Modelling tools for assessing lagoon water quality and biological resources

Arturas Razinkovas-Baziukas

Petras Zemlys

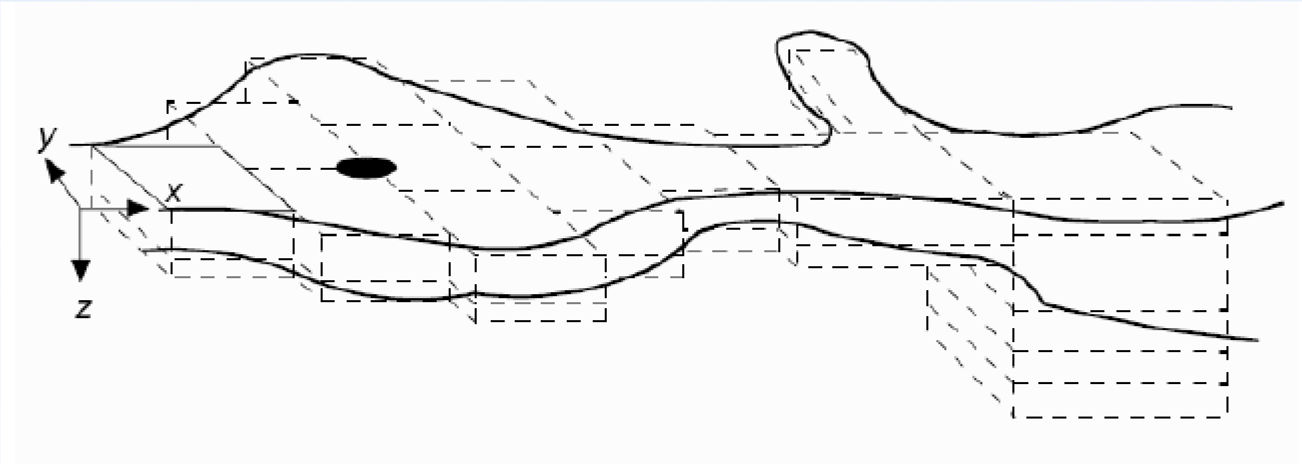
2011-03

Klaipėdos universitetas
Baltijos pajūrio aplinkos tyrimų ir planavimo institutas

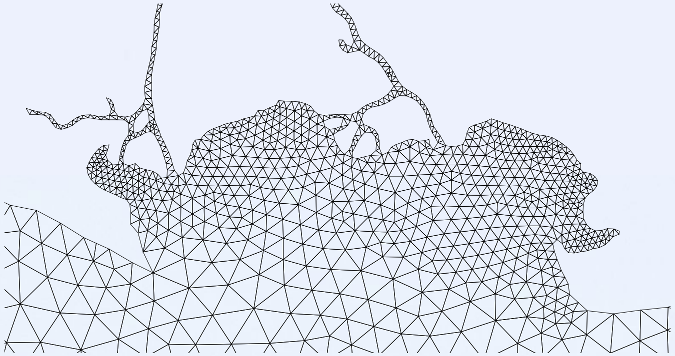
– Spatial heterogeneity and morphological complexity requires not traditional tools for modelling of the Curonian lagoon ecosystem.

Two modelling approaches

- Box model (ESTAS)



- High resolution multi dimensional finite element model (SHYFEM)

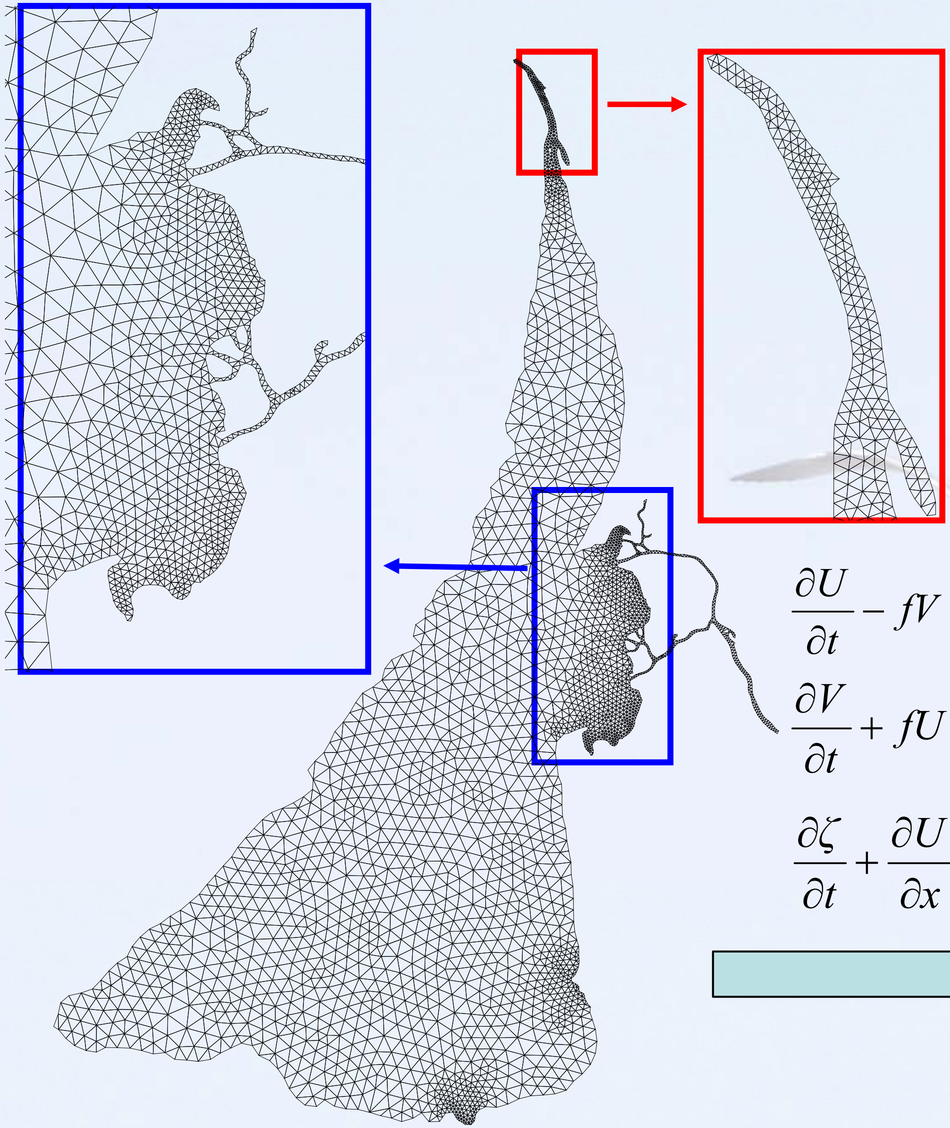


Introduction

- Spatial heterogeneity and morphological complexity requires not traditional tools for modelling of the Curonian Lagoon ecosystem.
- Only application of coupled hydrodynamic-ecological models with varying spatial resolution enables to reproduce important features related to the water exchange between the Curonian lagoon and the Baltic Sea.
-
- Finite element model SHYFEM developed at Venice Marine institute (G.Umgiesser – now also part of our team) is a good basis for development of such ecological models.

