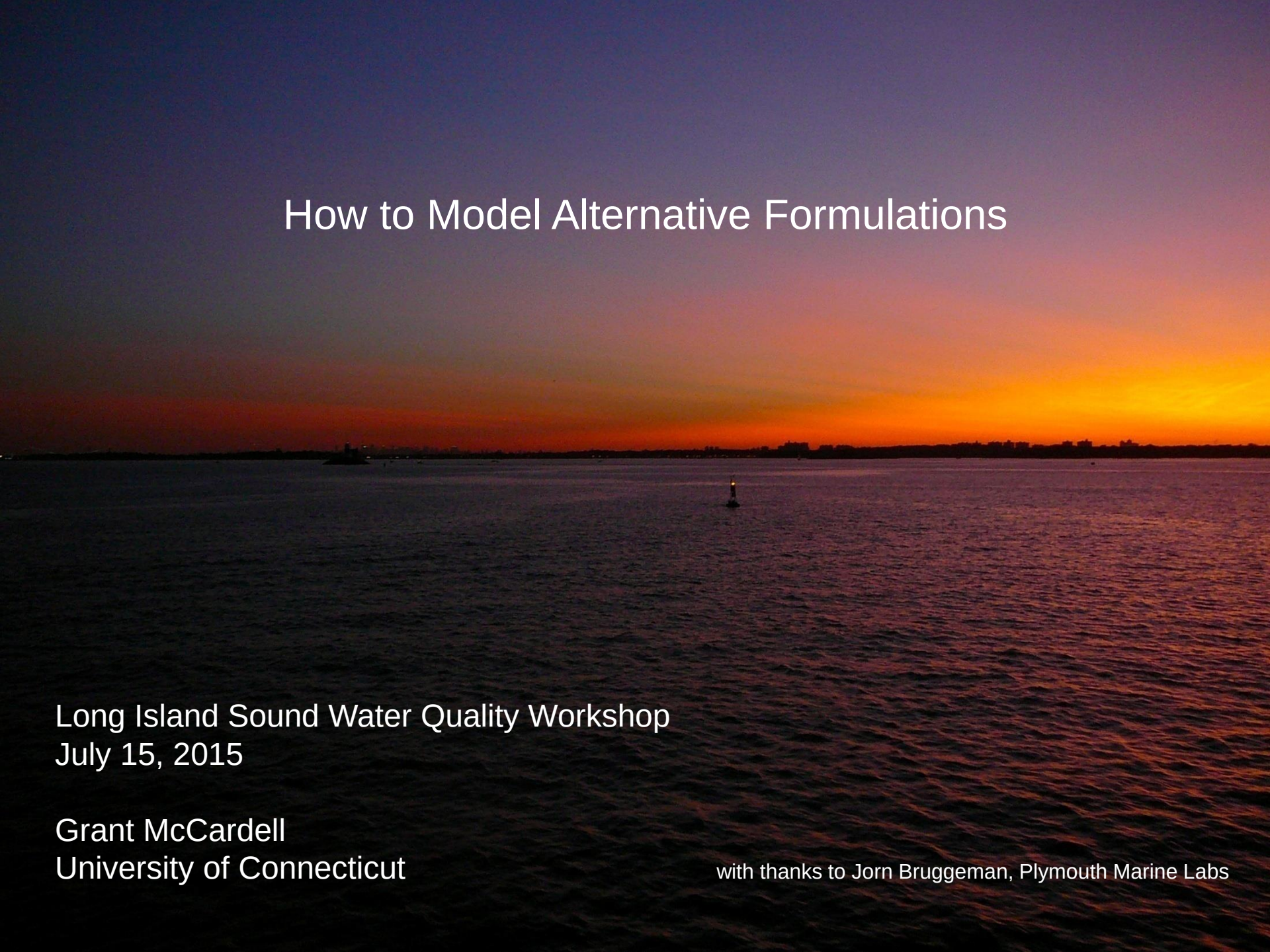
Alternative Formulations and ~~Modifications to SWEM~~

Long Island Sound Water Quality Workshop
July 15, 2015

Grant McCardell
University of Connecticut



How to Model Alternative Formulations

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with thanks to Jorn Bruggeman, Plymouth Marine Labs

Overview

- Model Considerations
- Alternative example: GEM
- Modular Models
- FVCOM
- GOTM
- FABM

Model Complexity vs. Model Resolution

Complexity and resolution are different:

- Complex box model (e.g. EcoGEM)
- Simple high-rez 3-D (e.g. primitive equation LES)

Increased complexity:

- Allows inclusion of “missing” processes
- More difficult to code/ tune / validate (needs more data)
- More likely to get it “right” for the “wrong” reason

Higher resolution:

- Captures finer scale detail (e.g. embayments)
- Better parameterization of smaller-scale processes
- Computationally expensive (nesting = partial solution)

Modeling Objectives

Prediction purposes:

- In theory, more complex = better “fit”
- In practice, model “calibration” is limited by data availability

Heuristic purposes:

- Simplest model that represents the process
- Multiple processes = multiple (simple) models
- “Divide and conquer” – simple models inform complex models
- e.g. water age (Scully) vs. RCA

Parsimony:

- Occam’s Razor
- Improvement vs. DOFs (more complex + worse skill = problem)
- “Start at the ground and work your way up”

