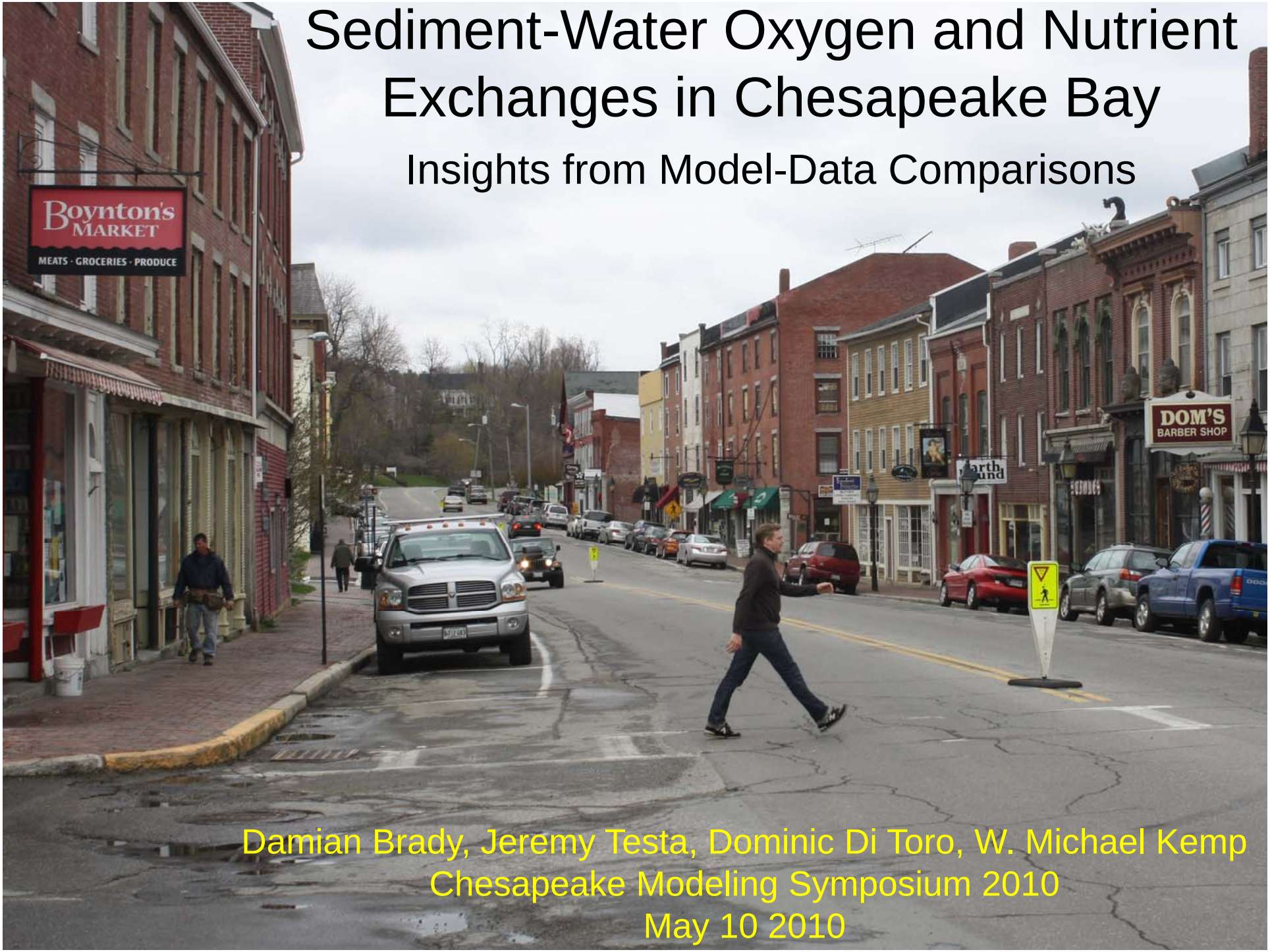
Sediment-Water Oxygen and Nutrient Exchanges in Chesapeake Bay

