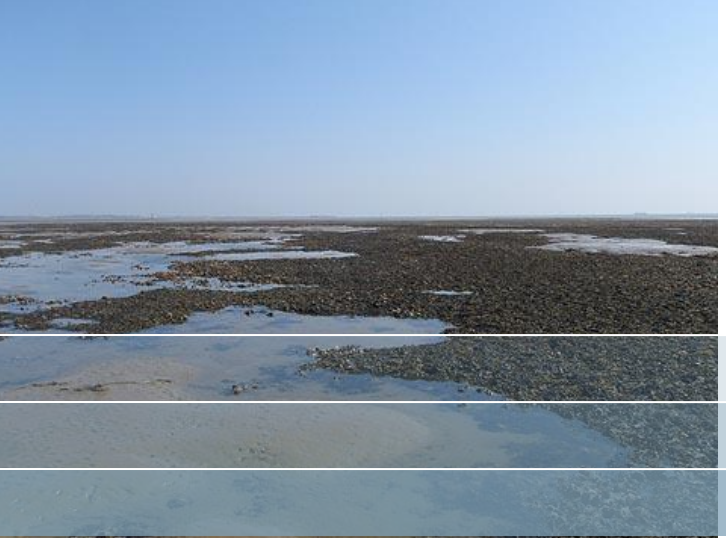
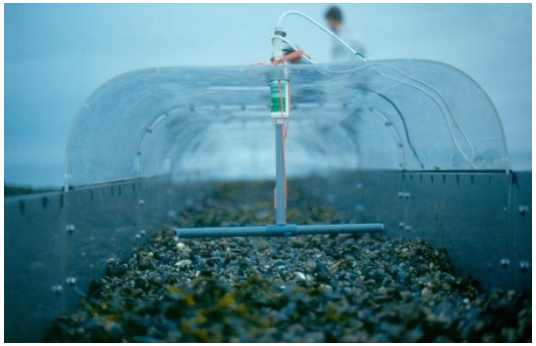


Deltares
Enabling Delta Life

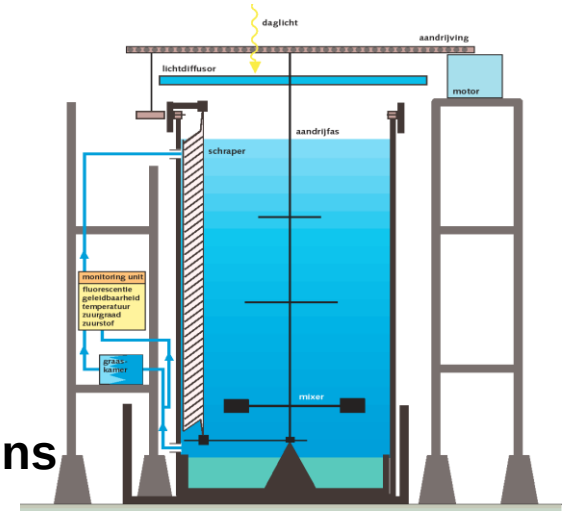
Feedbacks of shellfish on nutrients and phytoplankton

Theo Prins

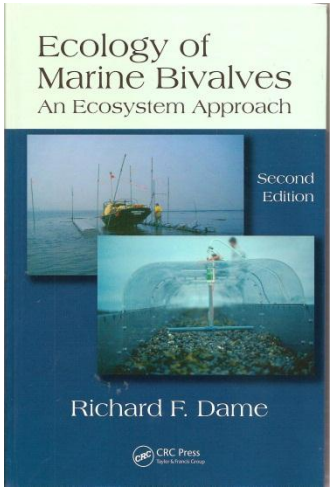
15 May 2012



Field studies on nutrient fluxes on intertidal mussel beds



Mesocosm studies on interactions between mussel grazing and phytoplankton development



Deltares

Feedbacks in shellfish dominated ecosystems

Process	Direct effect	Consequences
Filtration (system scale)	Top-down control of phytoplankton biomass	No/reduced effect of nutrient loading on phytoplankton
	Reduced storage of nutrients in algal biomass	Increase in pelagic inorganic nutrient pool
	Exclusion of slow-growing phytoplankton species	Change in phytoplankton composition
	Increased mortality of zooplankton	Change in pelagic food web structure
Changed phytoplankton composition	Changes in primary production	Changes in carrying capacity
Changed pelagic inorganic nutrient pool		
Changed nutrient limitation of phytoplankton		

Prins, Smaal & Dame, 1998

Deltares

Top-down control on phytoplankton by shellfish grazing

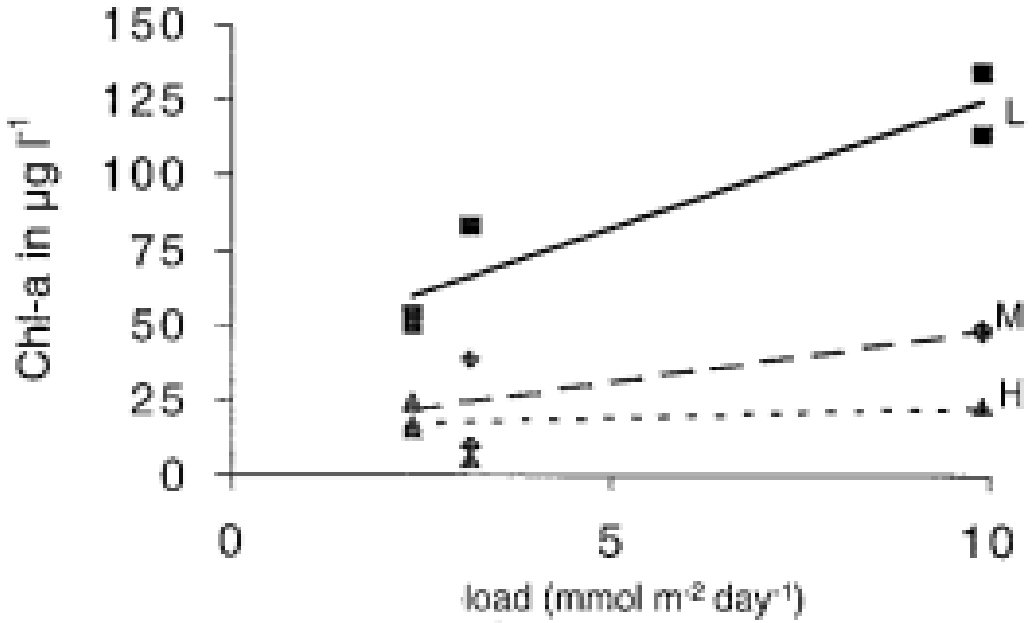
Low mussel biomass (L):