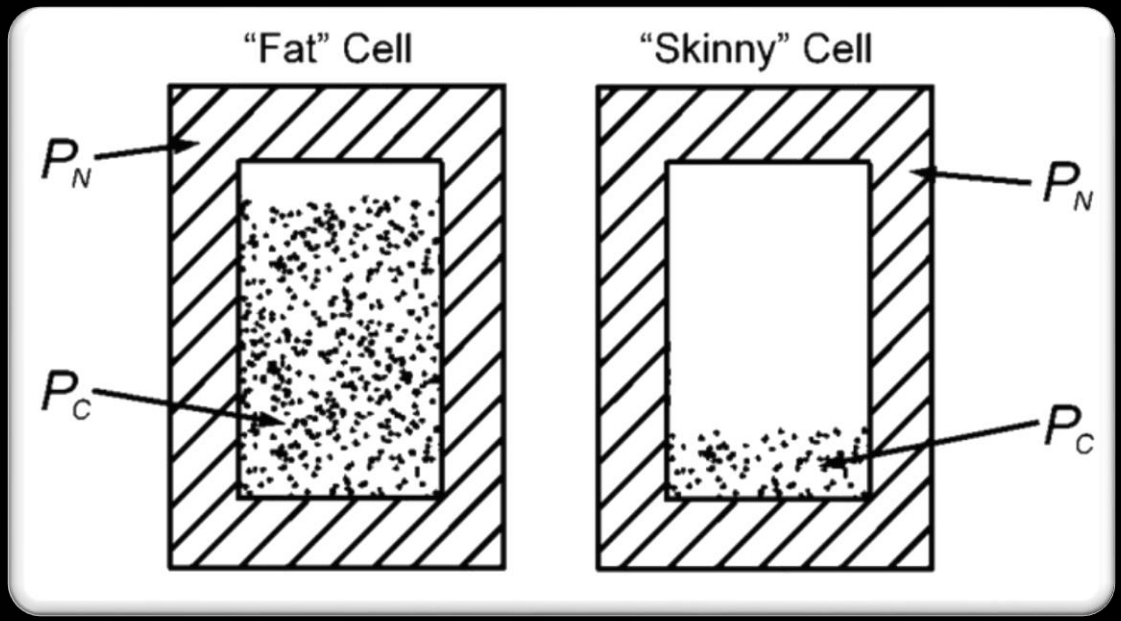
Alternative model example: GEM

Simplified version of Law-Chalup variable stochiometry model

Models algae as containing two types of OC:

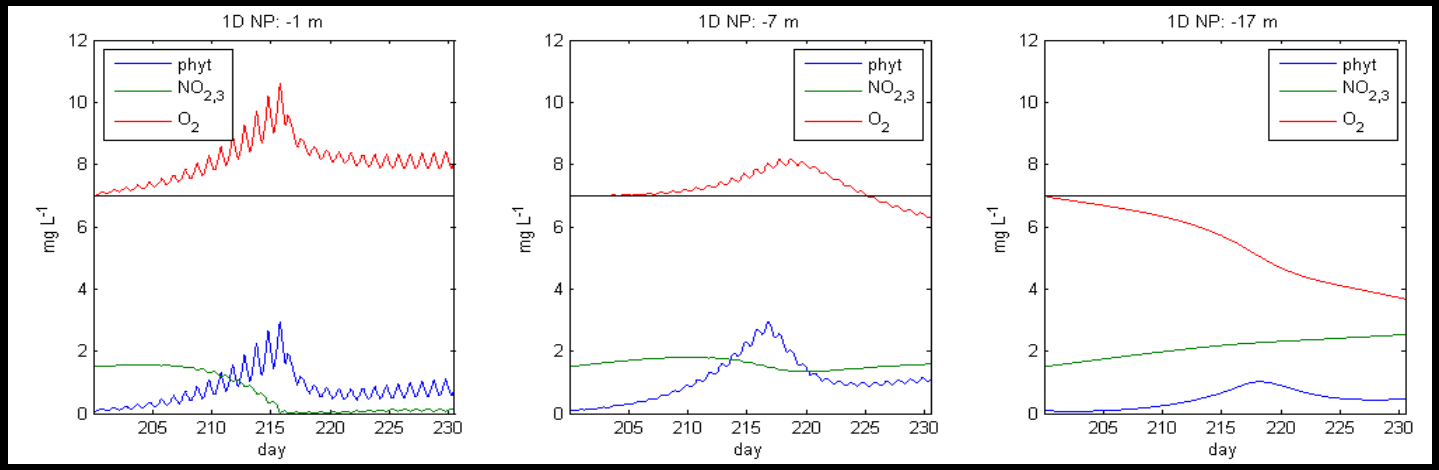
A nitrogenous cellular “framework,” P_N
An internal carbohydrate / lipid pool, P_C

Total biomass is sum of these two

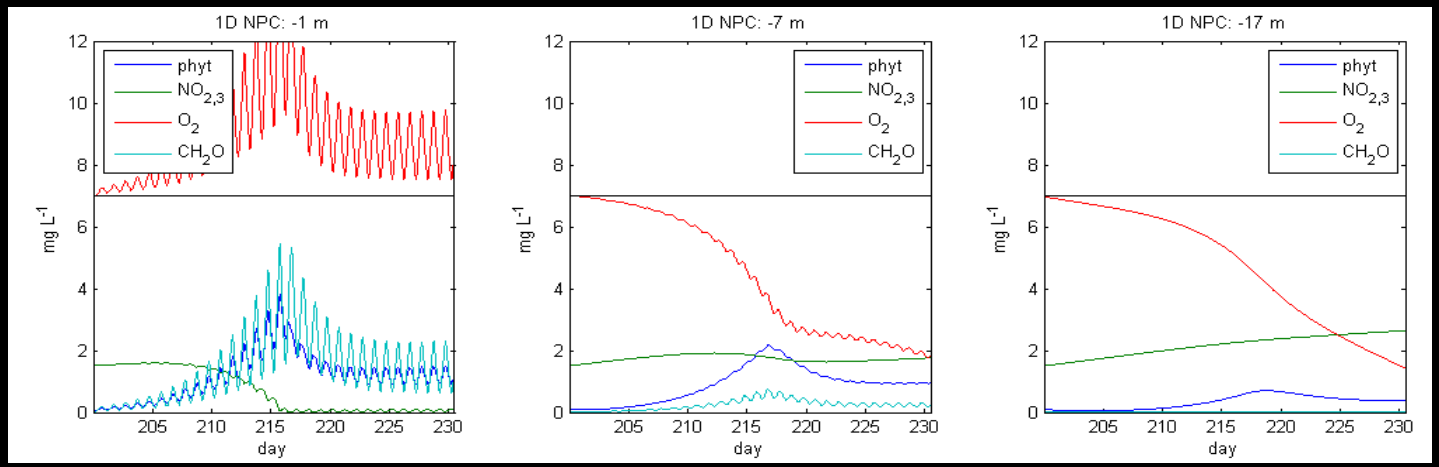


Surface O_2 variance is increased, bottom O_2 is decreased:

NP type model (i.e SWEM)



Grant's Eutrophication Model (GEM)



