A user-friendly, online model for computing particulate and nutrient removals by restored oysters

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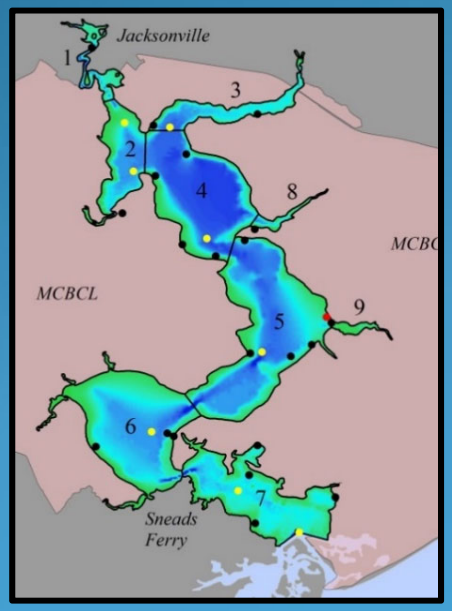
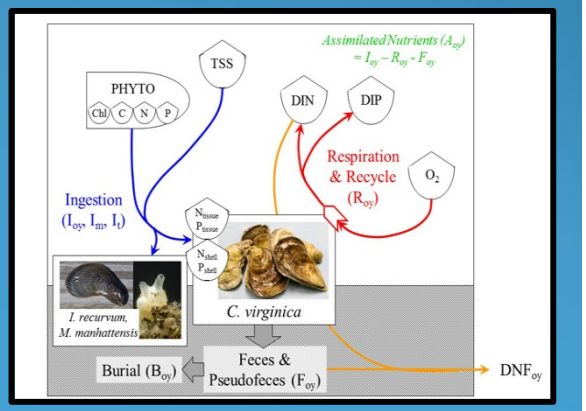
VIMS | William & Mary
Virginia Institute of Marine Science

Supported with funding from:

Jacksonville NC
Camp Lejeune
MCAS New River
A Caring Community





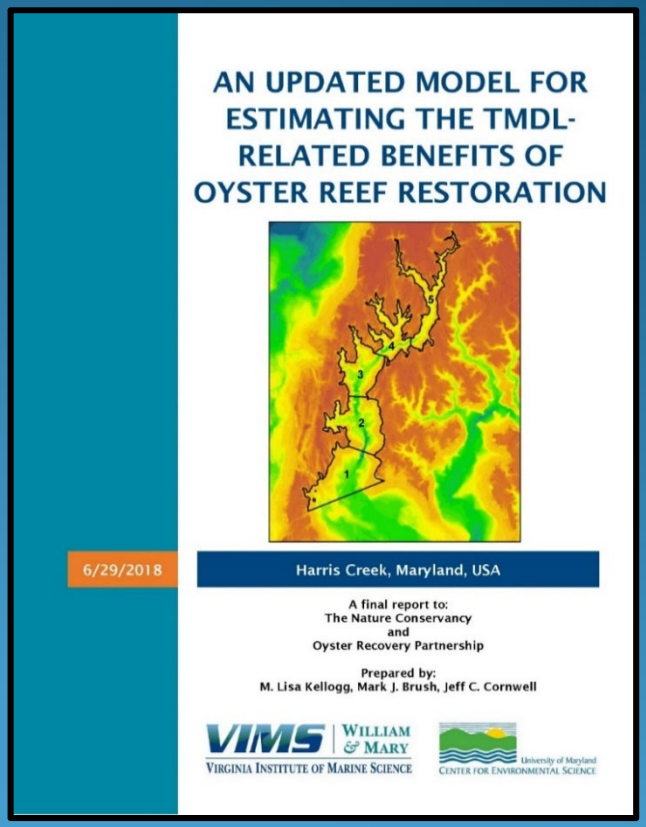
Disclaimers

Model simulation results in this presentation are presented primarily for demonstrative purposes. They are subject to specific conditions of each run and are subject to revision as new data are collected. Thus, they should not be taken as final results.

The original New River Estuarine Simulation Model was developed with funding from the Strategic Environmental Research and Development Program through the Defense Coastal/Estuarine Research Program (DCERP; RC-1413 and RC-2245). Views, opinions, and/or findings contained in this presentation are those of the author and should not be construed as an official U.S. Department of Defense position or decision unless so designated by other official documentation. The author wishes to thank the U.S. Marine Corps Base Camp Lejeune, NC, USA for serving as the host site for the DCERP.

EcoOyster

- A user-friendly, web accessible estuarine ecosystem model with an oyster sub-model
- Developed for specific estuaries and served online with a user interface
- User-defined inputs for restored acres, oyster density, mean weight, and $/lb for N and P
- Model outputs include:
  - Volume filtered
  - Chl-a, TSS, and nutrients removed
  - N and P assimilated in tissues and shells
  - N removed via denitrification
  - N and P removed by burial
  - Economic value of N and P removal