Insights from Model-Data Comparisons

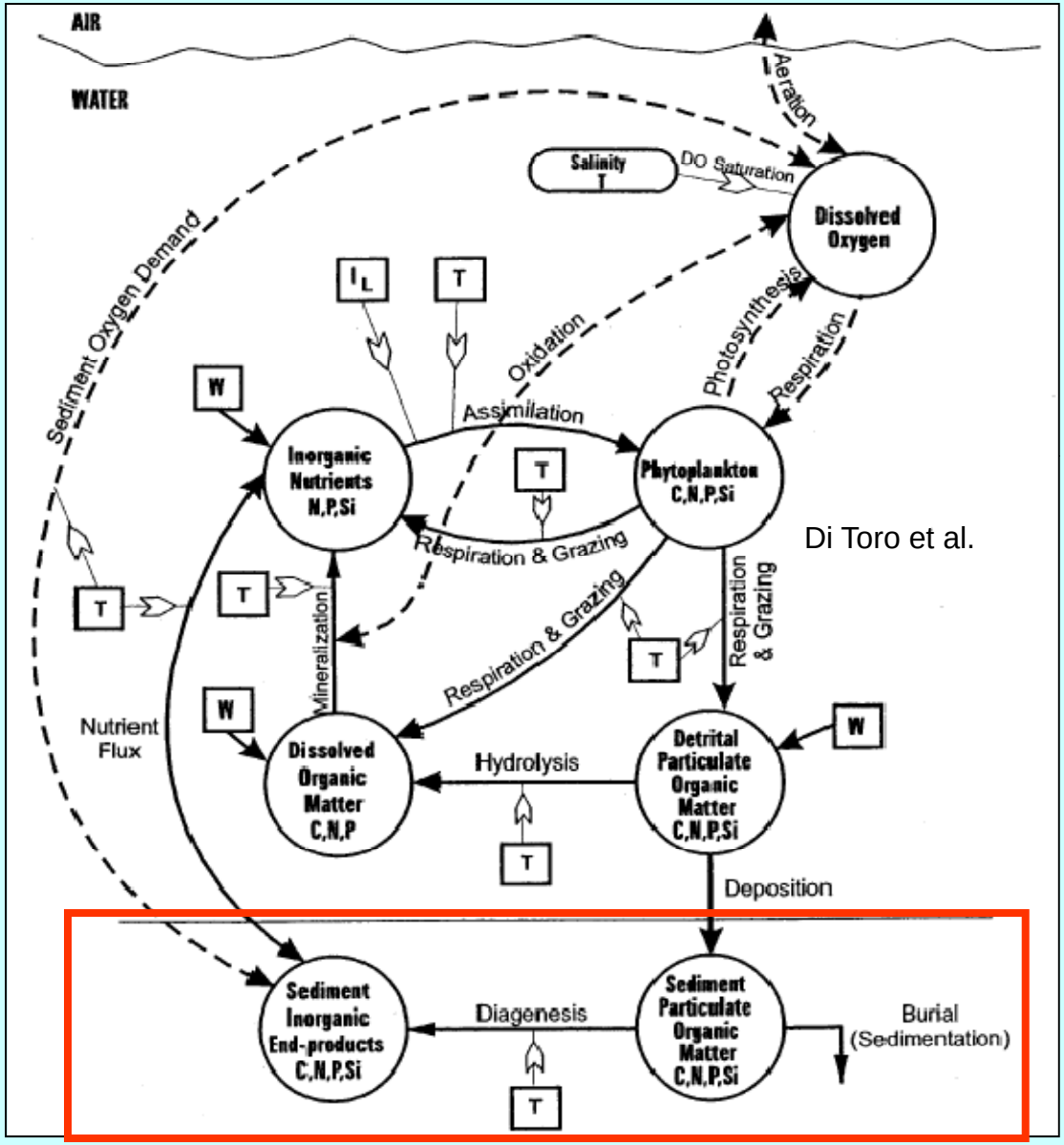


Damian Brady, Jeremy Testa, Dominic Di Toro, W. Michael Kemp

Chesapeake Modeling Symposium 2010

May 10 2010

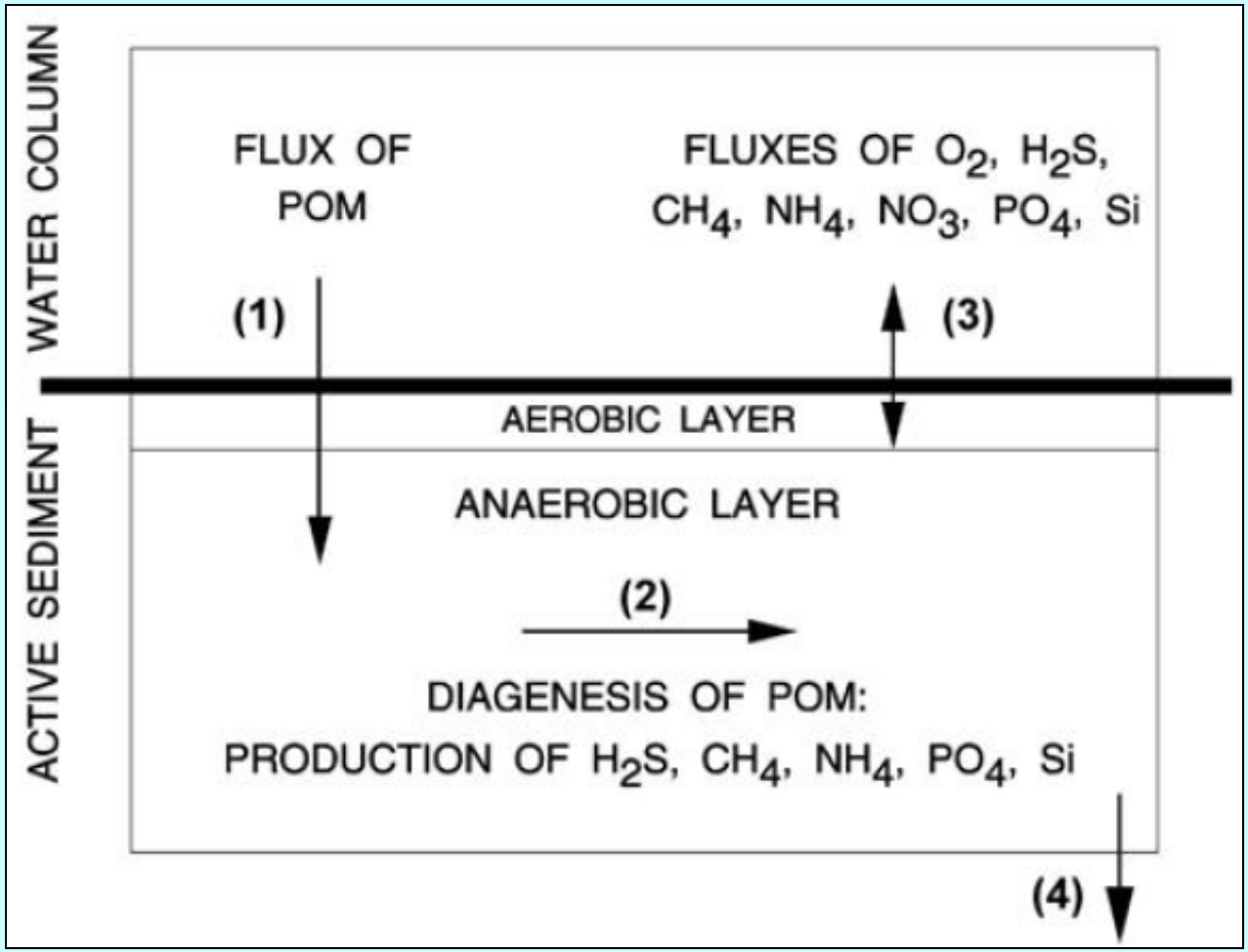
Sediments in Biogeochemical Models



Di Toro et al.

Sediment Model

Sediment Flux Model For Chesapeake Bay



- Sediment Flux Model (SFM, Di Toro 2001) is incorporated into Chesapeake Bay Water Quality Modeling Package
- Advantages:
  - Mechanistic
  - Mass balance equations fully integrated into Hydrodynamic and Water Quality Models
  - Investigate feedback and sediment contribution to overall water quality

Project Goals:

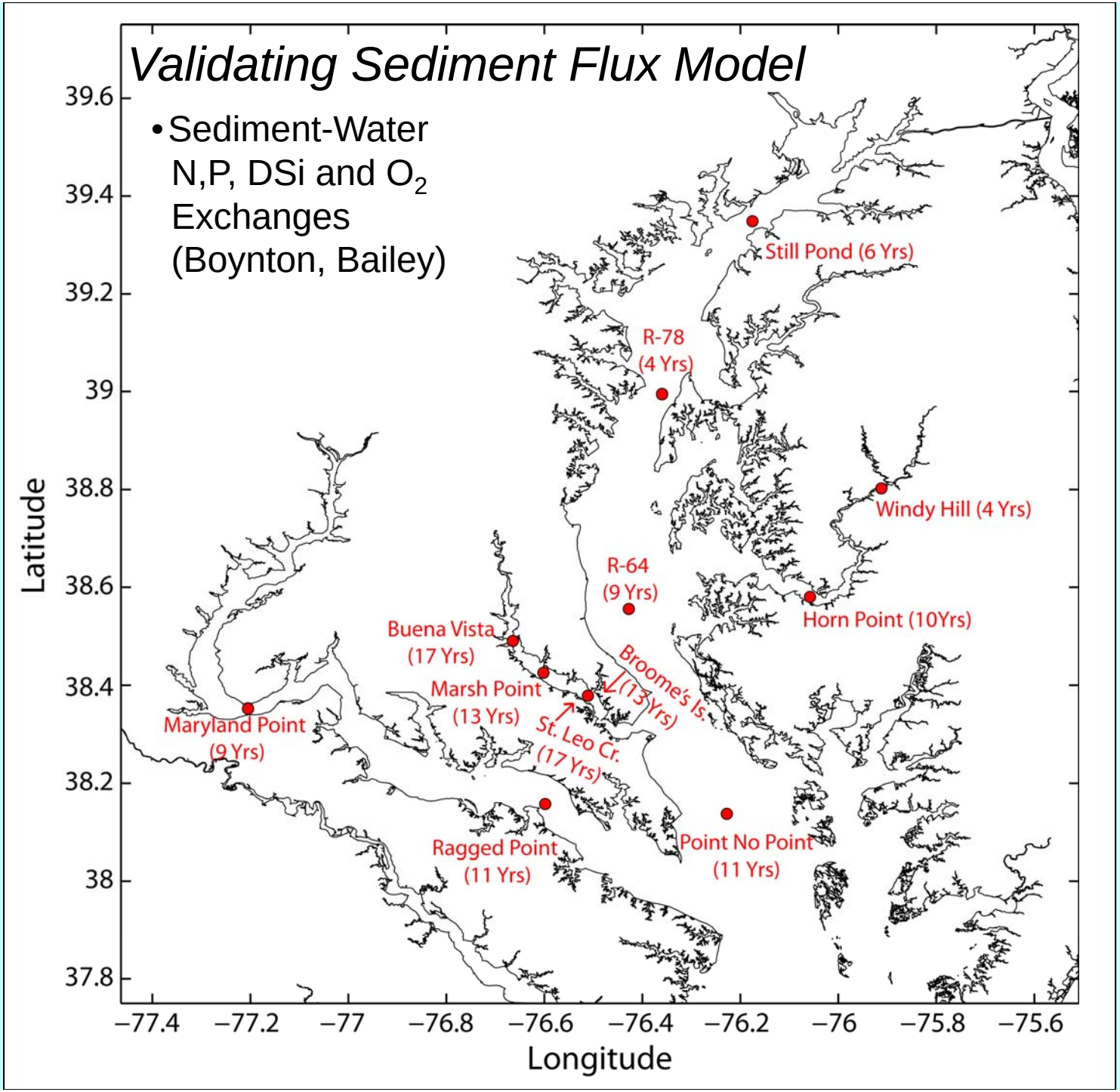
(1) Develop Stand-Alone version of sediment model for Chesapeake Bay and other sites

