Simulating Shallow-Water Processes in Chesapeake Bay: Progress in the Corsica River Case Study

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Corsica River

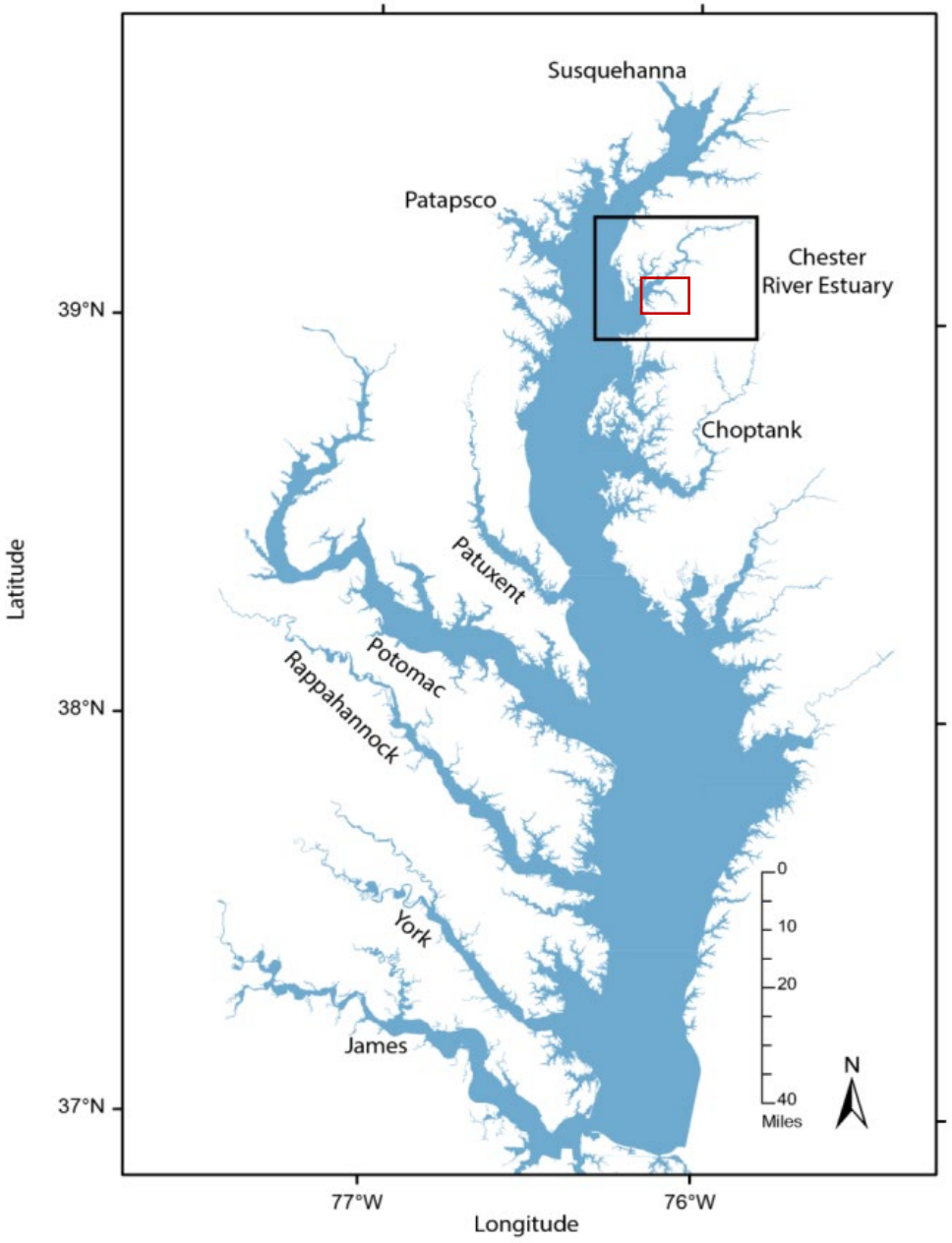


Photo courtesy of Cal Gray III

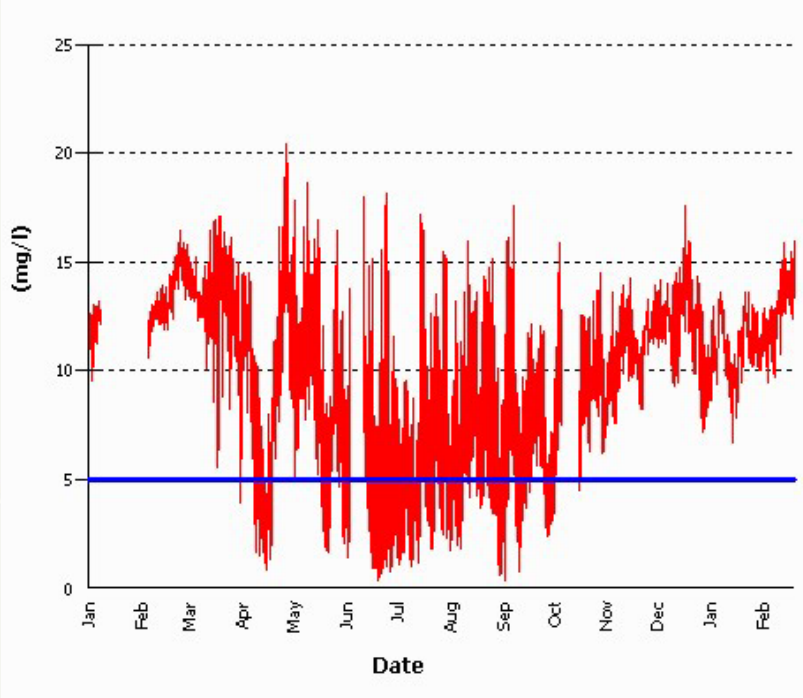
Why the Corsica River?

