RISCS research into impacts & safety in CO_2 storage

Marine scenarios of *Posidonia oceanica* and trophic web changes

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SEVENTH FRAMEWORK PROGRAMME

OGS

- ***Objectives:*** **To develop marine modelling studies for biogeochemical and environmental impacts of CO_2**

✓ Definition of relevant subsystems:
  - ✓ carbon geochemistry in sediment
  - ✓ biogeochemical cycling
  - ✓ carbon fluxes and trends

- ***Activities***

✓ Dynamics of the carbon cycle in sediment layers
✓ Changes of the trophic web due to specific leakage events
✓ Impact of CO_2 on specific plants/organisms

- ***Methods***

✓ Geochemical stationary evolution in short and medium time
✓ Potential extension to leakage transients
✓ Collaboration with other groups for introducing other processes, laboratory and experimental results

Marine Biogeochemistry

- ***Modelling Marine CO Impacts:*** **To develop marine modelling for the biogeochemical impact of CO_2 leakages and seepages**

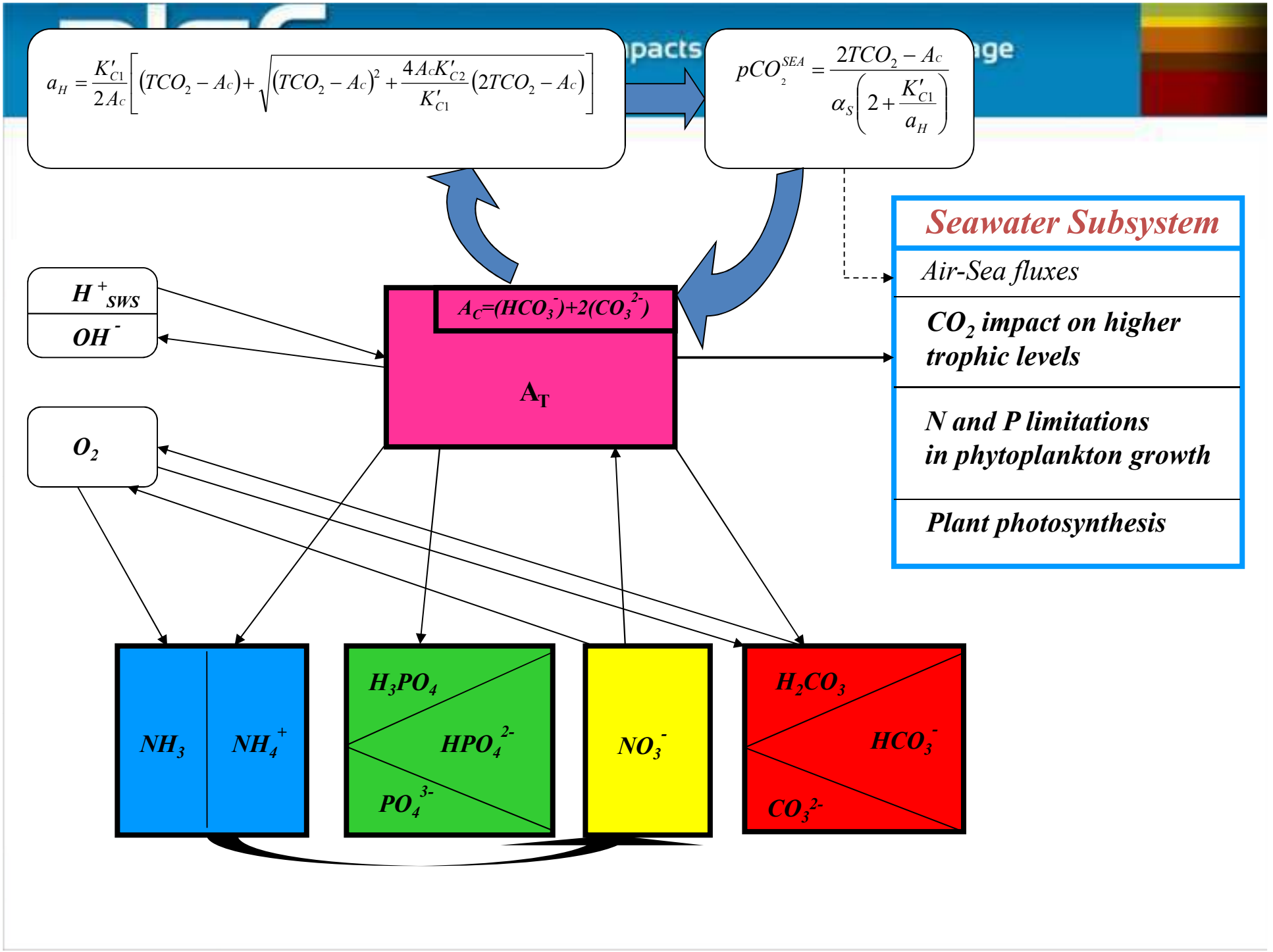
✓ definition of four subsystems:
  - ✓ benthos
  - ✓ bottom boundary layer
  - ✓ seawater ecology
  - ✓ benthic biology

