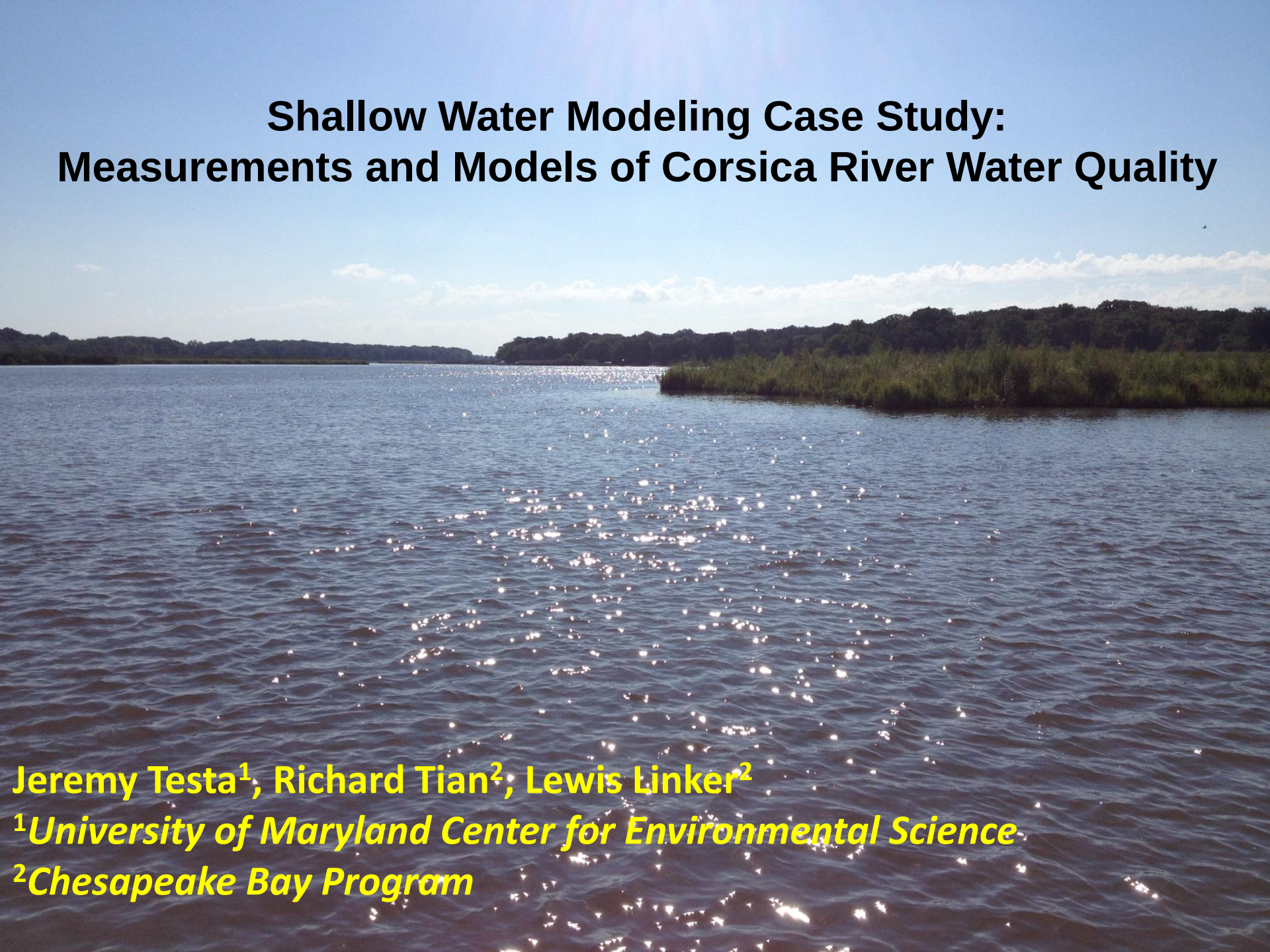
Shallow Water Modeling Case Study: Measurements and Models of Corsica River Water Quality



Jeremy Testa[1], Richard Tian[2], Lewis Linker[2]

[1]*University of Maryland Center for Environmental Science*

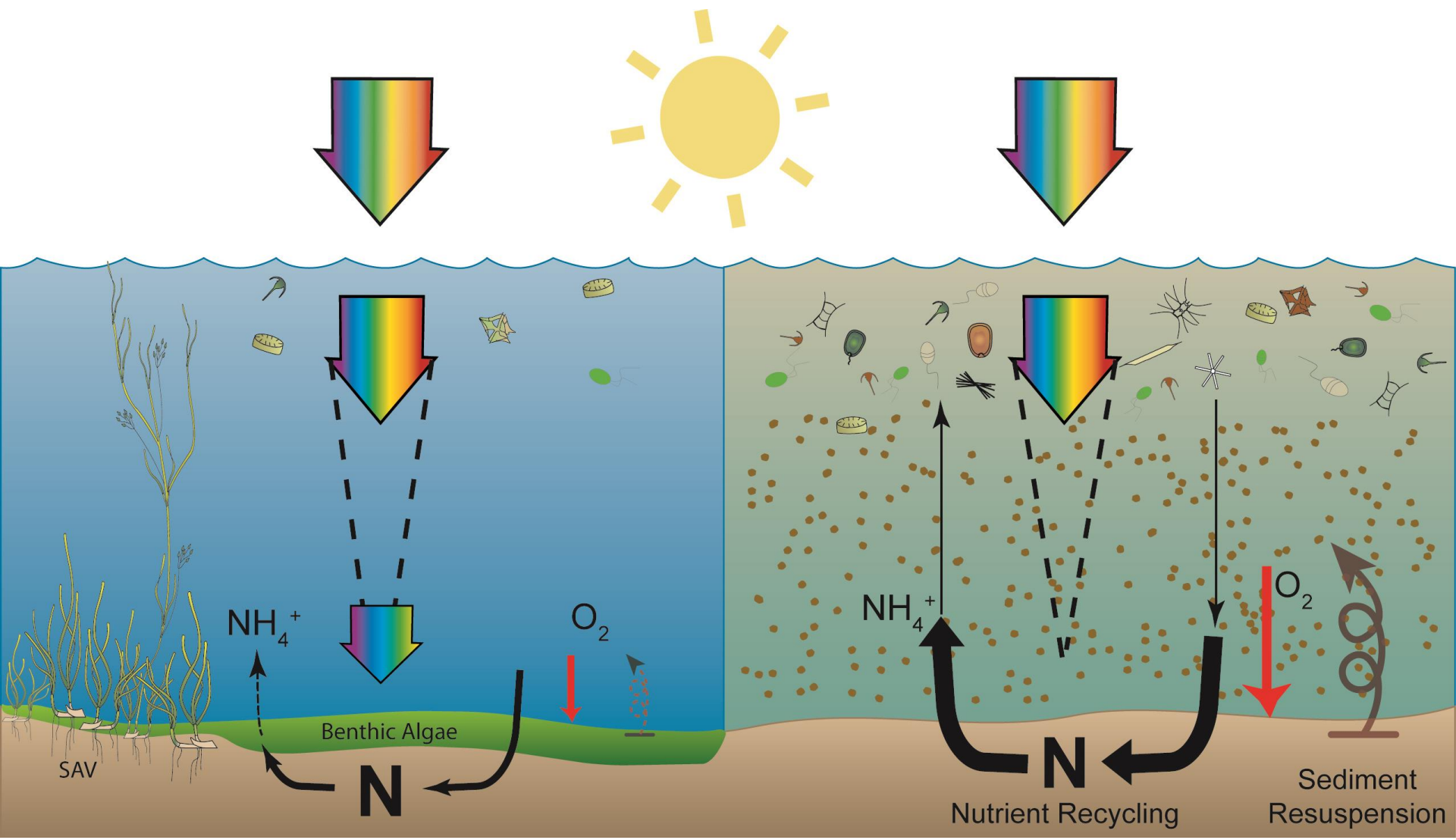
[2]*Chesapeake Bay Program*

Why Shallow Waters?

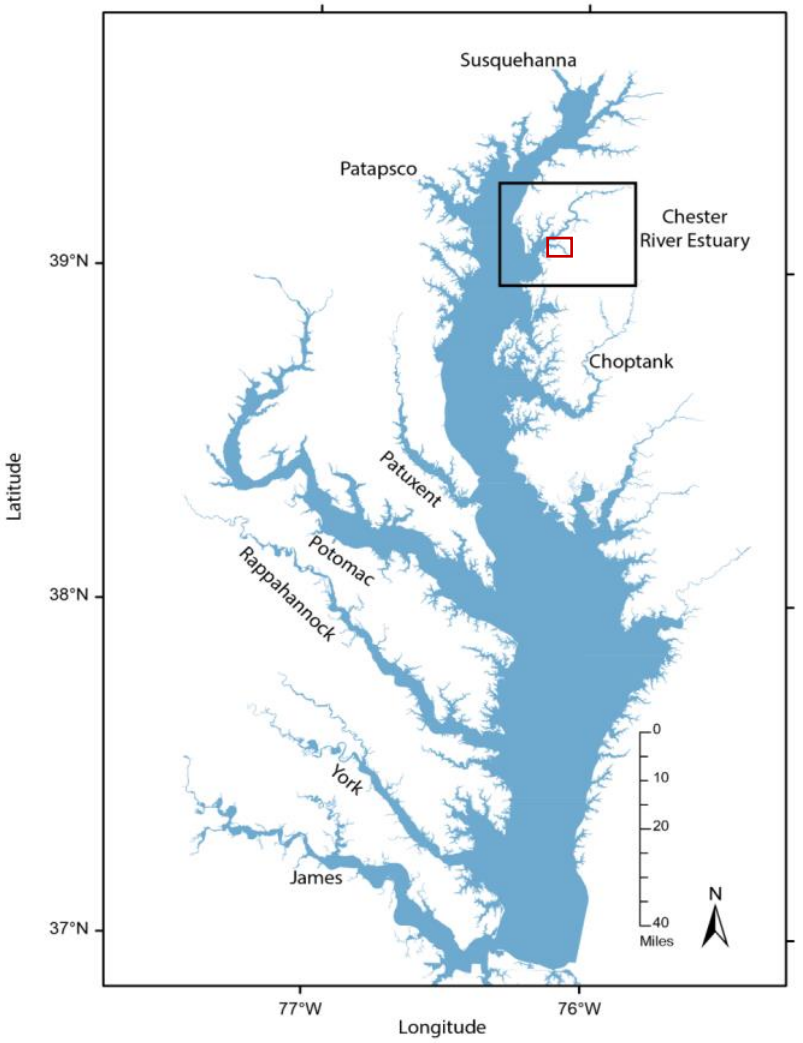
- Often reside at the land-water interface, mediate or process watershed loads
- Support key habitats (tidal marshes, SAV)
- Accessible to large fraction of population
- Have unique challenges (diel cycling hypoxia, erosion, monitoring)