Hypoxia, Fish Kills,
Targeted for Restoration

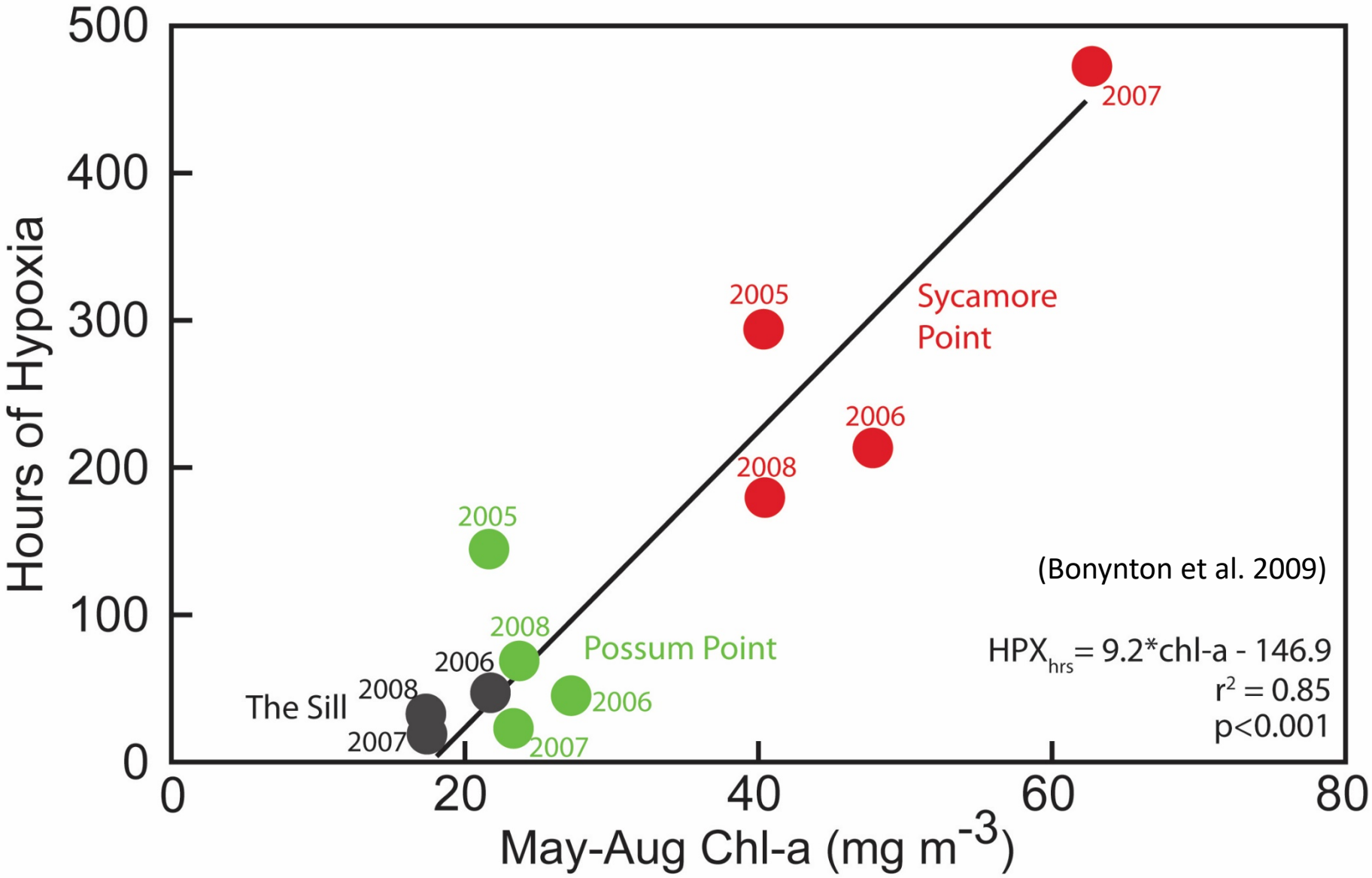
Corsica River Targeted Initiative

Progress Report: 2005-2011

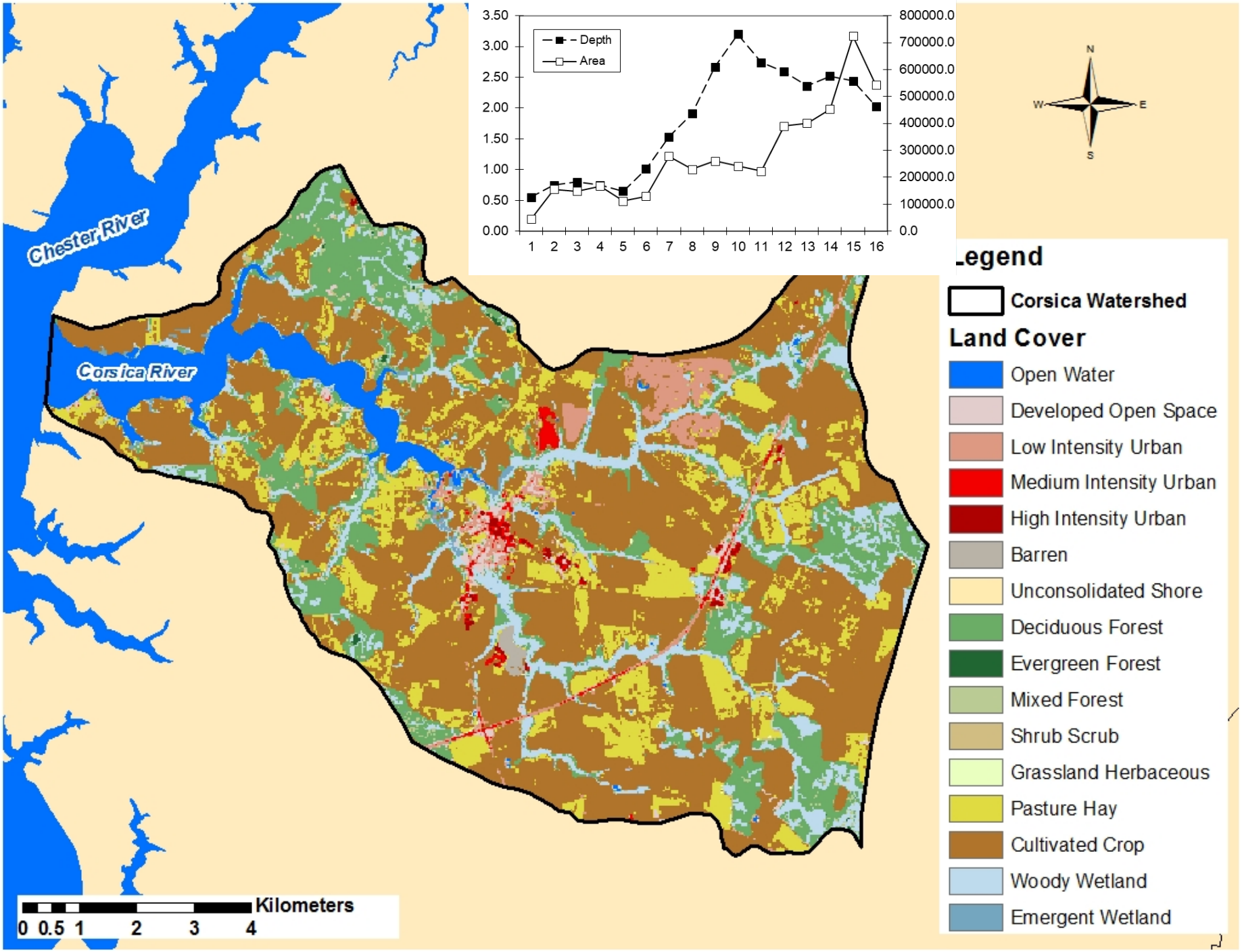
The Corsica River Initiative is nationally recognized for its Watershed Plan and restoration effort that continues to receive attention for its outstanding contributions in research, monitoring and implementation.

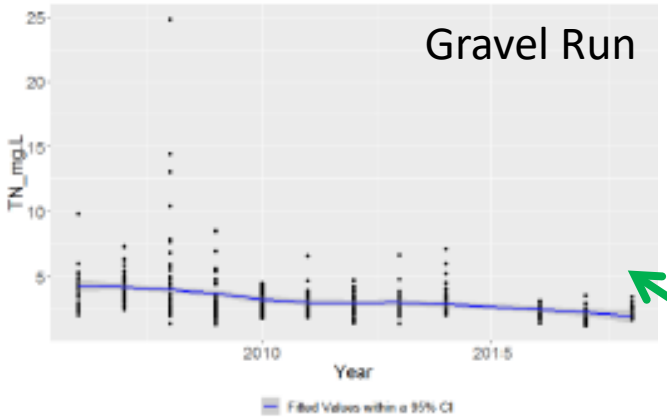


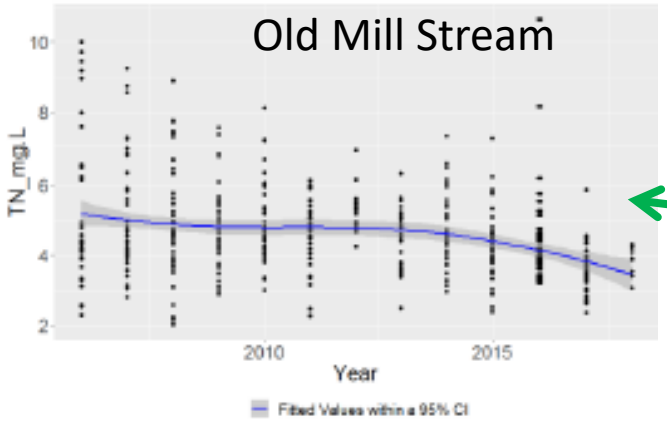
Duration of Diel Cycling Hypoxia and Chlorophyll