- Phytoplankton biomass increases with increased nutrient loading

High mussel biomass (H):

- No increase in phytoplankton biomass

- *Eutrophication control (Cloern 1982; Officer et al. 1982)*
- *More resilient ecosystem (Herman & Scholten 1990)*



Prins, Smaal & Dame, 1998

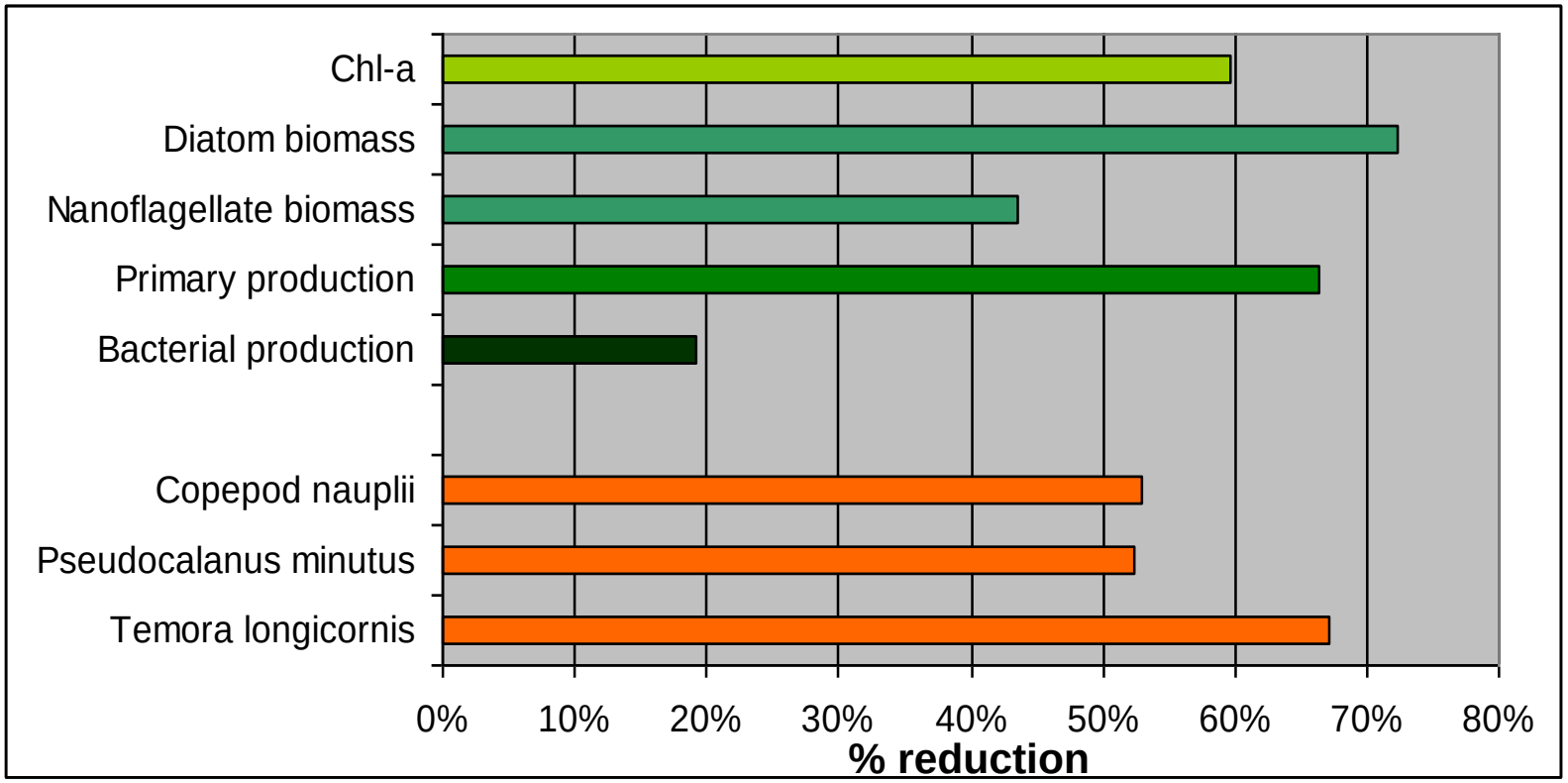
Deltares

Top-down control shellfish <-> zooplankton

Mesocosm experiment

- With mussels - Grazing 10% volume/day
- Without mussels - Development of mesozooplankton

Reduction in mesocosms with mussels



Prins & Escaravage, 2005

Deltares

Oosterschelde as a case study

Conclusions (1996):