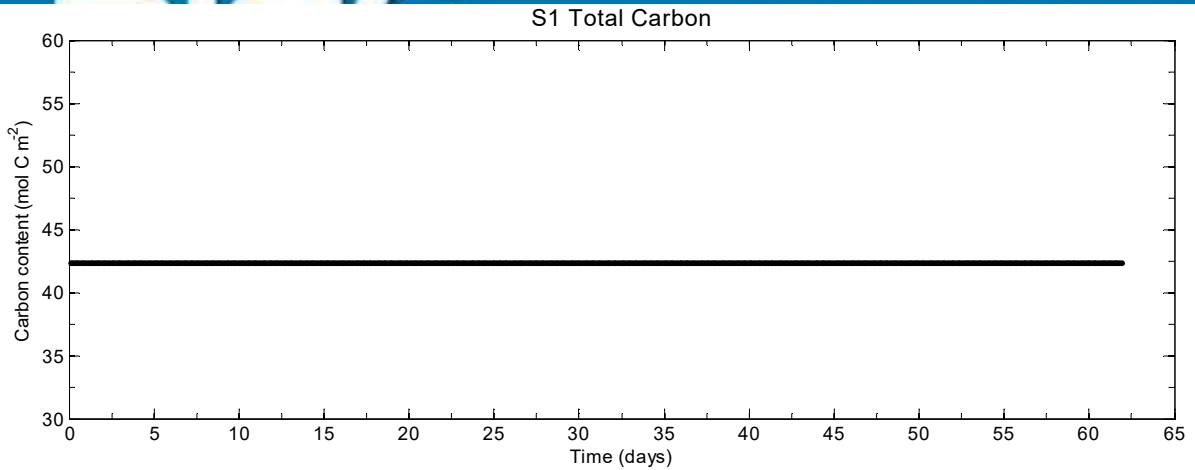
- ***Activities:***

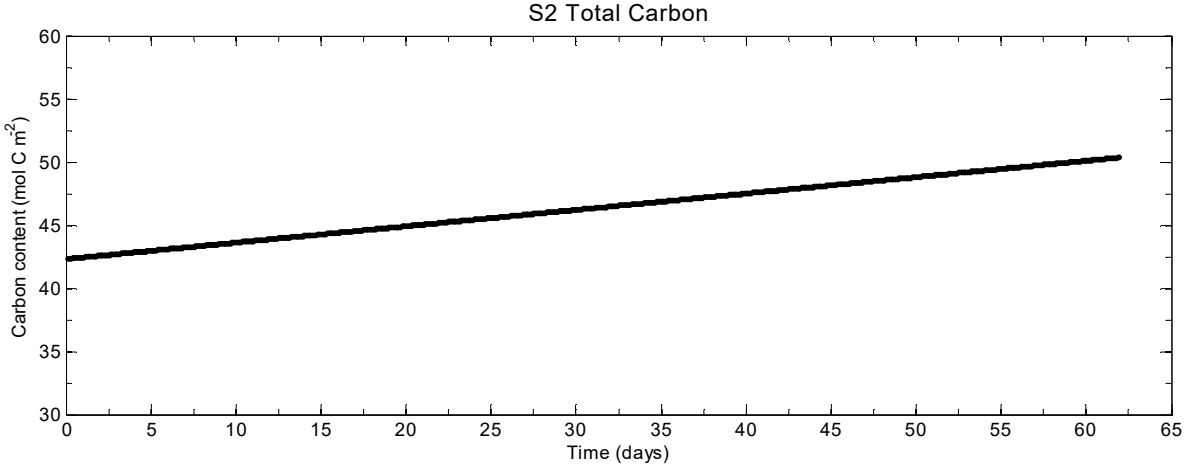
✓ study of nutrients (C, N , P) cycles in oxic and reducing sediment layers
✓ study of the impact of CO_2 on flora and fauna
✓ characterization of variability of the concentrations in the bottom boundary layer

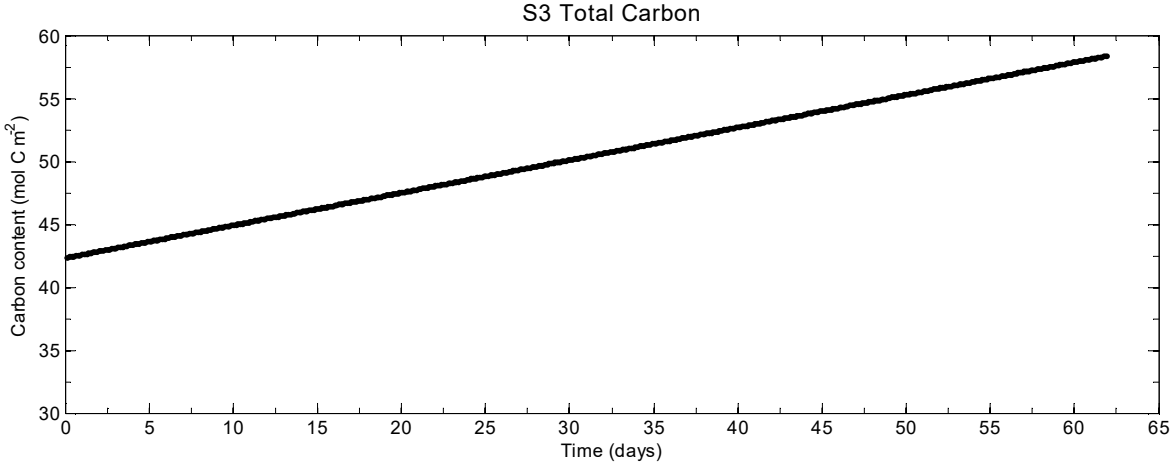
- ***Methods:***

✓ Implementation of seawater processes
✓ Modelling of the variability of the ecosystem with specific leakages


$a_H = \frac{K'_{C1}}{2A_C}\left[(TCO_2 - A_C) + \sqrt{(TCO_2 - A_C)^2 + \frac{4A_C K'_{C2}}{K'_{C1}}(2TCO_2 - A_C)}\right]$
$pCO_2^{SEA} = \frac{2TCO_2 - A_C}{\alpha_S\left(2 + \frac{K'_{C1}}{a_H}\right)}$
Seawater Subsystem
Air-Sea fluxes
CO_2 impact on higher trophic levels
N and P limitations in phytoplankton growth
Plant photosynthesis
H^+_{SWS}
OH^-
$A_C=(HCO_3^-)+2(CO_3^{2-})$
A_T
O_2
NH_3
NH_4^+
H_3PO_4
HPO_4^{2-}
PO_4^{3-}
NO_3^-
H_2CO_3
HCO_3^-
CO_3^{2-}