- A challenge for modeling:
  - Need high resolution (grids, loads)
  - High variability in time and space – difficult to simulate and properly ‘force’
  - Processes needed that may not be as relevant in deeper water
    - Erosion, benthic algae, complex shorelines

Tightly-Linked Pelagic-Benthic Processes: Potential for Non-linear Dynamics



Case Study: Numerical Model of a Shallow Water Estuary



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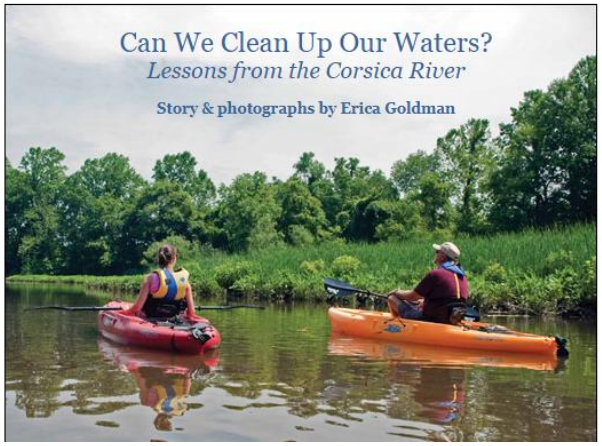
Can We Clean Up Our Waters?
Lessons from the Corsica River

Story & photographs by Erica Goldman



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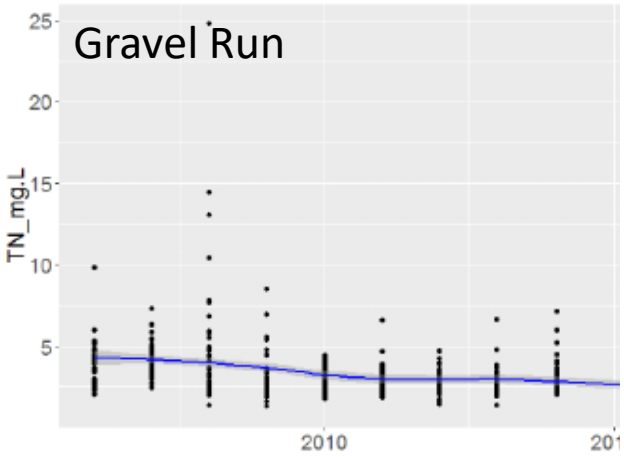
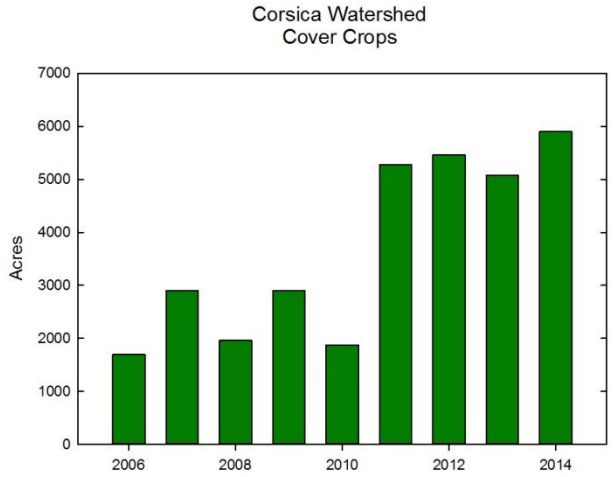
State to clean up Corsica River

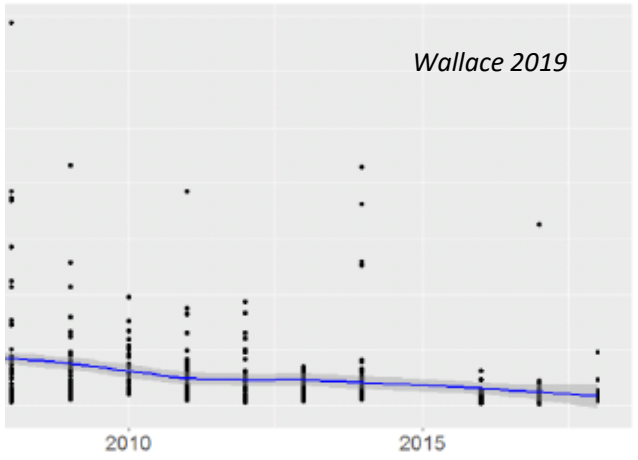
By CHRIS GUY
THE BALTIMORE SUN

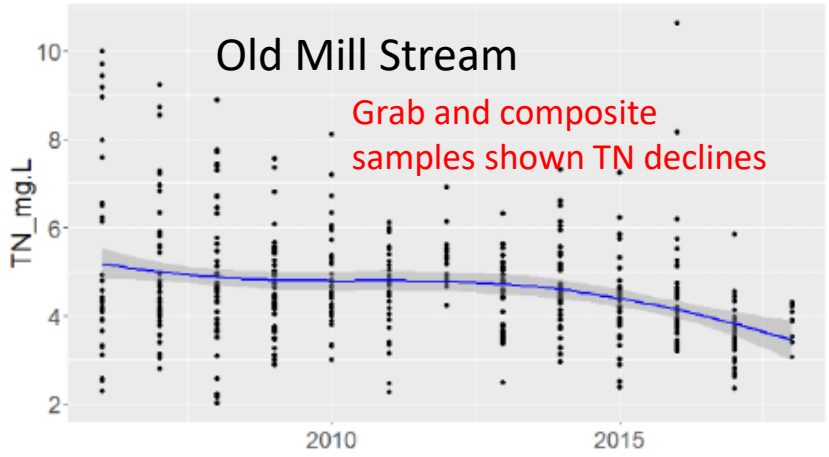
SEPTEMBER 28, 2005 | CENTREVILLE

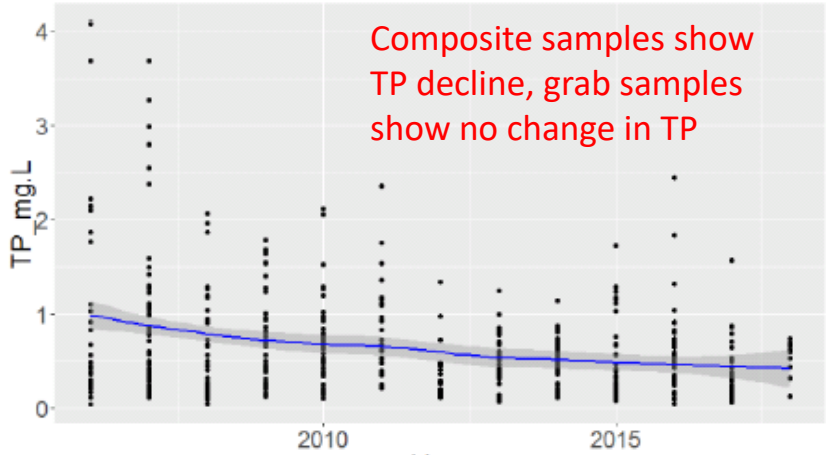
Centreville -- Anxious for results in the state's Chesapeake Bay cleanup effort, Gov. Robert L. Ehrlich Jr. announced plans yesterday for spending nearly $20 million and concentrating the research of 30 state, federal and private environmental agencies on improving the Corsica River - a small

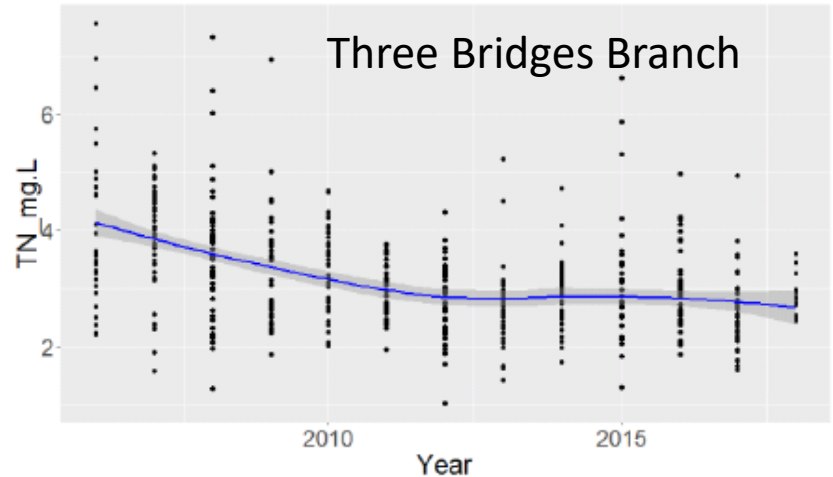

Gravel Run
TN_mg.L
25
20
15
10
5
2010

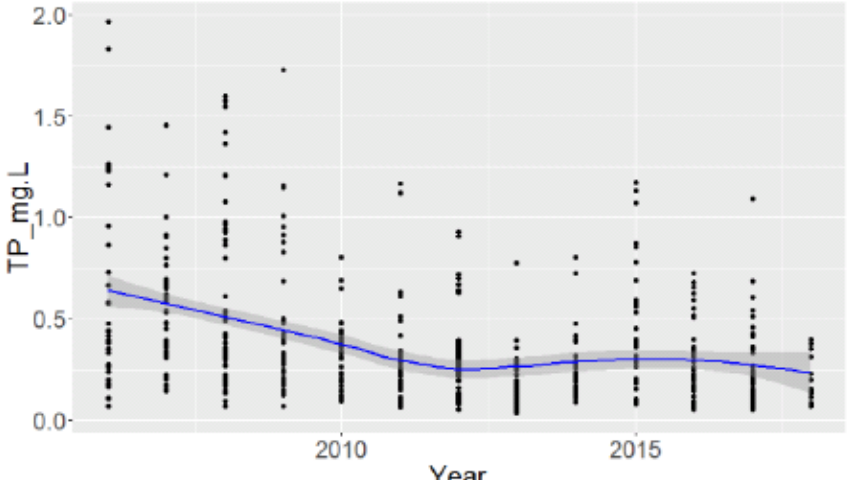

Corsica Watershed
Cover Crops
Acres
7000
6000
5000
4000
3000
2000
1000
0
2006
2008
2010
2012
2014