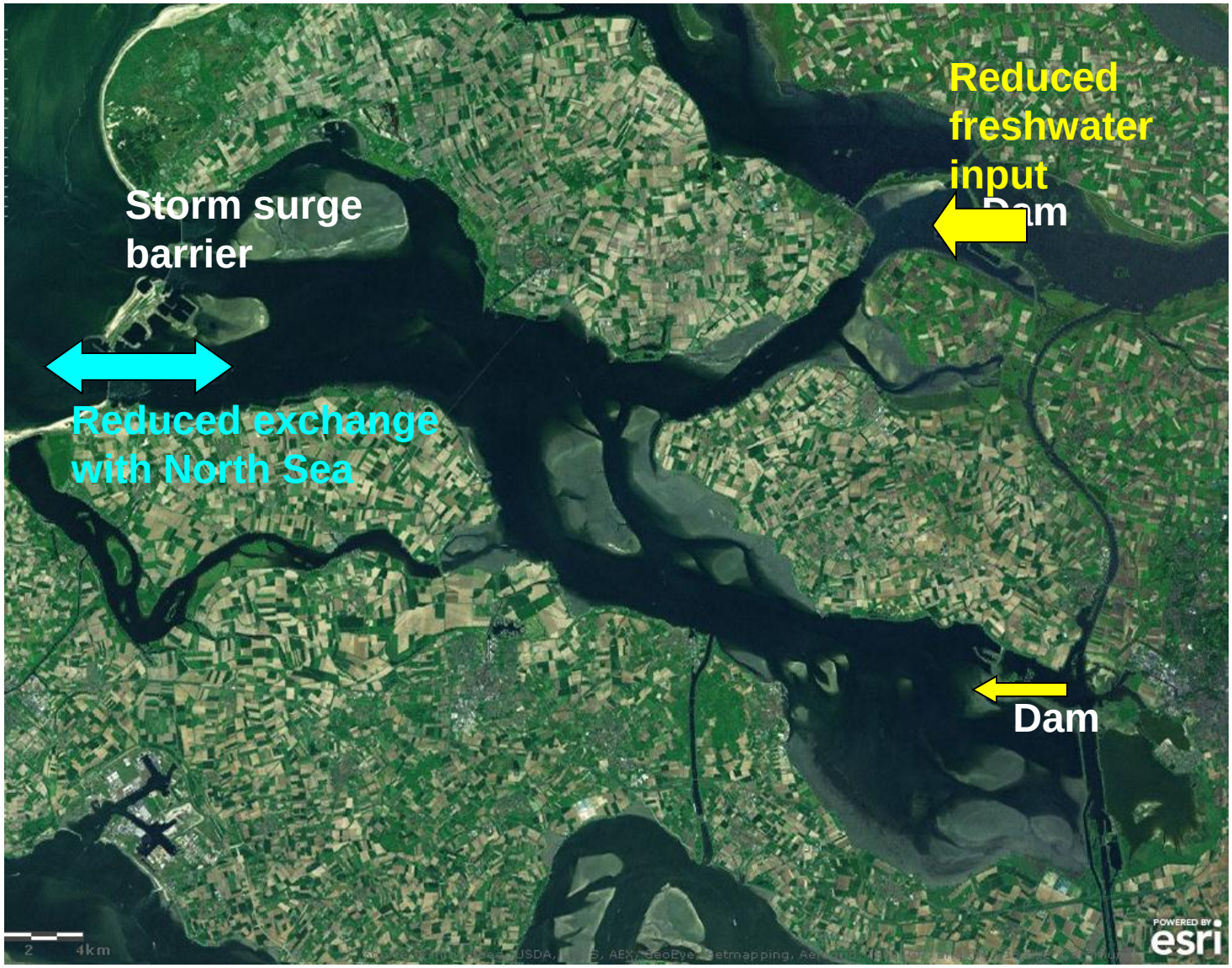
- Mussel grazing controls phytoplankton in the Oosterschelde
- Nitrogen regeneration enhances nutrient availabilty
- Potentially positive effect on primary production

Present situation (2011):

- Strong decrease in N and P inputs since 1990
- Sustained high biomass of shellfish

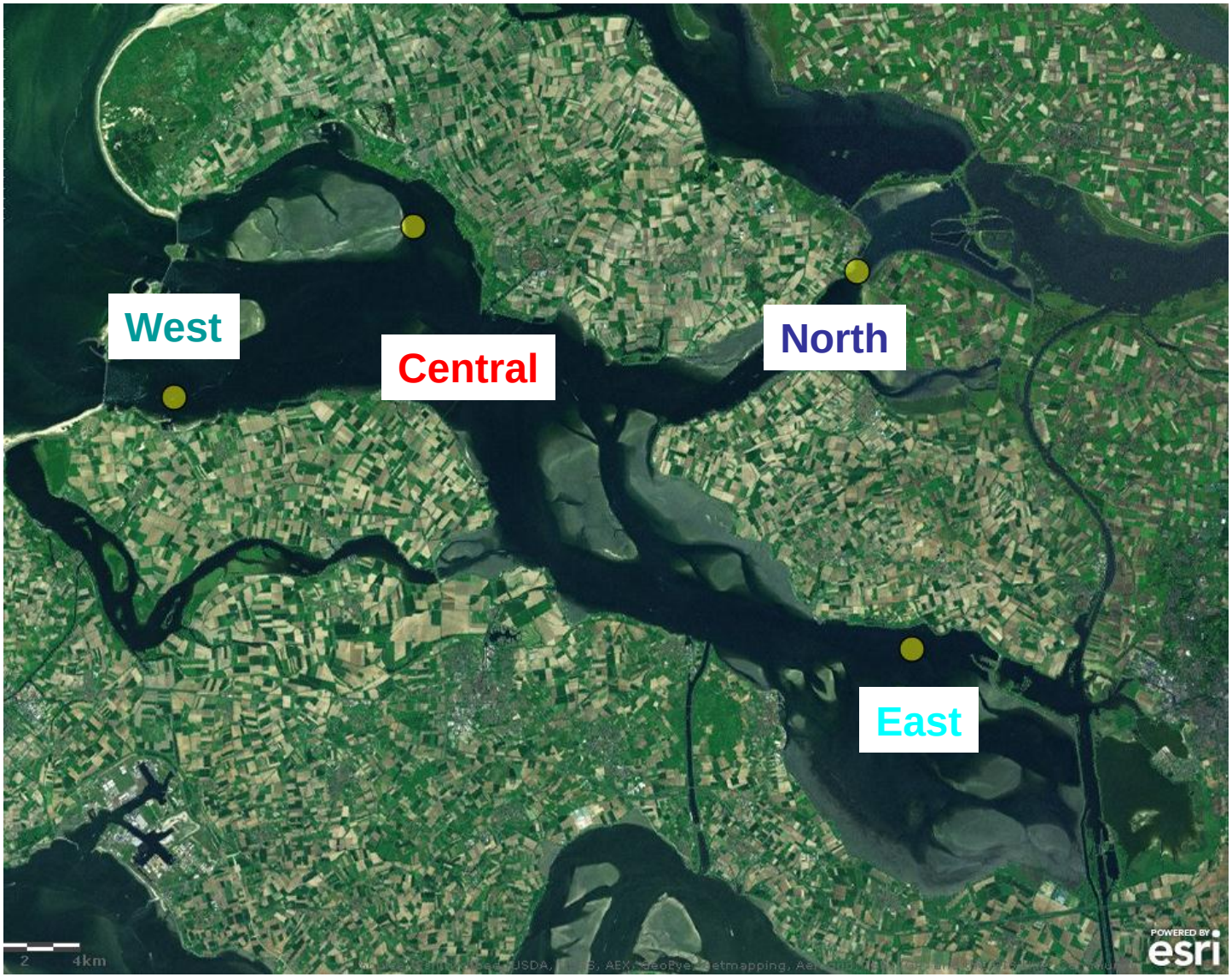
Evaluation of monitoring data:

- Effects on nutrients?
- Effects on phytoplankton?



Oosterschelde after 1987

Deltares



North:
lowest salinity,
highest nutrients

North/East:
longest residence time

Monitoring
salinity, nutrients
chlorophyll-a
phytoplankton

frequency
monthly/bi-weekly

Deltares

North Sea sampling stations
- shallow waters (10-20 m)
- salinity 29-32

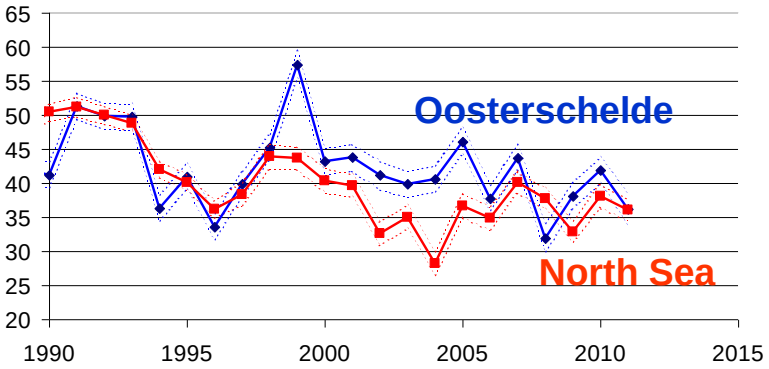
Monitoring
salinity, nutrients
chlorophyll-a
(1988-2011)

phytoplankton
(1990-2007)

frequency
monthly/bi-weekly

Deltares

Nutrient concentrations (standardized for salinity)