Surface Mid Bottom

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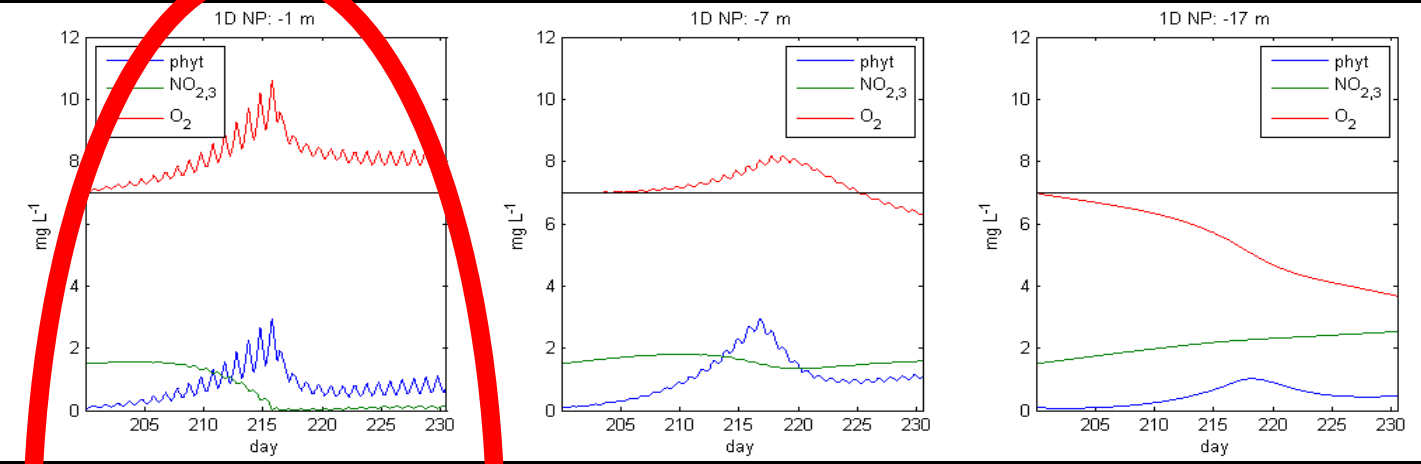

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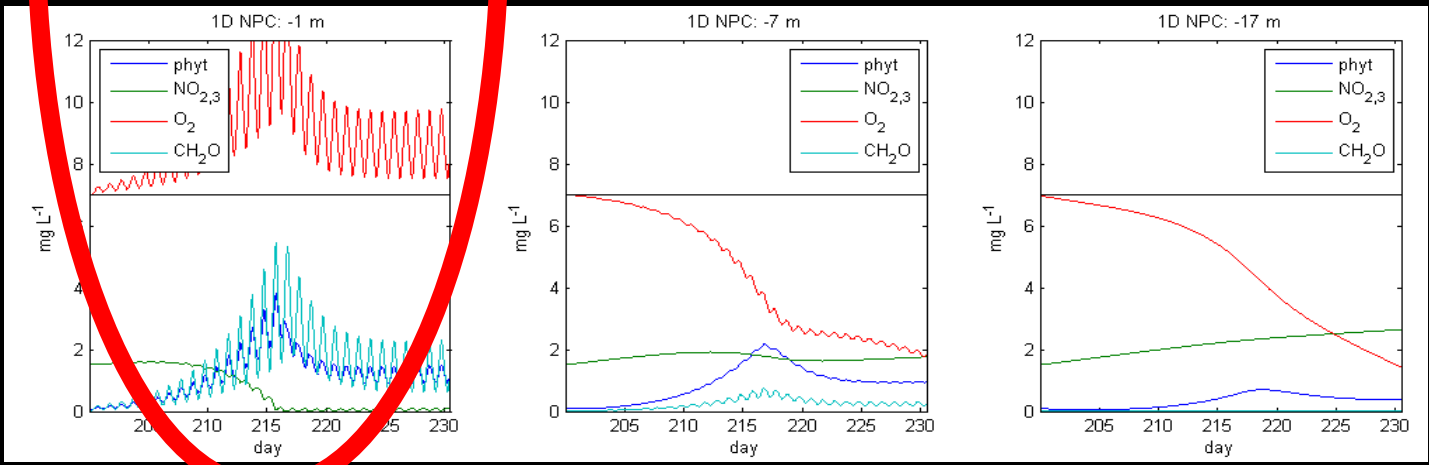

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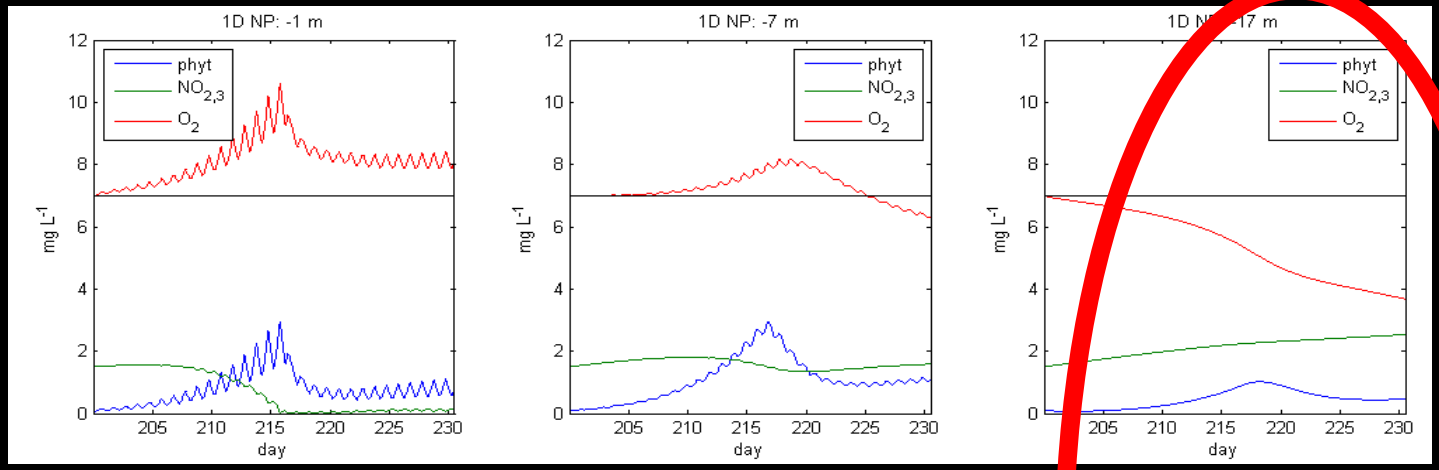