(2) Calibrate and Validate model over multidecadal time period for water quality models

(3) Use model to test eutrophication effects on sediment-water processes/interactions

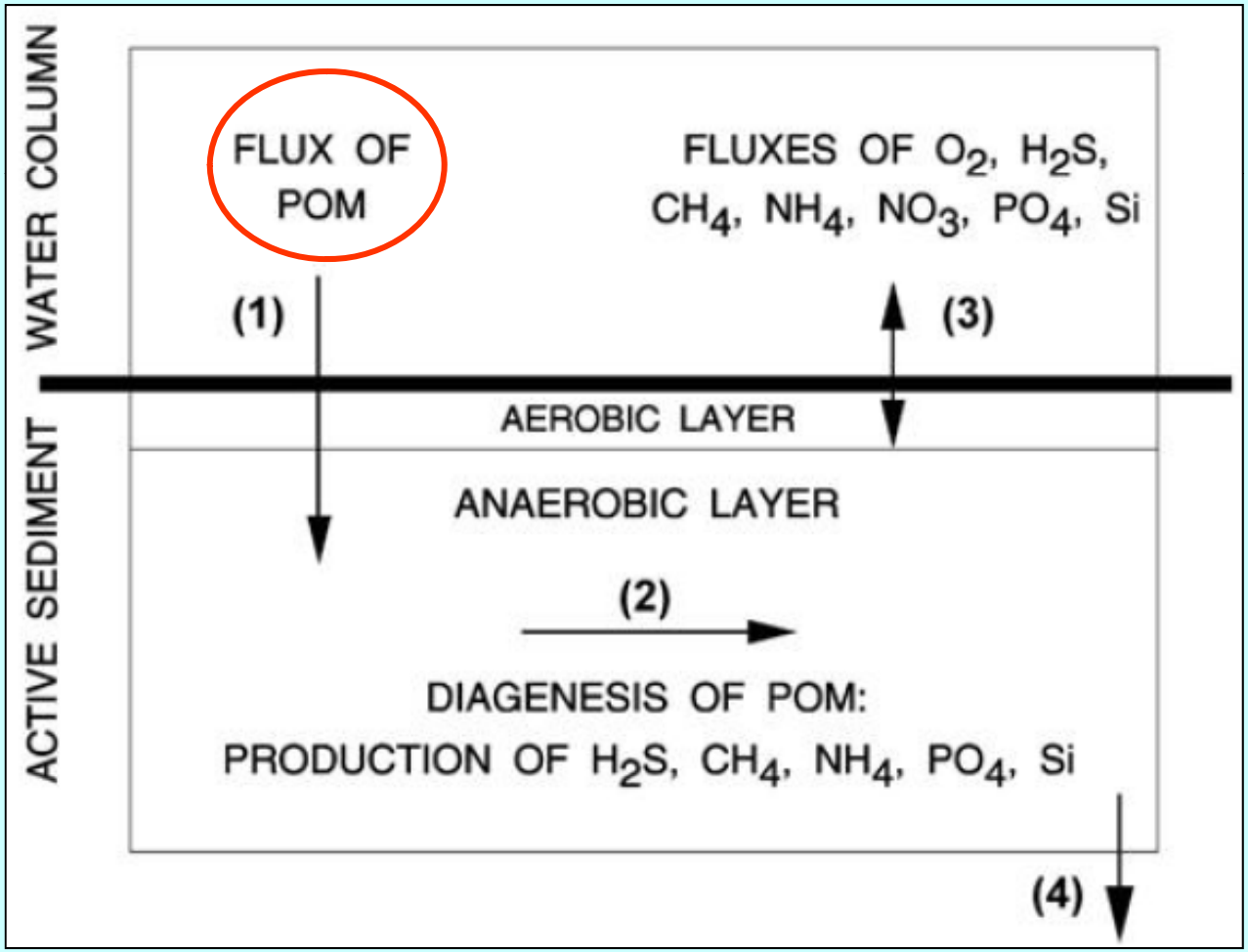
Validating Sediment Flux Model

- Sediment-Water N,P, DSi and O_2 Exchanges (Boynton, Bailey)