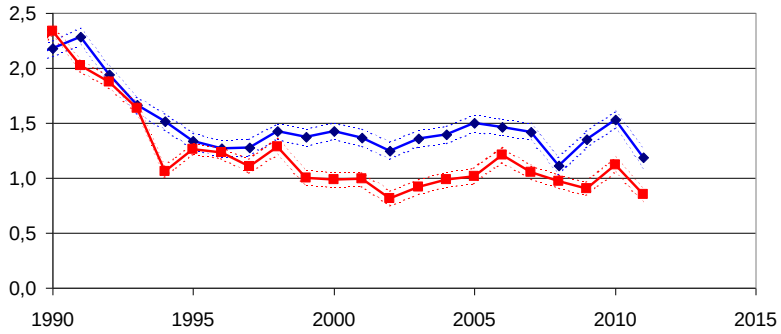


Concentration changes following eutophication measures

DIN

North Sea

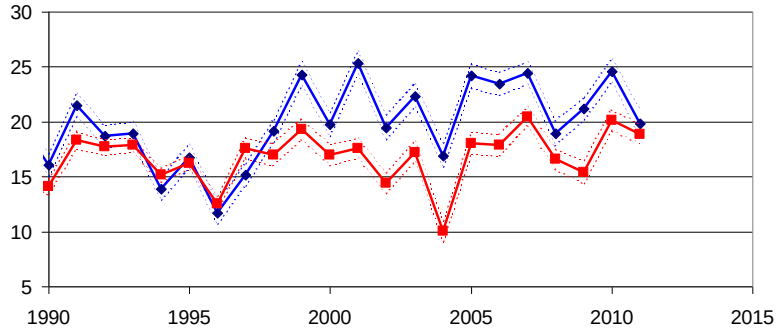
decrease in concentration 30%



PO_4

North Sea

decrease in concentration 60%



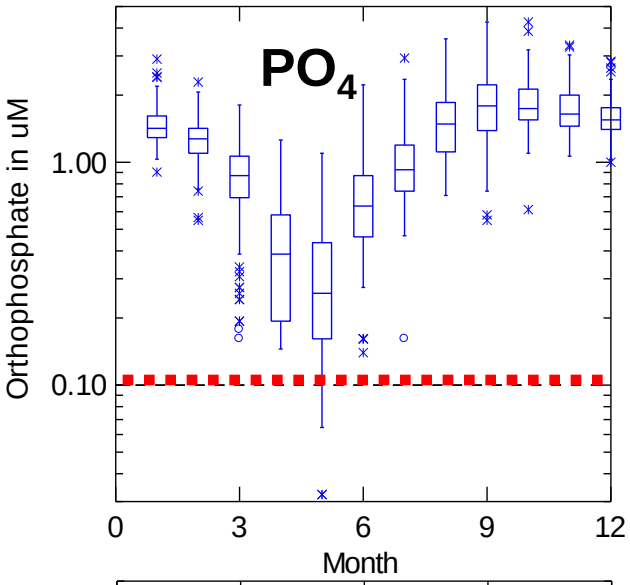
SiO_2

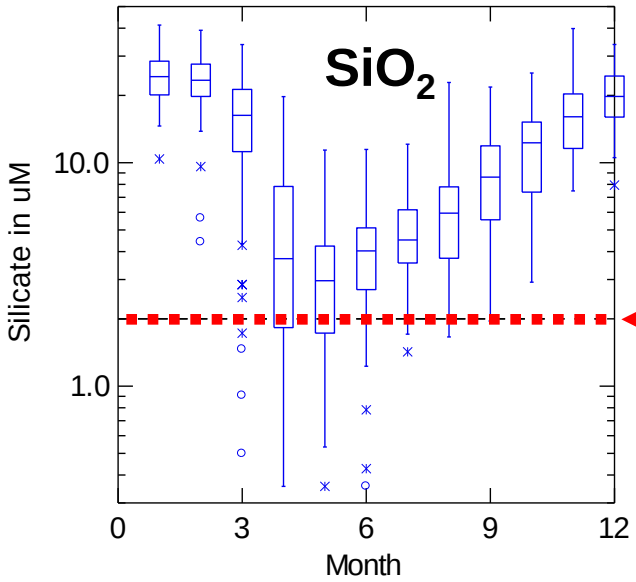