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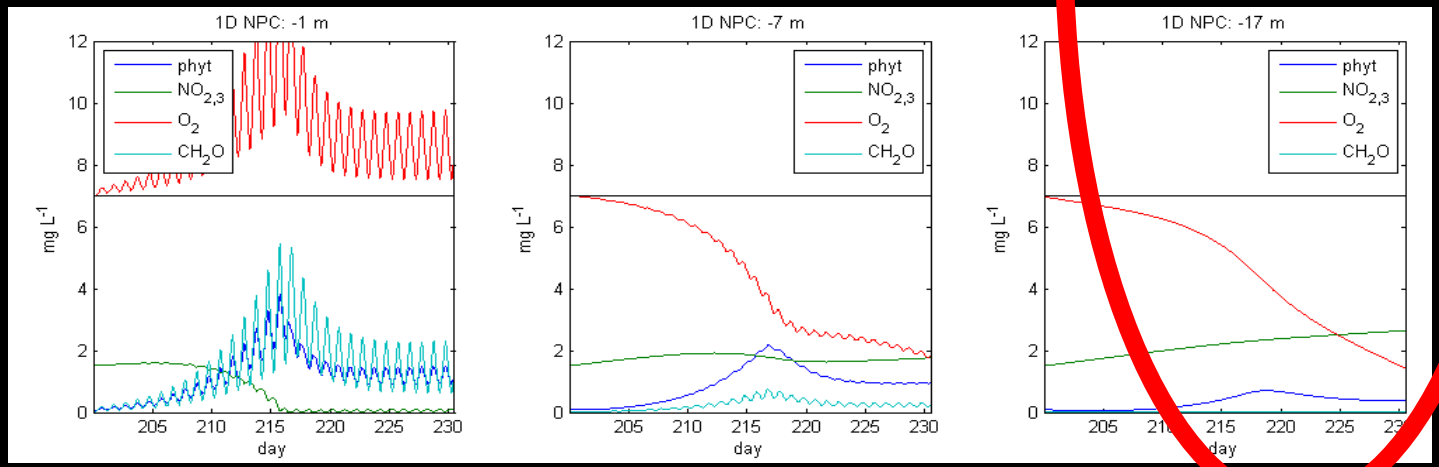


Surface Mid Bottom

Modular modeling

Desirable Requirements:

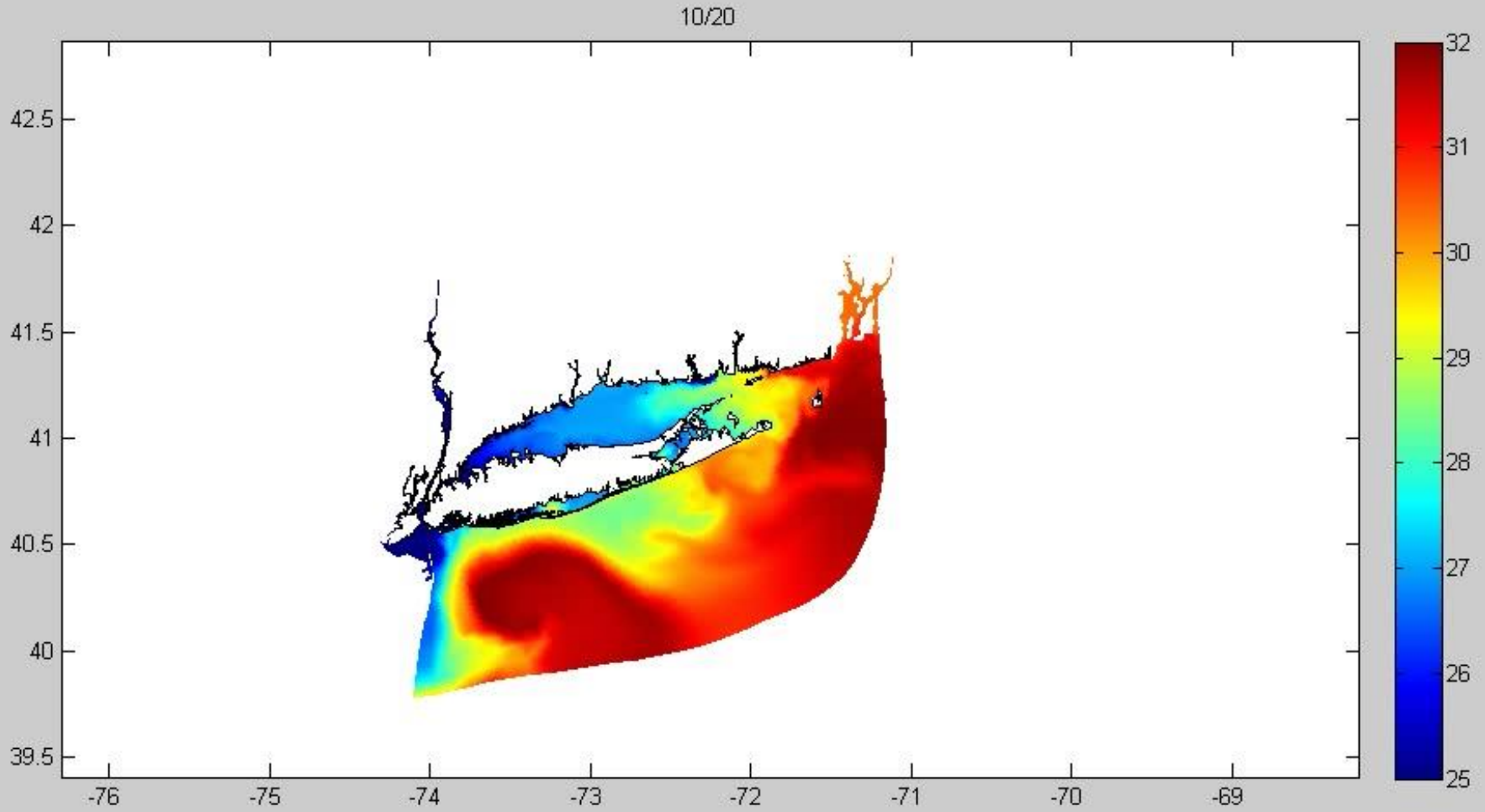
- Flexible (ensemble modeling of multiple formulations)
- Scalable and device independent (easier collaboration)
- Multiple language support (broader user development)
- Open source with version control (community development)
- Support for community I/O standards (e.g. NetCDF)

Examples:

- Finite Volume Community Ocean Model (FVCOM) – UMass
- General Ocean Turbulence Model (GOTM) – IOW
- Framework for Aquatic Biogeochemical Models (FABM) – PML