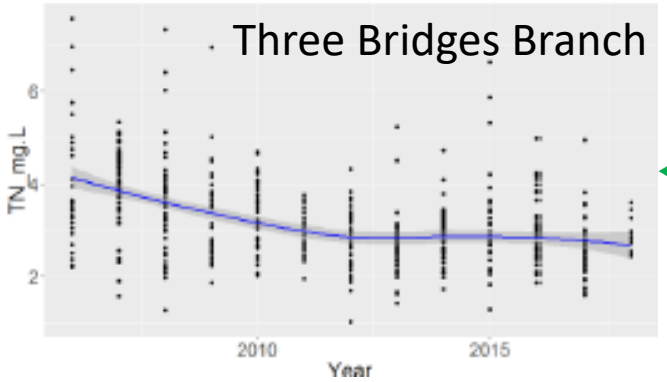


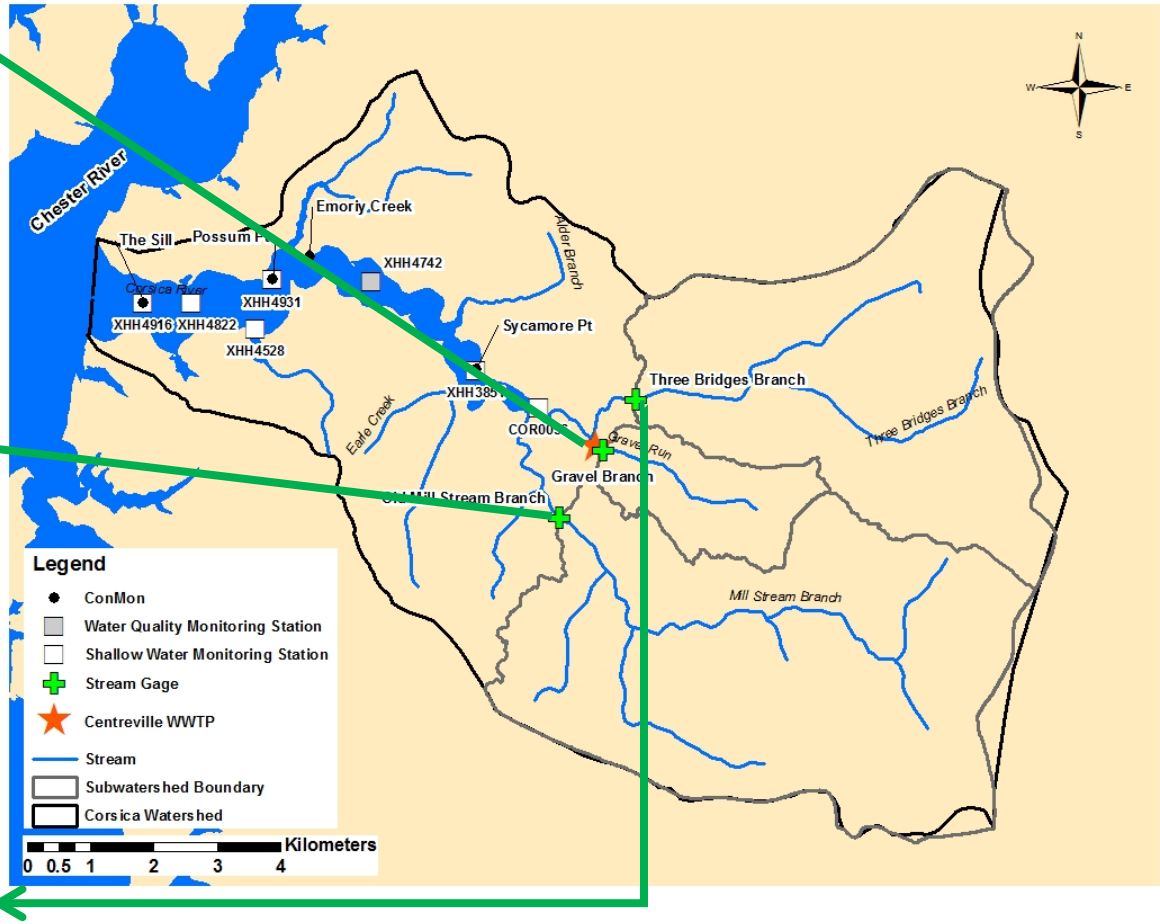
Again, both spatial and inter-annual components of this relationship


Chester River
Corsica River
Depth
Area
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
800000.0
700000.0
600000.0
500000.0
400000.0
300000.0
200000.0
100000.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
N
W
E
S
Legend
Corsica Watershed
Land Cover
Open Water
Developed Open Space
Low Intensity Urban
Medium Intensity Urban
High Intensity Urban
Barren
Unconsolidated Shore
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub Scrub
Grassland Herbaceous
Pasture Hay
Cultivated Crop
Woody Wetland
Emergent Wetland
Kilometers
0 0.5 1 2 3 4



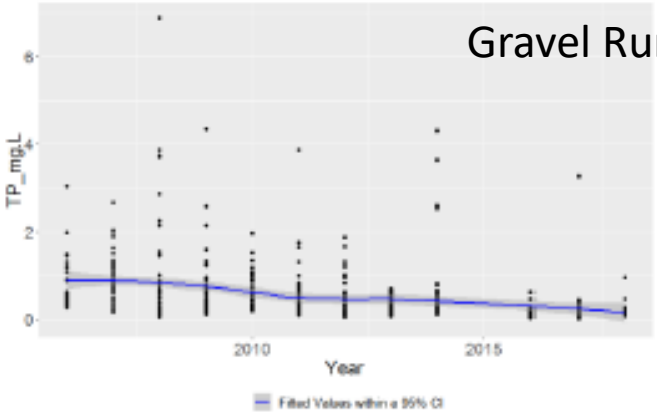




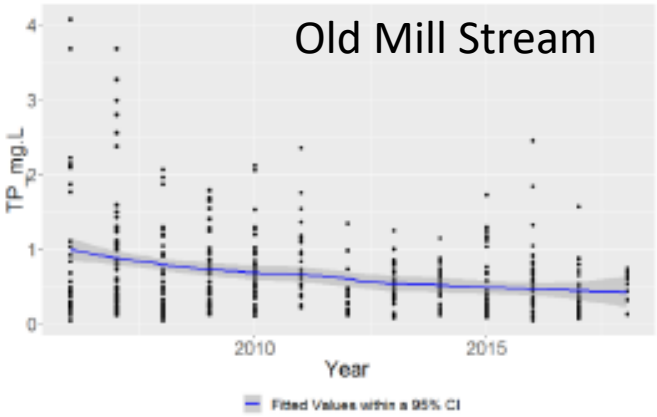


(Wallace 2019)