Wallace 2019
2010
2015

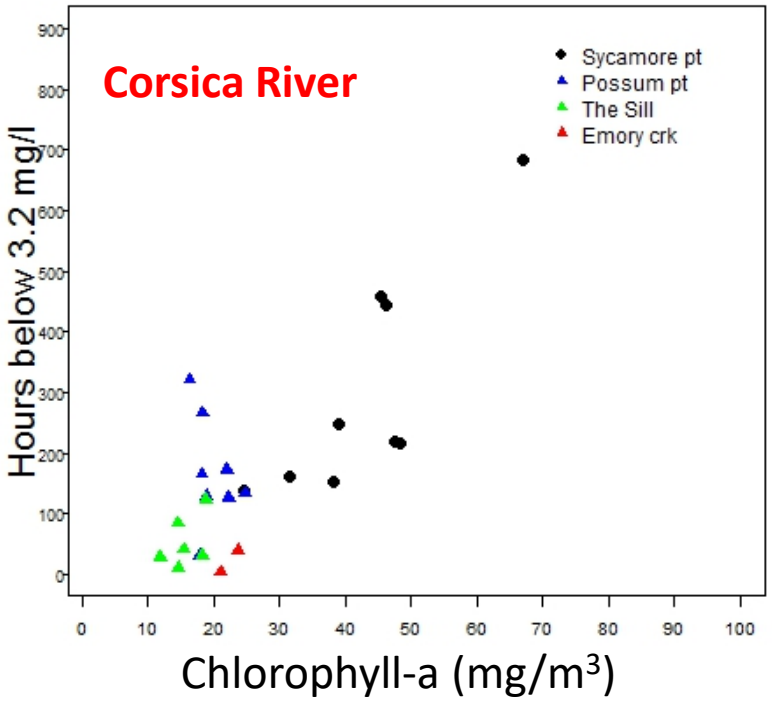

Old Mill Stream
Grab and composite samples shown TN declines
TN_mg.L
10
8
6
4
2
2010
2015

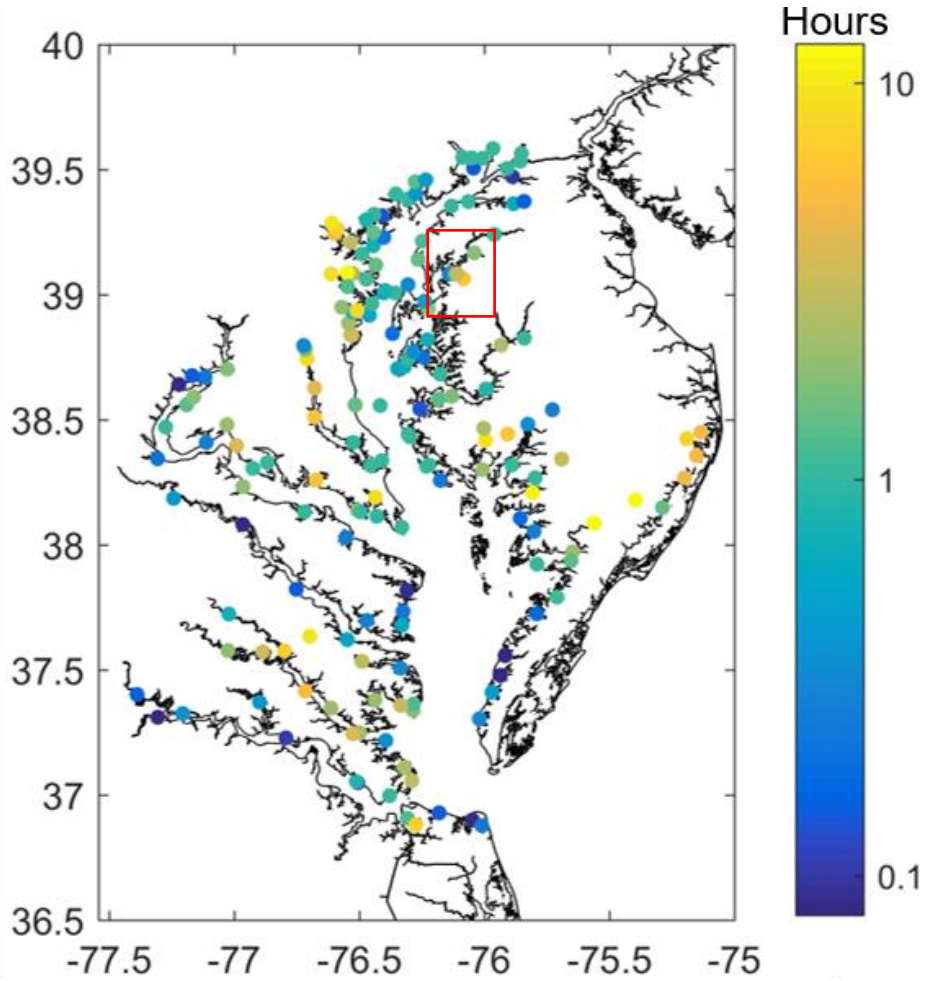

Composite samples show TP decline, grab samples show no change in TP
TP_mg.L
4
3
2
1
0
2010
2015


Three Bridges Branch
TN_mg.L
6
4
2
2010
2015
Year

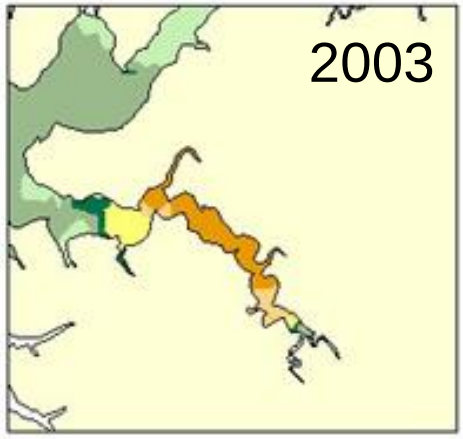

TP_mg.L
2.0
1.5
1.0
0.5
0.0
2010
2015
Year

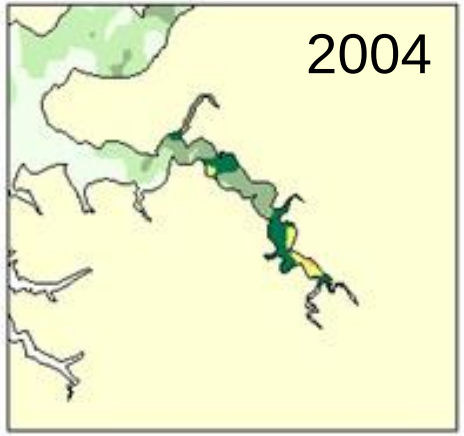
Chl-a Effect on Hypoxia?

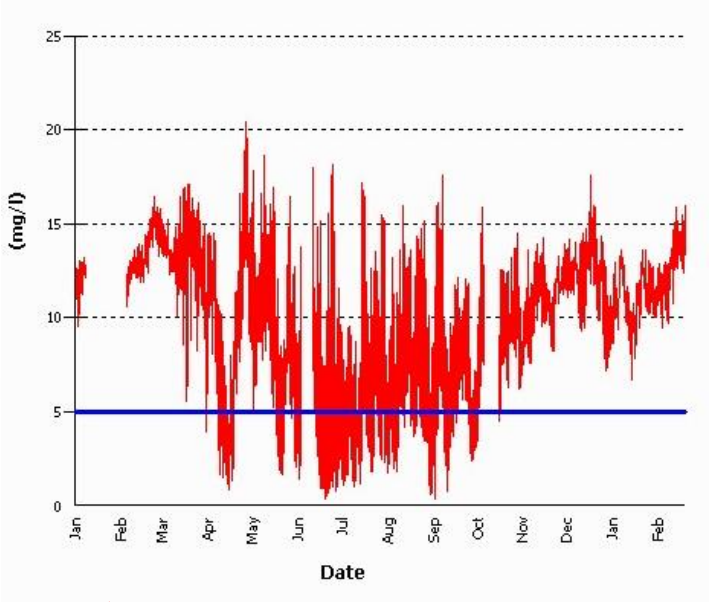




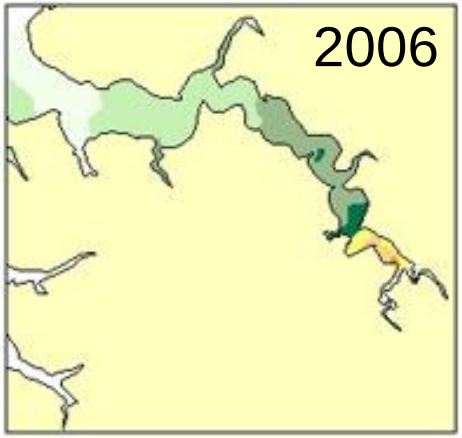
Inter-Annual and Spatial Changes in CHL-a