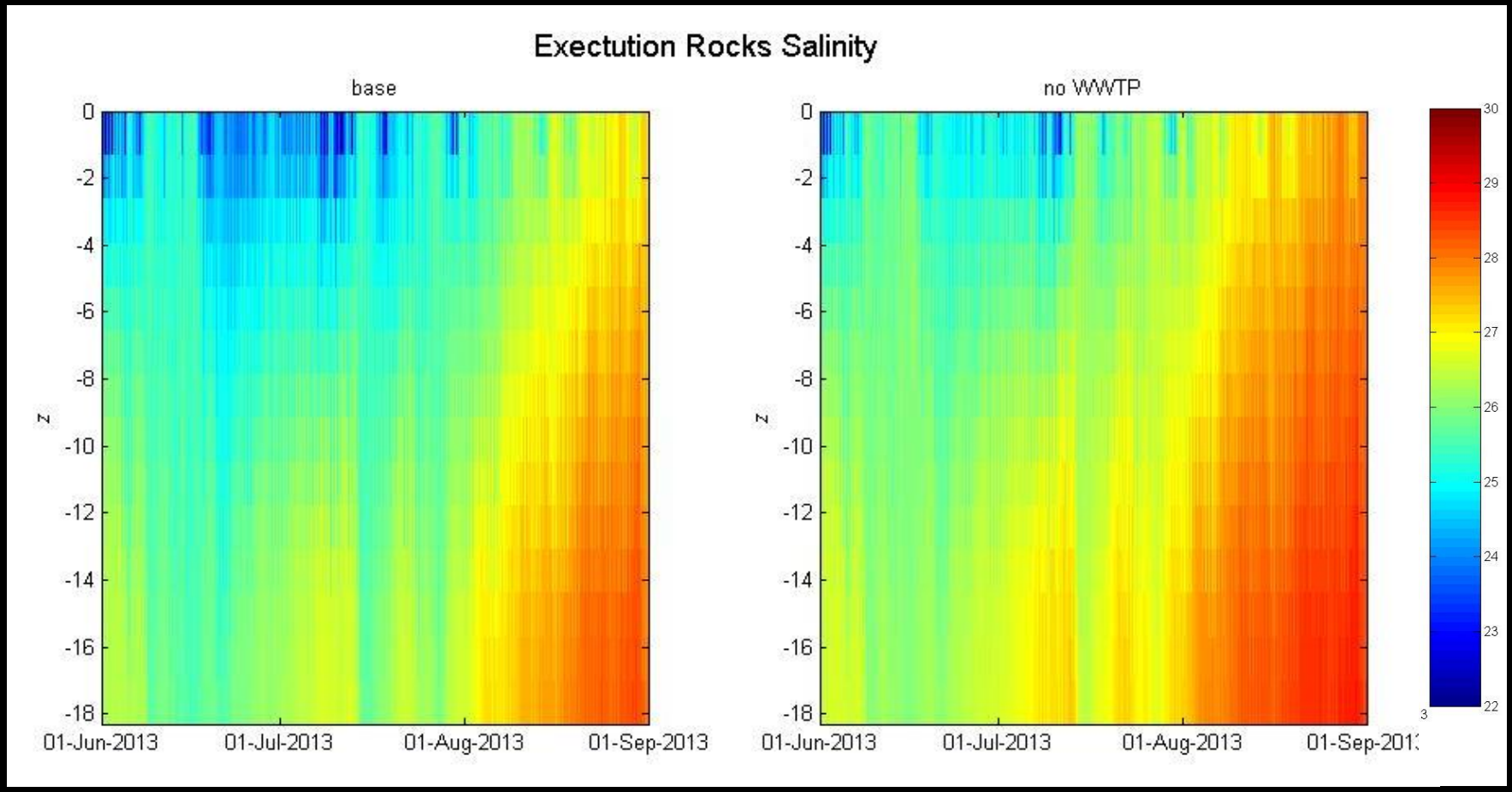
FVCOM (modular hydrodynamic model)

(Umass, WHOI: Chen, Beardsley, Cowles)



FVCOM (modular hydrodynamic model)

What would happen to the salinity (and stratification) structure of WLIS if there were no fresh-water fluxes from NYC WWTPs?



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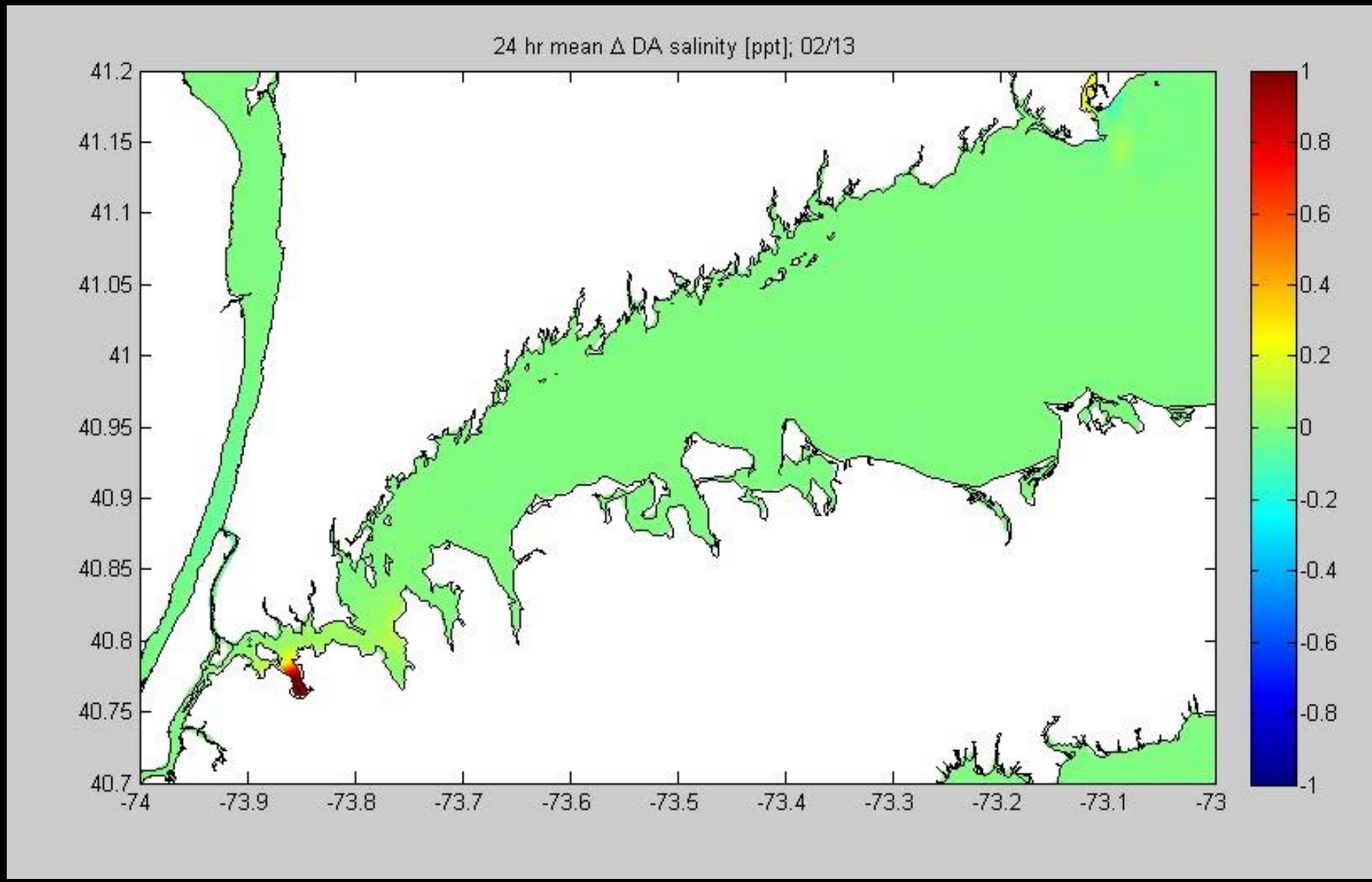
FVCOM (modular hydrodynamic model)



