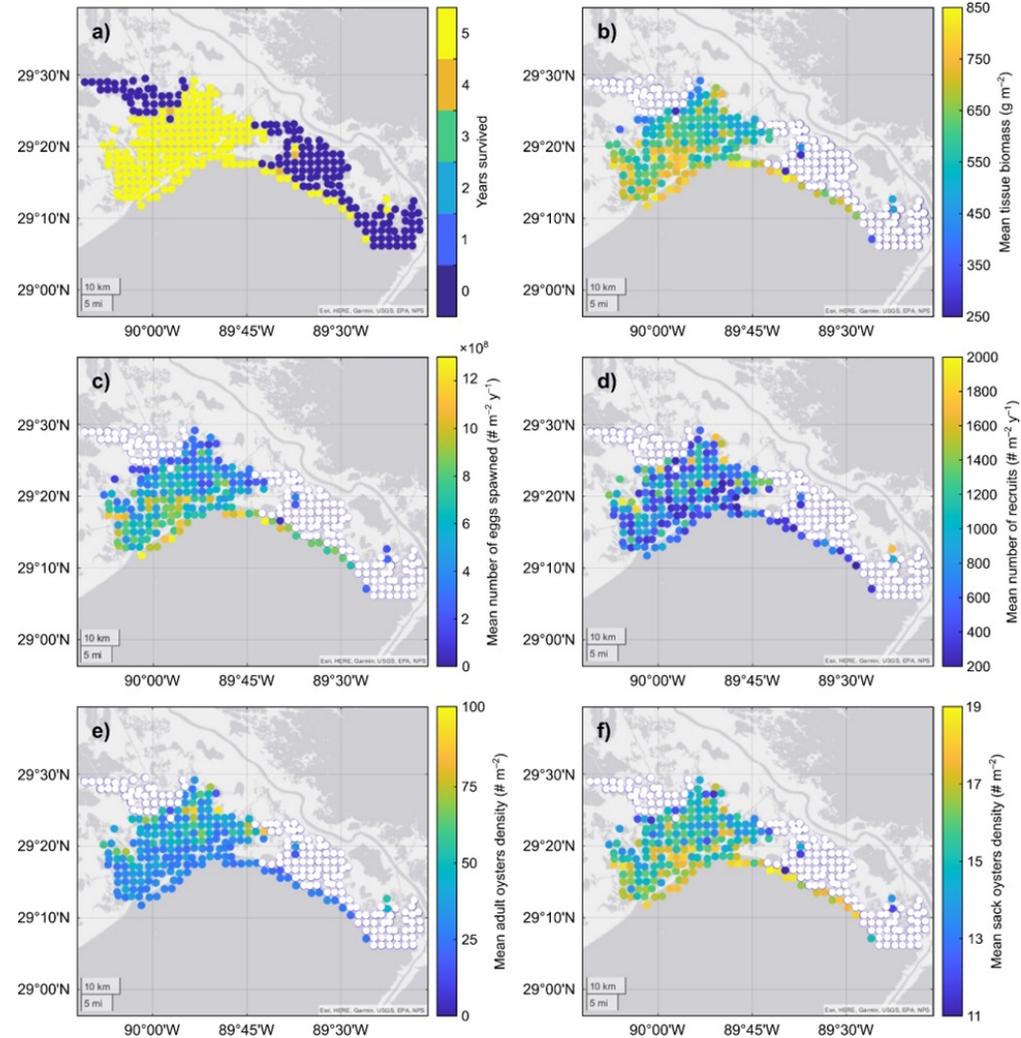


40 day simulation
period Spring 2016

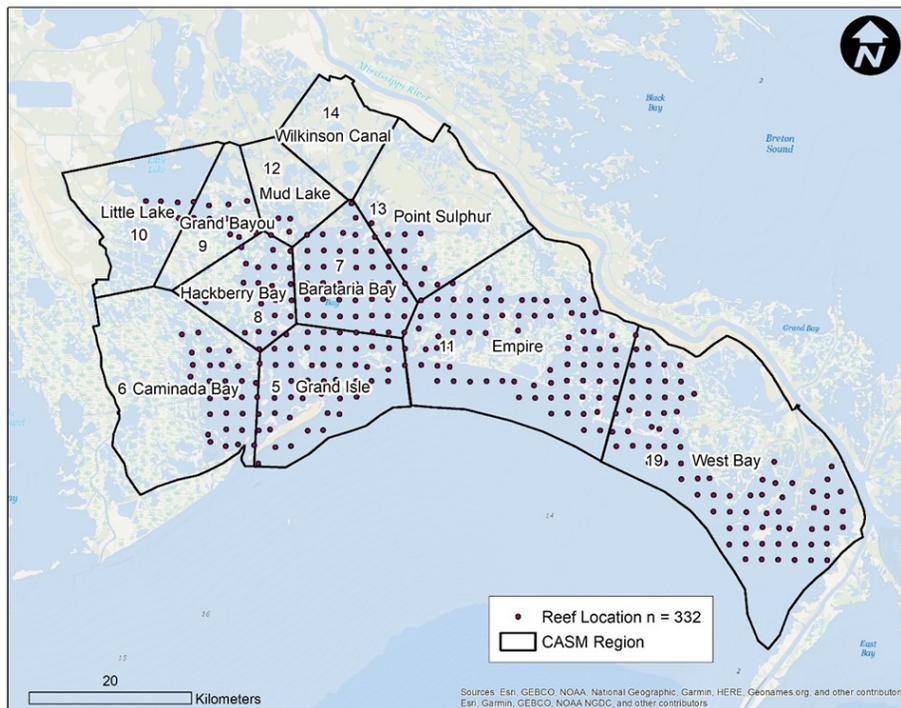
Red = adrift larvae
Green = settled
Black = dead

Example Results: Fully-Coupled Barataria Basin OMM

- **IBM reef grid results** averaged over 2014-2018 showing: (a) number of years reefs survived; (b) total oyster reef biomass; (c) total annual eggs spawned; (d) total annual recruits settled on reef; (e) adult oyster density; (f) sack oyster density



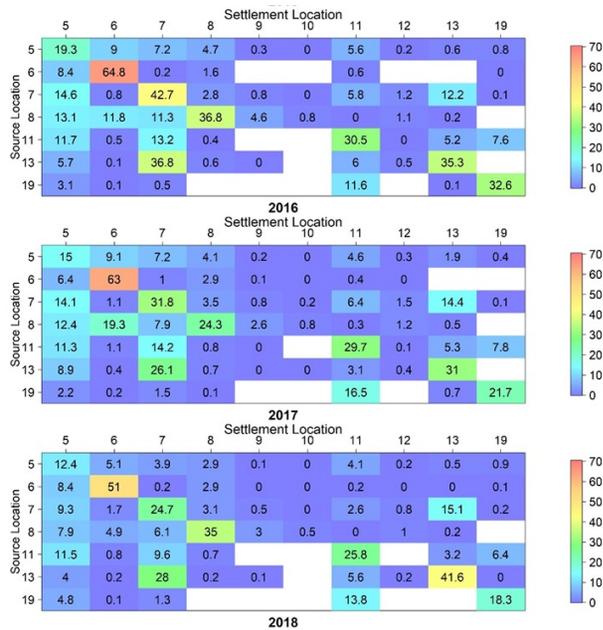
Example Results: Fully-Coupled Barataria Basin OMM



- **Larval transport results** showing source and settlement reefs scaled to CASM polygons for larval connectivity matrices among subregions by years
- Looking for consistently good source and settlement CASM subregions and then groups of reef cells within the CASM subregions

Example Results: Fully-Coupled Barataria Basin OMM

Larval transport model results for percent of all larval oysters sourced (top) and settled (bottom) in CASM subregions by years