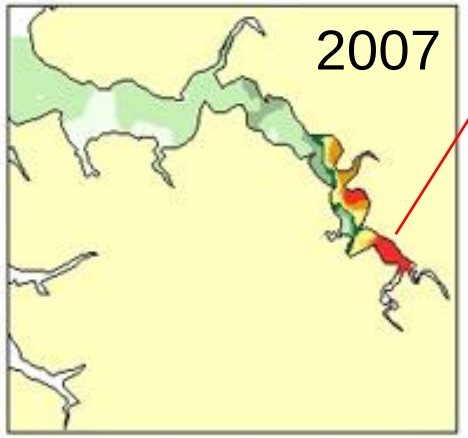


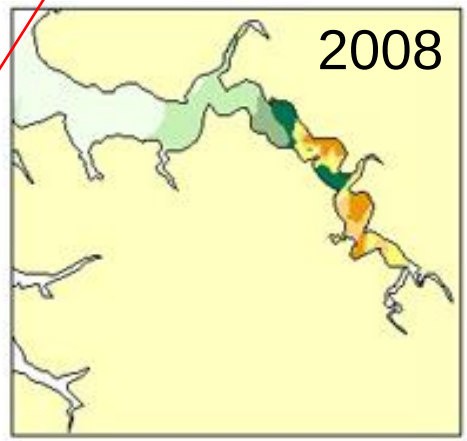


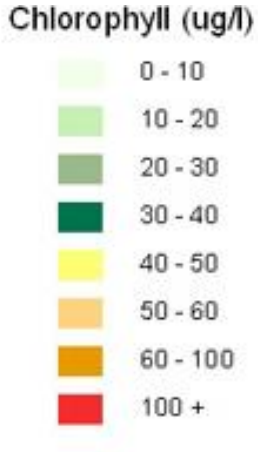


June

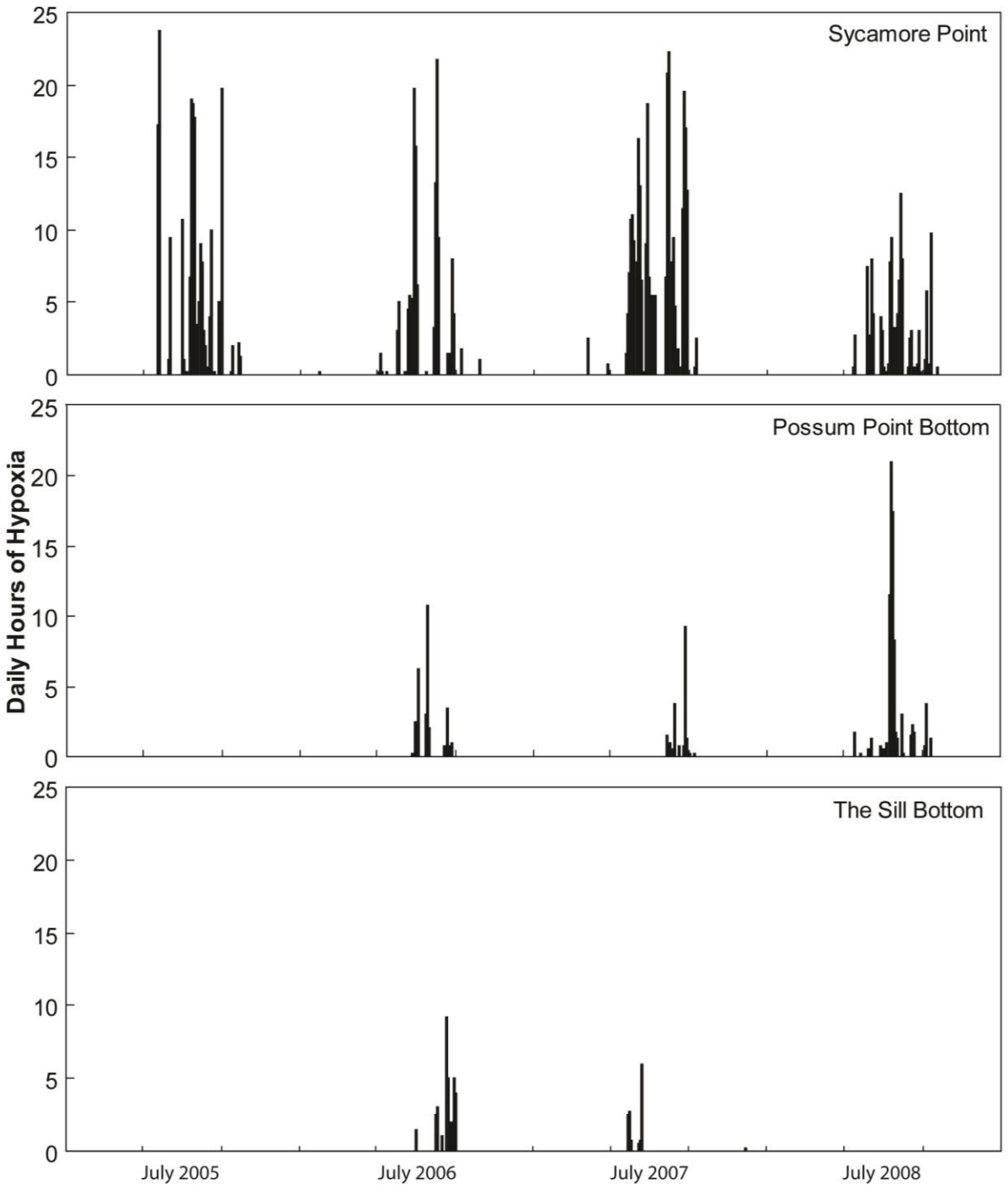








Low O_2 Water



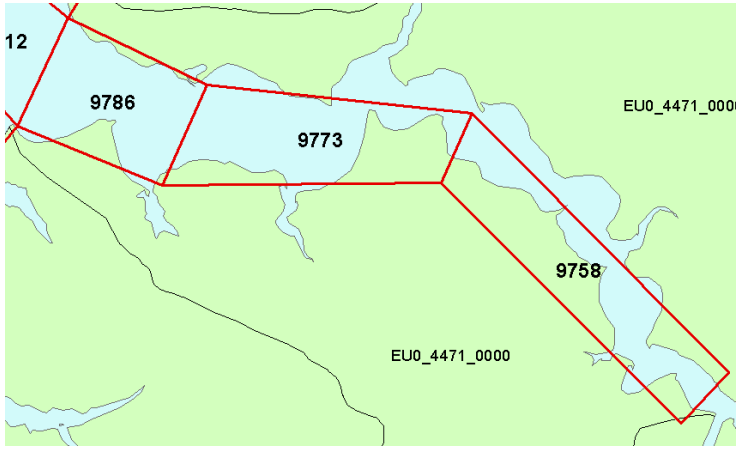
Upper Corsica

Lower Corsica

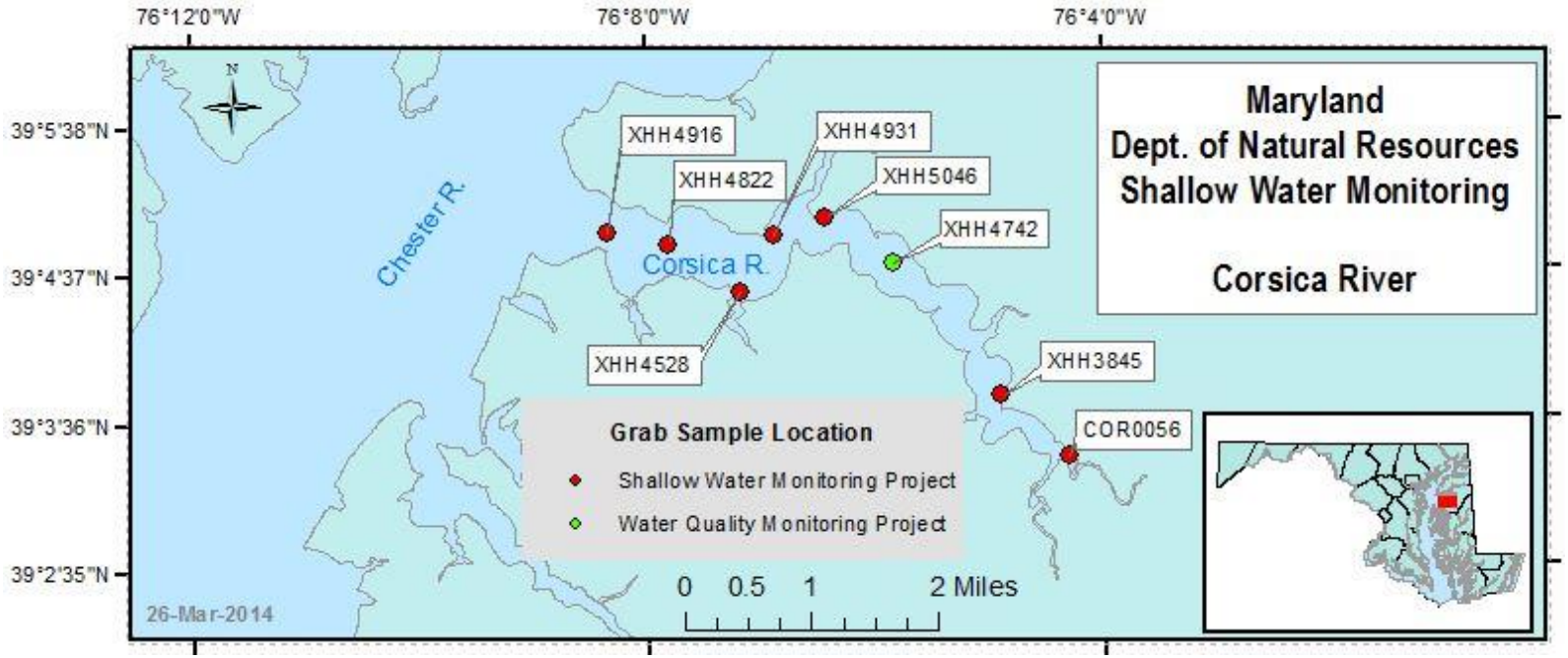
Corsica Model Grid

SCHISM-ICM

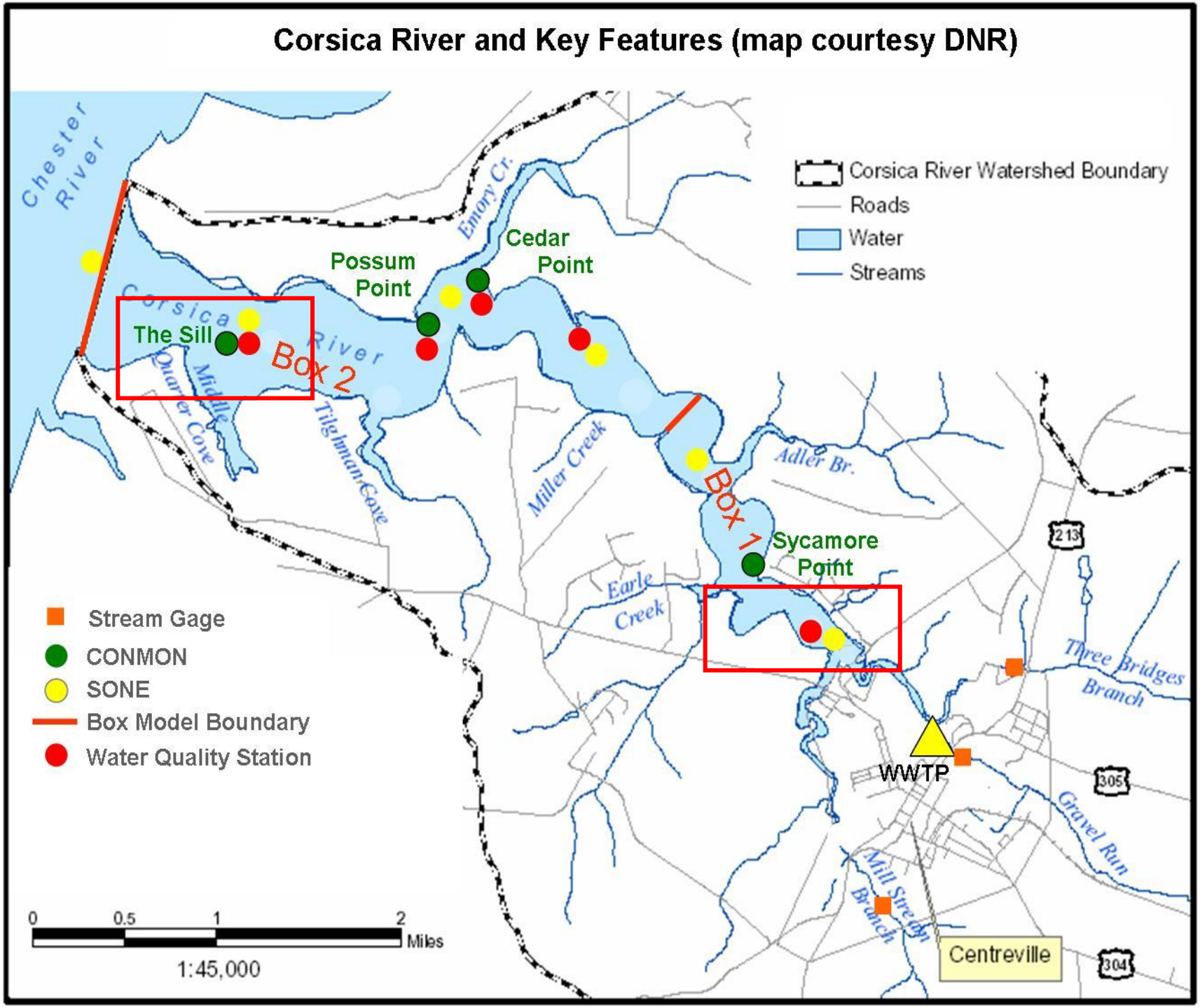
- 20m resolution on coast, 100m at the mouth;
- 5029 cells, 5 layers
- Simulation year = 2006
- Phase 5.3 Watershed Model Loads

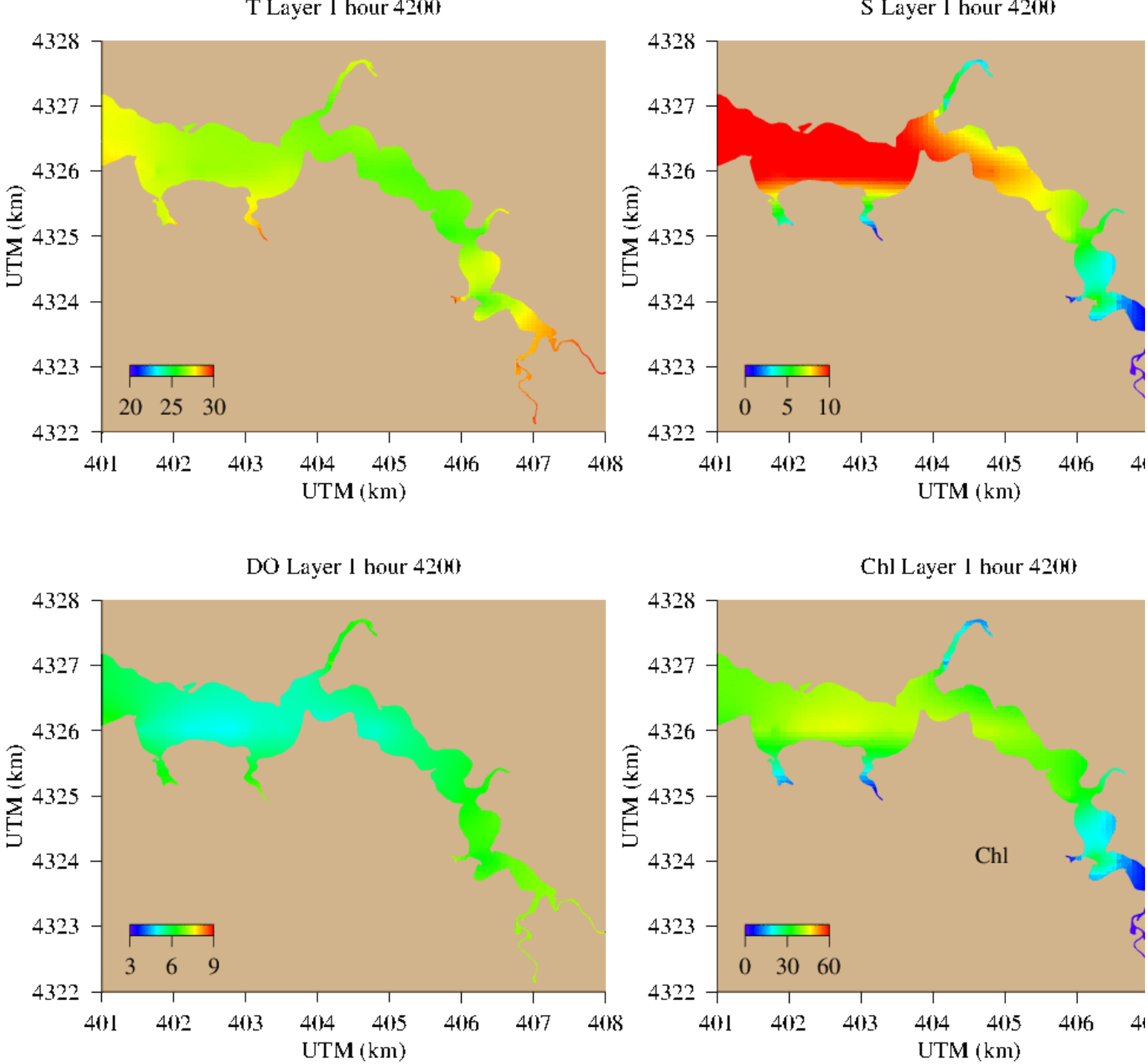


DNR monitoring stations in Corsica R.

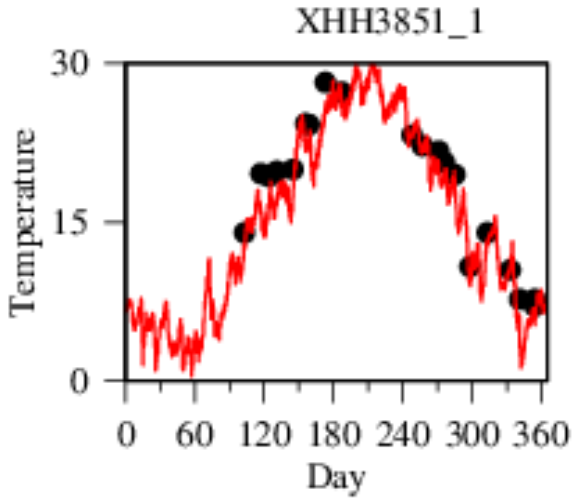


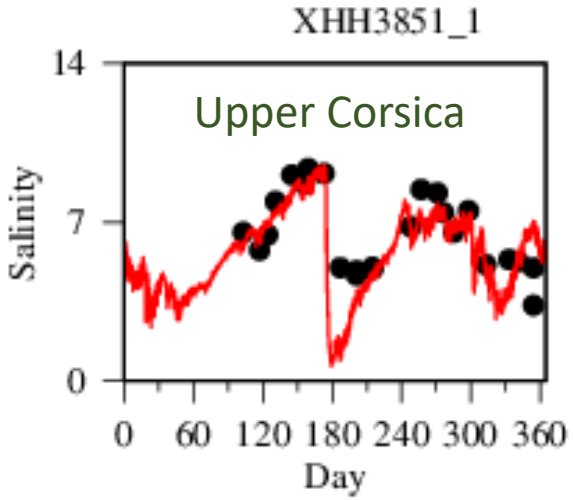
Station	Cmon	Dflow	Tributaries	CMON yrs	Dflo yrs