AVI WMV2

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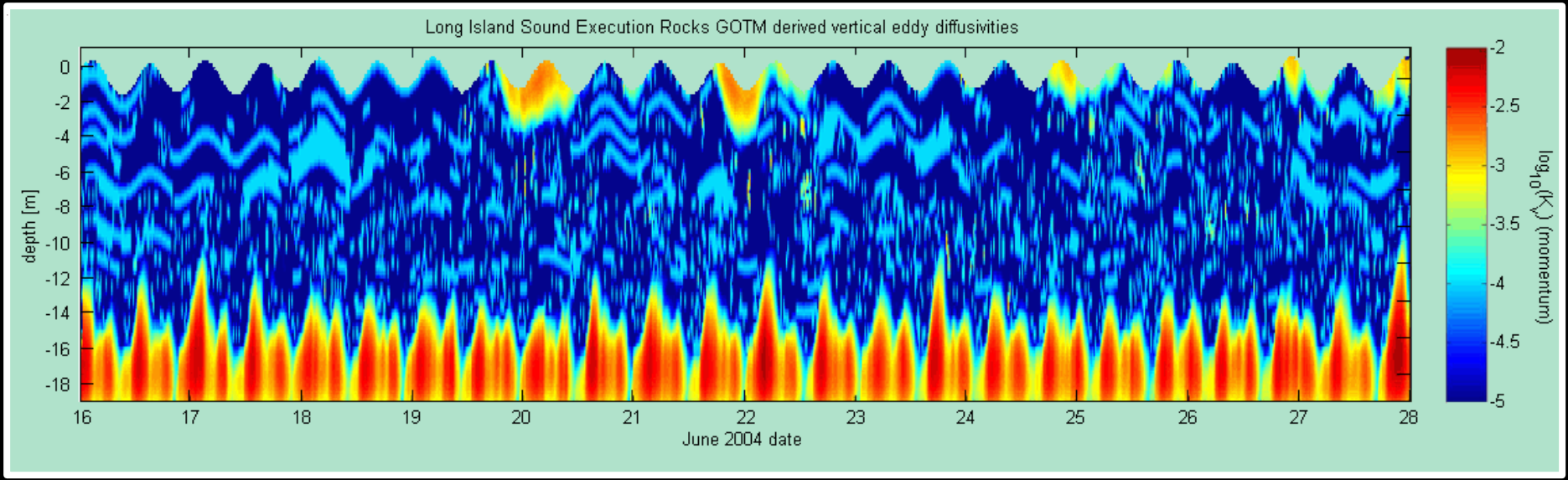
GOTM (modular turbulence model)

(IOW: Burchard, Bolding, Umlauf)

GOTM estimates of vertical eddy diffusivities at Execution Rocks June 16 2004 – June 24 2004 using LISICOS buoy and ADCP data



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FABM (modular biogeochemistry model)

(PML: Bruggeman, Bolding)

choice of driver

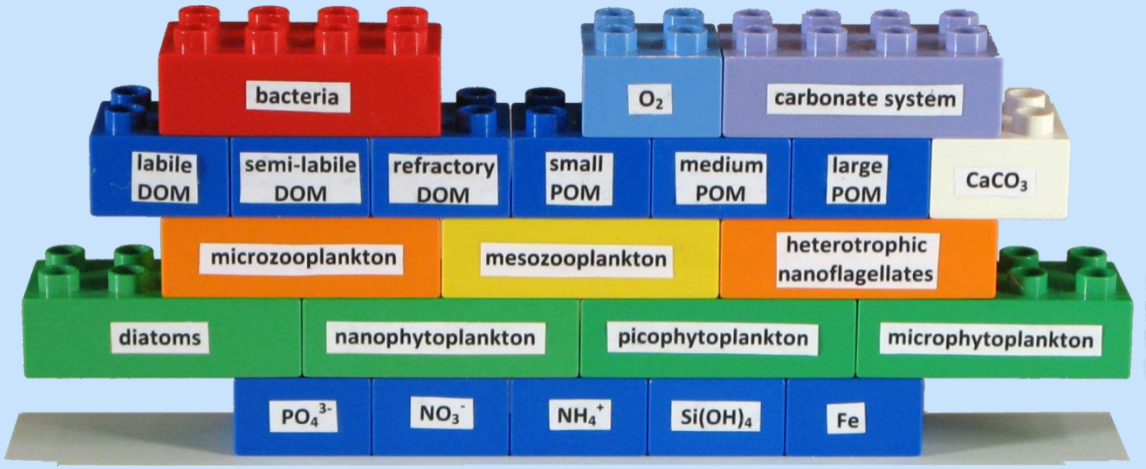
0D: box model

1D: GOTM, GLM, Simstrat

3D: GETM, MOM, FVCOM, NEMO, ROMS, COHERENS

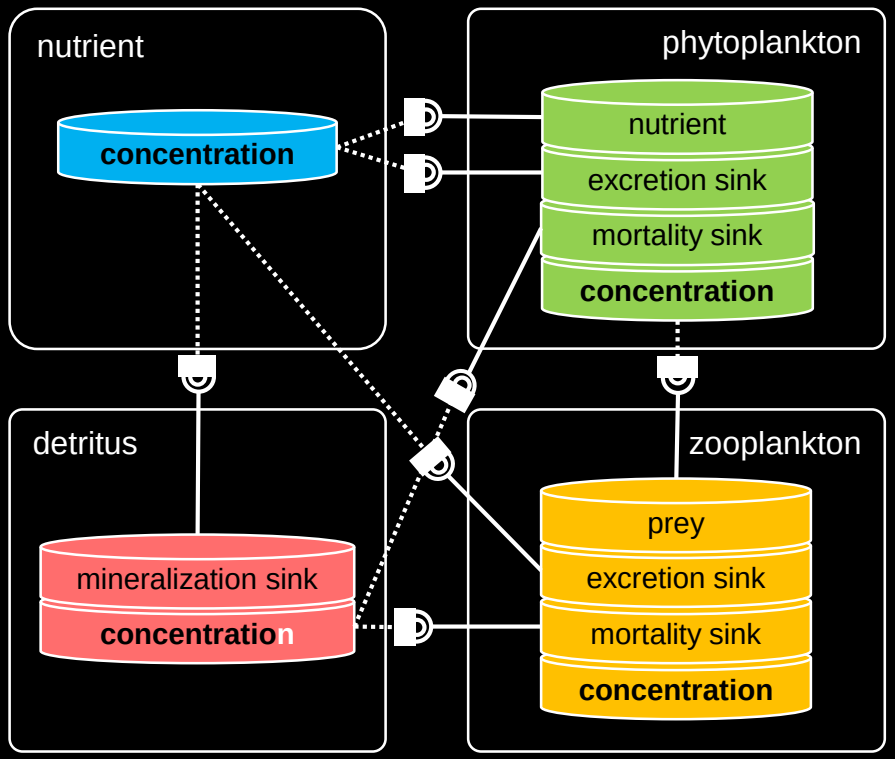
scripting: Python, MATLAB, R, C

Framework for Aquatic Biogeochemical Models (FABM)