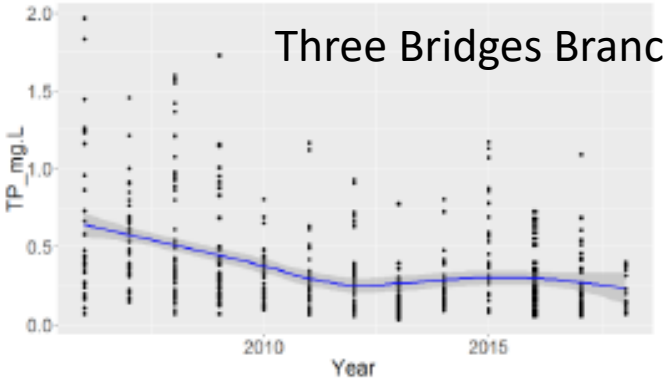
Gravel Run

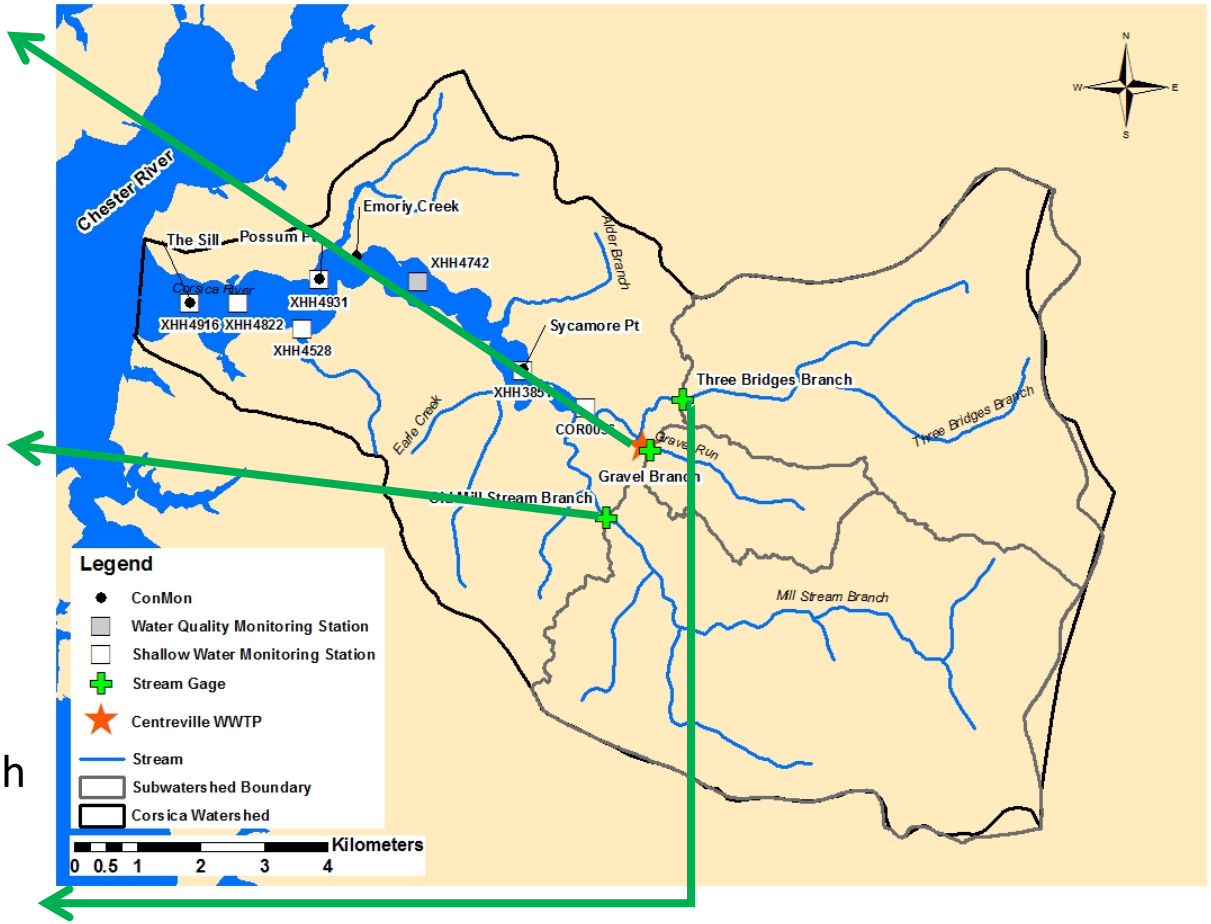


Old Mill Stream



Three Bridges Branch

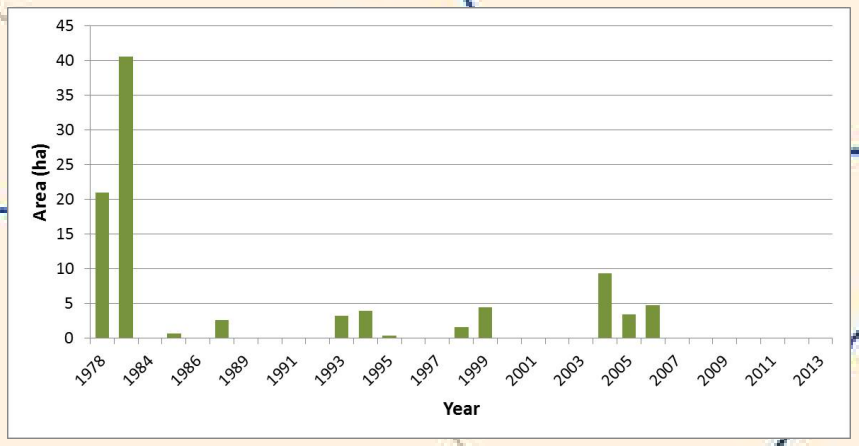




(Wallace 2019)

2004-06

SAV distribution in Corsica and Coverage over time



Why the Corsica River estuary?

(a) The Corsica presents a unique opportunity to examine the effects of nutrient load reductions on a shallow ecosystem with both models and data

(b) The Corsica tests available model's ability to reproduce diel-cycling hypoxia and the forces that drive it (metabolism, wetland inputs, etc)

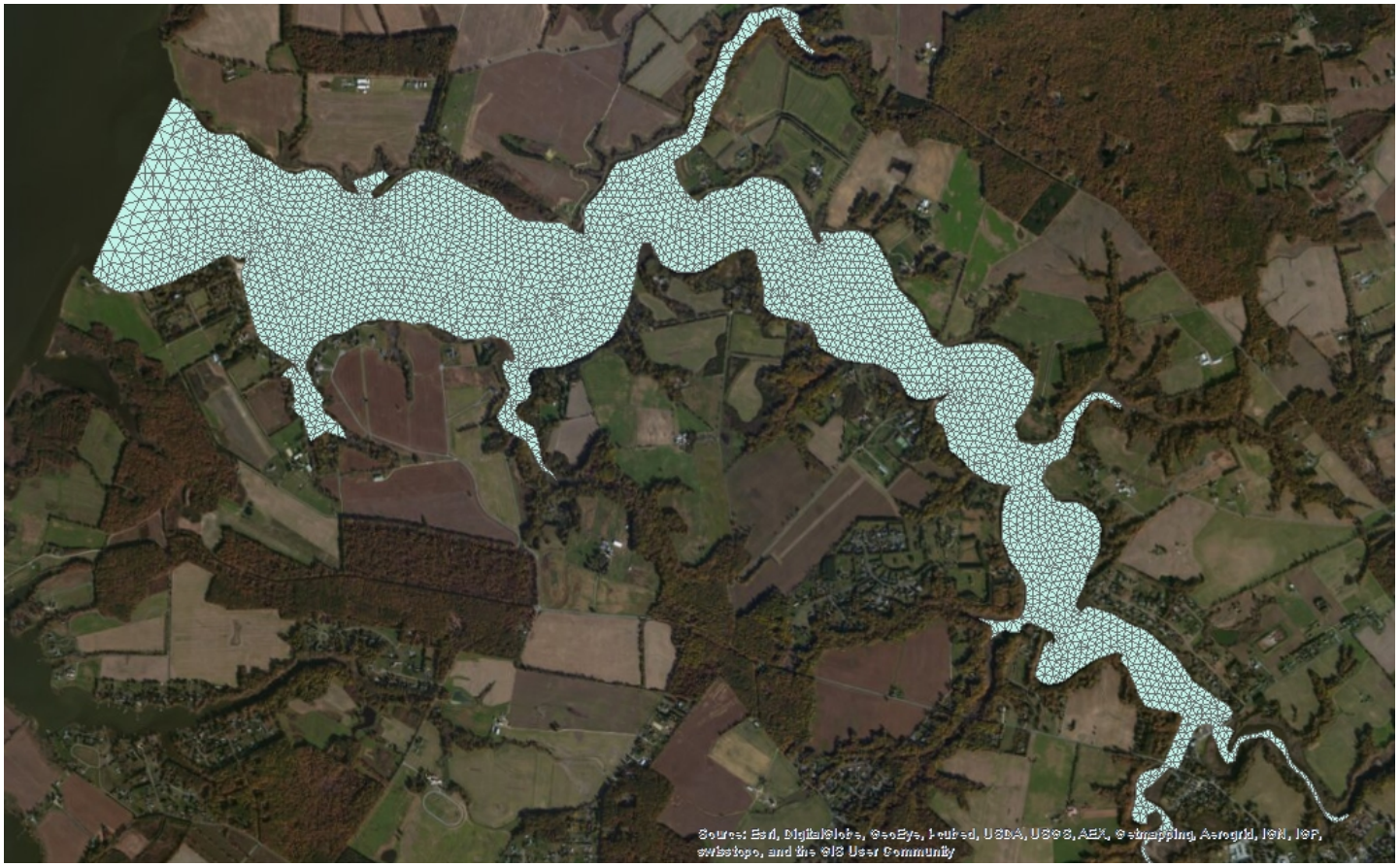
(c) There is a unique opportunity to validate a shallow-water model at fine time-scales

(d) Will be a useful example to apply fine-scale watershed model inputs to represent fine-scale effects of freshwater inputs and circulation effects

Corsica Model Grid

SCHISM-ICM

- 20m resolution along the shore, 100m at mouth;
- 5029 cells, 5 layers, 5 m max depth
- Simulation year = 2006
- Phase 6 Watershed Model Loads, CH3D for seaward boundary
- Hourly ERA5 PAR