SHYFEM features

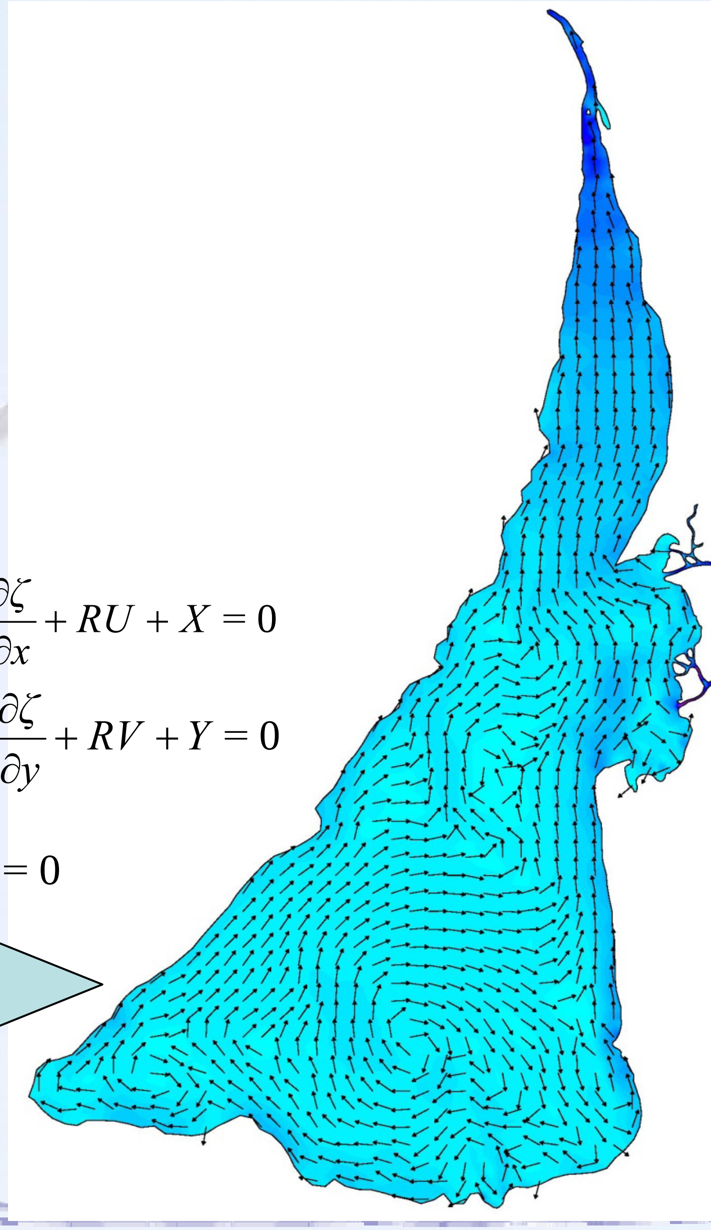
- Flexible mesh enables to resolve complex spatial features.



$$\frac{\partial U}{\partial t} - fV + gH\frac{\partial \zeta}{\partial x} + RU + X = 0$$

$$\frac{\partial V}{\partial t} + fU + gH\frac{\partial \zeta}{\partial y} + RV + Y = 0$$

$$\frac{\partial \zeta}{\partial t} + \frac{\partial U}{\partial x} + \frac{\partial V}{\partial y} = 0$$



- Multidimensionality. Possibility to create 2D and 3D models.

- Interface for coupling of hydrodynamics with ecological models (code level).

Model SHYFEM/AQUABC

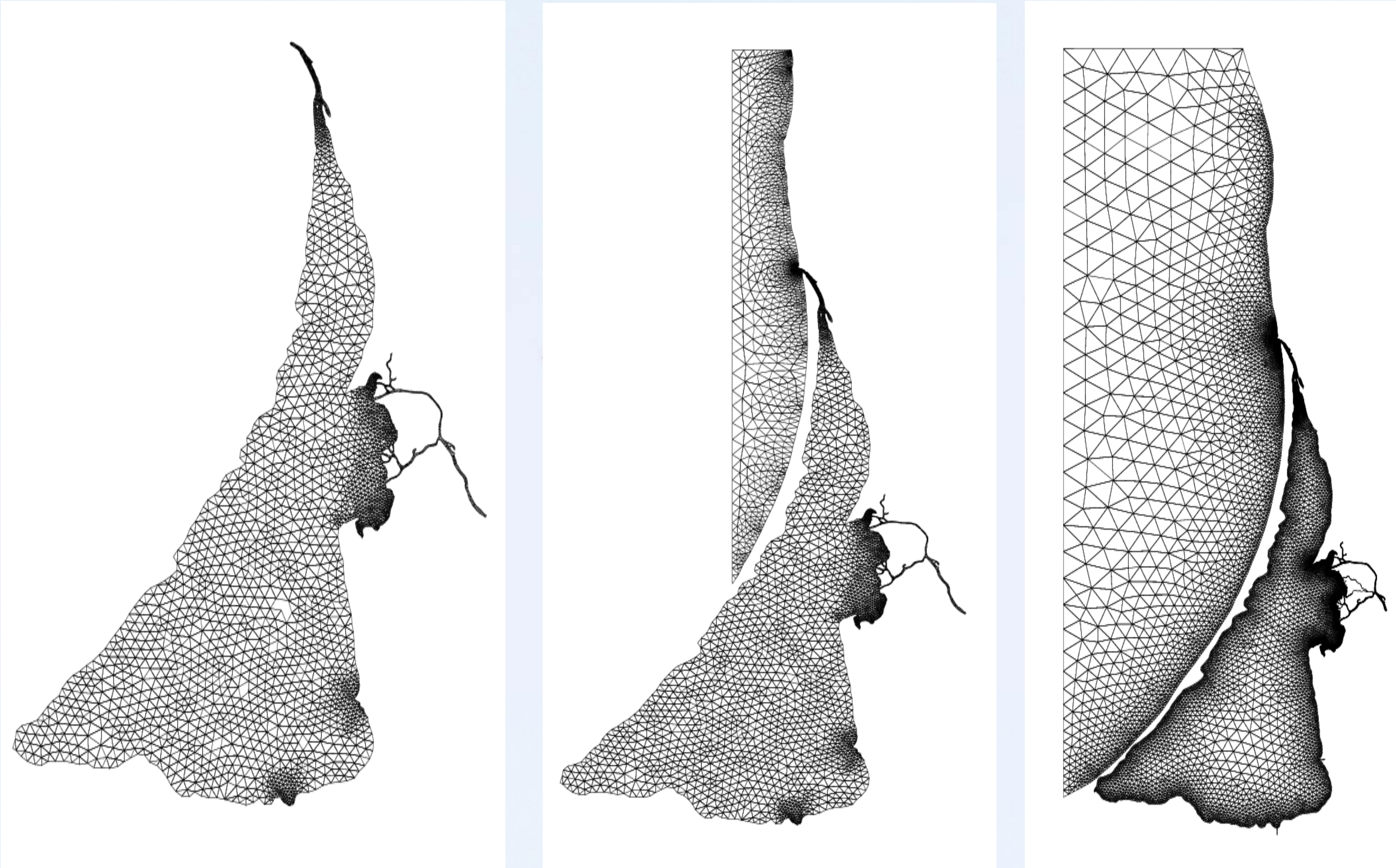
- SHYFEM/AQUABC is coupled WQ-hydrodynamic model developed for the Curonian lagoon and coastal area of the Baltic Sea.
- AQUABC is WQ model coupled with finite element model SHYFEM.
- AQUABC consists of two modules: 1) Water column module; 2) Bottom sediment module (under development)

- Main features of the water column module:
  - 22 WQ state variables.
  - 3 phytoplankton groups (diatoms, cyanobacteria, greens). Simulation of nitrogen fixation.
  - One zooplankton group.
  - Nutrients: Nitrogen, phosphorus, silica