biogeochemical modules by individuals and institutes, combined at run-time

FABM Python example



fabm.yaml

```yaml
instances:
  nutrient:
    model: examples/npzd/nut
    initialization:
      c: 1.0
  phytoplankton:
    model: examples/npzd/phy
    initialization:
      c: 0.001
    coupling:
      nutrient_source: nutrient/c
      excretion_sink: nutrient/c
      mortality_sink: detritus/c
  zooplankton:
    model: examples/npzd/zoo
    initialization:
      c: 0.001
    coupling:
      prey_source: phytoplankton/c
      excretion_sink: nutrient/c
      mortality_sink: detritus/c
  detritus:
    model: examples/npzd/det
    initialization:
      c: 0.0
    coupling:
      mineralization_sink: nutrient/c
```

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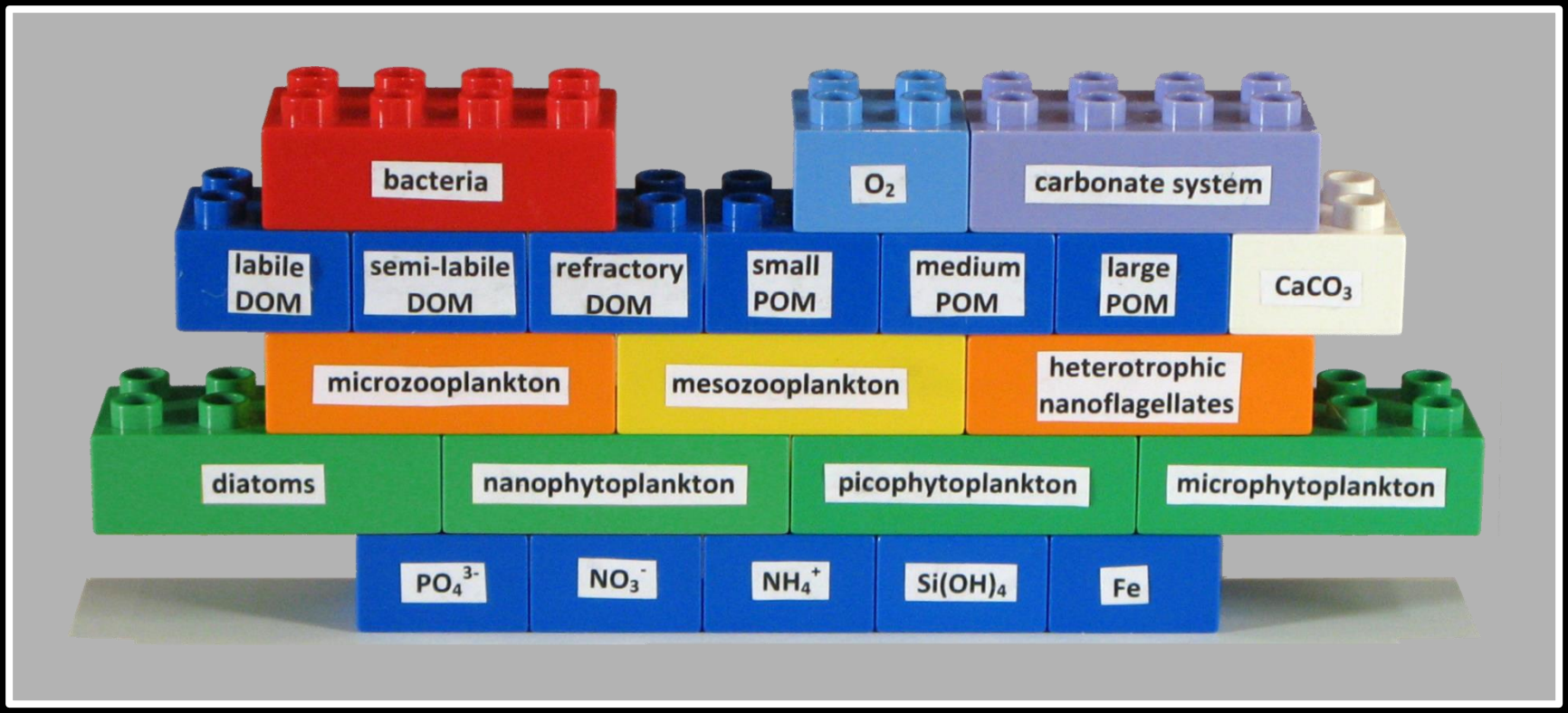
Complex FABM model



passive particle
calcium carbonate
oxygen
carbonate system

primary producer
predator with variable stoichiometry
predator with fixed stoichiometry
bacteria