Primary Simulations To-Date

(1) Validation of concentrations and rates at three estuarine locations

*Diel cycling hypoxia

*Extremely high chlorophyll-a concentrations

*water-column and sediment rate processes

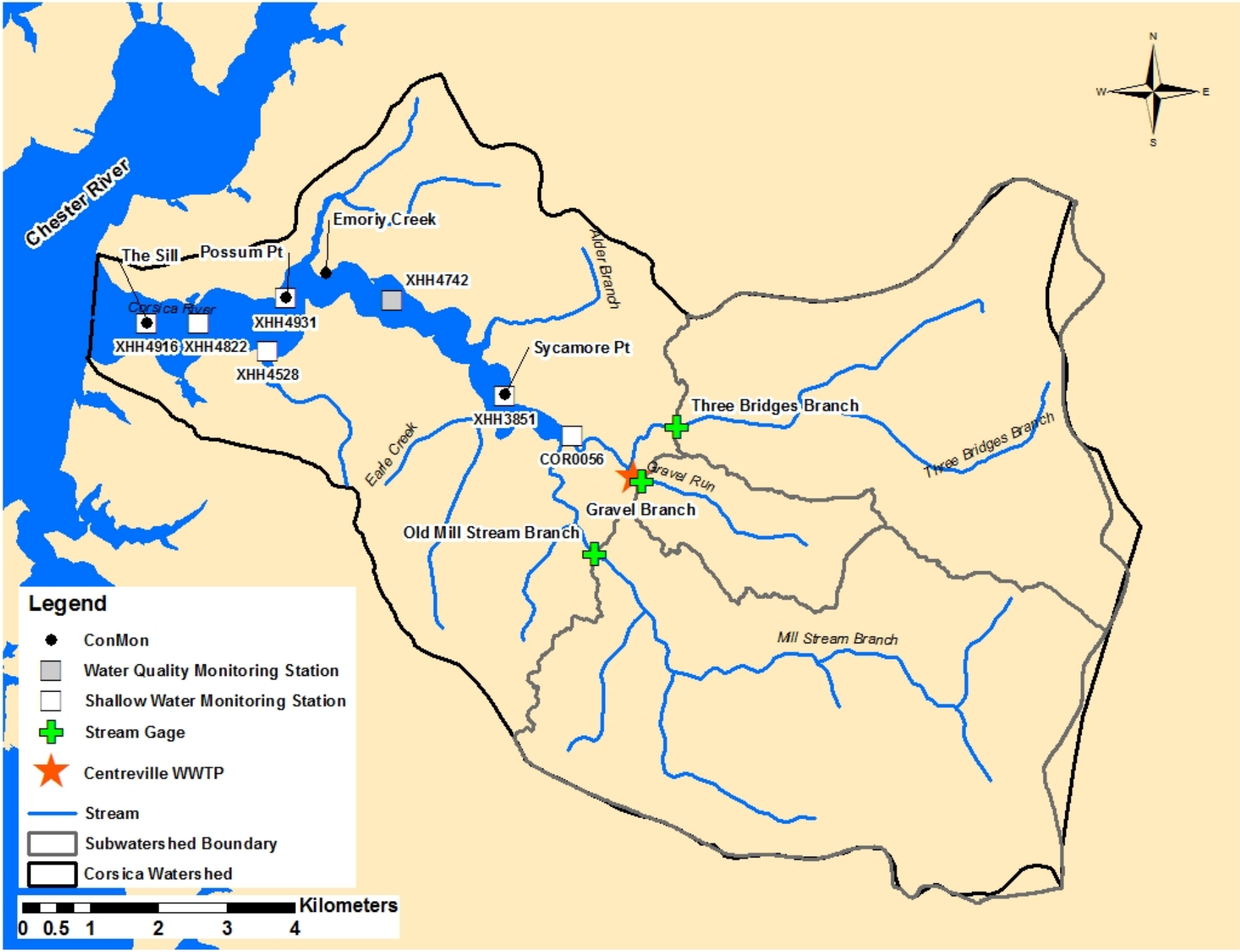
(2) Testing of wetland inputs of organic carbon and oxygen impacts

Ultimate Driving Questions

(1) How have nutrient load declines impacted water-quality attainment in last decade?

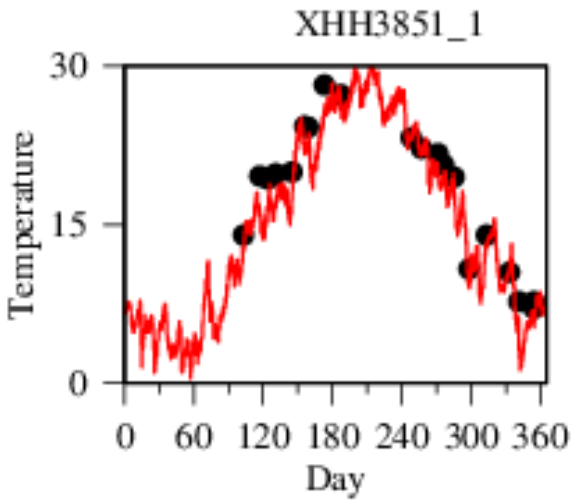
(2) What biogeochemical and physical processes drive diel cycling hypoxia?

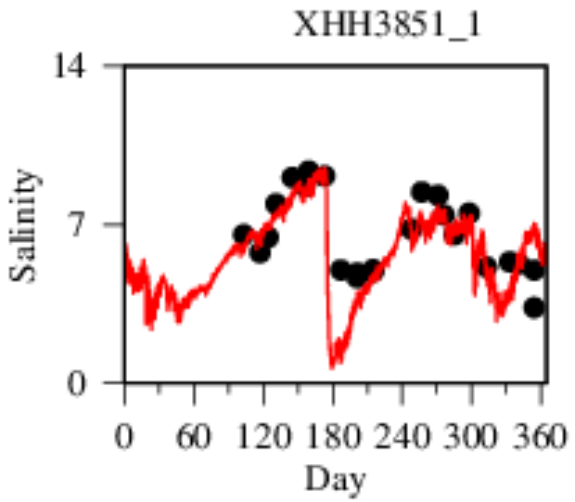
(3) Will SAV recover with nutrient load reductions, and are there feedbacks?


Chester River
Emoriy Creek
The Sill
Possum Pt
Corsica River
XHH4742
XHH4931
XHH4916
XHH4822
XHH4528
Alder Branch
Sycamore Pt
XHH3851
COR0056
Earle Creek
Three Bridges Branch
Three Bridges Branch
Gravel Run
Gravel Branch
Old Mill Stream Branch
Mill Stream Branch
N
W
E
S
Legend
ConMon
Water Quality Monitoring Station
Shallow Water Monitoring Station
Stream Gage
Centreville WWTP
Stream
Subwatershed Boundary
Corsica Watershed
Kilometers
0 0.5 1 2 3 4

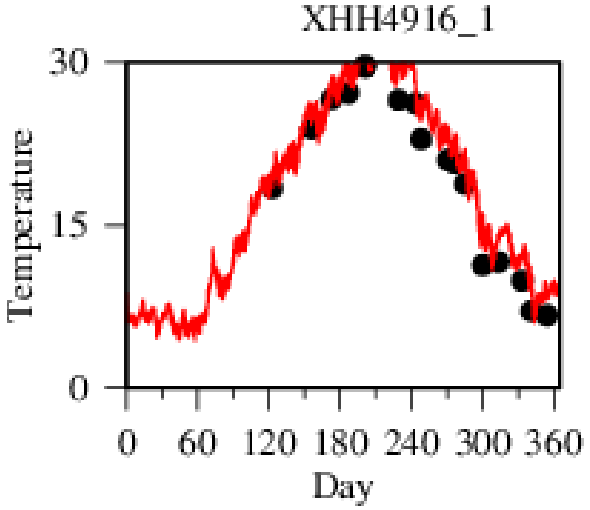
Validation of Water Temperature, Salinity