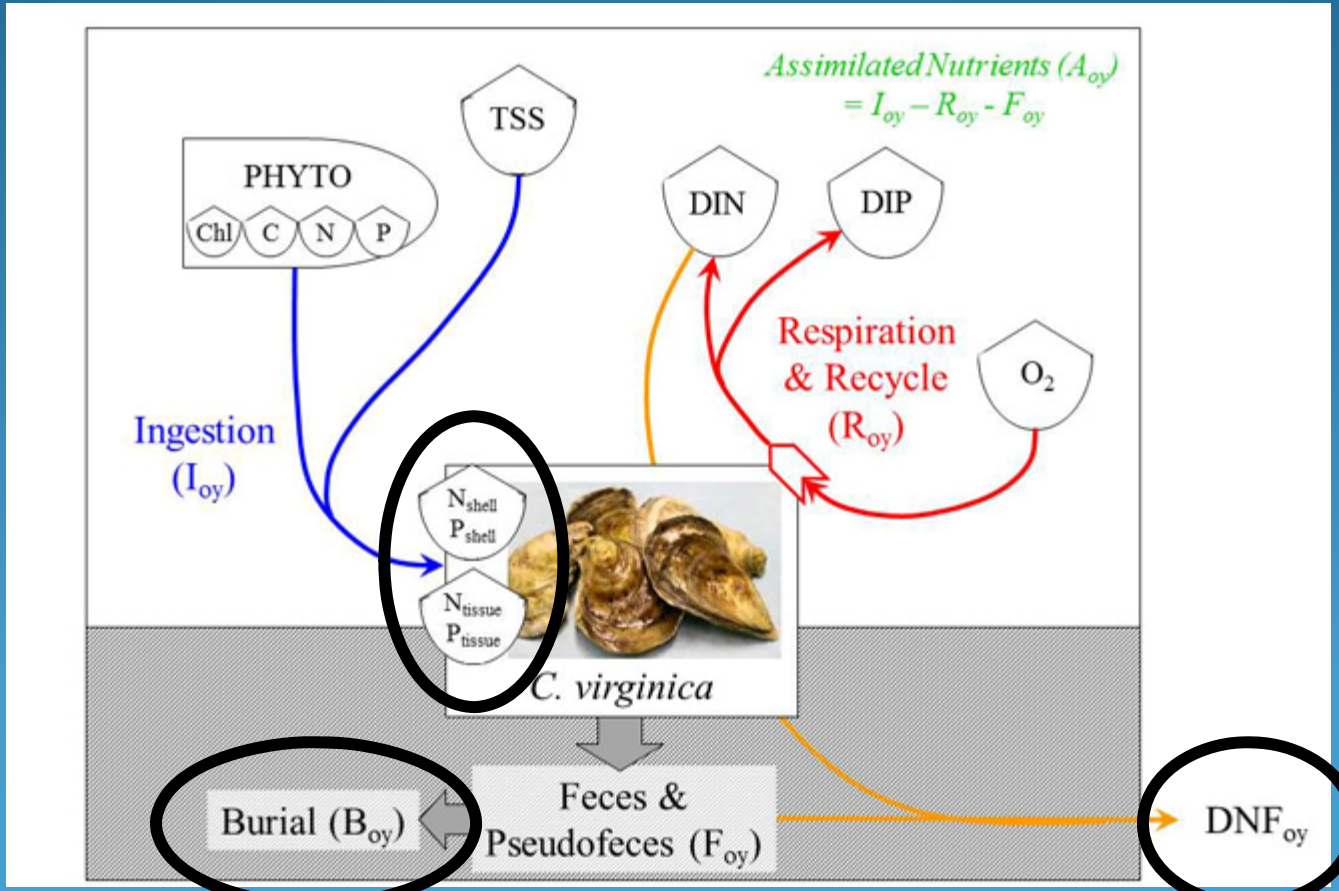
National Fish and Wildlife Foundation

Oyster Recovery Partnership

The Nature Conservancy

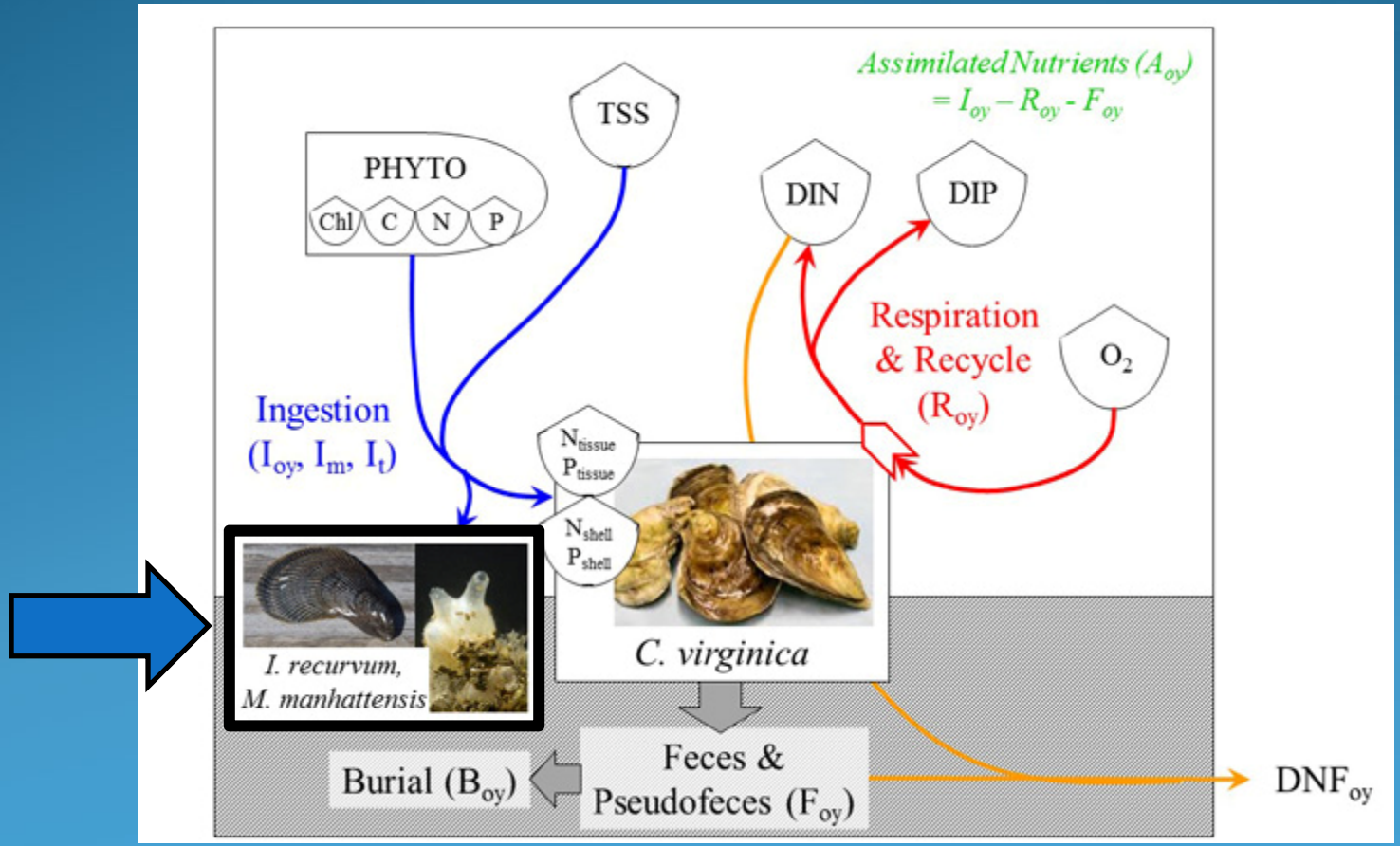
EcoOyster: Oyster Submodel

N removal = assimilation (tissues, shells) + denitrification + burial