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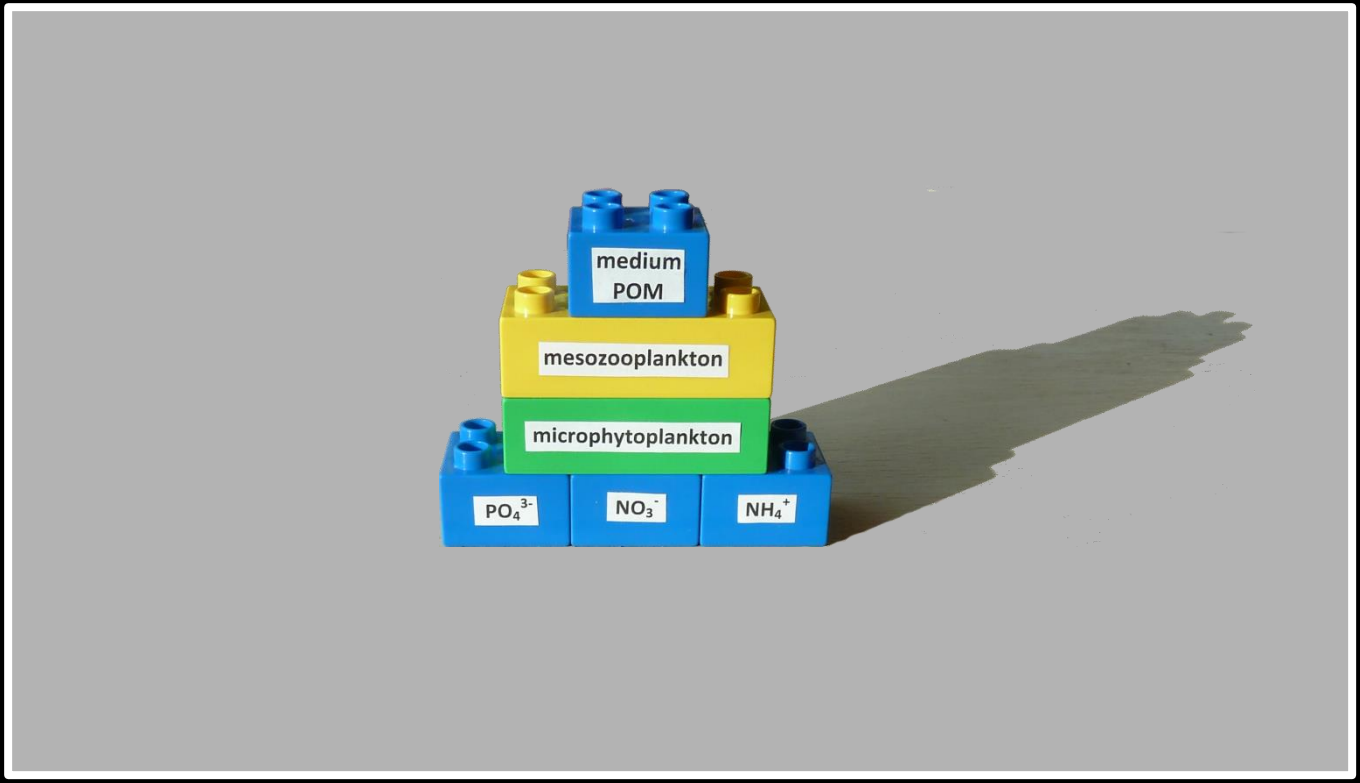
Simple FABM model



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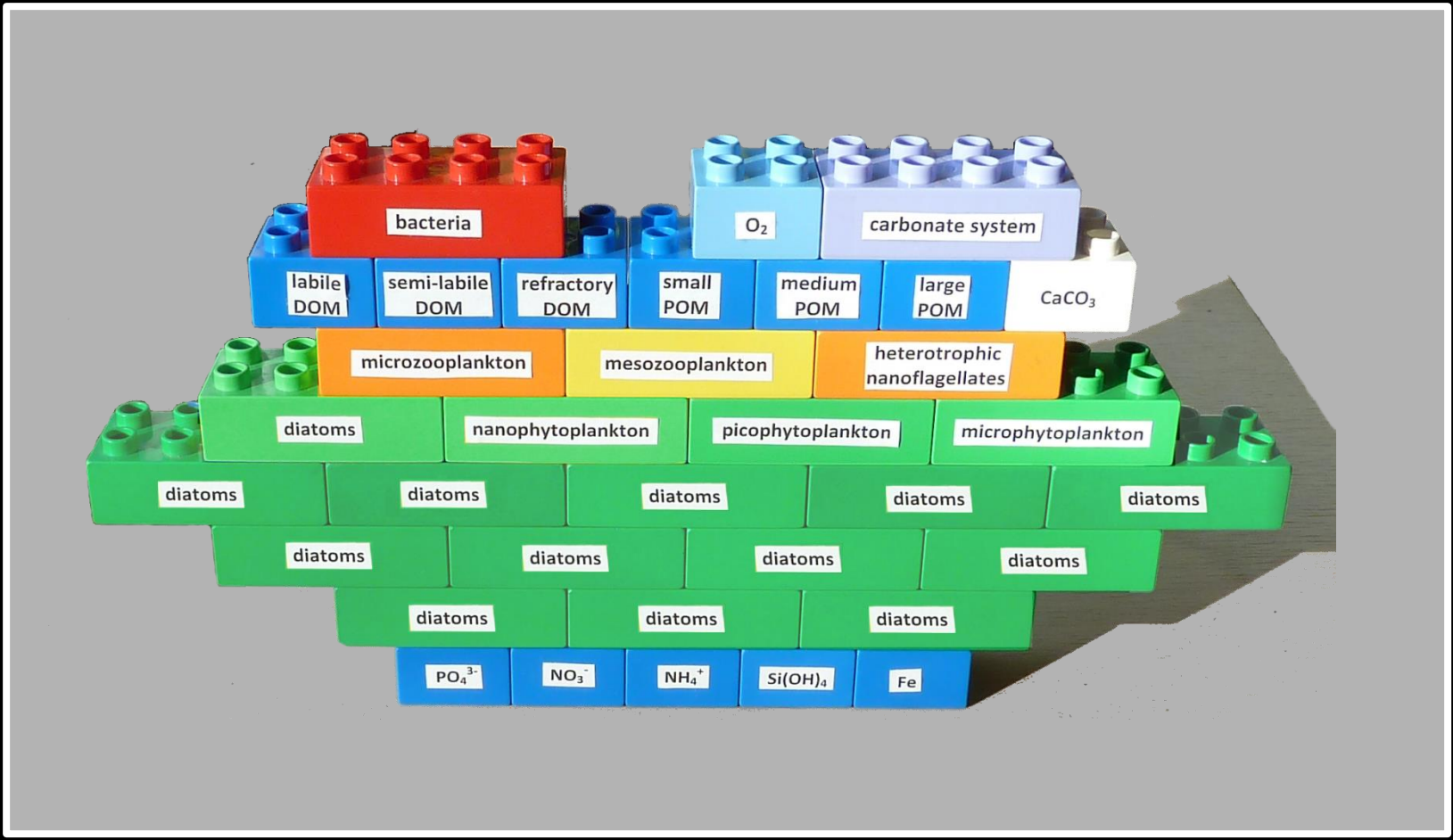
Unique FABM model



DivERSEM: Artioli & Allen, ASLO 2015, Granada, Spain “Modelling the impact of planktonic interspecific competition on ecosystem functions and responses to global change”

Summary

- Complexity and resolution are not the same
- Heuristic models inform predictive models
- Parsimony is vital
- Multiple formulations should be pursued
- Modular design allows flexibility
- FVCOM, GOTM and FABM combine already

Questions?

Alternative Formulations / How to Model Alternative Formulations

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