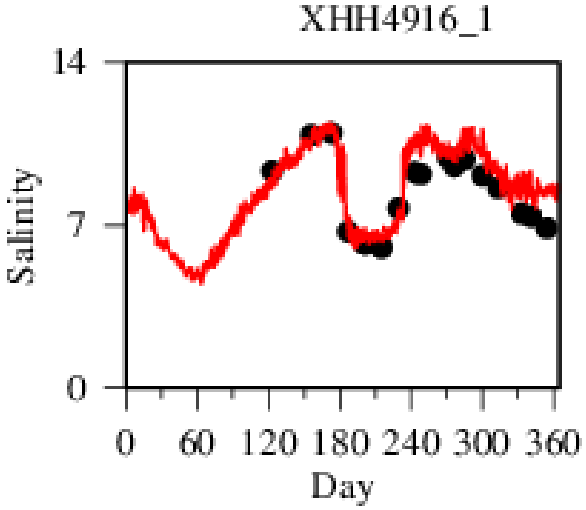
Upper Corsica

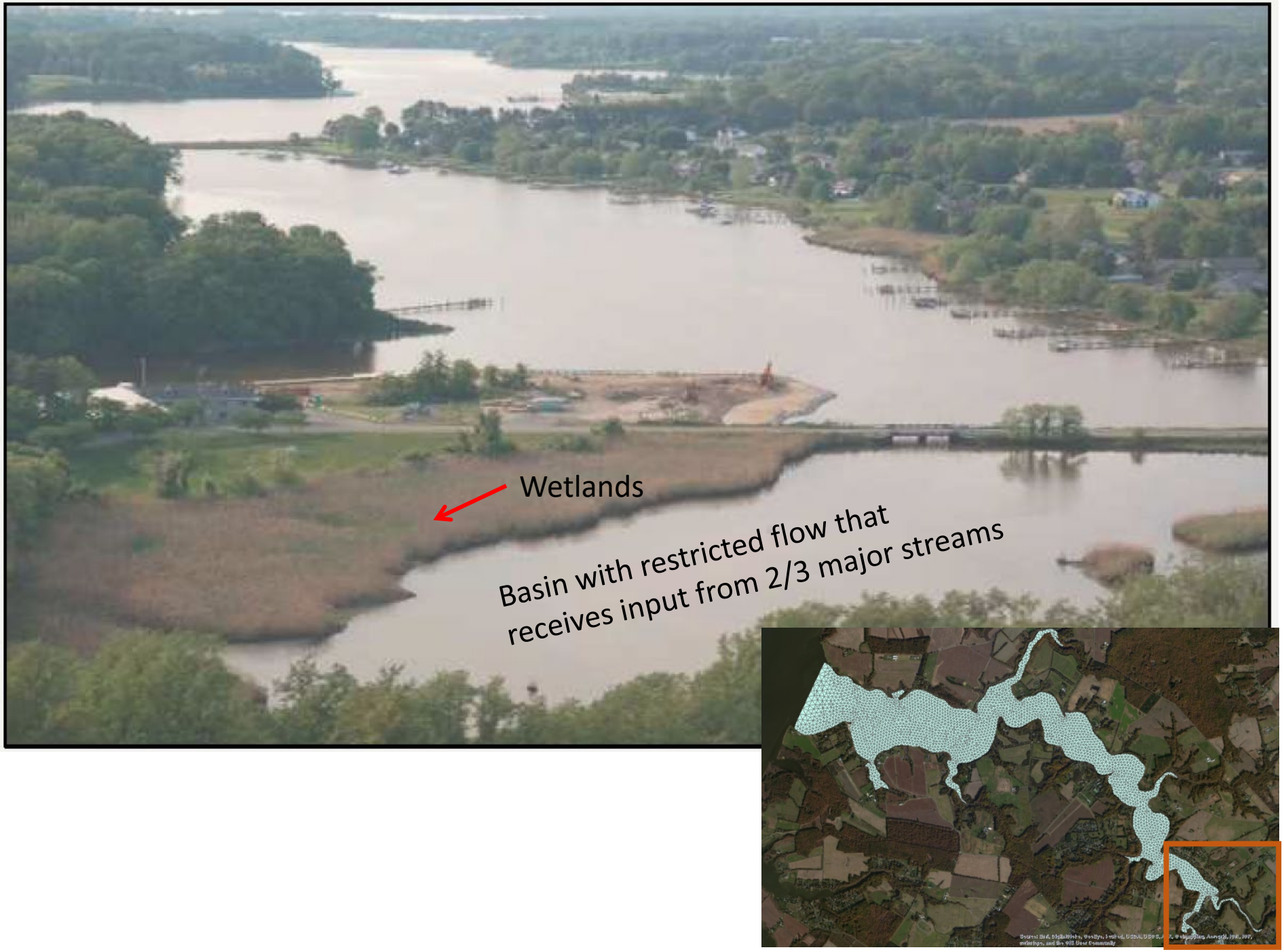




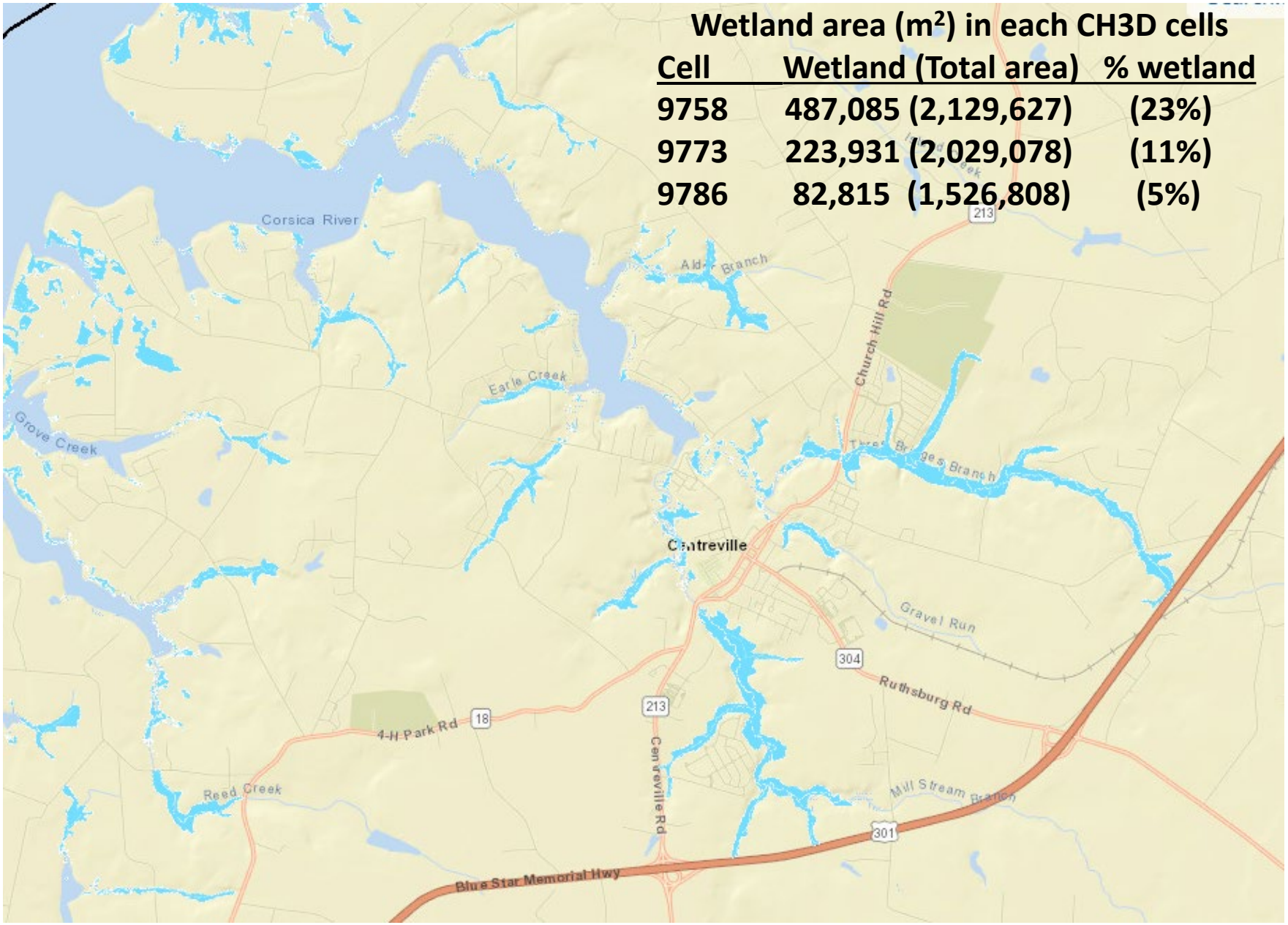
Lower Corsica






Wetlands
Basin with restricted flow that
receives input from 2/3 major streams

Wetland distribution in the Watershed (sky blue)

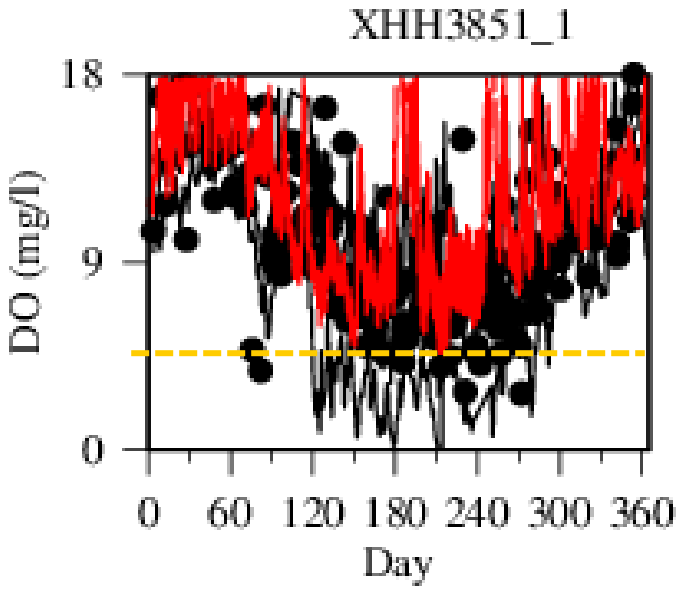


Wetland area (m^2) in each CH3D cells

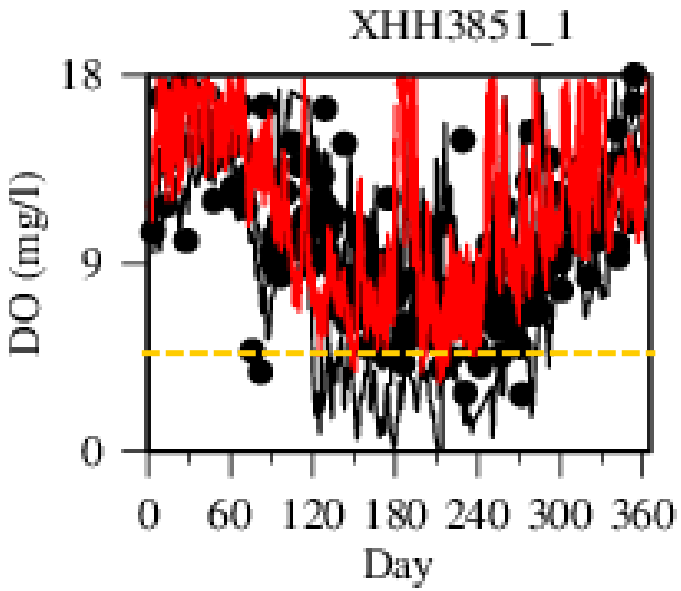
Cell	Wetland (Total area)	% wetland
9758	487,085 (2,129,627)	(23%)
9773	223,931 (2,029,078)	(11%)
9786	82,815 (1,526,808)	(5%)