XHH3851	x	x		2005 - 2013	2005 - 2013
XHH4528		x			2006 - 2013
XHH4742			x		
XHH4822		x			2003 - 2005
XHH4916	x	x		2006 - 2011	2006 - 2013
XHH4931	x	x		2006 - 2013	
XHH5046	x			2005 2006	2006 - 2013
COR0056		x			2006 - 2013

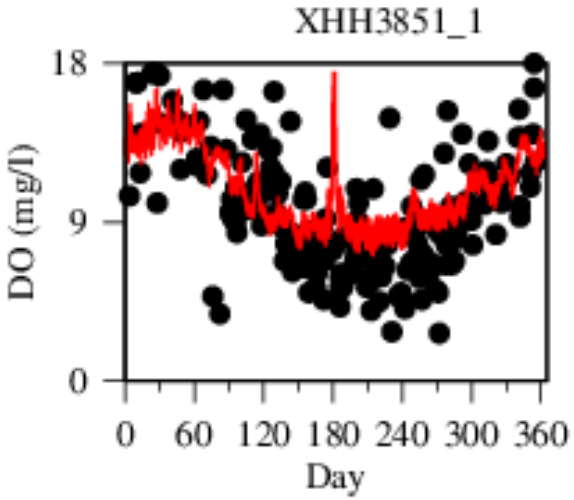

Corsica River and Key Features (map courtesy DNR)
Chester River
Corsica River
Emory Cr.
Possum Point
Cedar Point
The Sill
Box 2
Middle Quarter Cove
Tilghman Cove
Miller Creek
Box 1
Adler Br.
Sycamore Point
Earle Creek
Three Bridges Branch
WWTP
305
Gravel Run
Mill Stream Branch
Centreville
304
213
Corsica River Watershed Boundary
Roads
Water
Streams
Stream Gage
CONMON
SONE
Box Model Boundary
Water Quality Station
0
0.5
1
2
Miles
1:45,000