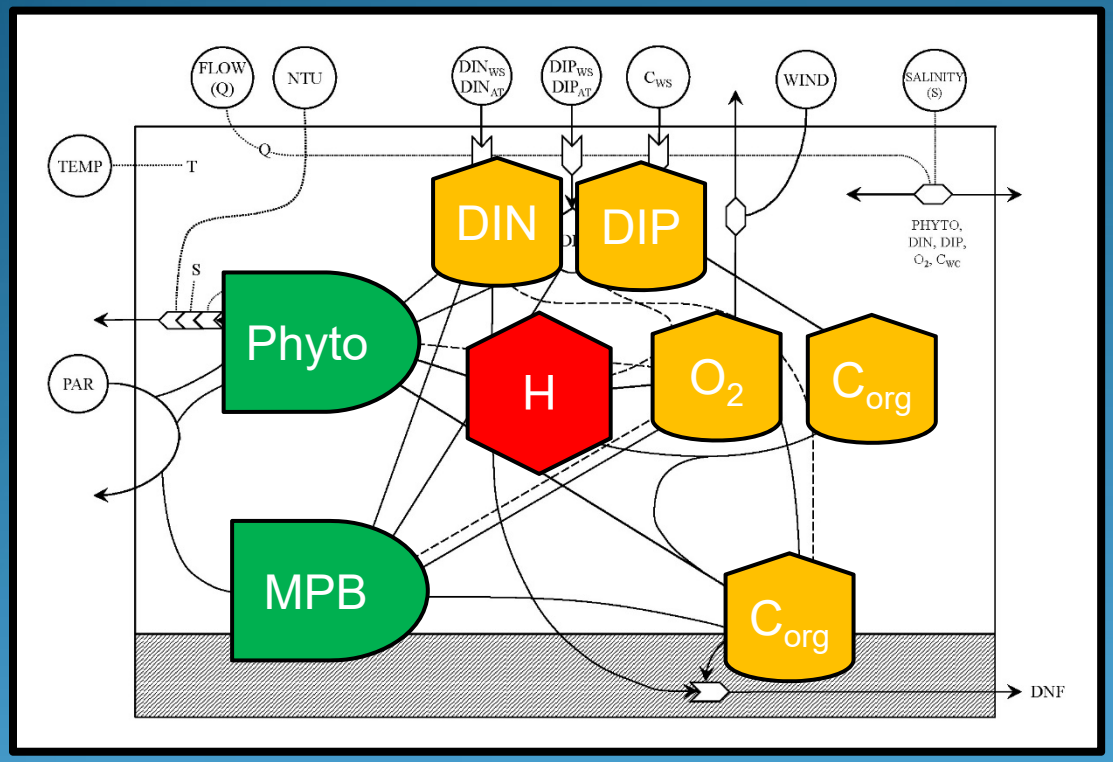


EcoOyster: Oyster Submodel

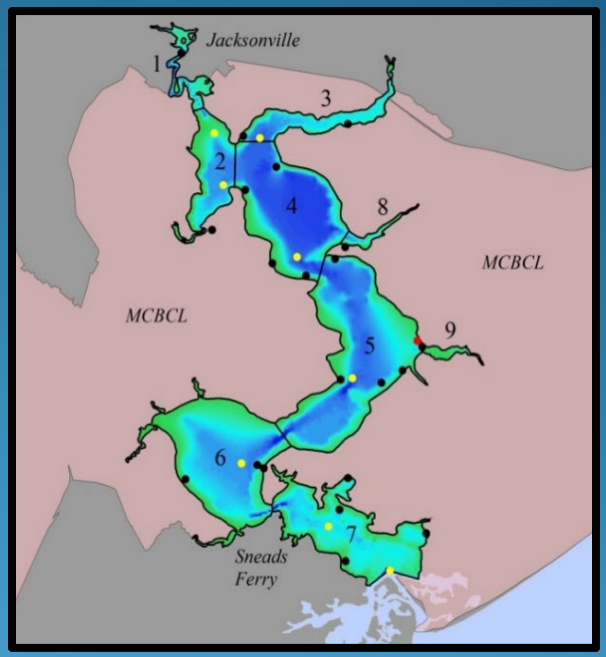
Additional filter feeding capacity



EcoOyster: Estuarine Simulation Model



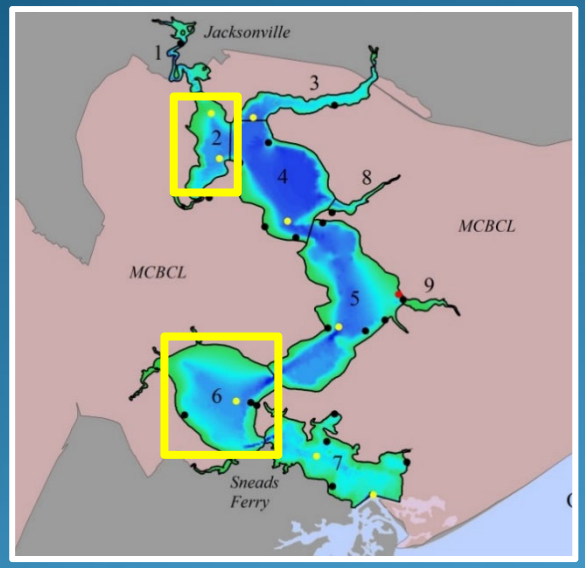
Brush & Nixon (2017)