Wetland DOC Load Impact on DO

No Wetlands



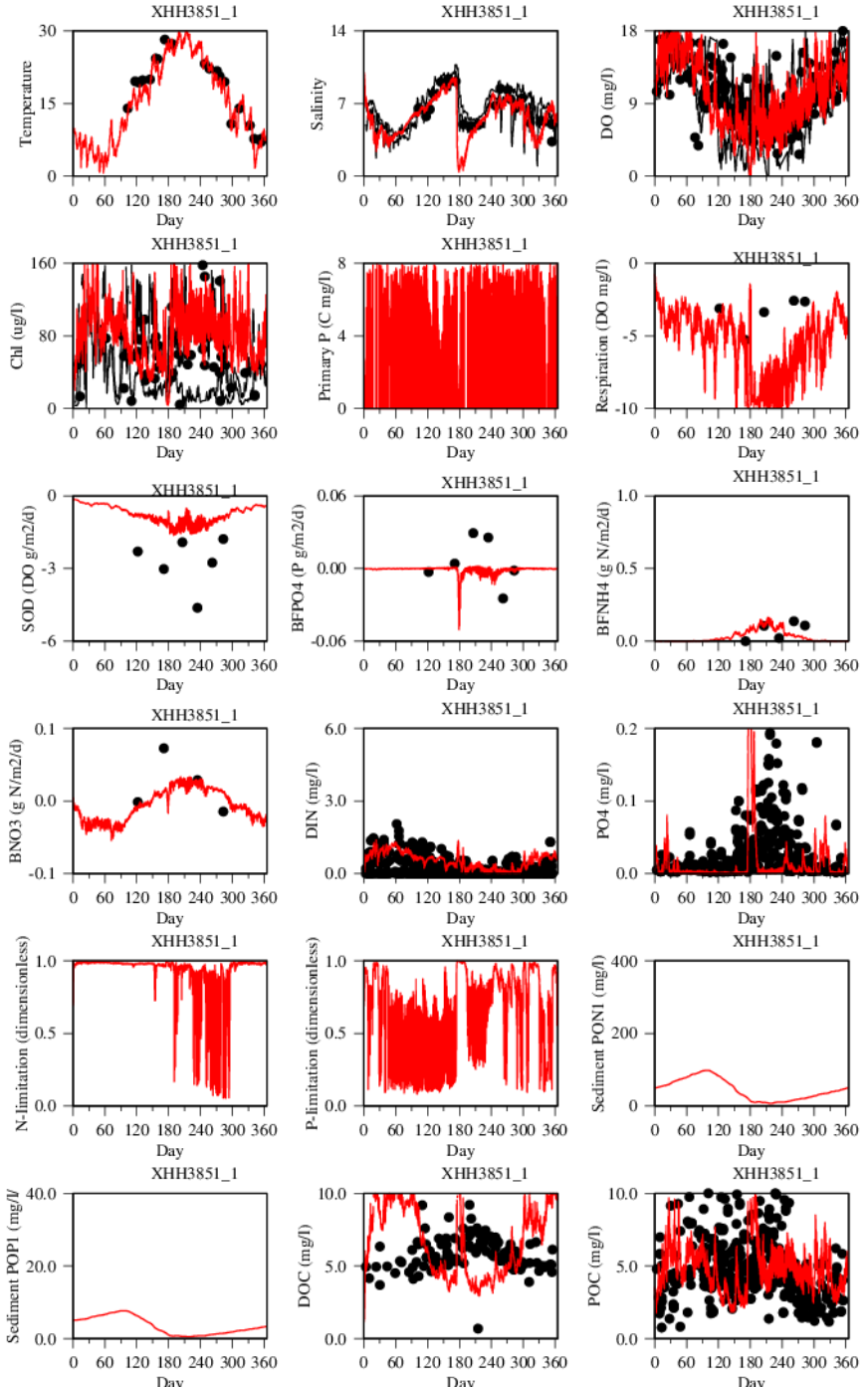
Wetlands



Addition on wetland export of DOC lowers the floor for DO, but not the variability

Lower and middle estuary unaffected by wetlands

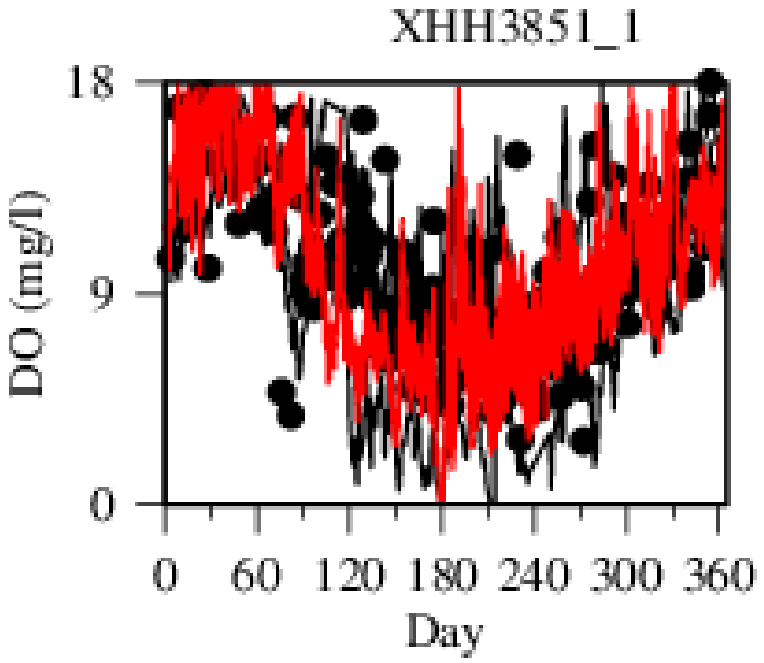
Validation: Concentrations and Metabolic Rates