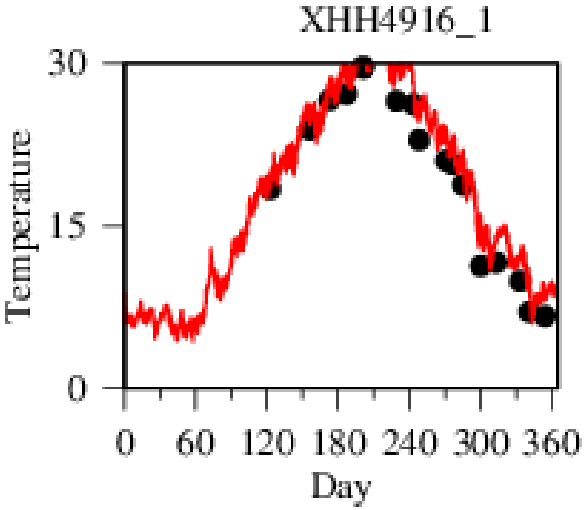

T Layer 1 hour 4200
S Layer 1 hour 4200
DO Layer 1 hour 4200
Chl Layer 1 hour 4200
UTM (km)
4328
4327
4326
4325
4324
4323
4322
401
402
403
404
405
406
407
408
20 25 30
0 5 10
3 6 9
0 30 60
Chl

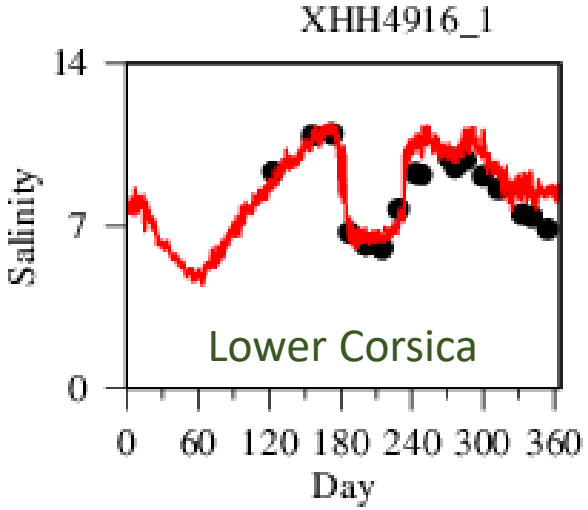
Case Study: Validation of Water Temperature, Salinity, DO