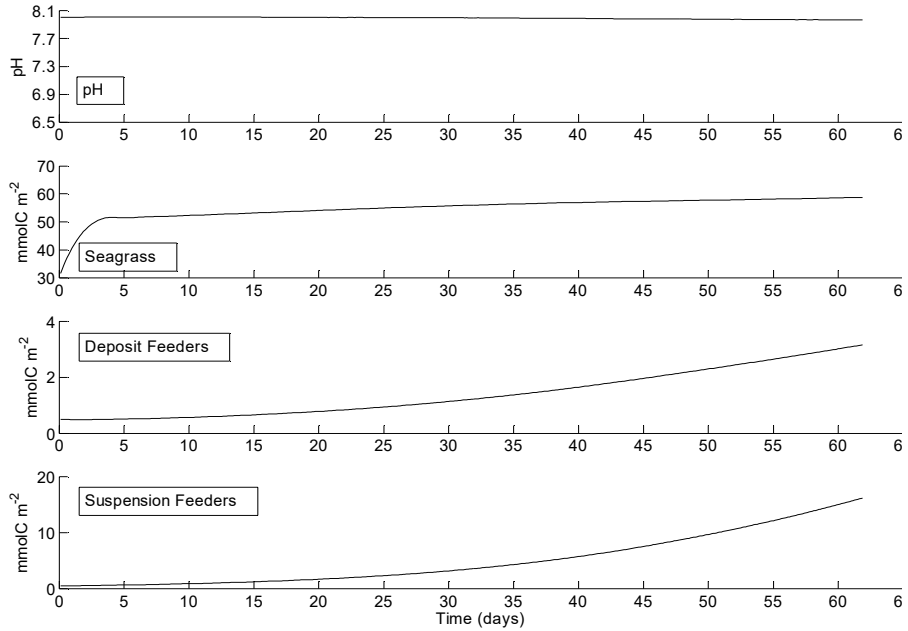


Total carbon in the system

S1 (baseline): the total carbon is constant.

S2 (intermediate leakage): total carbon in the system increases 0.57 kg C m^{-2} $year^{-1}$.

S2 (high leakage): total carbon reaches higher carbon content per square metre.