Water column state variables

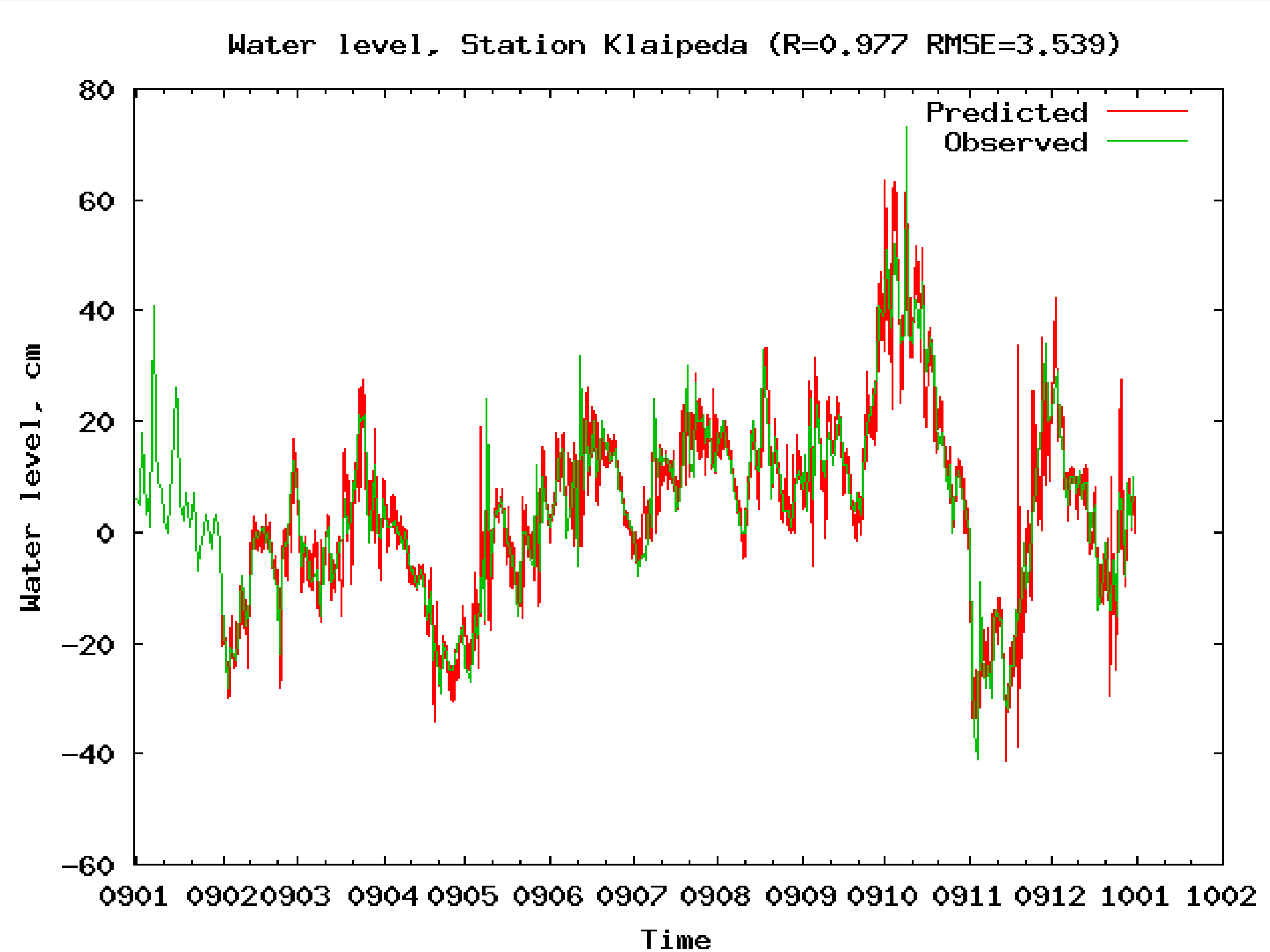
- 1. AMMONIUM NITROGEN
- 2. NITRATE NITROGEN
- 3. ORTHOPHOSPHATE PHOSPHORUS
- 4. PHYTOPLANKTON CARBON FOR GREENS
- 5. EXTERNAL LABILE DISSOLVED DETRITUS CARBON
- 6. DISSOLVED OXYGEN
- 7. EXTERNAL LABILE PARTICULATE DETRITUS CARBON
- 8. EXT. REFRACTORY DISS. DETRITUS CARBON
- 9. ZOOPLANKTON CARBON
- 10. NONBIOGENIC SILICA
- 11. EXTERNAL REFRACTORY PARTICULATE DETRITUS CARBON
- 12. PHYTOPLANKTON CARBON FOR DIATOMS
- 13. PHYTOPLANKTON CARBON FOR CYANOBACTERIA
- 14. INORGANIC CARBON
- 15. GREENS DISSOLVED DETRITUS CARBON
- 16. GREENS PARTICULATE DETRITUS CARBON
- 17. DIATOM DISSOLVED DETRITUS CARBON
- 18. DIATOM PARTICULATE DETRITUS CARBON
- 19. CYANOBACTERIA DISSOLVED DETRITUS CARBON
- 20. CYANOBACTERIA PARTICULATE DETRITUS CARBON
- 21. ZOOPLANKTON DISSOLVED DETRITUS CARBON
- 22. ZOOPLANKTON PARTICULATE DETRITUS CARBON

Possibility to choose different modelling domains

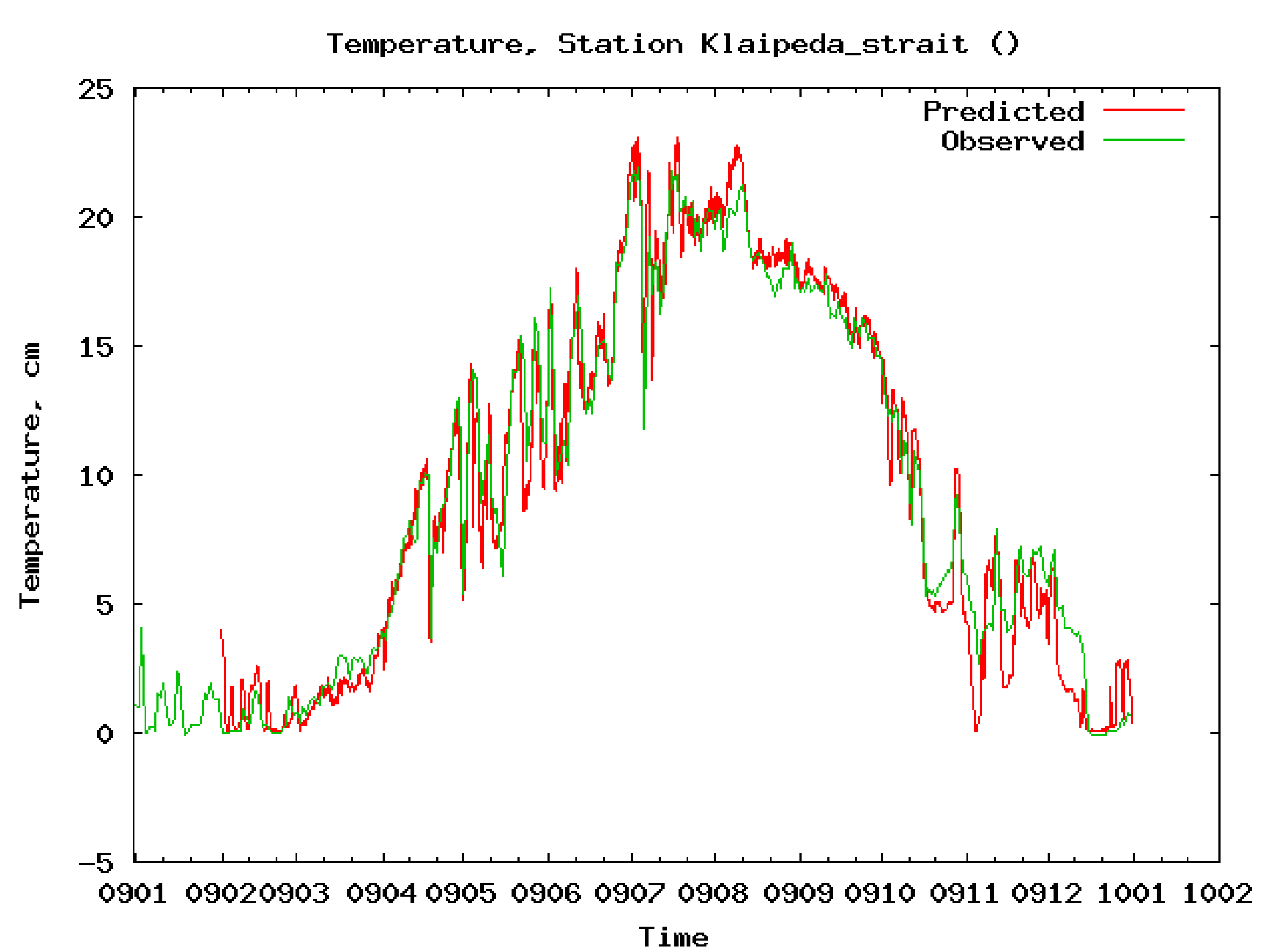


- Open sea boundary condition:
  - Operational hydrodynamic model HIROMB (1 nautical mile horizontal resolution).
  - Lithuania coastal area HIROMB (300m horizontal resolution).