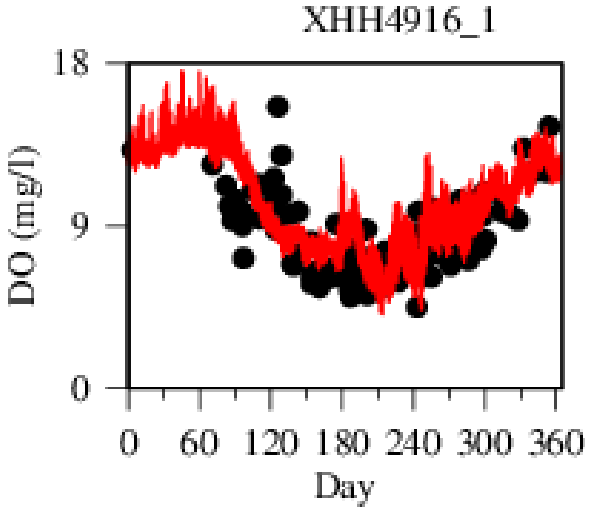






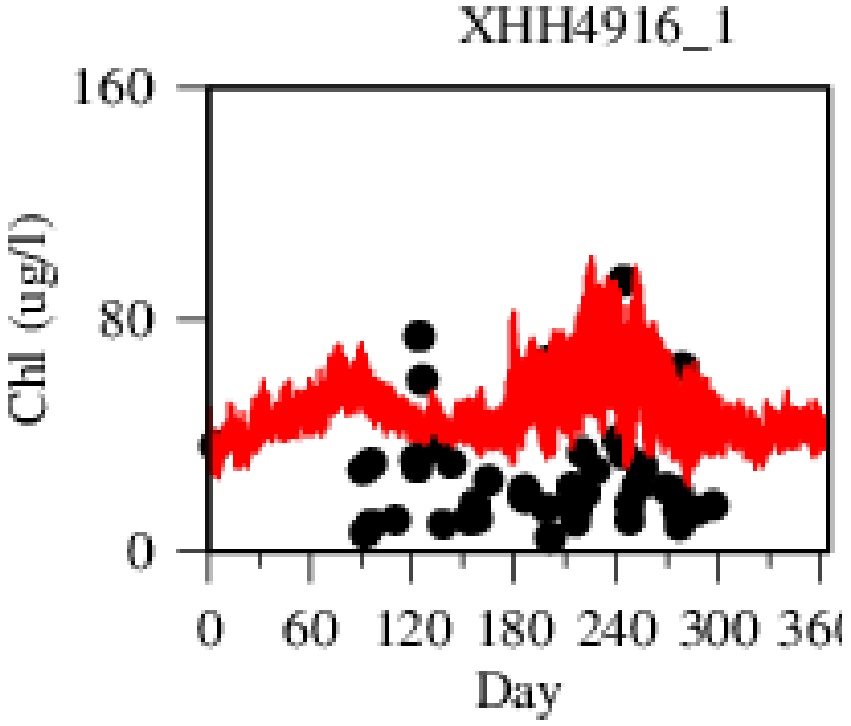


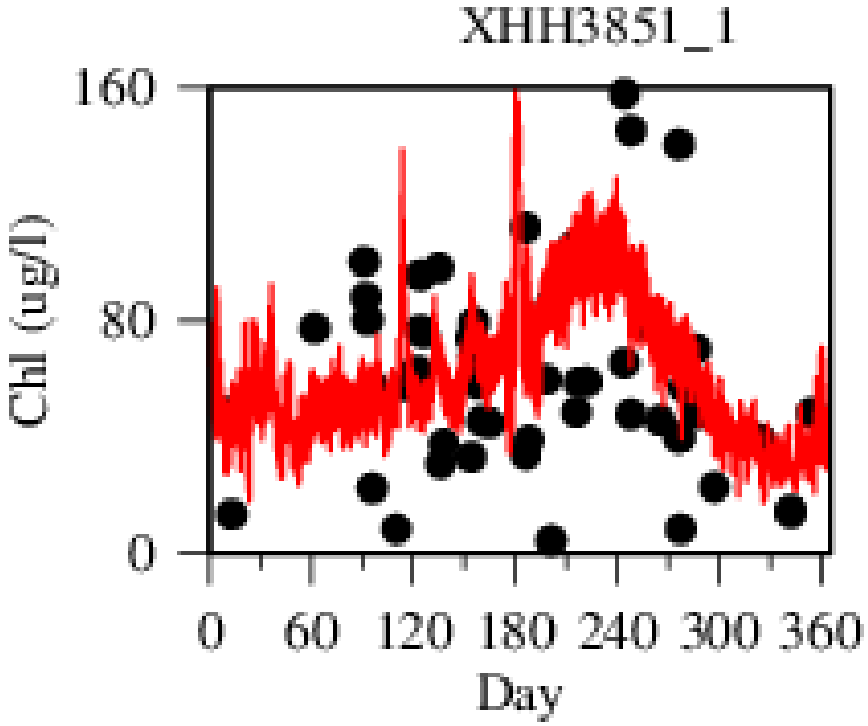




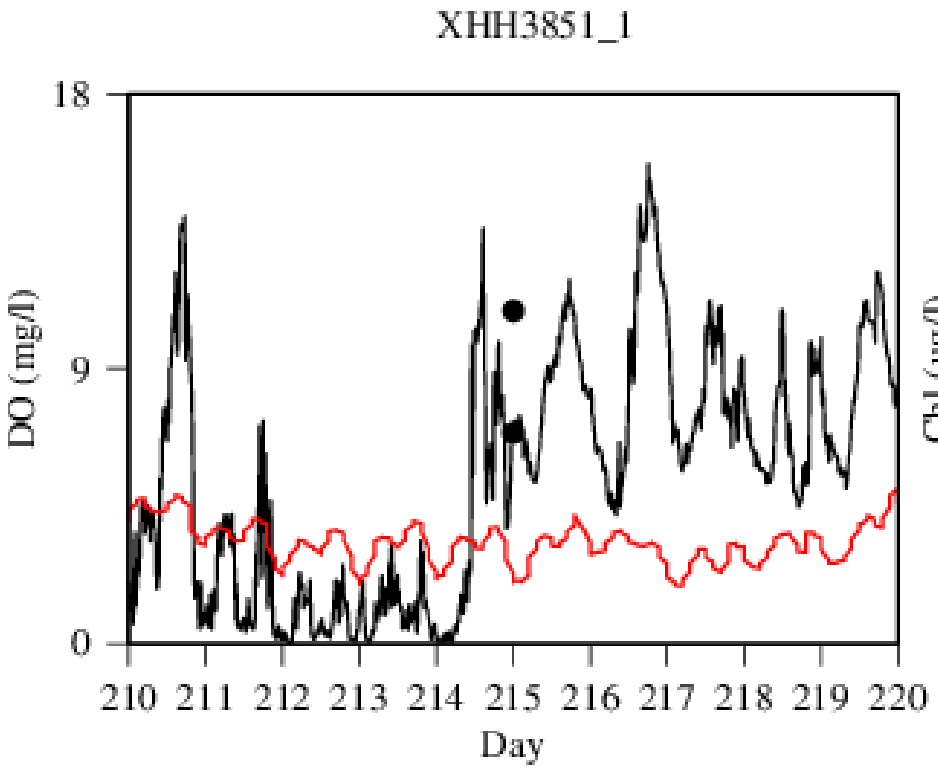
Case Study: Validation of Surface CHL-a

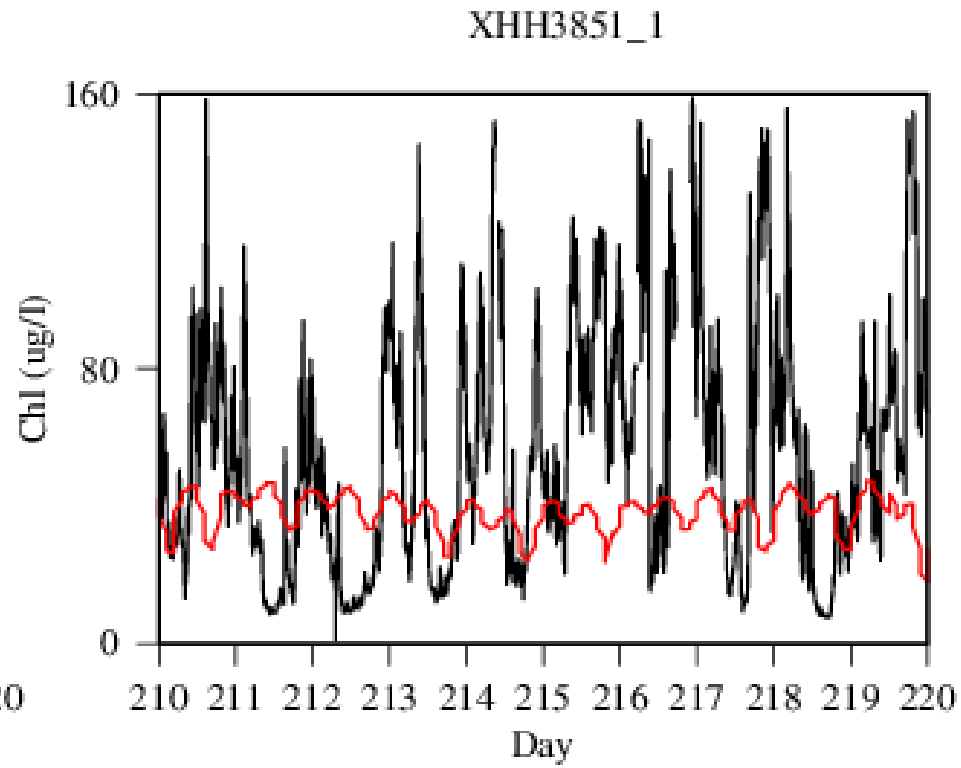
Very high chl-a concentrations predicted, but variability missed

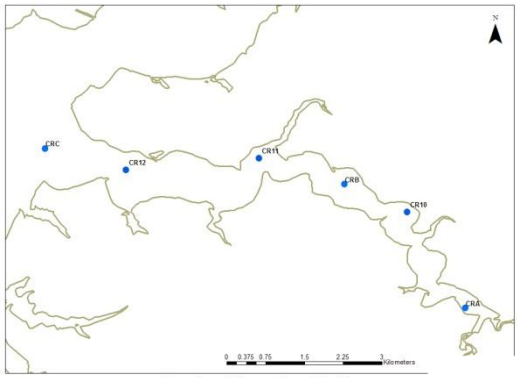




Short-Term Variation in Model *Underestimates* Observations



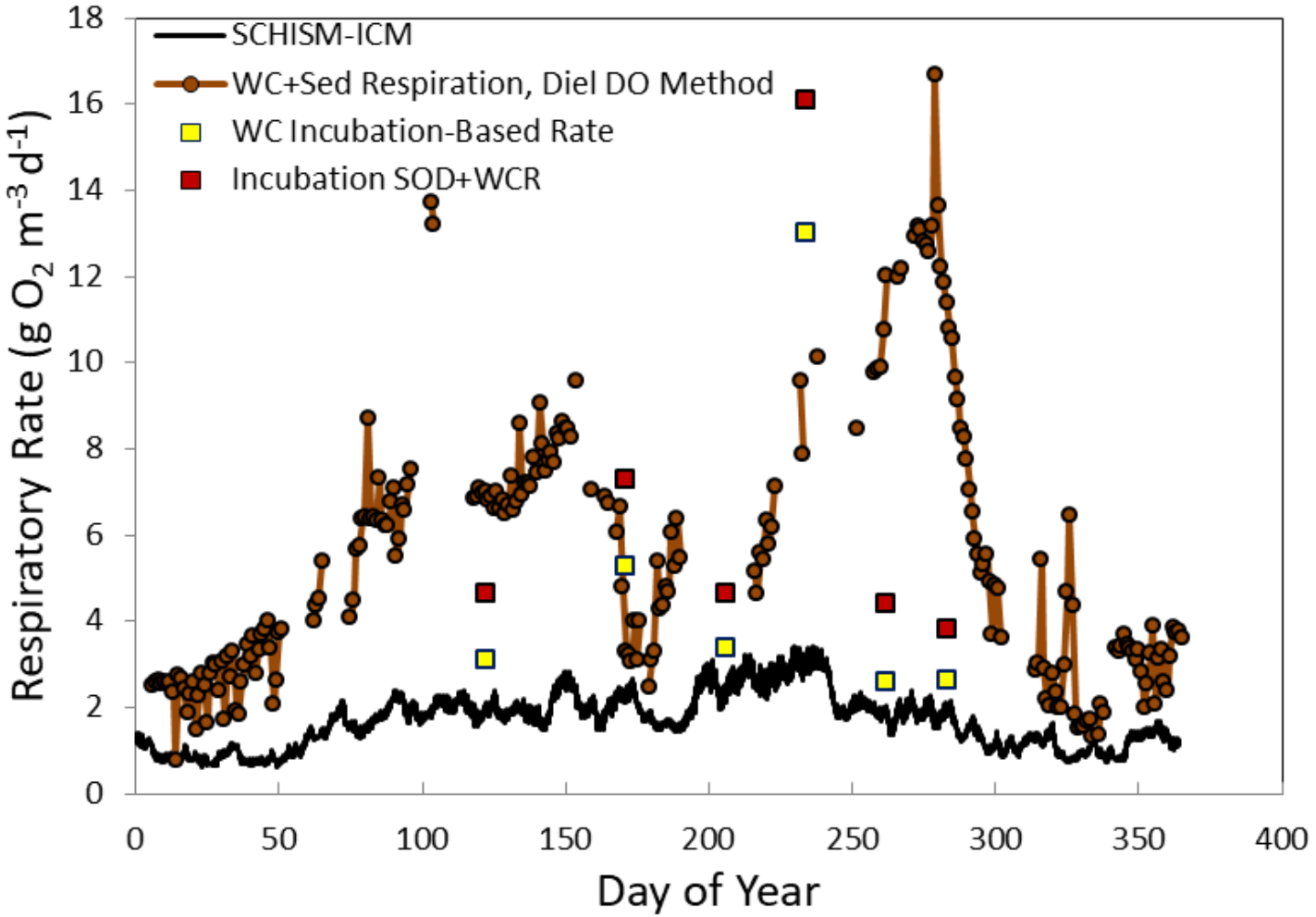




Corsica River Flux Stations

Model ***Underestimates*** Overall O_2 consumption

Consistent with missed O_2 Variability



Conclusions to Date

(1) Even when implemented at extremely high resolution, current model does not capture diurnal variations in dissolved oxygen in a highly dynamic site.

(2) Continued investigations will continue, particularly addressing the following questions:

(a) Is natural variability in PAR adequately forced on the model at short enough (~hour) time steps?

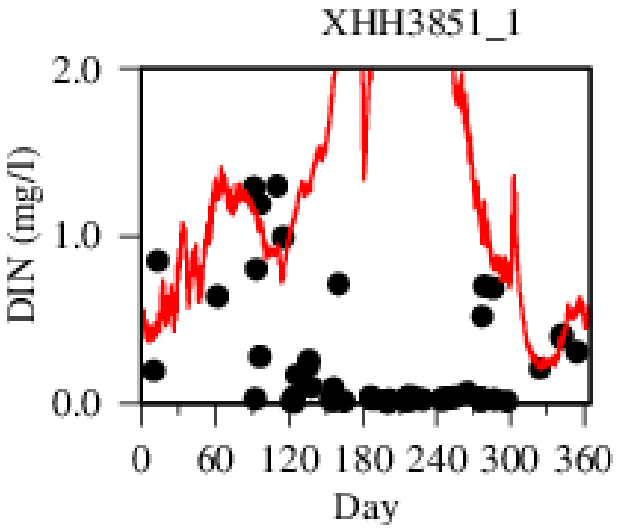
(b) Do the metabolic rates of primary production and respiration computed within the model agree with the substantial rates derived from observations?

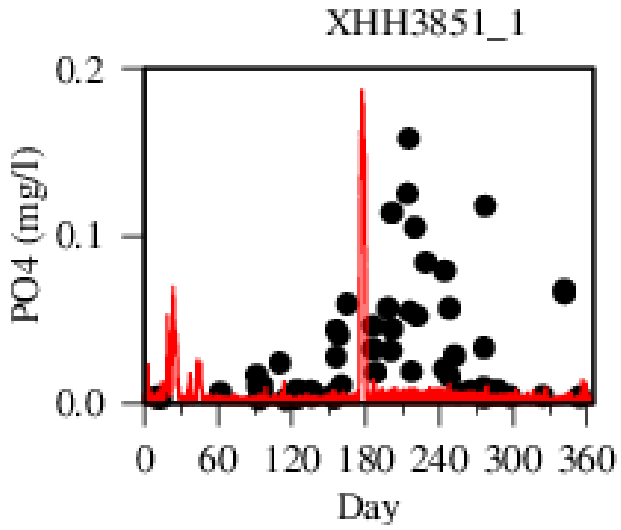
(c) Is wind-stress properly applied in protected shallow tributaries, given most wind products are based on larger scales?

(b) Will fine-scale watershed model inputs be necessary to represent fine-scale effects of freshwater inputs to shallow waters and their associated circulation effects?