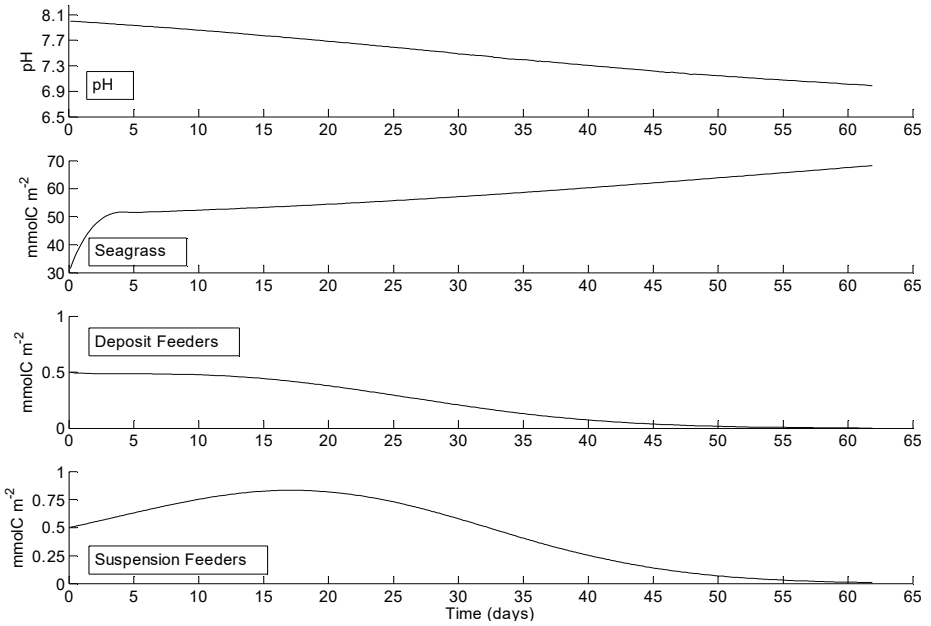


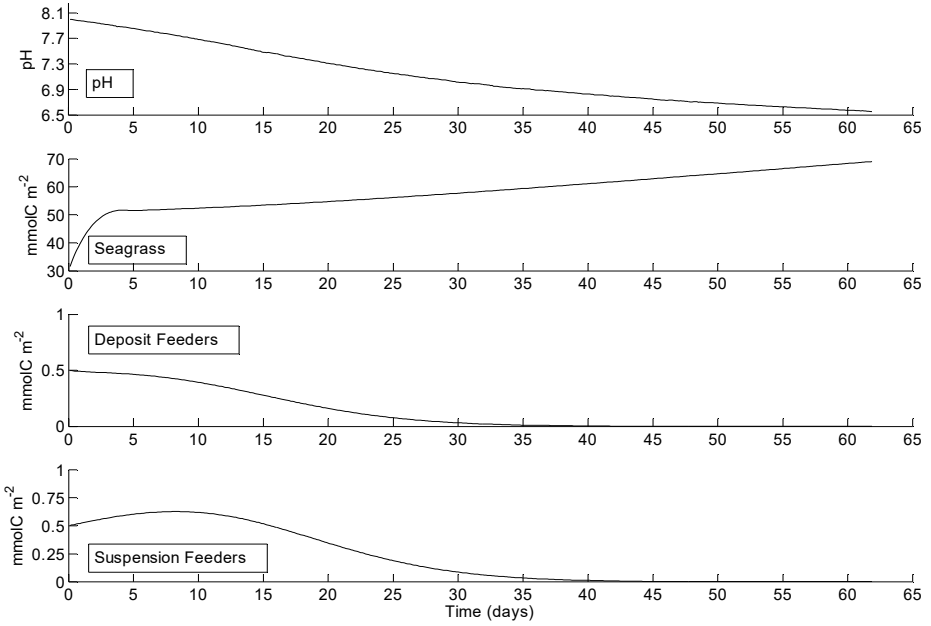
pH, ***Seagrass***, ***Deposit*** and ***Suspension Feeders*** are shown

above in the case of baseline evolution (***S1***),

on the right side for intermediate leakage (***S2***)

and for high leakage (***S3***) ⟶





Carbon Dioxide Production Sources (+ stands for CO_2 production) and Sinks (- stands for CO_2 loss)

- ***CDPSS =***

  = + METHANOGENESIS
  + SULFATE REDUCTION ←
  + IRON REDUCTION
  + MANGANESE REDUCTION
  + DENITRIFICATION
  + AEROBIC RESPIRATION
  + AEROBIC OXIDATION OF METHANE - AEOM
  – PRIMARY PRODUCTION →
  + ANAEROBIC OXIDATION OF METHANE - AOM ←
  – BACTERIAL PRODUCTION
  – BIOLOGICAL CALCIFICATION
  + DISSOLUTION OF CALCITE, ARAGONITE, Mg-CALCITE, other carbonates
  – PRECIPITATION OF CALCITE, ARAGONITE, etc.
  – ANAEROBIC AMMONIA OXIDATION
  + NITRATE REDUCTION TO AMMONIA
  - NITRIFICATION

  Explicit treatments of the last three geochemical carbon processes are not fully decribed in applications due to their inefficience in most marine environments