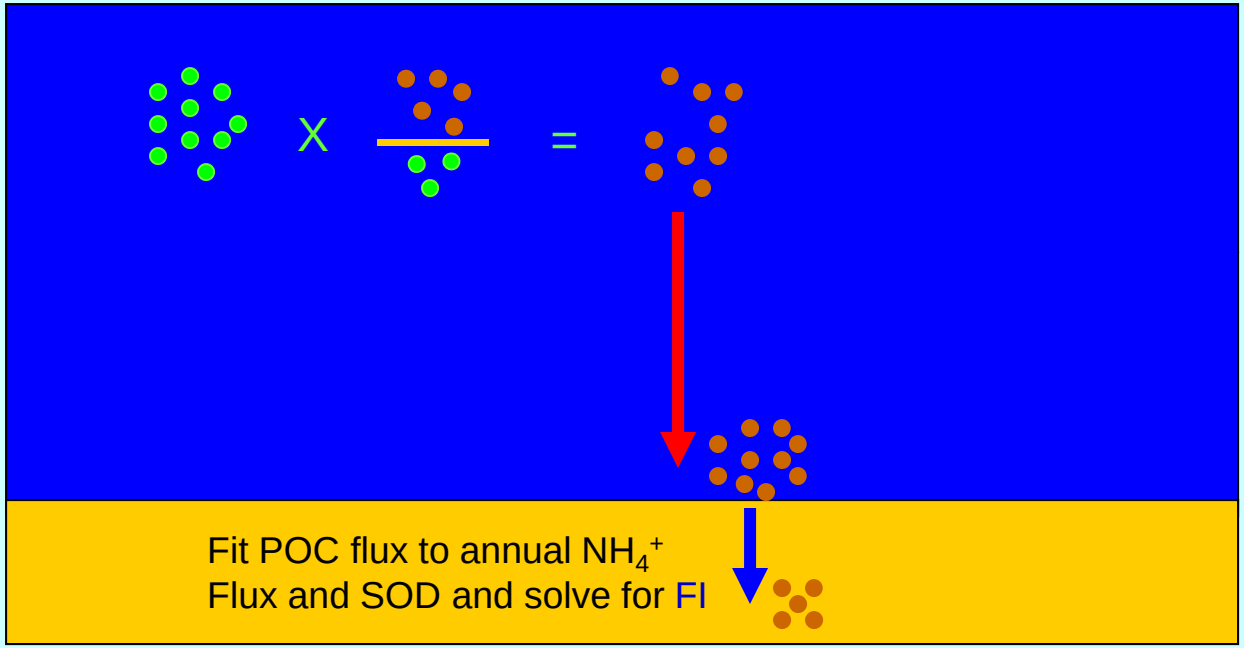
Estimating POM Deposition

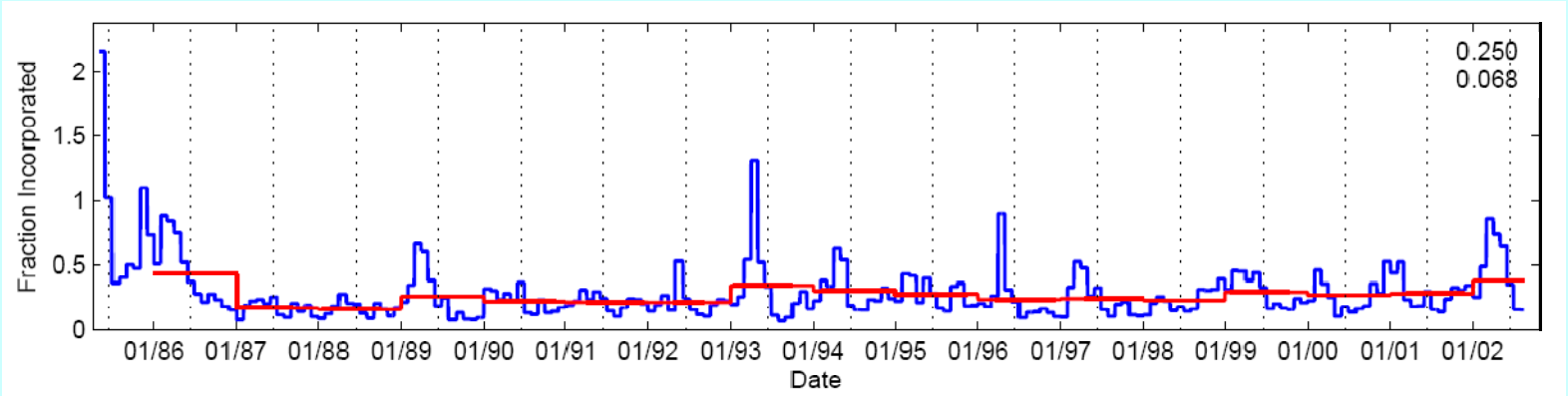
(1) Sediment Trap Data: 1985-1992 (1-2 Stations)
(2) Water Quality Model (All Stations)
(3) Compute everywhere in Bay from widely available constituents (All)