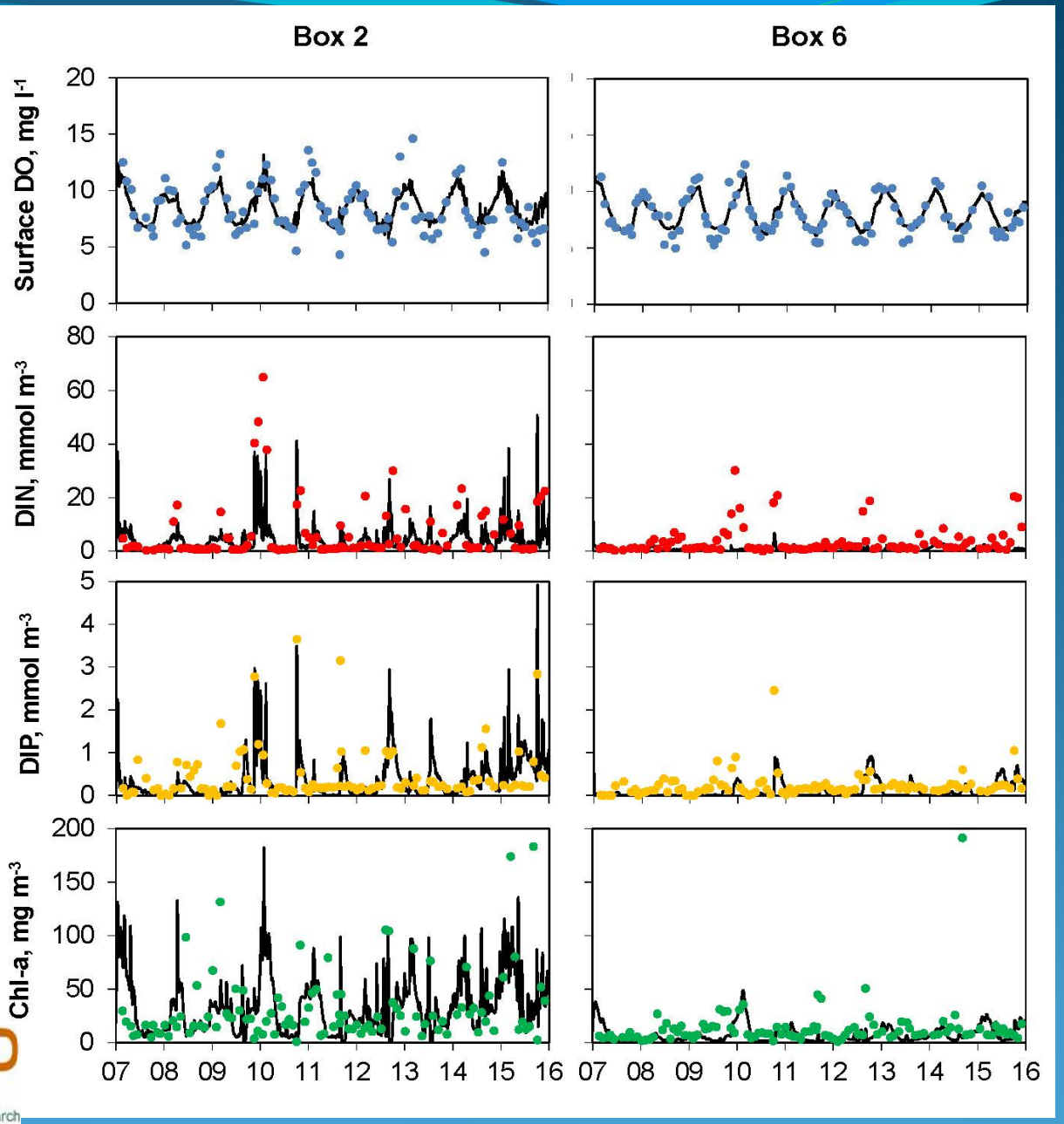


DoD EPA DOE SERDP Strategic Environmental Research and Development Program

DCERP DEFENSE COASTAL/ESTUARINE RESEARCH PROGRAM

DCERP ESM Validation





DCERP DEFENSE COASTAL/ESTUARINE RESEARCH PROGRAM

DoD EPA DOE SERDP Strategic Environmental Research and Development Program

Modeling Oyster Nutrient Removals

A Data-Constrained Approach

Nitrogen assimilation

- Oyster growth model combined with %N and %P in tissue and shell (Kellogg et al. 2013):

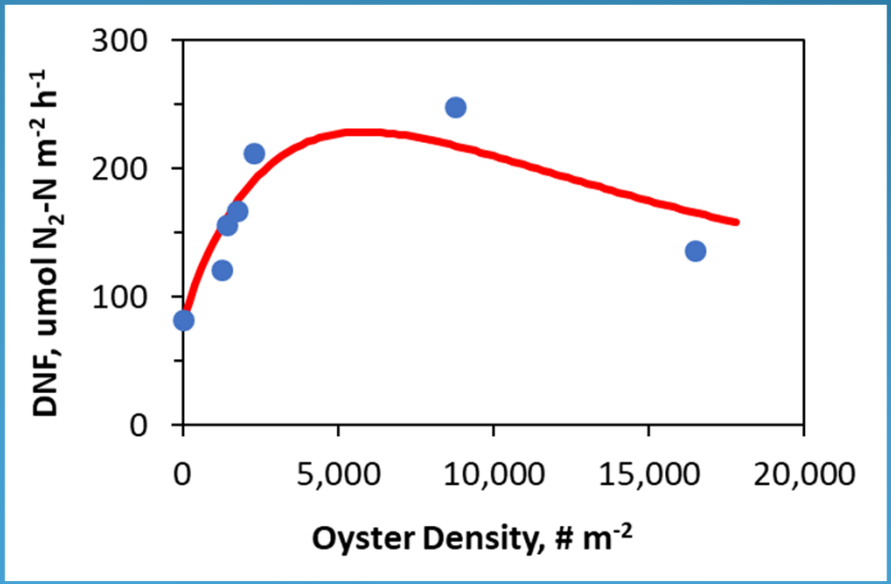
Box	%N	%P
Tissue	9.27	1.26
Shell	0.21	0.04