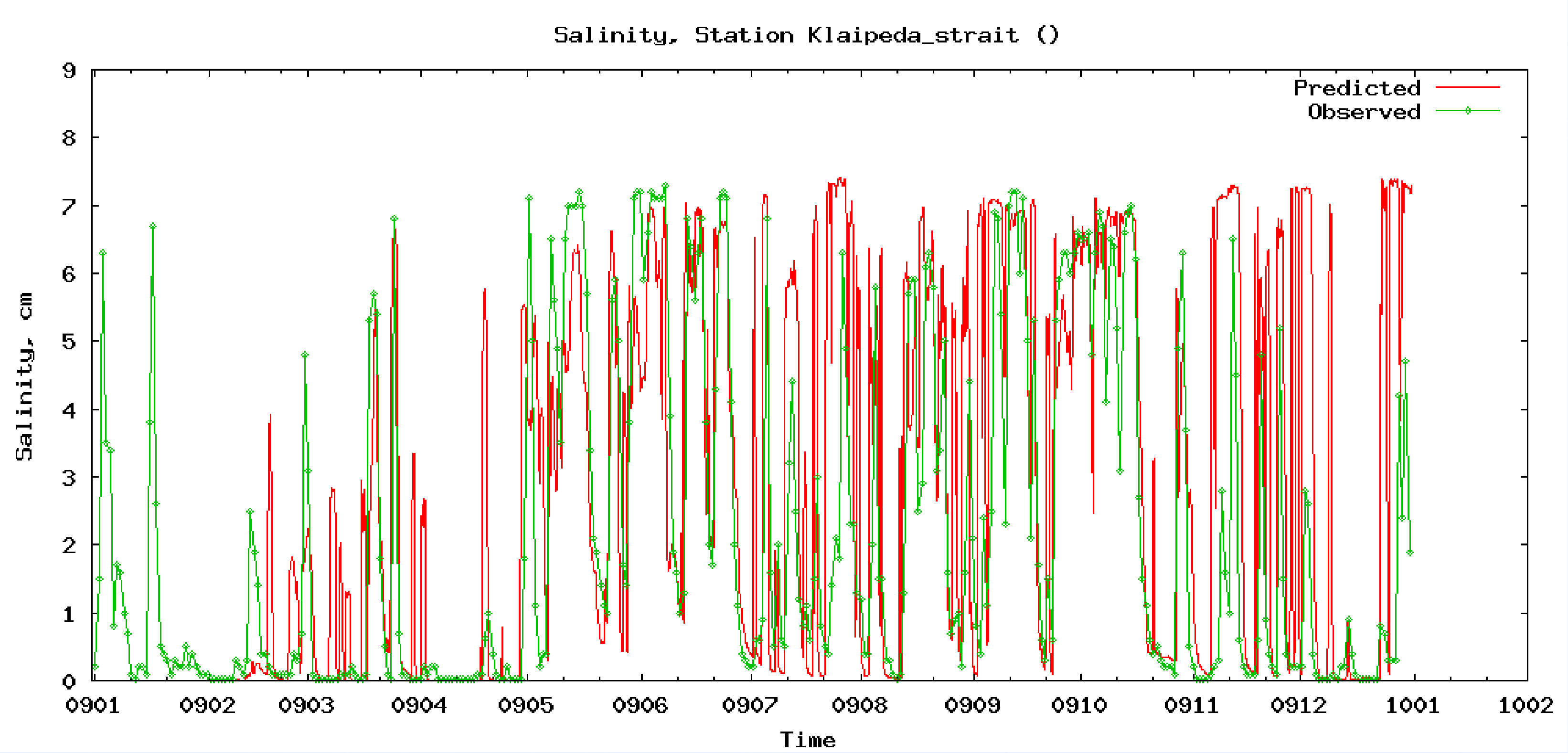
Performance. *Water level*



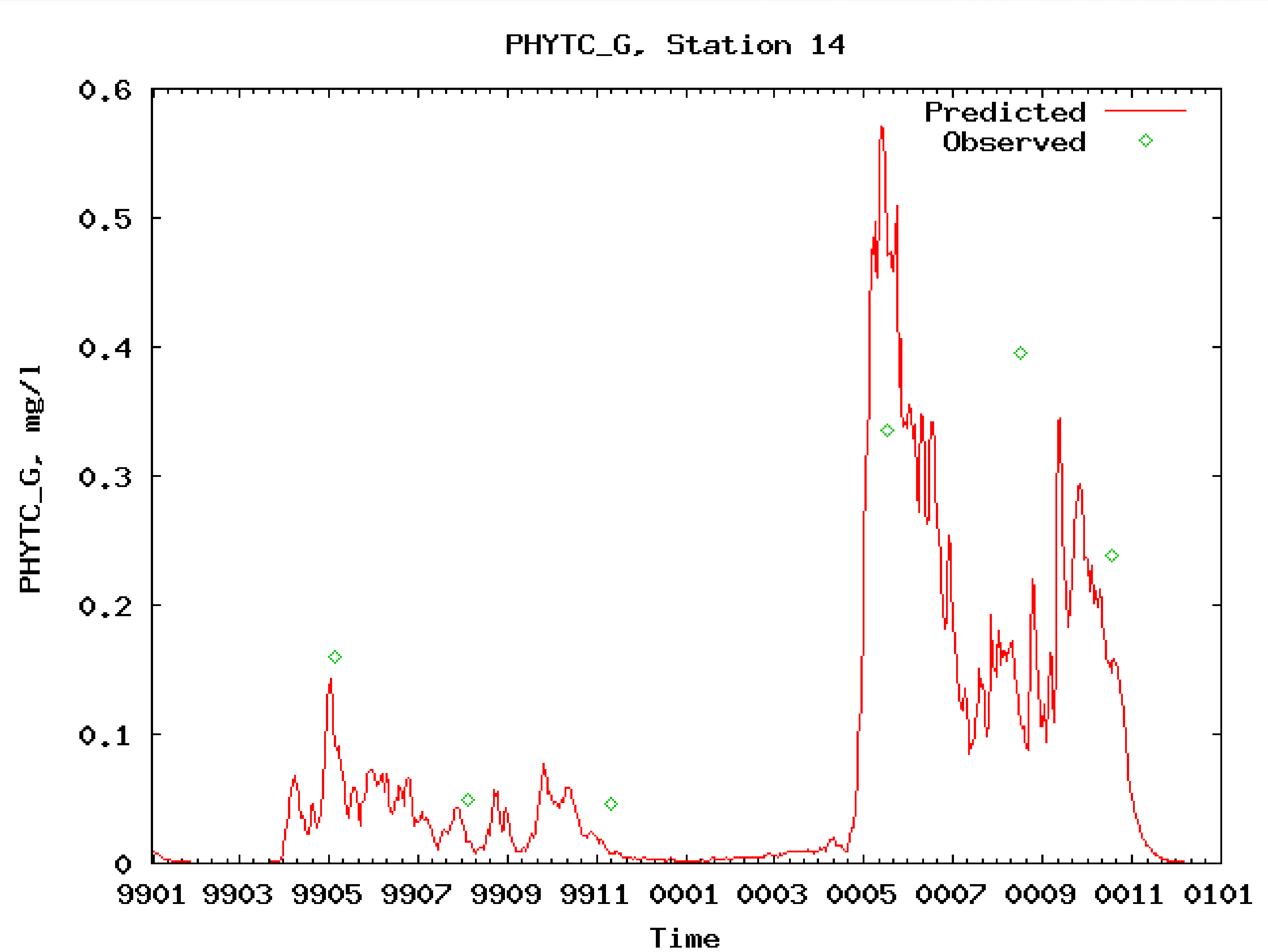
Temperature



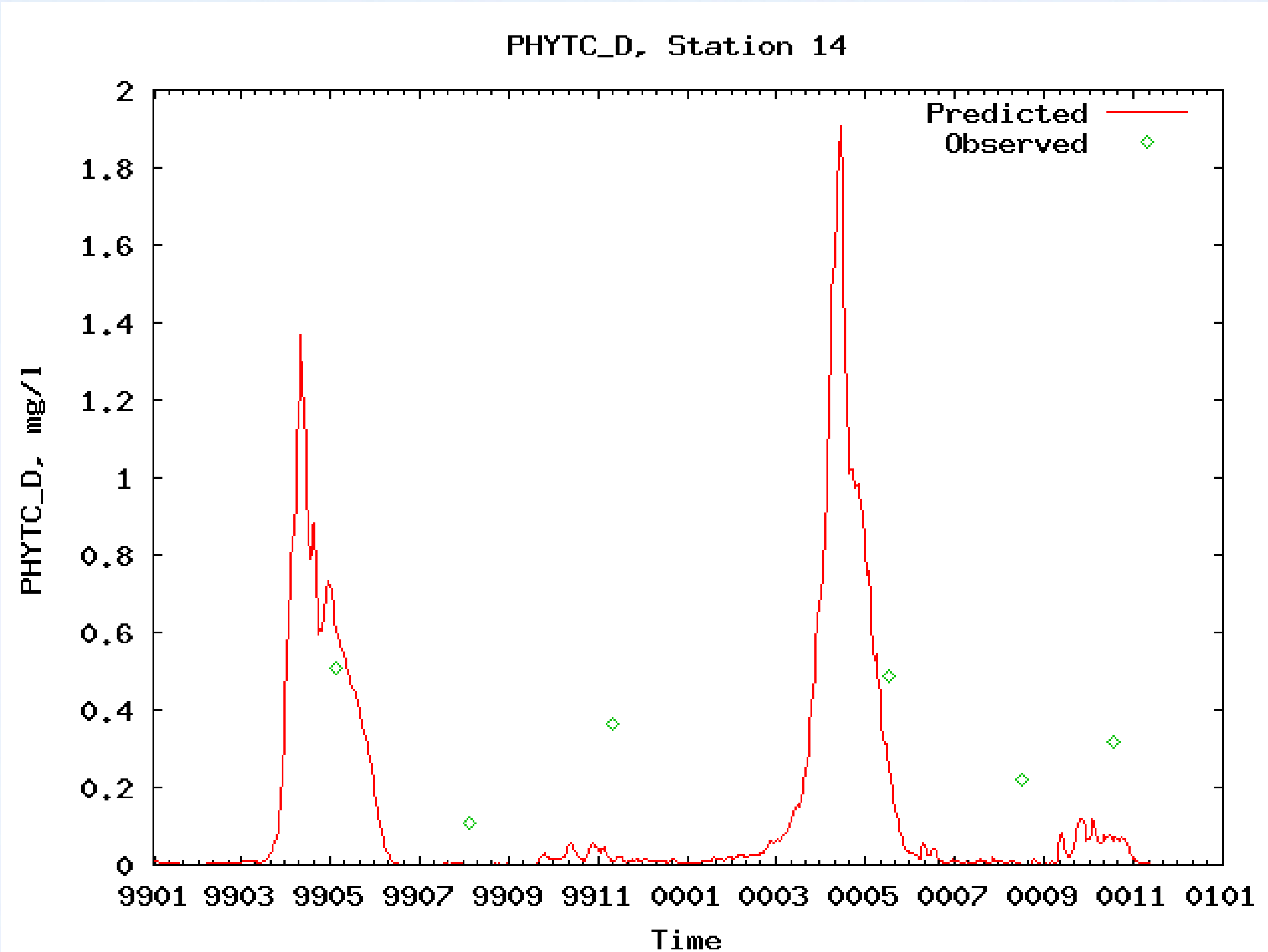
Salinity


Salinity, Station Klaipeda_strait ()