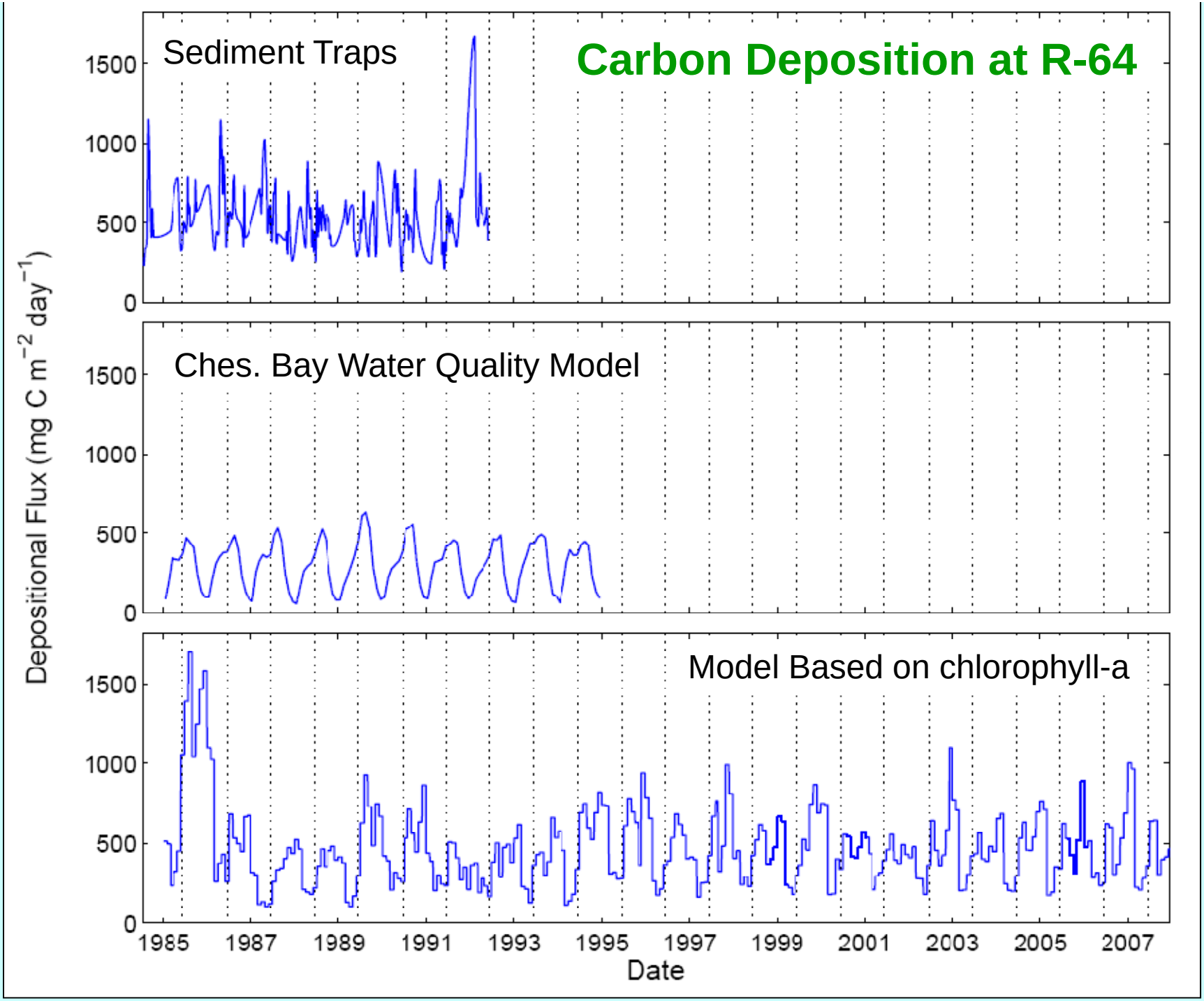


Estimating POC Deposition to Sediments

POC Flux = $CHLA_{surface}$ * C:CHLA * Vsettling * FI



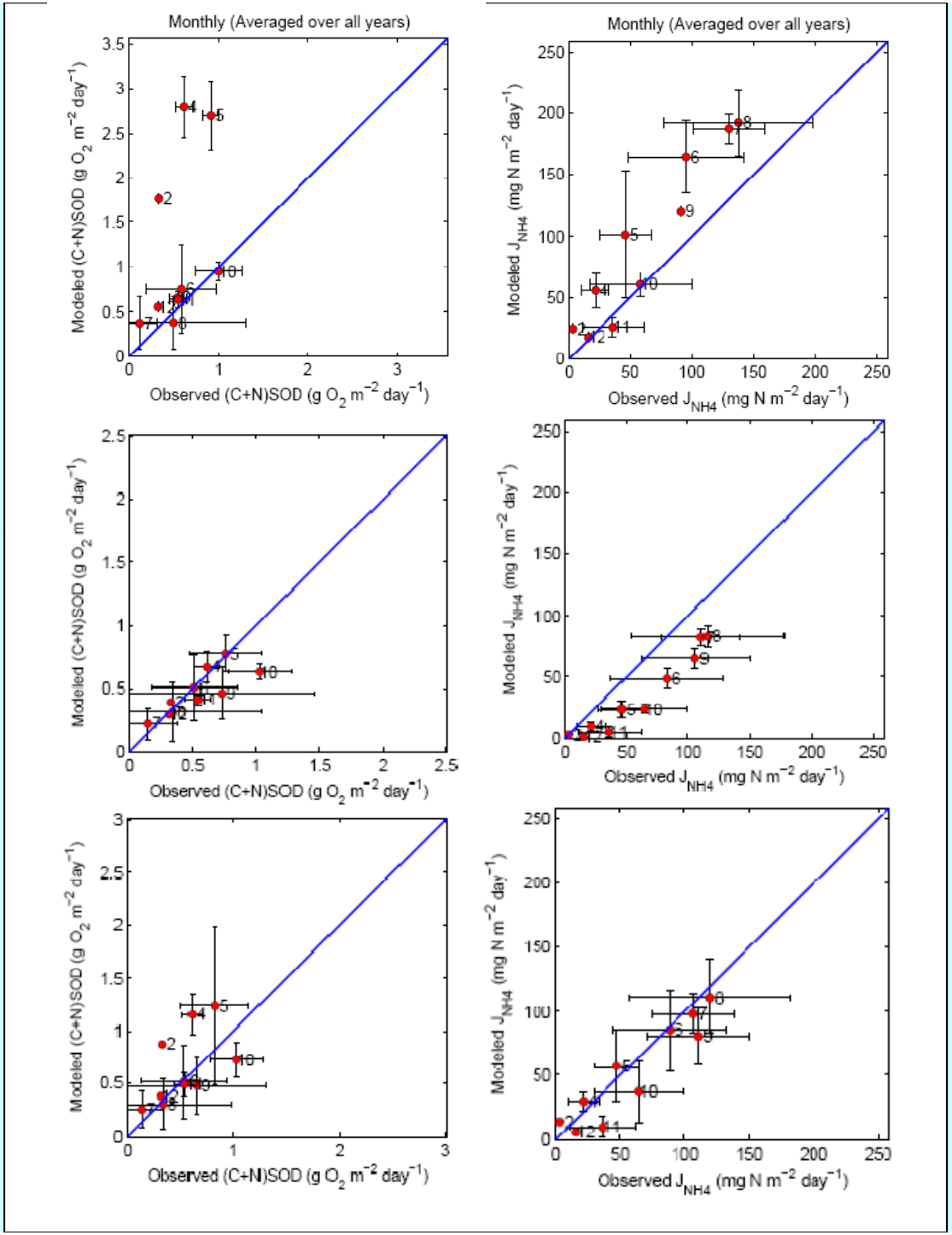



Carbon Deposition at R-64
Sediment Traps
Ches. Bay Water Quality Model
Model Based on chlorophyll-a
Depositional Flux (mg C m^{-2} day^{-1})
0
500
1000
1500
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Date

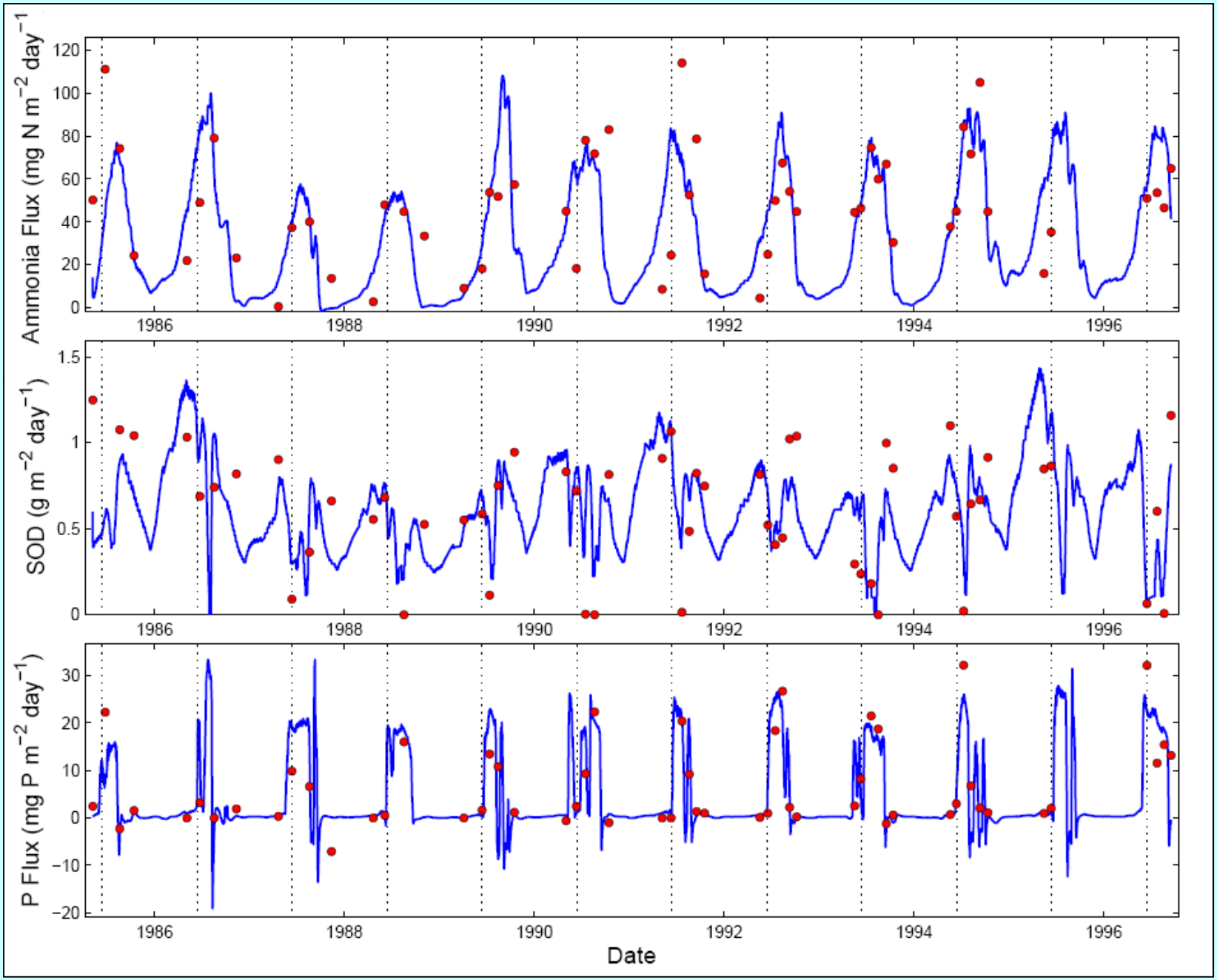
Sediment Traps
(J_{POC} overestimated)

CB Water Quality Model
(No inter-annual variability in J_{POC})