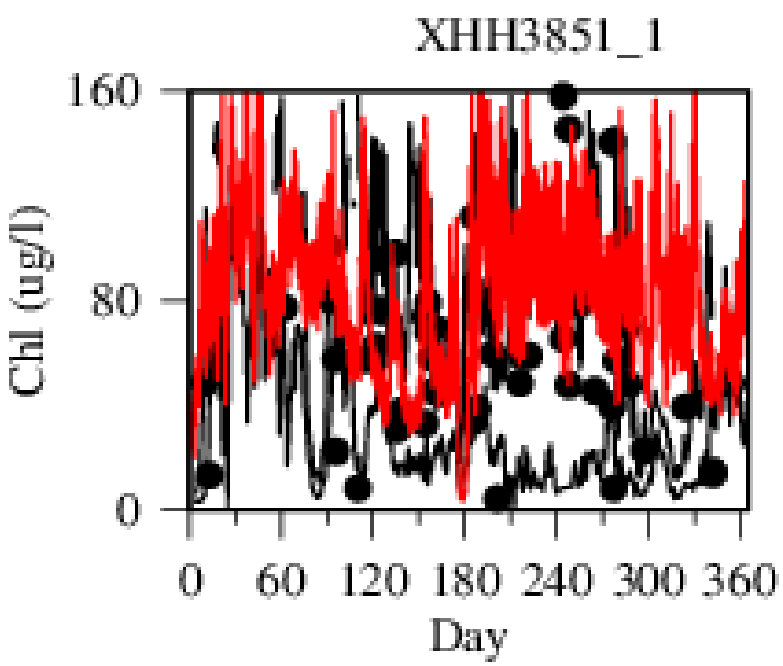


Upper Corsica

Validation:
Dissolved Oxygen and Chlorophyll-a

Upper Corsica



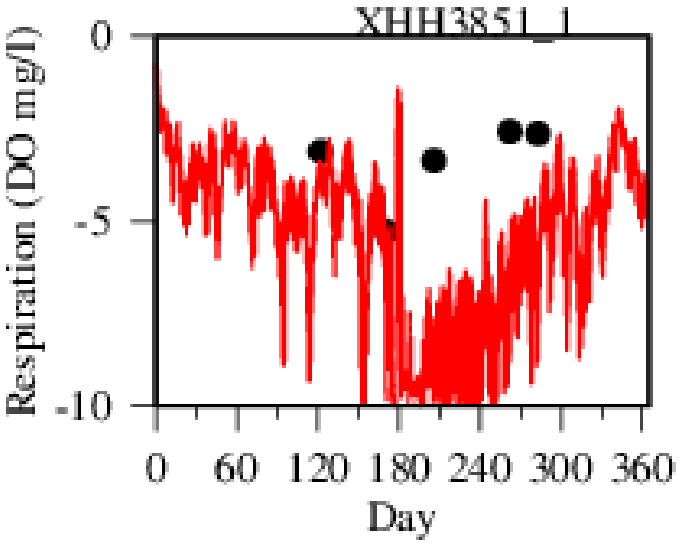


Model reproduces high variability,
Generates some hypoxia,
Diurnal cycle somewhat weaker than observed

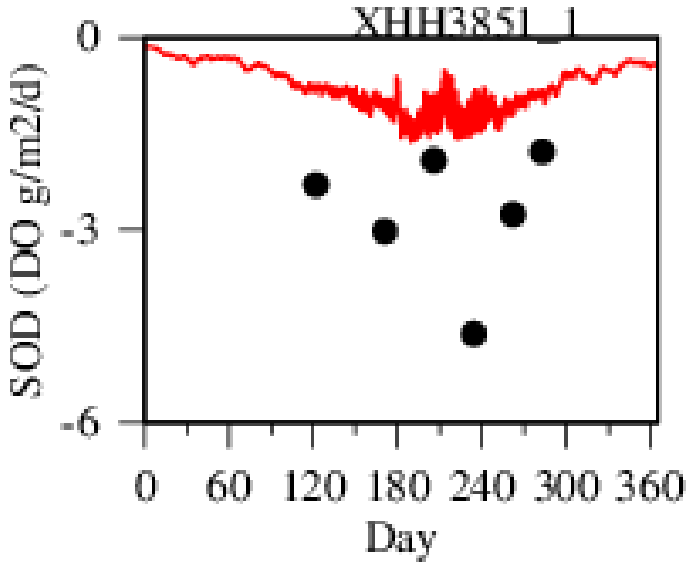
Consistently-high chlorophyll-a
year round

Validation:
Oxygen Consumption Rates

Upper Corsica



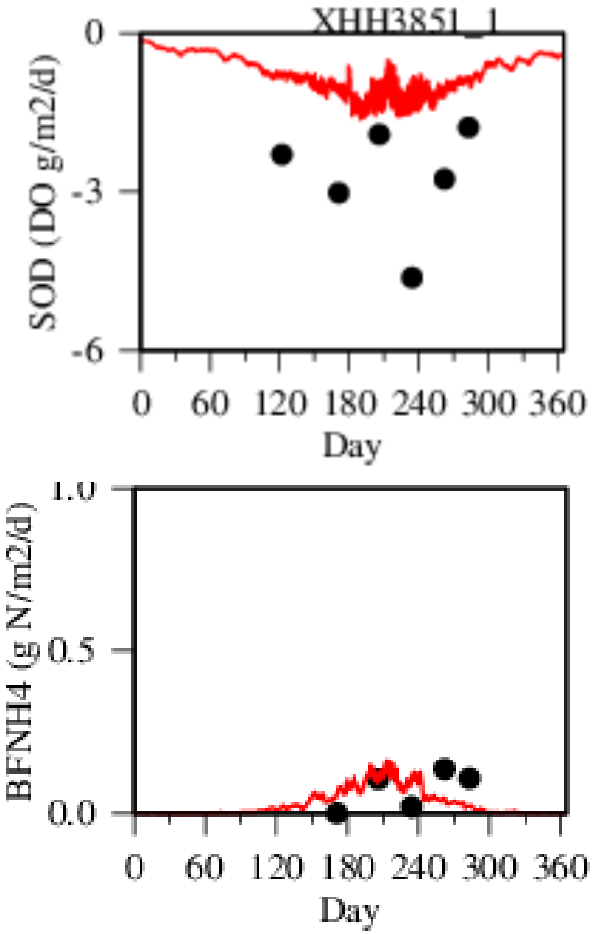
Water-Column:
Overestimated

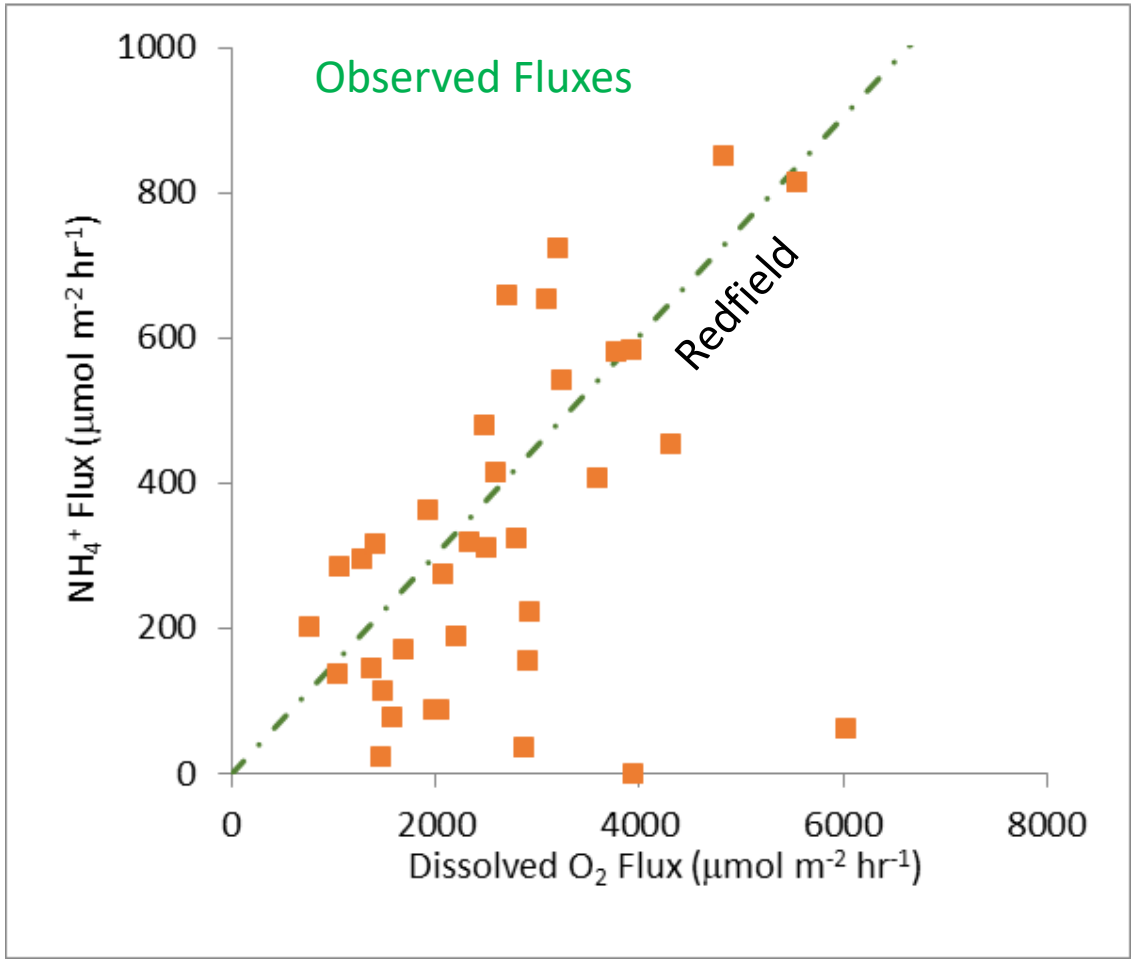


Sediment:
Underestimated

BUT, combined SOD+Water-column respiration in model and data are comparable
SO, oxygen consumption may be modeled reasonably, but in the wrong environment
THUS, challenge in reproducing biogeochemistry in ~1 m water-column is clear

Sediment-Water Fluxes: NH_4 versus SOD





Questions