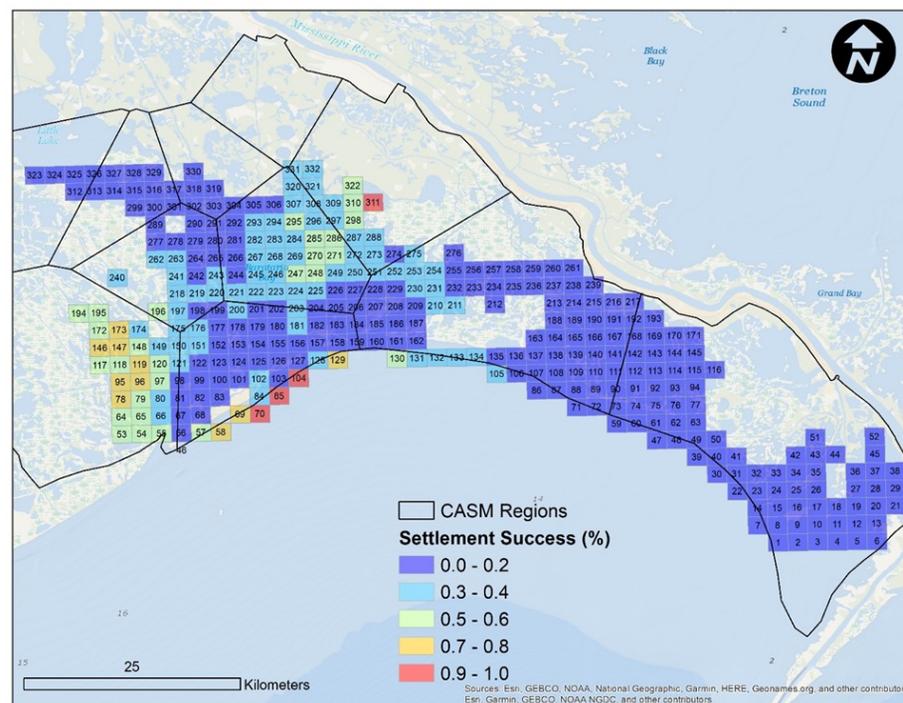
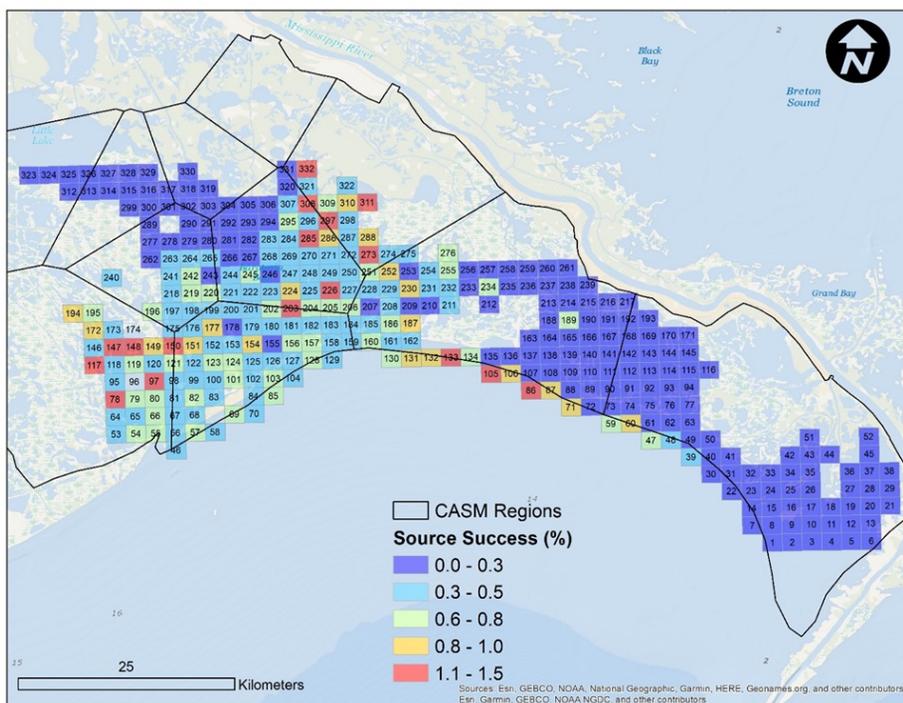
CASM Polygon "nicknames"

5 – Grand Isle	6 – Caminada Bay
7 – Barataria Bay	8 – Hackberry Bay
9 – Grand Bayou	10 – Little Lake
11 – Empire	12 – Mud Lake
13 – Port Sulphur	19 – West Bay

Source Location	Year				
	2014	2015	2016	2017	2018
5	15.0	13.8	17.3	16.3	9.8
6	16.2	15.0	12.8	10.4	10.6
7	8.8	11.4	12.0	9.8	6.7
8	5.5	3.3	3.6	2.7	3.0
11	12.5	13.5	12.8	12.9	11.8
13	7.8	4.6	4.3	5.4	6.5
19	1.6	2.3	1.9	2.0	2.1

Settlement Location	Year				
	2014	2015	2016	2017	2018
5	17.8	12.2	13.8	11.8	9.8
6	14.3	15.8	15.0	13.5	10.9
7	10.1	12.9	13.8	12.1	8.8
8	6.5	5.6	4.2	3.6	3.8
9	1.0	0.4	0.5	0.3	0.3
10	0.4	0.1	0.1	0.1	0.0
11	9.1	10.1	9.4	9.2	8.1
12	0.4	0.3	0.3	0.4	0.2
13	5.0	4.1	4.8	6.0	6.0
19	2.9	2.3	3.0	2.6	2.6
Total	67.5	63.8	64.7	59.6	50.5

Example Results: Fully-Coupled Barataria Basin OMM



- Larval oyster transport model results averaged over 2014-2018 showing: (left) overall reef success for sourcing oyster larvae that recruited (settled); (right) overall settlement success of oyster larvae in each reef cell