Predicted
Observed
Salinity, cm
9
8
7
6
5
4
3
2
1
0
0901
0902
0903
0904
0905
0906
0907
0908
0909
0910
0911
0912
1001
1002
Time

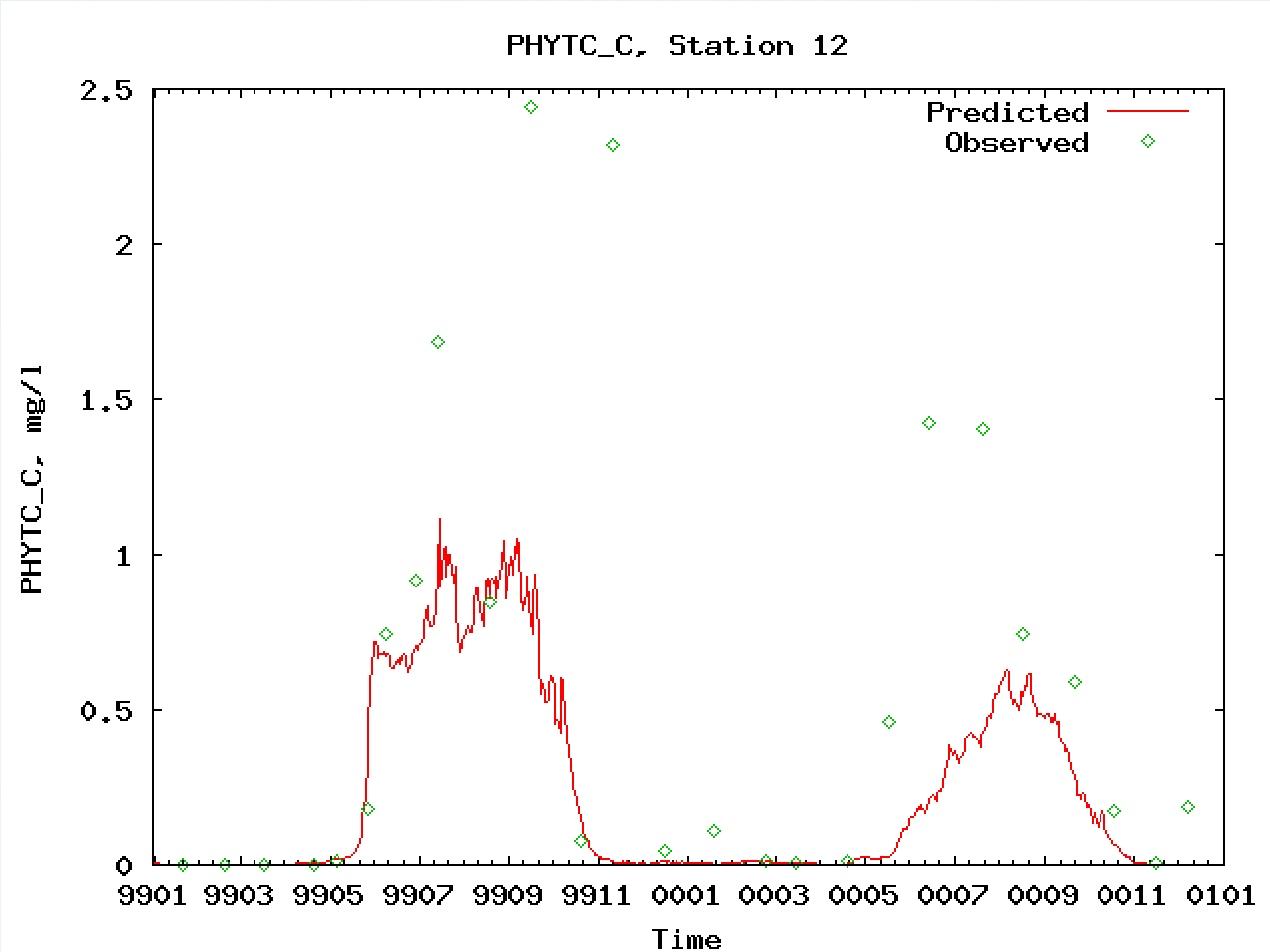
Phytoplankton carbon. Greens.