Burial

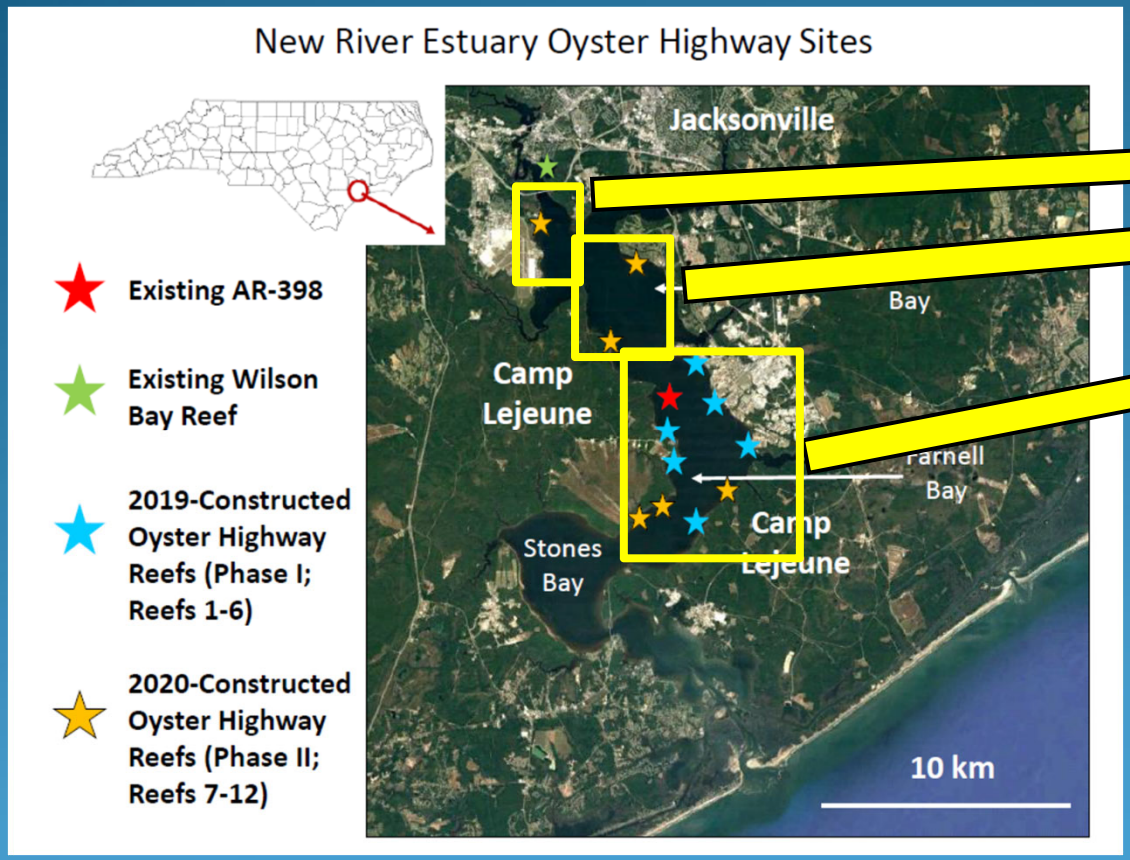
- Estimated as 10% of N deposited (Newell et al. 2005)

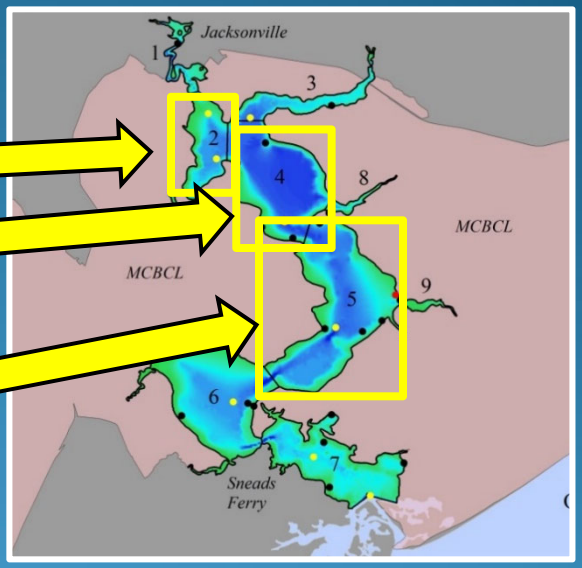
Denitrification

- DNF vs. oyster biomass density (M. Piehler data)