North Sea

Increase in concentration 30%

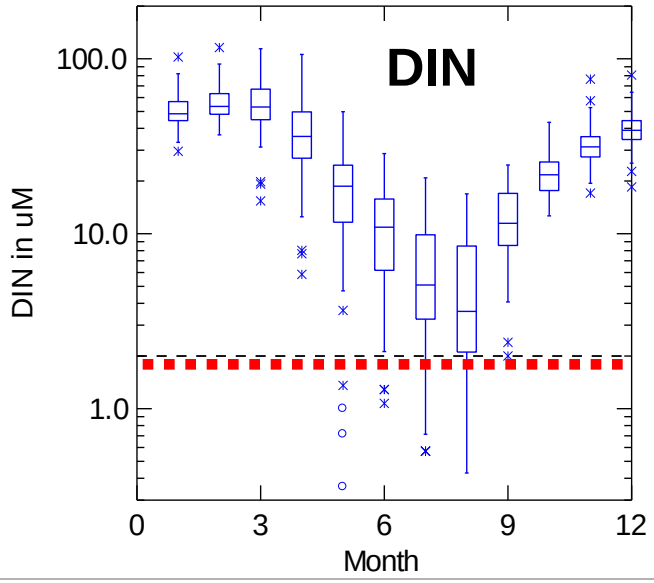
Deltares

Oosterschelde nutrient concentrations 1990-2011





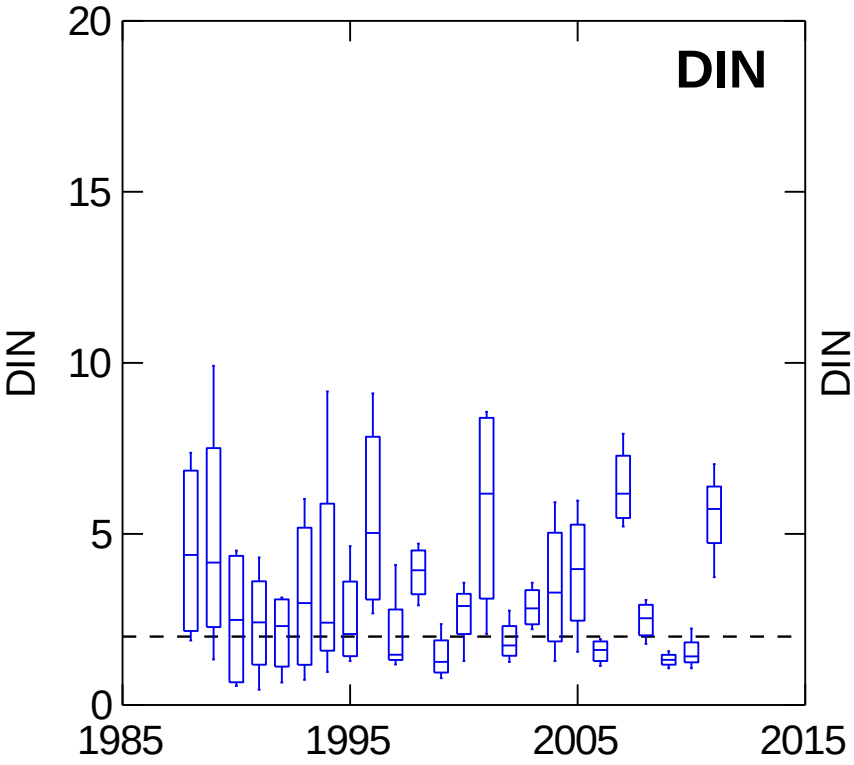
Nutrient limitation



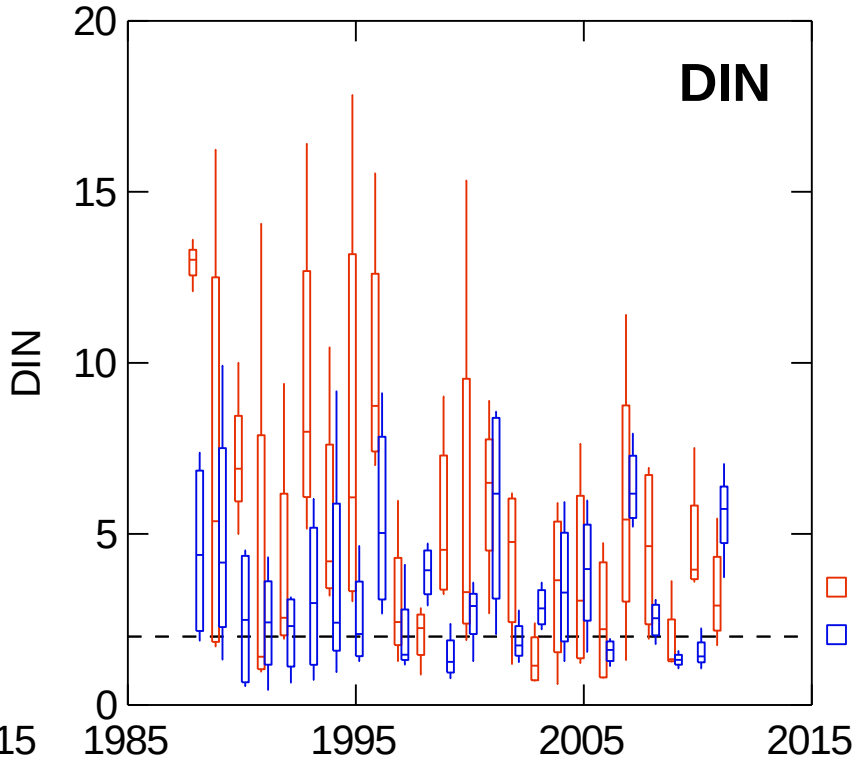
Spring: Si limitation
Summer: Si/N limitation