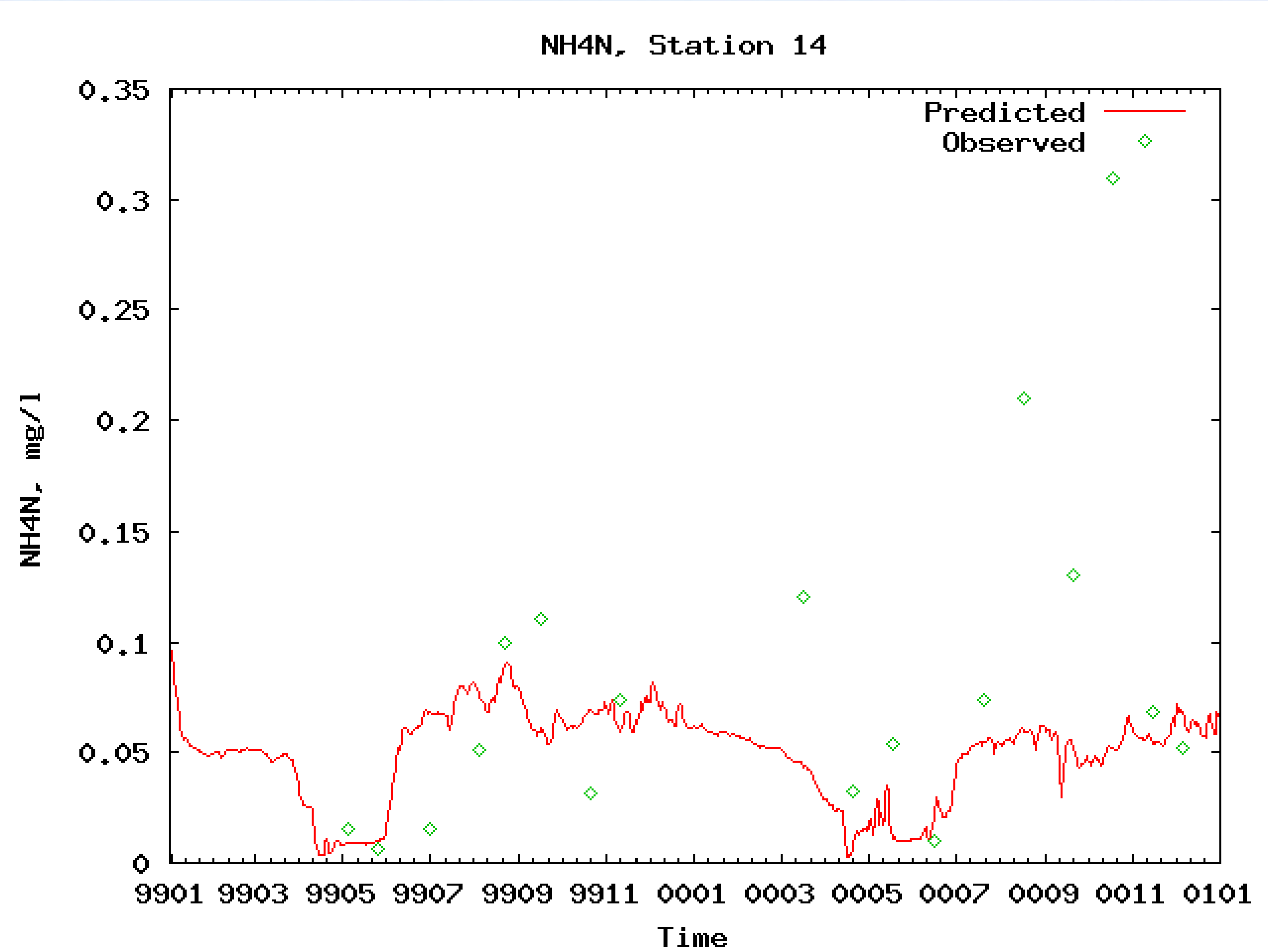
Phytoplankton carbon. Diatoms



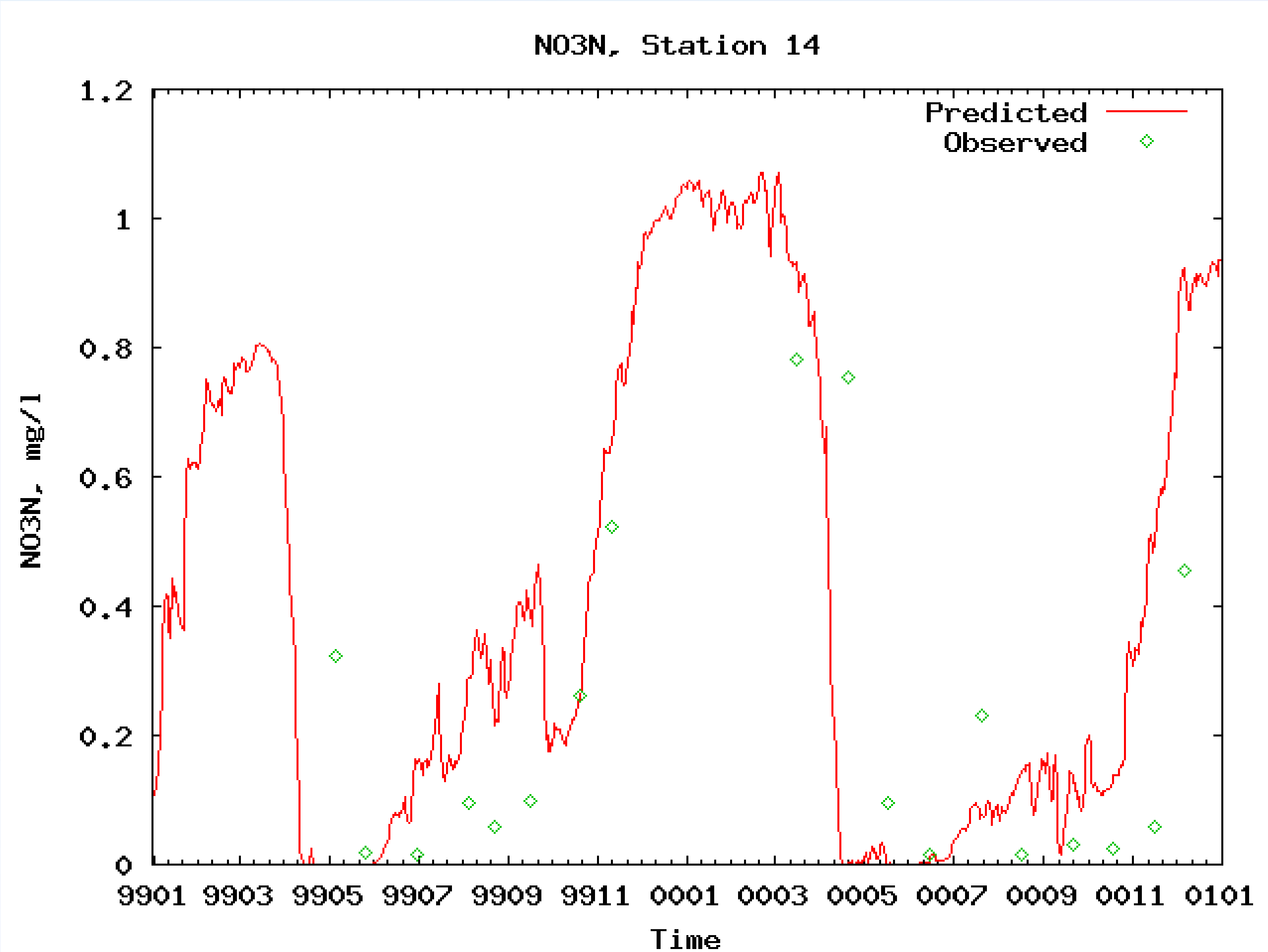
Phytoplankton carbon. Cyanobacteria



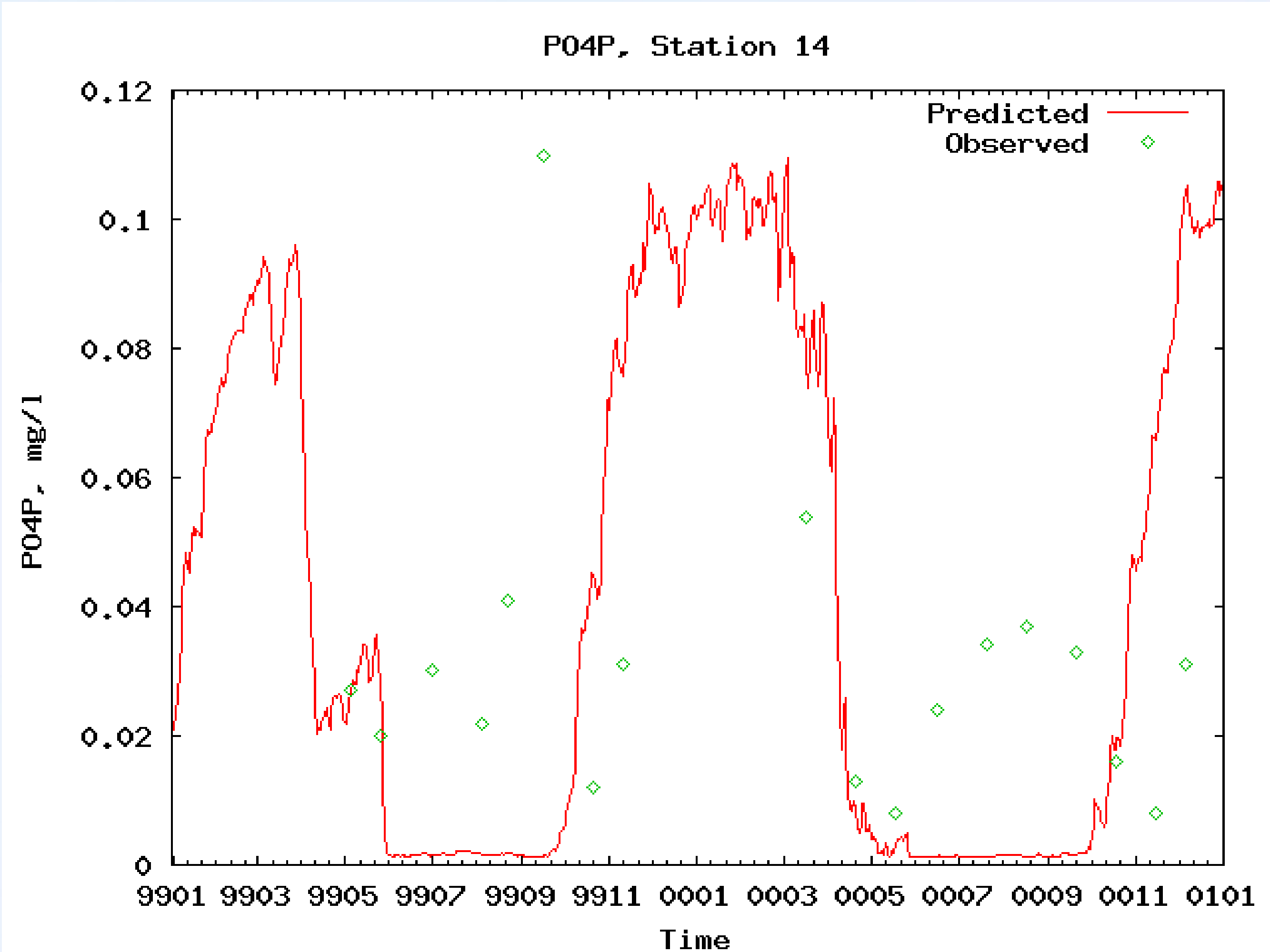
Ammonia nitrogen



Nitrates nitrogen



Phosphates phosphorus

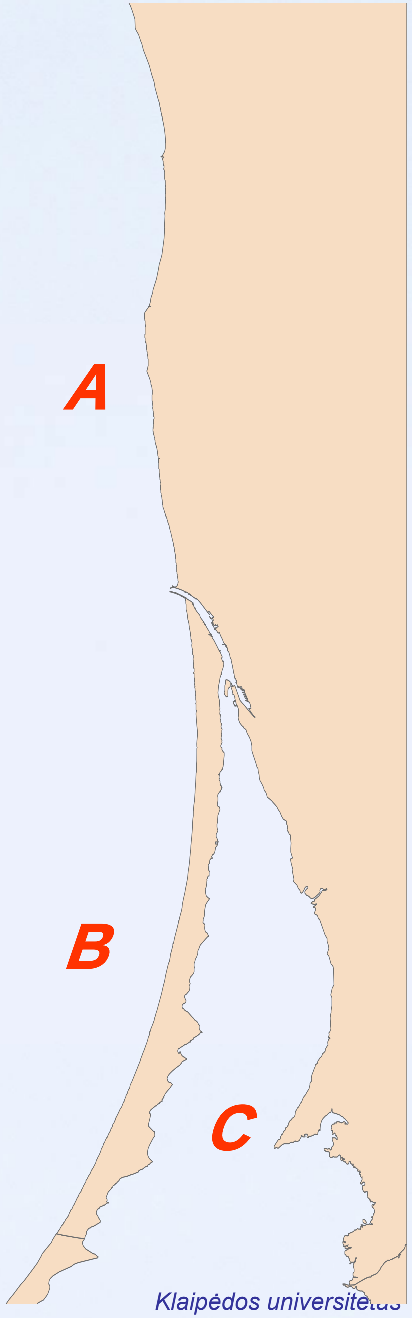


Under the development 2011: Bottom sediments model

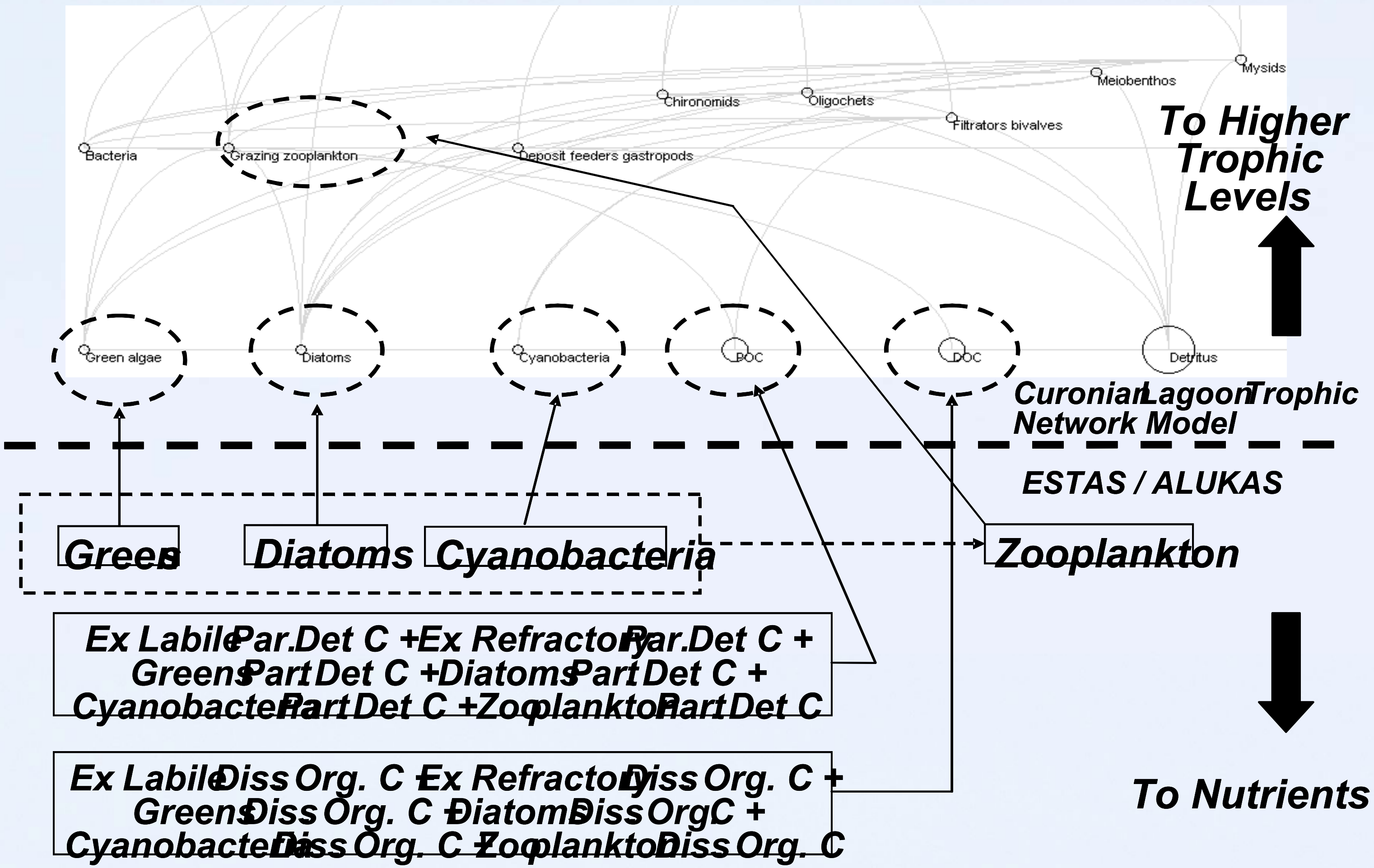
- 12 state variables
- 3 vertical layers

- List of state variables:
- 1 BS amonia
- 2 BS nitrates
- 3 BS dissolved organic nitrogen
- 4 BS particulate organic nitrogen
- 5 BS dissolved orthophosphates phosphorus
- 6 BS dissolved organic phosphorus
- 7 BS particulate organic phosphorus
- 8 BS dissolved oxygen
- 9 BS dissolved organic carbon
- 10 BS particulate organic carbon
- 11 BS dissolved silica
- 12 BS particulate silica

ECOPATH /ECOSIM SUBMODELS



ECOPATH - NPZD LINKAGE (A.Erturk & A. Razinkovas, 2009



Curonian lagoon ECOSIM compartments

	Species	Age groups
1	Bream	13
2	Roach	10
3	White bream	12
4	Vimba	1
5	Pikeperch	6
6	Perch	8
7	Ruffe	6
9	Three spine stickleback	1

Coastal Baltic sea ECOSIM compartments

	Species	Age groups
1	Bream	3
2	Smelt	3
3	White bream	2
4	Flounder	2
5	Pikeperch	3
6	Perch	3
7	Lesser sandeel	1

Under the development 2011: ECOSIM coupling to NPZD model at the code level

- Provide possibility of dynamic simulations
- Provide possibility of water quality related forcing in ECOSIM
- Provide possibility of the feedback from ECOSIM to NPZD