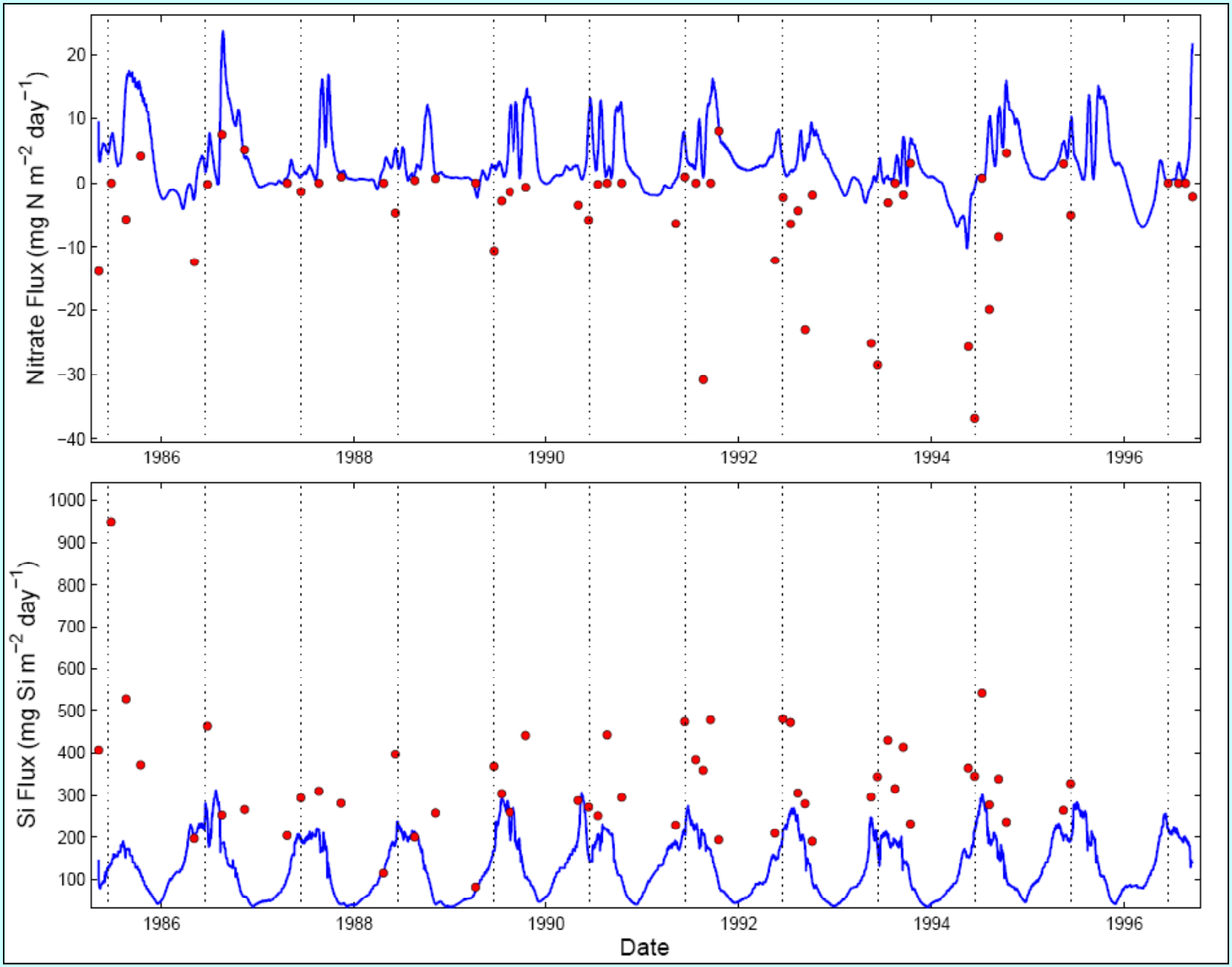
Model Based on Surface CHLA-a
(Inter-annual and seasonal variability captured J_{POC})