Application to the New River Oyster Highway



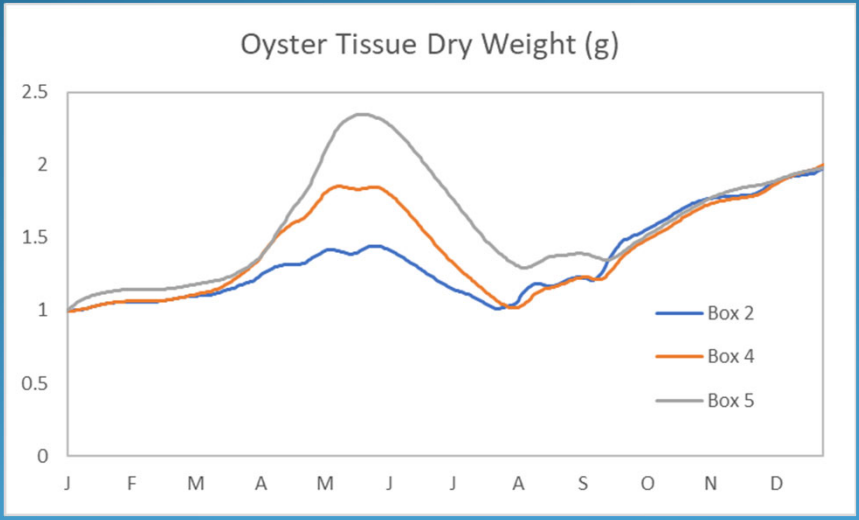


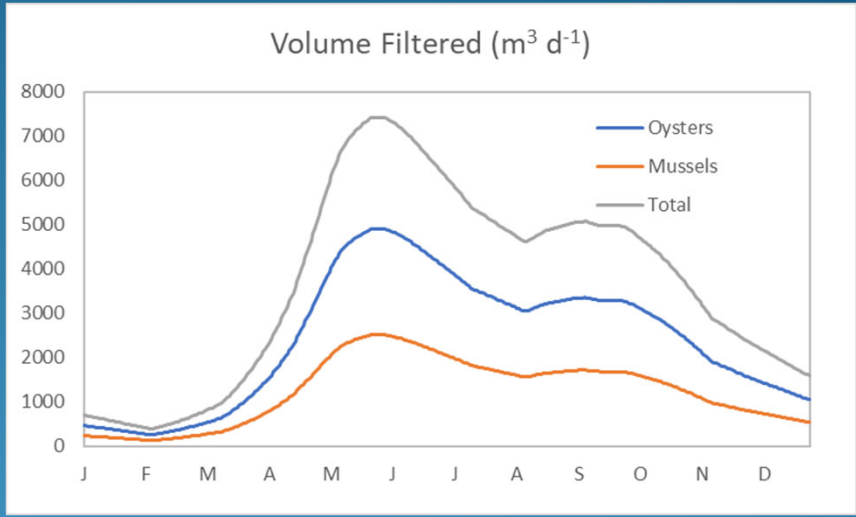
Box 2: 1 reef (~ 0.52 acres)
Box 4: 2 reefs (~1.04 acres)
Box 5: 9 reefs (~ 4.67 acres)

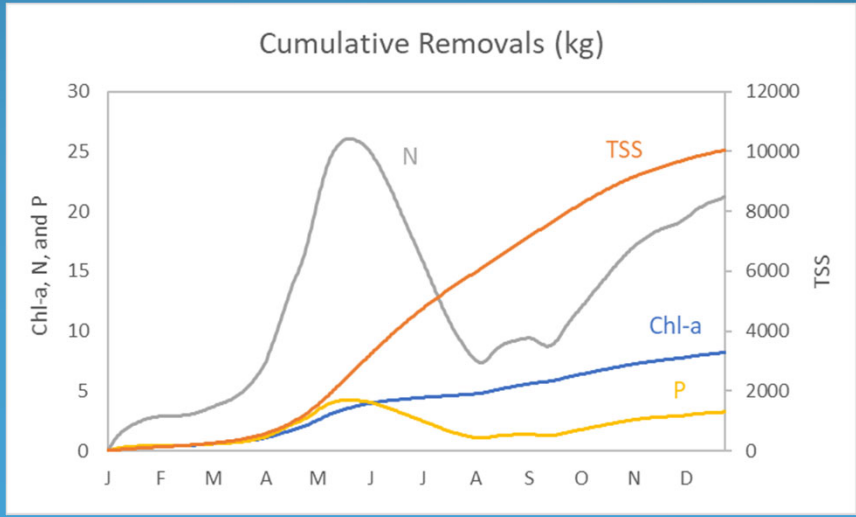
Parameterized with reef area and observed densities

Application to the New River Oyster Highway

- 2014 (average discharge)
- Starting tissue DW = 1 g
- Annual growth ~ 1 g DW
- Mean observed densities

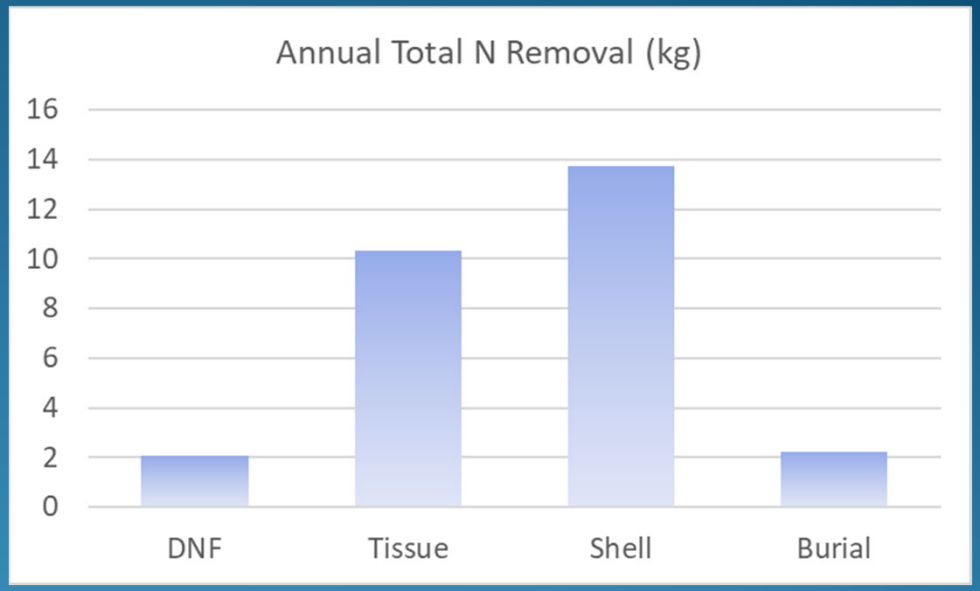


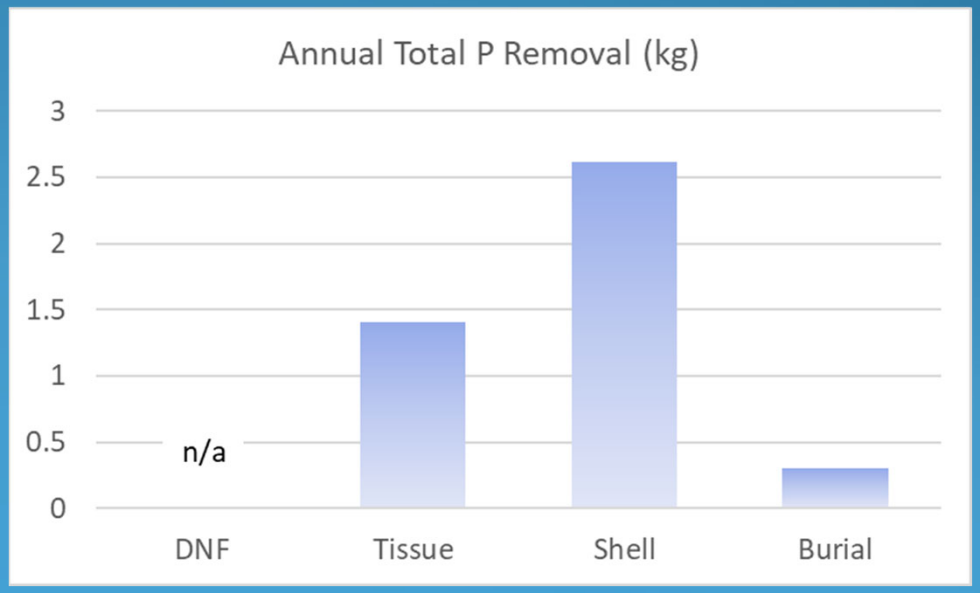




Application to the New River Oyster Highway

Annual N and P Removal Pathways





Application to the New River Oyster Highway

N Loading, kg y^{-1}:

	Box 2	Box 4	Box 5	Total
Atmos.	3,101	7,964	10,938	41,060
Off-Base	85,609	0	0	373,517
MCBCL	2,747	867	2,875	16,652
WWTF	0	0	60,086	60,086

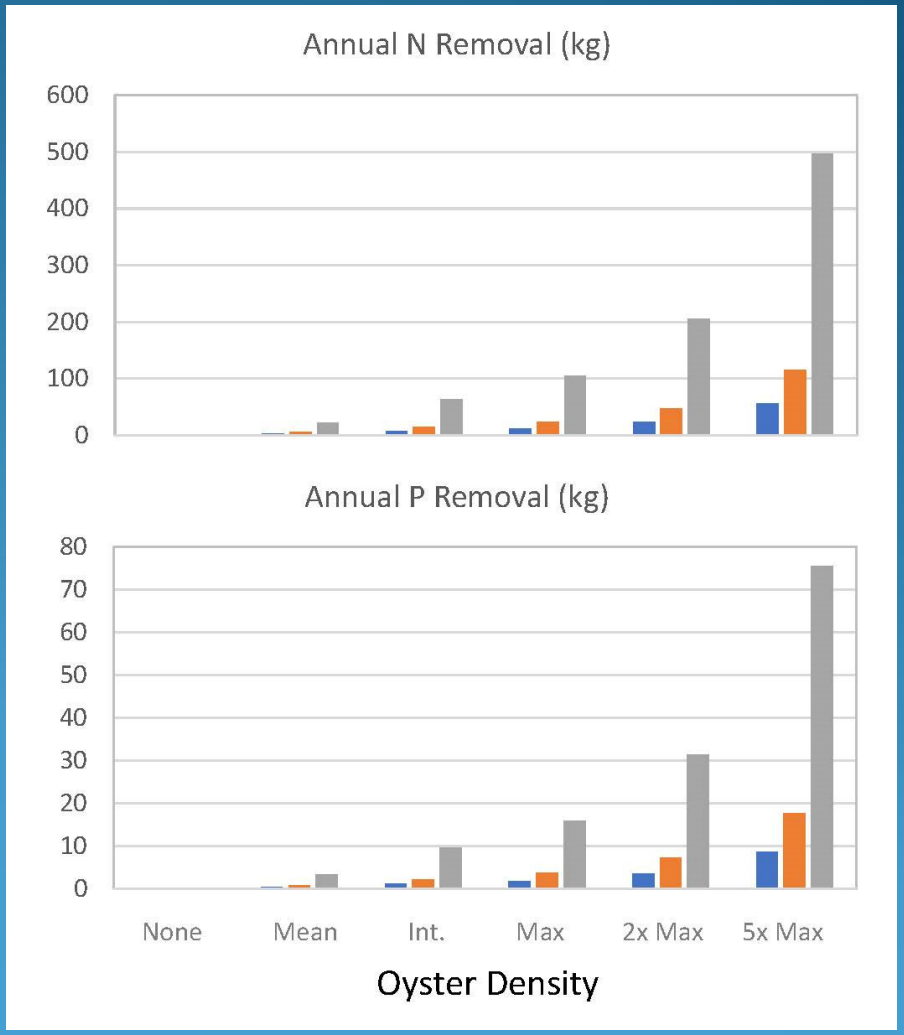
Oyster Removals: 28.4 - 139.3 (avg - max densities)

P Loading, kg y^{-1}:

	Box 2	Box 4	Box 5	Total
Atmos.	0	0	0	0
Off-Base	7,330	0	0	35,123
MCBCL	342	108	358	2,074
WWTF	0	0	1,356	1,356

Oyster Removals: 4.3 - 21.3 (avg - max densities)

Results are scalable →



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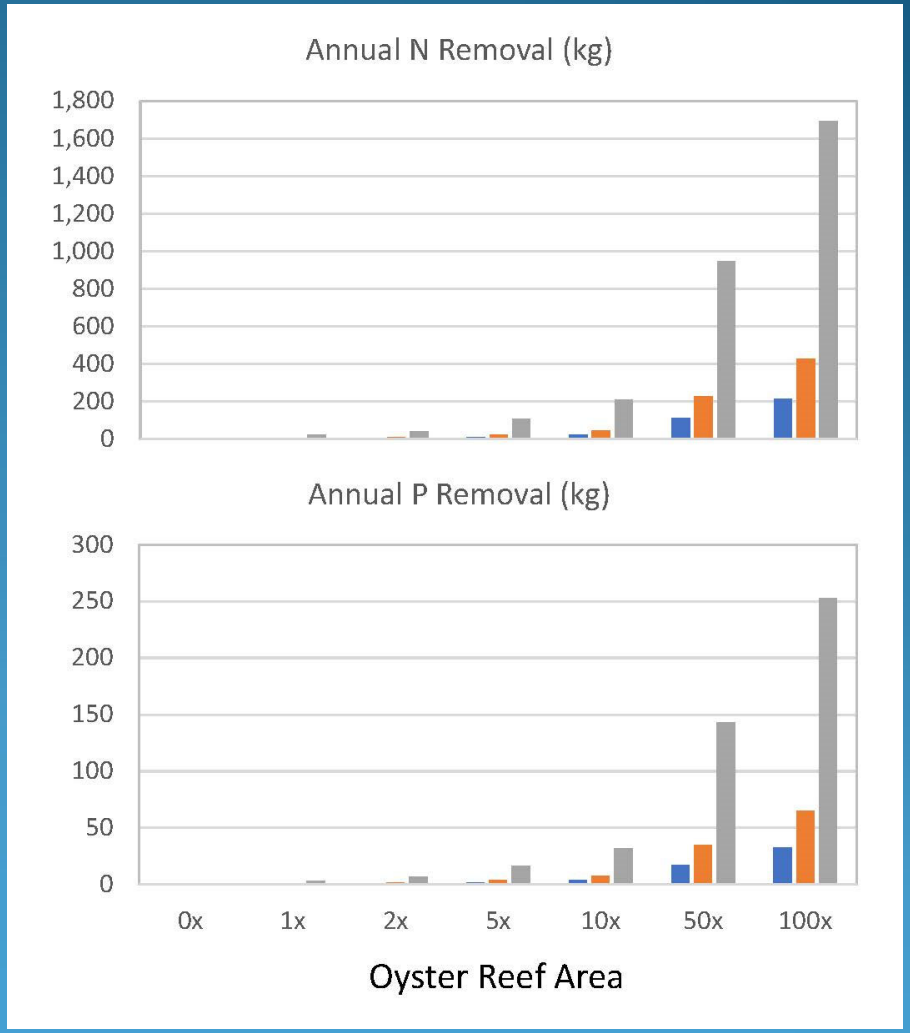