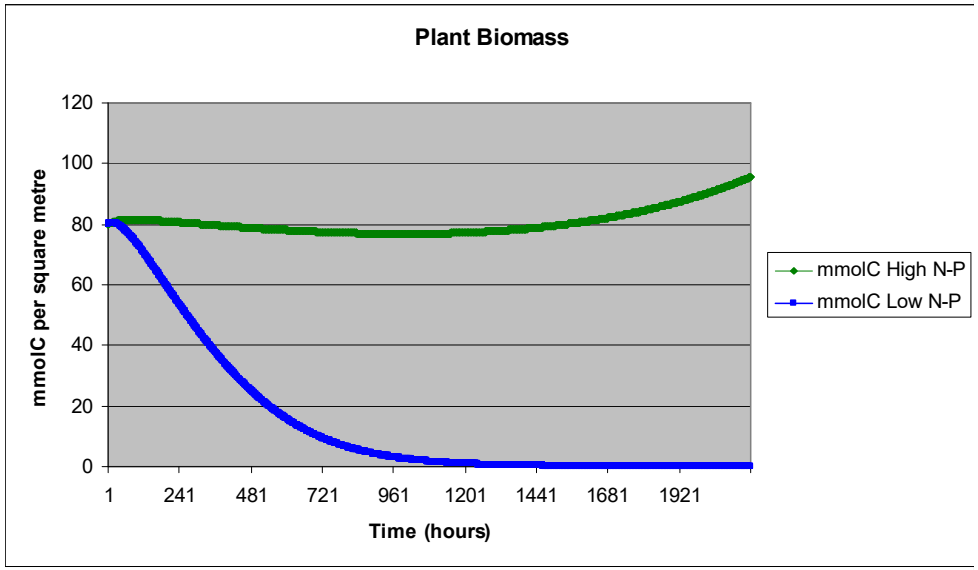
Carbon biomasses in the cases of low and high seawater nutrients

- **Low** nutrients:

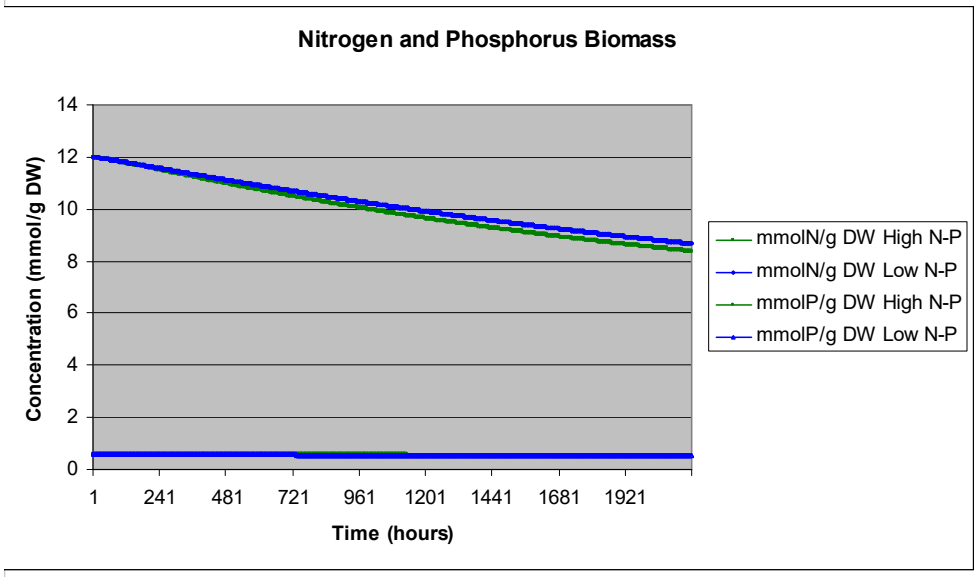
  nitrate=0.3 mmolNm^{-3}, NH_4^+=0.5 mmolNm^{-3} and phosphate=0.02 mmolPm^{-3}; ammonium and phosphate are null in the sediment

- **High** nutrients:

  concentrations are doubled



Nitrogen and Phosphorus contents



- Net primary production is about 47.8 gC m^{-2} $year^{-1}$ per gC of plant biomass in the case of high nutrients
- Net primary production is lower, about 30.2 gC m^{-2} $year^{-1}$ per gC of plant biomass, in the case of low nutrients