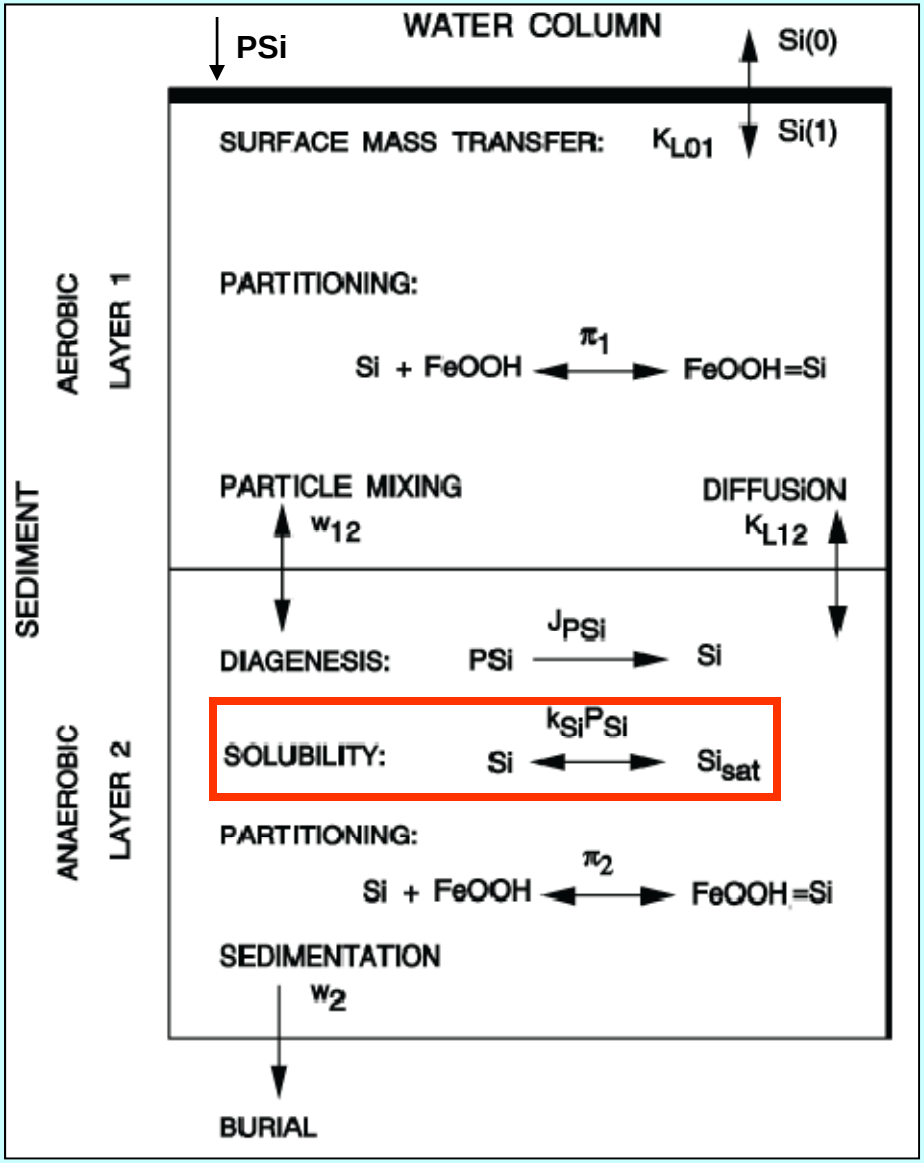
Model Performance Successes



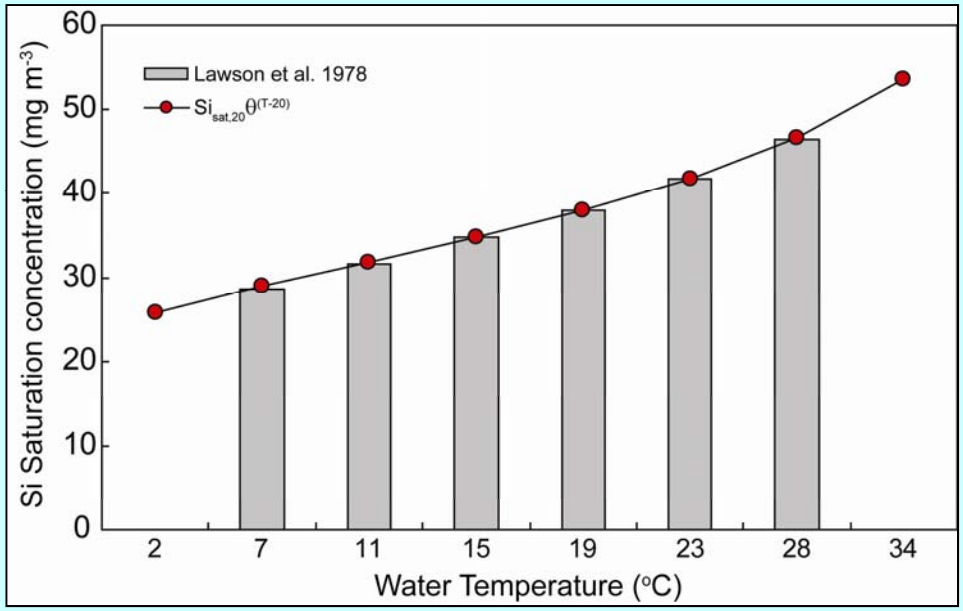
Model Performance Weaknesses



Improvements to Silica Model



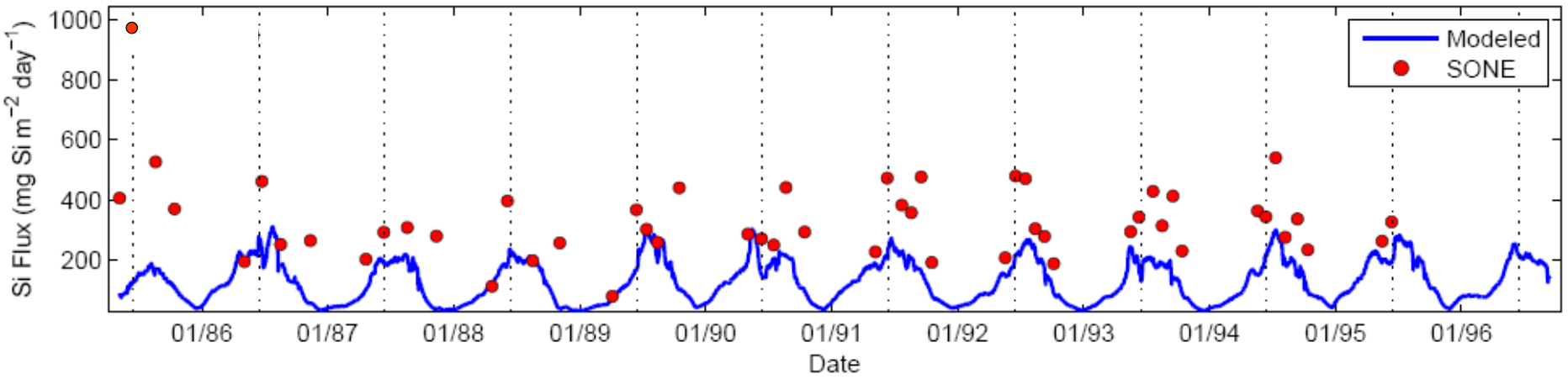
Original Formulation: Si_{sat} is constant

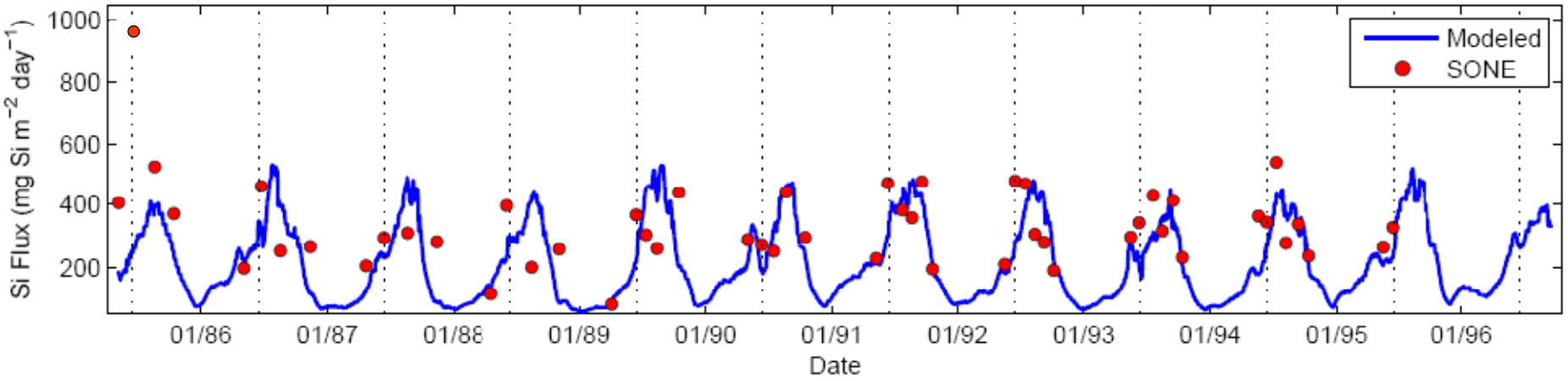


New Formulation:

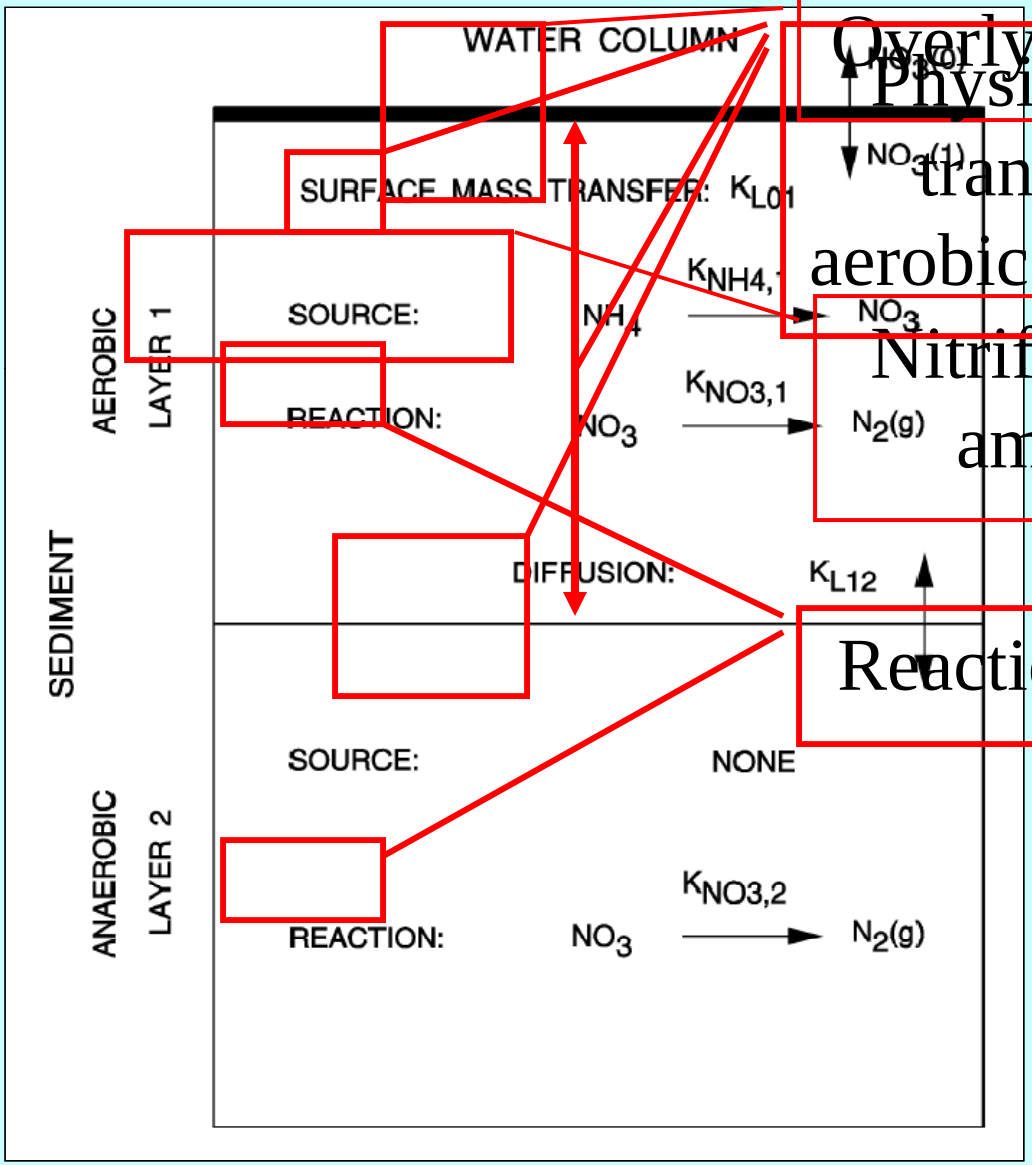
Si_{sat} is Temperature-Dependent

Temperature-Dependent Solubility Improves Silica Model





Nitrate Model

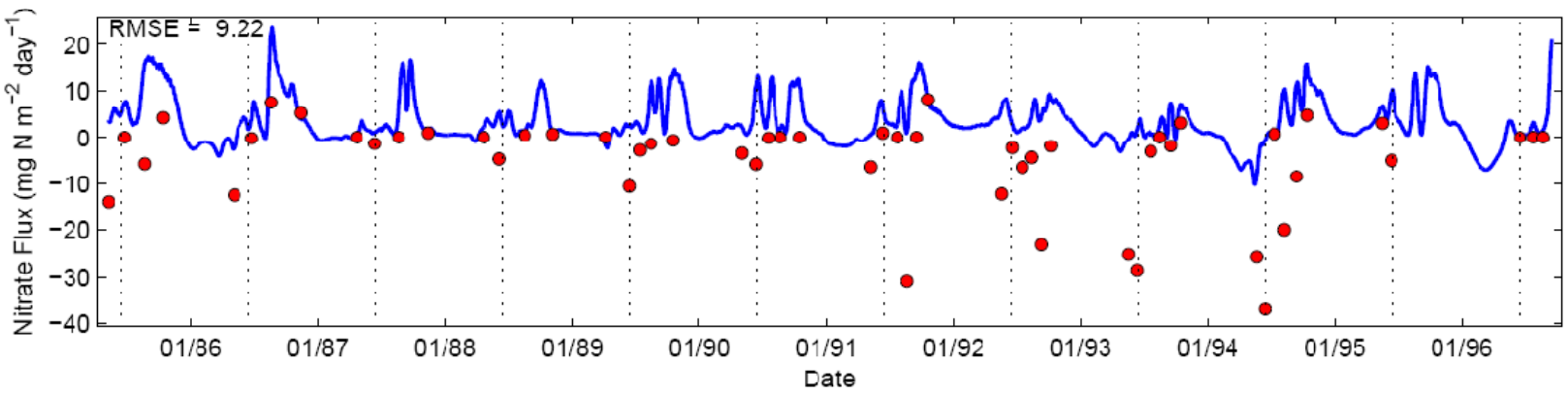


Overlying Water Physical: Mass transfer and aerobic layer depth

Nitrification of ammonia

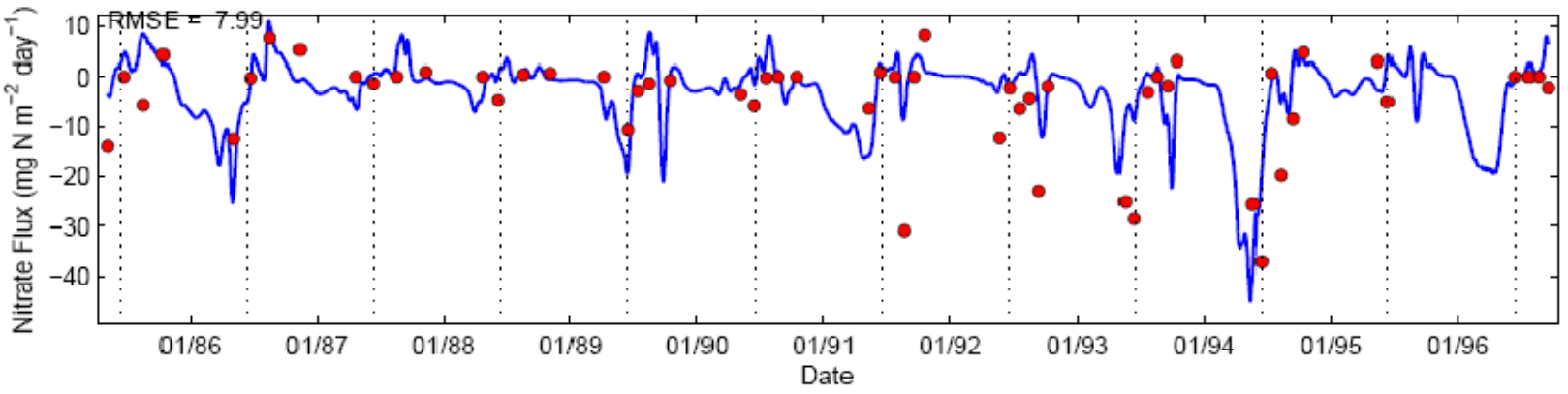
Reaction kinetics

Improved NO_3^- Model: Elevated Aerobic Layer Denitrification



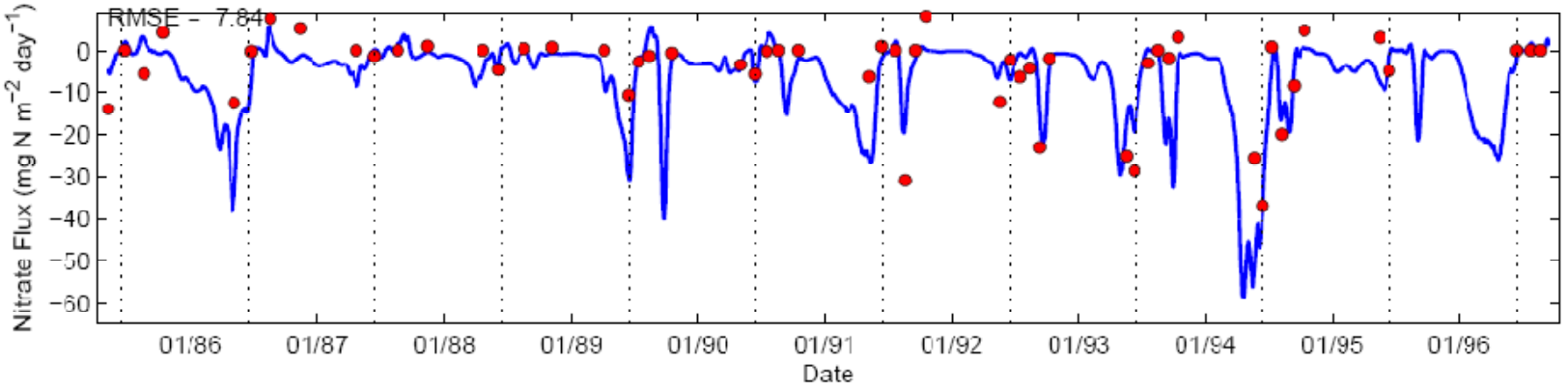
$K_{NO3,1}$ = 0.1

J_{N2} = 20-60 μmol m^{-2} h^{-1}



$K_{NO3,1}$ = 0.25

J_{N2} = 30-100 μmol m^{-2} h^{-1}



$K_{NO3,1}$ = 0.3

J_{N2} = 90-150 μmol m^{-2} h^{-1}

Future Work

- Utilize SFM at other sites
  - Model can be run if surface water chl-a and water column nutrients known
  - Tool to analyze sediment process measurements

- Use SFM to run scenarios to of elevated C deposition, reduced O_2, etc.
  - Relevant for management questions, parameterization

- Improve benthic biota effects in model
  - Role in particle and diffusive mixing, nutrient excretion important

Acknowledgements

- Sediment-Water Exchange Measurements: Walter Boynton, Eva Bailey, etc.
- Data: Maryland Department of Natural Resources, Chesapeake Bay Program
- Funding: National Science Foundation, NOAA CHRP, Horn Point Laboratory

CBEO
Chesapeake Bay Environmental Observatory

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Modeling Hypoxia & Ecological Responses to Climate & Nutrients
CHRP

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