Online User Interface:

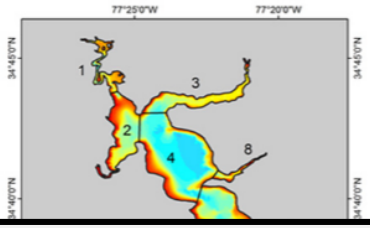
New River Estuary Oyster Highway Model

Dr. Mark J. Brush
Virginia Institute of Marine Science
November 2020

Introduction

The New River Estuary Oyster Highway Model is an adaptation of the Defense Coastal/Estuarine Research Program (DCERP) Estuarine Simulation Model developed during the DCERP project at Marine Corps Base Camp Lejeune, 2007-2017, funded by the Strategic Envrionmental Research and Development Program (SERDP).

The model was adapated with funding from the City of Jacksonville, NC to include oyster reefs restored through Summer 2020 as part of the New River Oyster Highway Project, for the purposes of computing volume filtration, particulate and nutrient removal, and



New River Estuary Oyster Highway Model

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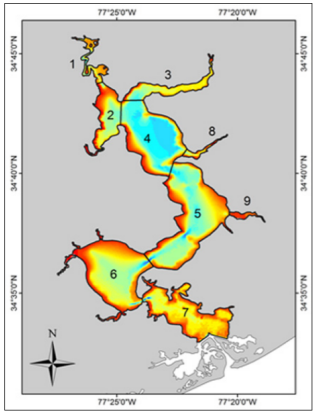
Fig. 1. Spatial elements (1-9) of the New River ESM. Each box has a surface and bottom layer separated by the pycnocline. For the purposes of this model, oysters are added only to the surface layer.



The DCERP ESM runs in a series of spatial elements (1-9). Each element contains a surface and bottom layer separated by the pycnocline. Color shading represents bathymetry. Full documentation of the ESM can be found in (available upon request from MJ Brush):

Brush, M.J., S.J. Lake, S. Blachman, and S. Williamson. 2018. Coupled ecosystem modeling of the NRE for research, synthesis, and management. Chapter 10 in: Final Technical Report to the Defense Coastal/Estuarine Research Program 2 (DCERP2), RTI International, Research Triangle Park, NC.

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New River Estuary Oyster Highway Model

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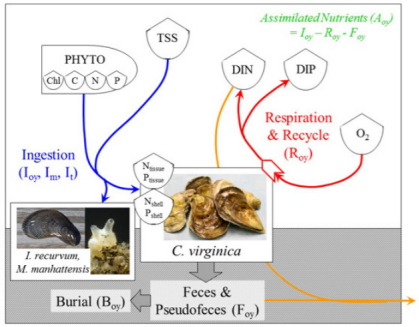
Fig. 3. Oyster submodel with linkages to the base ecosystem model in Fig. 2.

Oyster photo: New York State Department of Environmental Conservation;

Mussel photo: B. Hubick, Maryland Biodiversity Project.



The oyster reef sub-model simulates a number of parameters related to the impact of oyster restoration.

Click here for a definition of model terms in the diagram to the left:

Definitions

Details of the oyster reef model can be found in (available upon request from MJ Brush):

Kellogg, M.L., M.J. Brush, and J.C. Cornwell. 2018. An updated model for estimating the TMDL-related benefits of oyster reef restoration. Final report to The Nature Conservancy and Oyster Recovery Partnership.

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Online User Interface:

Scenario Analysis Page

Model output is graphically displayed and available for download:

New River Estuary Oyster Highway Model

Scenario Analysis Page

This page enables the user to conduct simulation analyses of restoration scenarios in each spatial element along the mainstem of the New River Estuary (Boxes 1-7). Enter the acres of restored reefs, restored oyster density, and mean oyster tissue weight in the tables below. Spatial element is shown in brackets. Clicking the arrow in the upper left corner of each table will restore default values, which reflect restored populations through 2020.

1. Specify the acres of restored oyster reefs in each spatial element.

Acres of Restored Reefs	Value
Oyster acres[S1]	0
Oyster acres[S2]	0.52
Oyster acres[S3]	0
Oyster acres[S4]	1
Oyster acres[S5]	5
Oyster acres[S6]	0

2. Specify the density of restored oysters (#/acre) in each spatial element.

Restored Oyster Density	Value
Oyster density[S1]	18211
Oyster density[S2]	18211
Oyster density[S3]	18211
Oyster density[S4]	18211
Oyster density[S5]	18211
Oyster density[S6]	18211

3. Specifiy the average tissue weight (g) of restored oysters in each spatial elem

Mean Oyster Weight	Value
Oyster DWio[S1]	
Oyster DWio[S2]	
Oyster DWio[S3]	
Oyster DWio[S4]	
Oyster DWio[S5]	
Oyster DWio[S6]	

4. Optional: Specify the value of nutrient removal ($/pound):

Nutrient Credits	Value
N price	0
P price	0

Click the 'Run' button below to run the model. You will automatically be taken to the Model Output Dashboard to view and download output. Click the 'Restore' button to clear all previous model runs from the graphs and reset values above to defaults.

Run

Restore