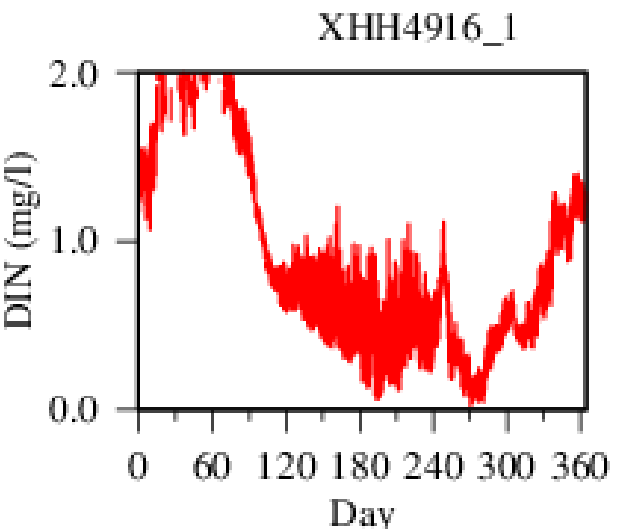
Model ***Underestimates*** DIP, Overestimates DIN
P-limitation emerges in the model

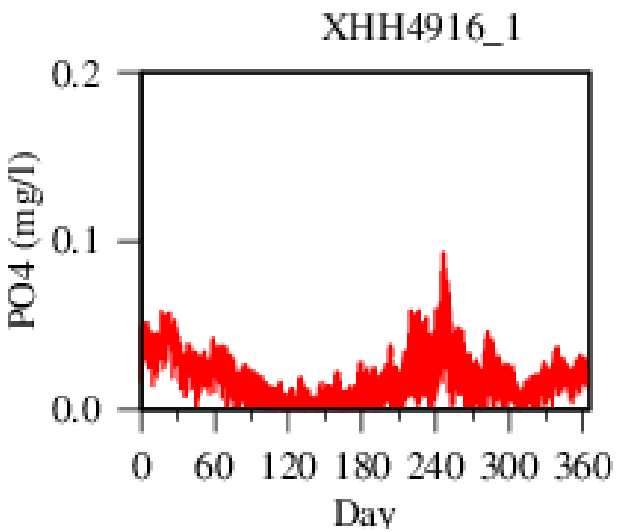
Upper Station



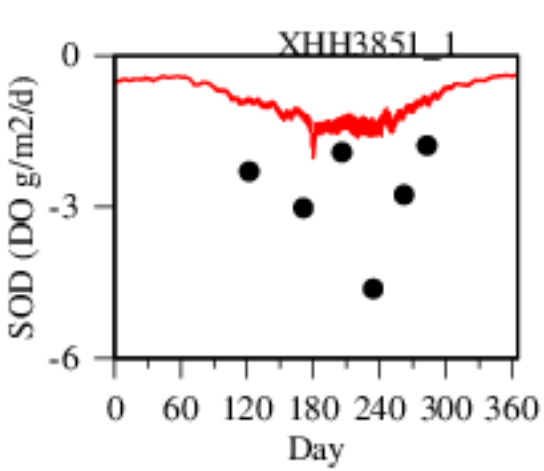


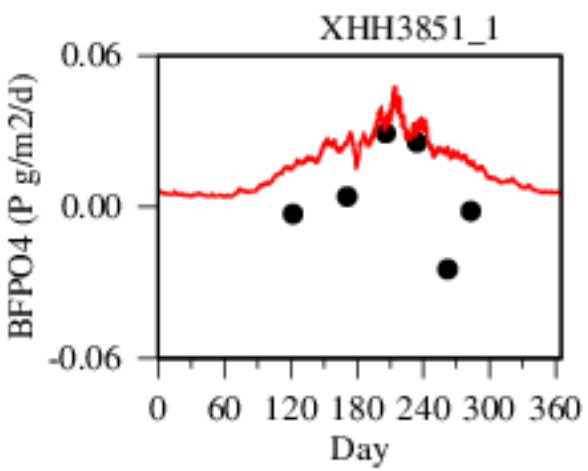
Lower Station

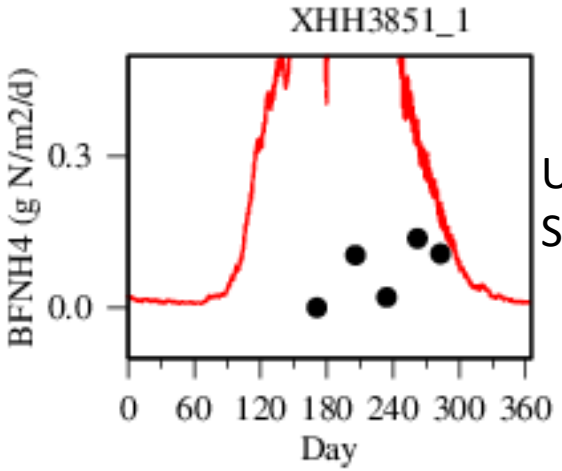




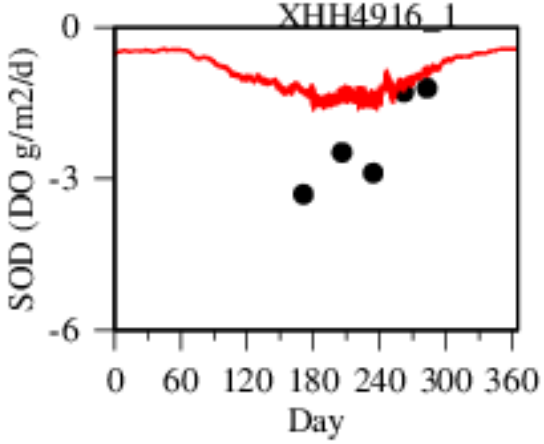
Model ***Underestimates*** Sediment Oxygen Consumption, Overestimates NH_4 Efflux Consistent with missed O_2 minima, and high WC DIN

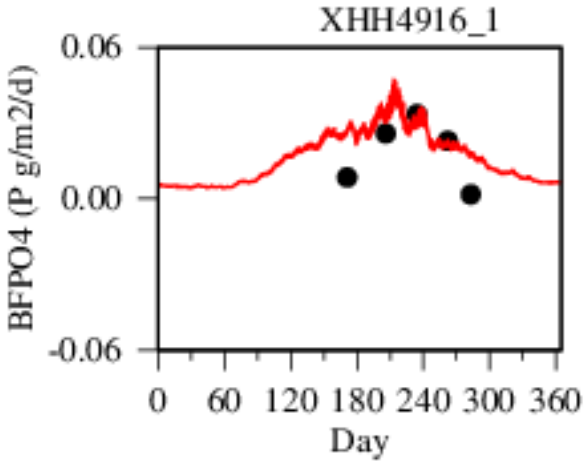


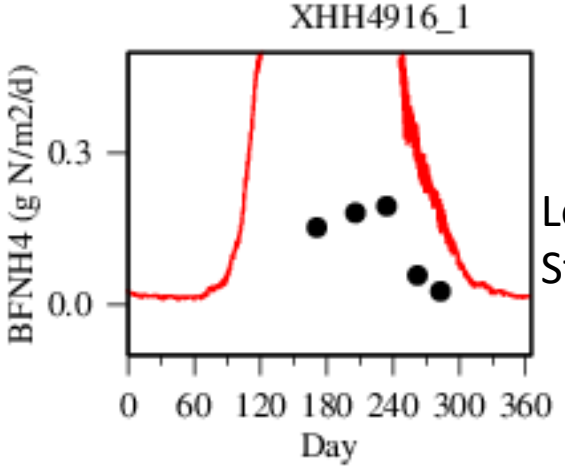




Upper Station

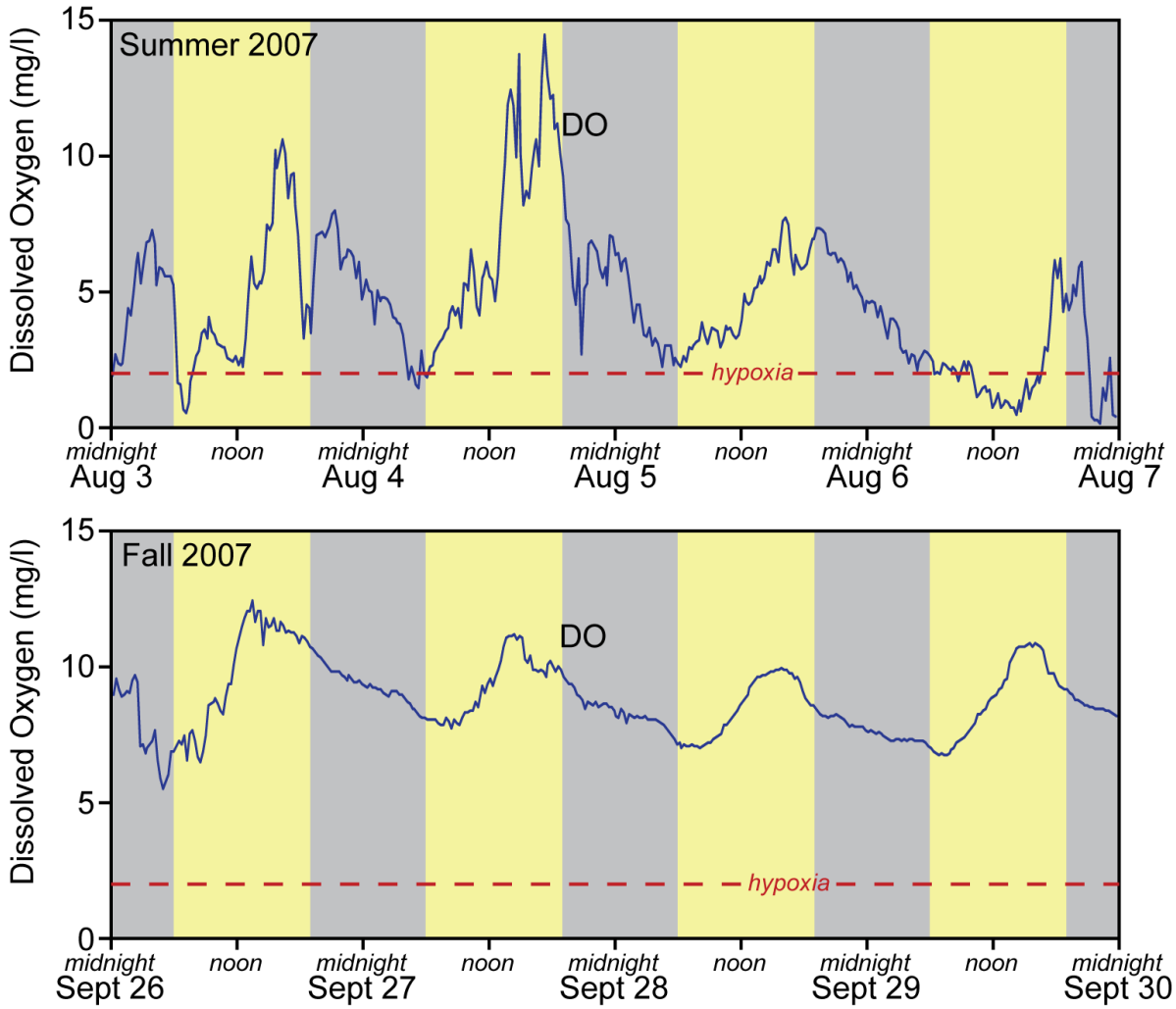






Lower Station

Dissolved O_2 Conditions Vary Seasonally and Daily



Contributors to Corsica Nutrient Loads