Deltares

Dissolved inorganic nitrogen
10-percentile values



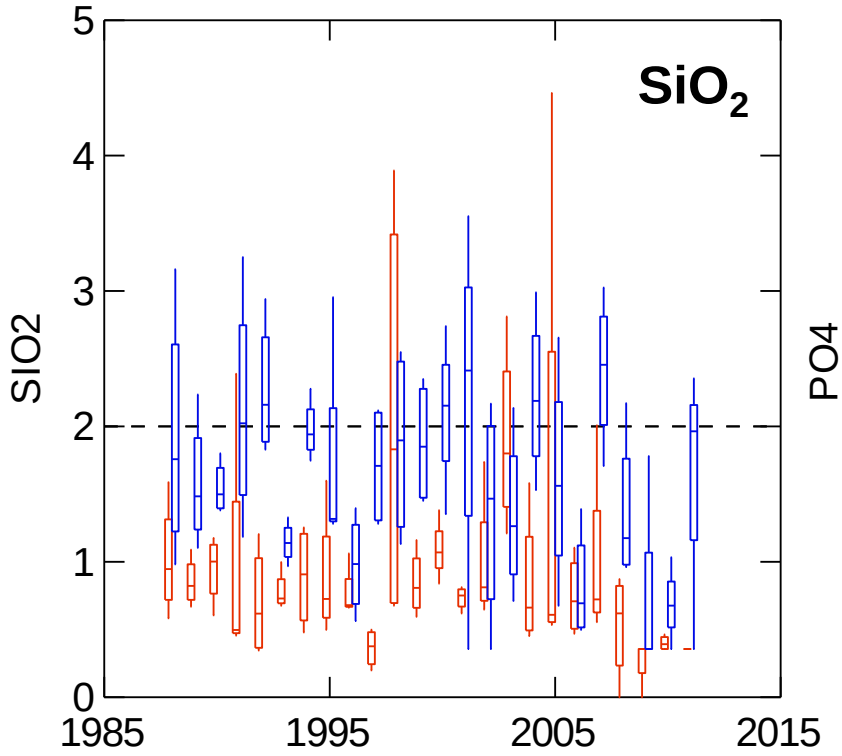
Oosterschelde:
No trend 1988-2011

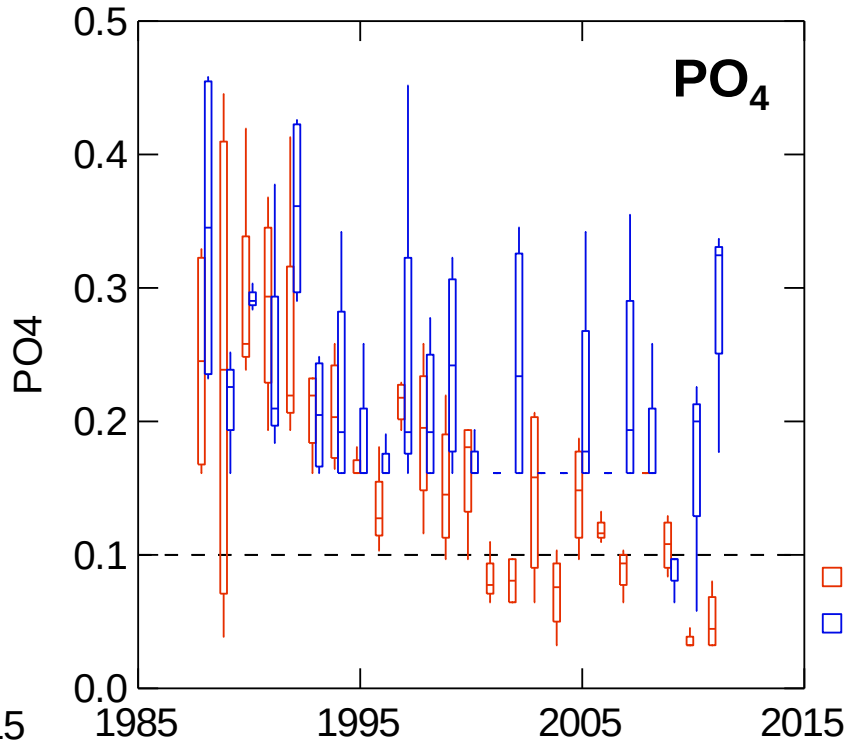


North Sea:
Decrease in concentration
Increased chance of N-limitation

Deltares

Silicate, phosphate
10-percentile values



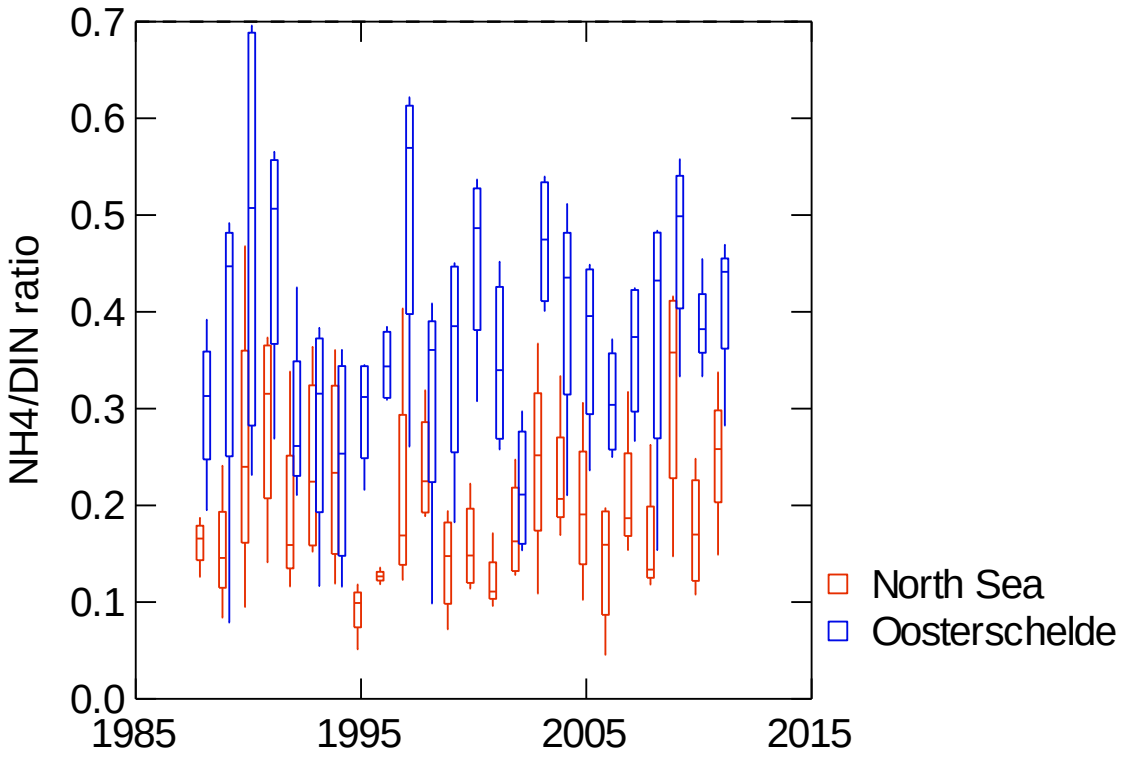


Oosterschelde / North Sea:
No trend
Stronger Si-limitation in North Sea

Oosterschelde / North Sea:
Decreasing concentrations
North Sea: increased chance of P-limitation
Oosterschelde: no limitation