Conclusions

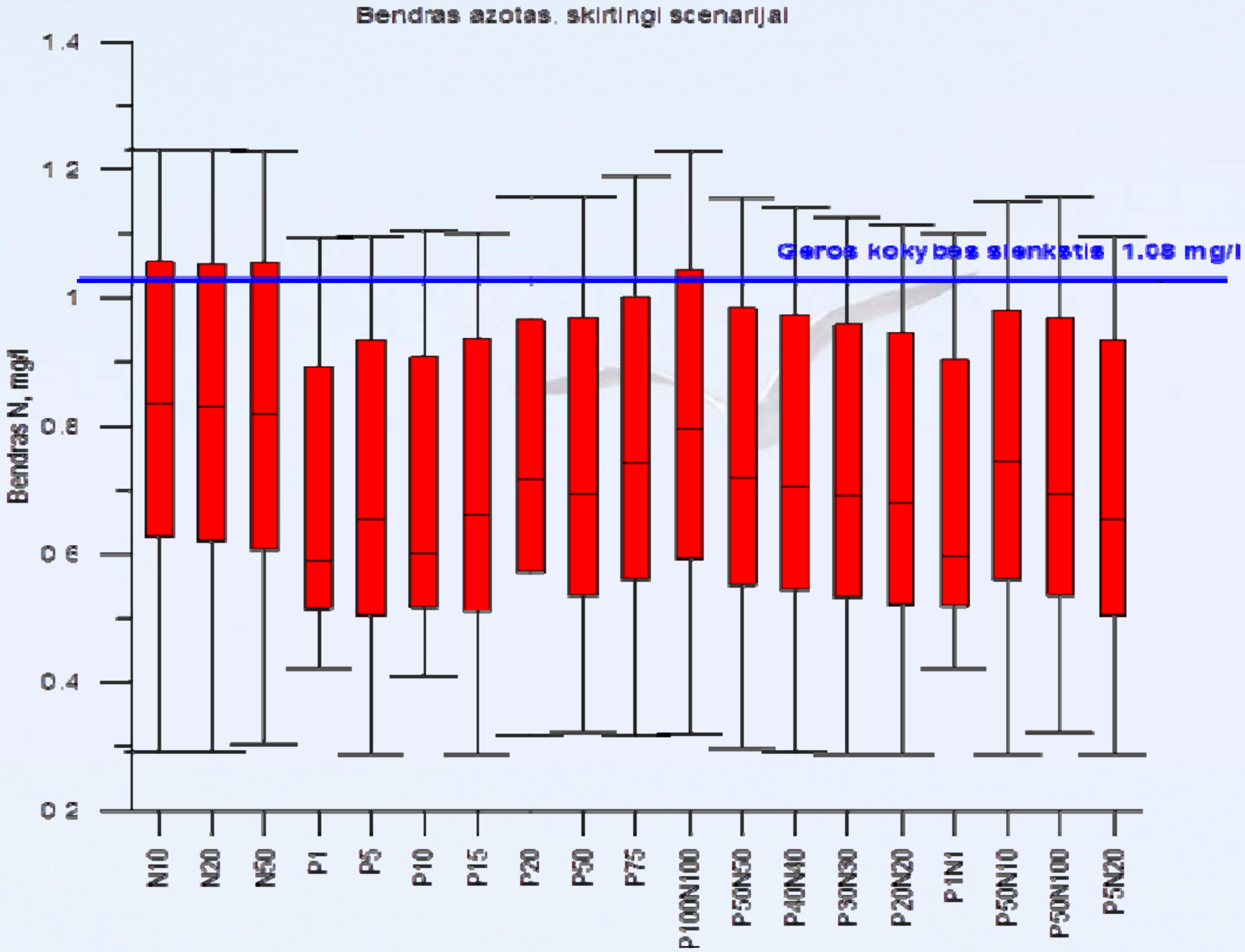
- Model SHYFEM/AQUABC satisfactory reproduces dynamics of the main hydrodynamic and WQ variables for the Curonian Lagoon under real atmospheric forcing and boundary conditions from the river Nemunas and the Baltic Sea.
- Model can be used for the calculation of climate change scenarios when supplied by water runoff and nutrients loads from the rivers and information for the open boundary of the Baltic Sea.

- Forthcoming publications:
- Razinkovas-Baziukas & Schernewski „Climate change effects in the Oder and Curonian lagoons of the Baltic sea“ prepared for *Transitional water bulletin*
- Razinkovas-Baziukas et al. Commercial fish stock dynamics in Curonian lagoon : modelling approach (due in 2011)
- P. Zemlys et al. paper on benthic model

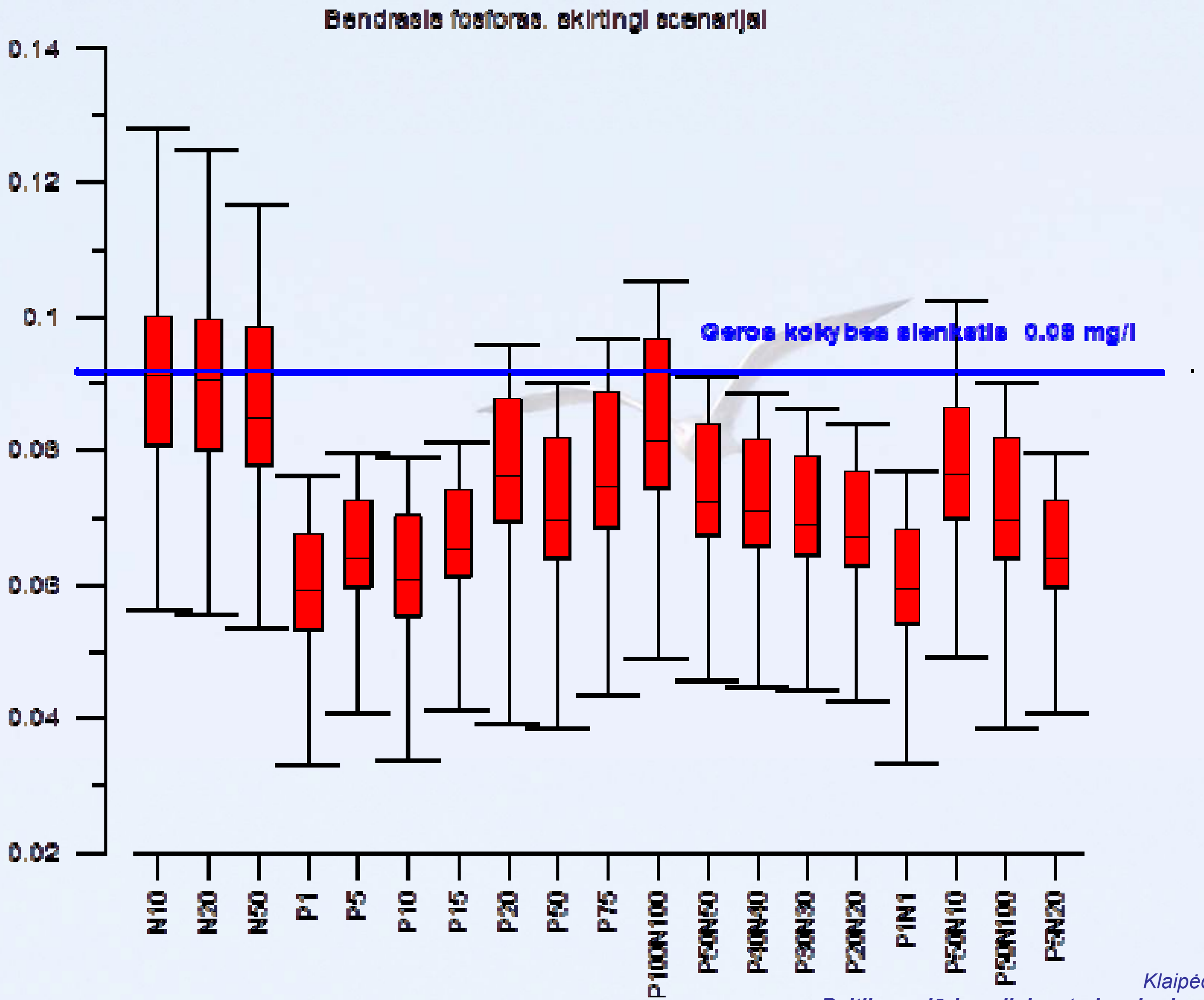
Message to the stakeholders: NPZD model results

- ***Different scenarios based on nutrient reduction measures in the catchment***
- ***Effectiveness of the in-catchement measures***

Total N


Bendras azotas, skirtingi scenarijai
Geros kokybes slenkstis 1.08 mg/l
Bendras N, mg/l
1.4
1.2
1
0.8
0.6
0.4
0.2
N10
N20
N50
P1
P5
P10
P15
P20
P50
P75
P100N100
P50N50
P40N40
P30N30
P20N20
P1N1
P50N10
P50N100
P5N20

Total P


Bendrasis fosforas, skirtingi scenarijai
0.14
0.12
0.1
0.08
0.06
0.04
0.02
Geros kokybes slenkstis 0.09 mg/l
N10
N20
N50
P1
P5
P10
P15
P20
P50
P75
P100N100
P50N50
P40N40
P30N30
P20N20
P1N1
P50N10
P50N100
P5N20

Message to the stakeholders: NPZD model results

Chlorophyll A