Deltares

NH_4/DIN ratio



Deltares

Nutrient limitation 1988-2011

<u>Oosterschelde:</u>

•decreases in N and P concentrations

- no clear increase in N- or P-limitation in Oosterschelde

• increase in Si concentrations

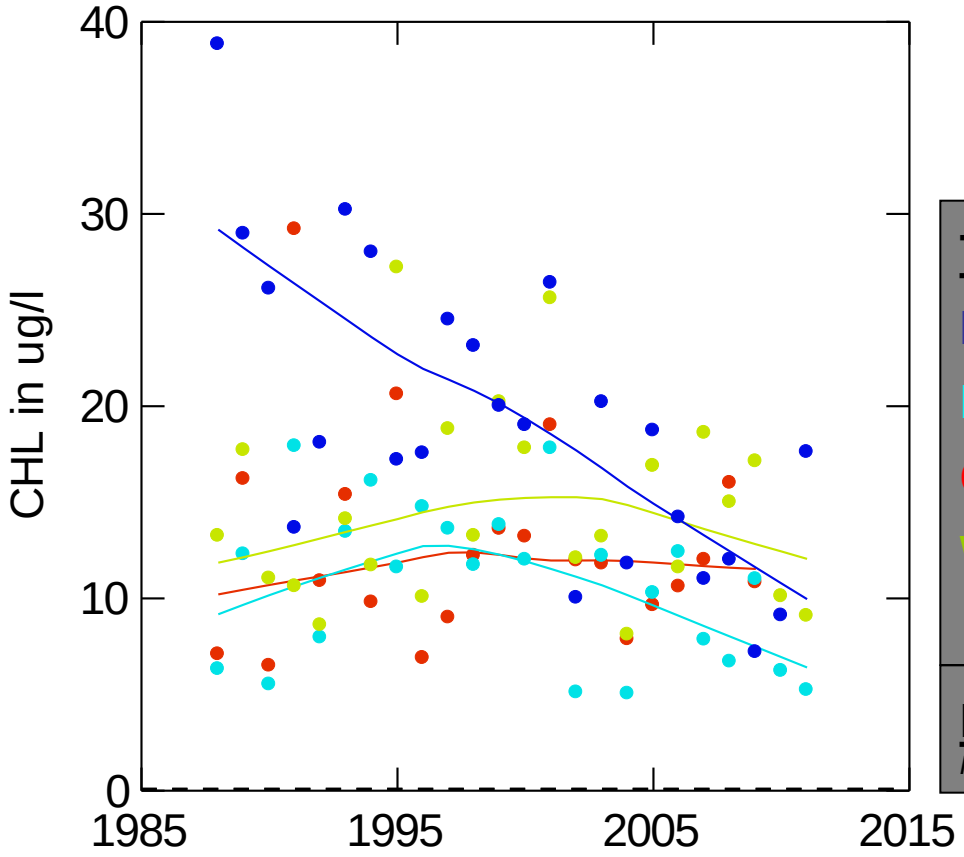
- no clear decrease in Si limitation

<u>North Sea:</u>

•potentially stronger Si/P limitation

Deltares

Chlorophyll



Trend analysis: 1990-2011

North: decrease 51% *

East:decrease 57% **

Central: no trend

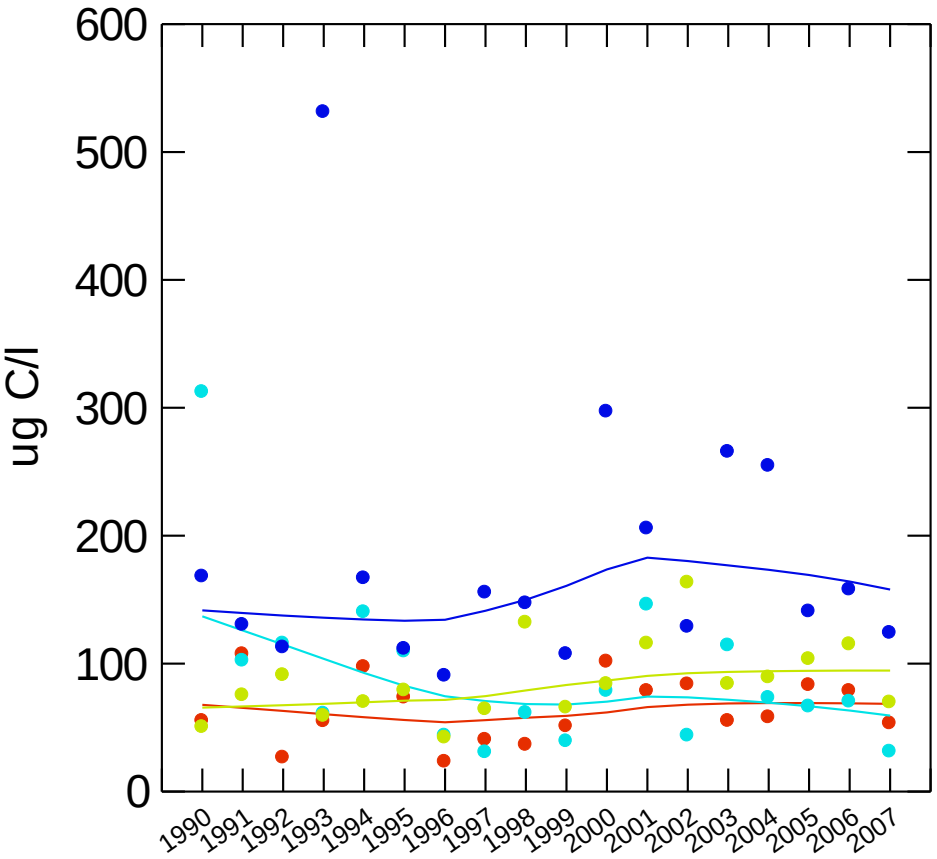
West: no trend

North Sea: no trend

Prins, Desmit & Baretta-Bekker, in press

Deltares

Dlatom biomass



Trend analysis: 1990-2007

North: no trend

East: no trend

Central: no trend

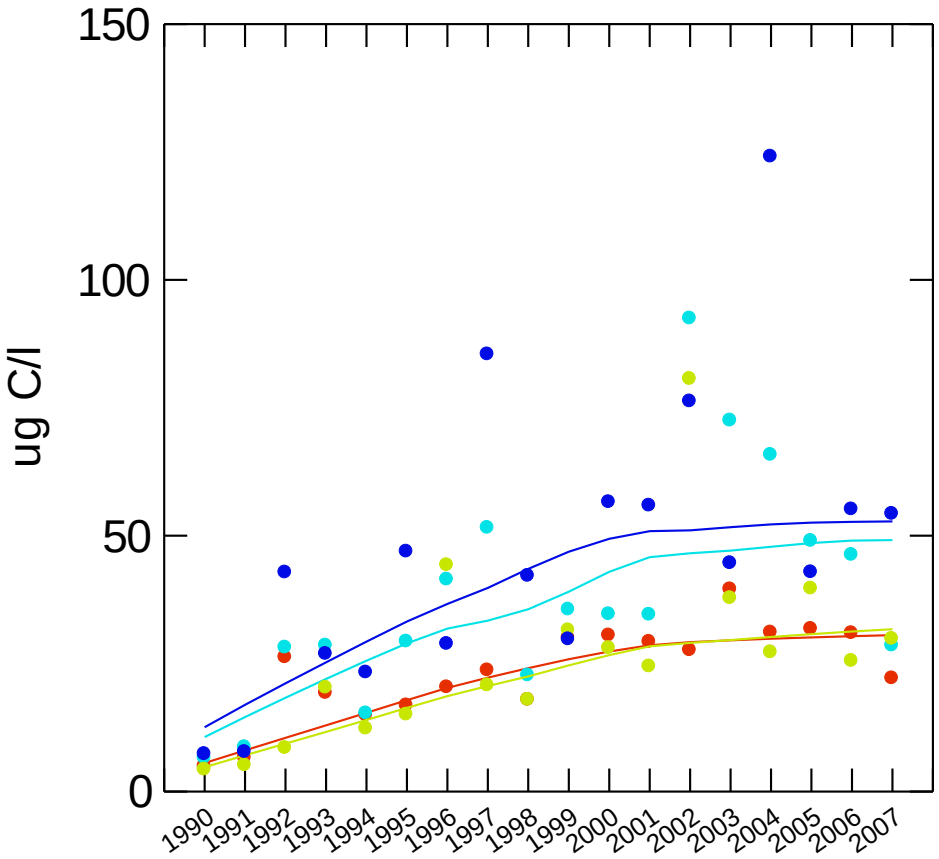
West: increase *

North Sea: increase (100%)

Prins, Desmit & Baretta-Bekker, in press

Deltares

Flagellate biomass



Trend analysis: 1990-2007

North: increase **

East: increase **

Central: increase ***

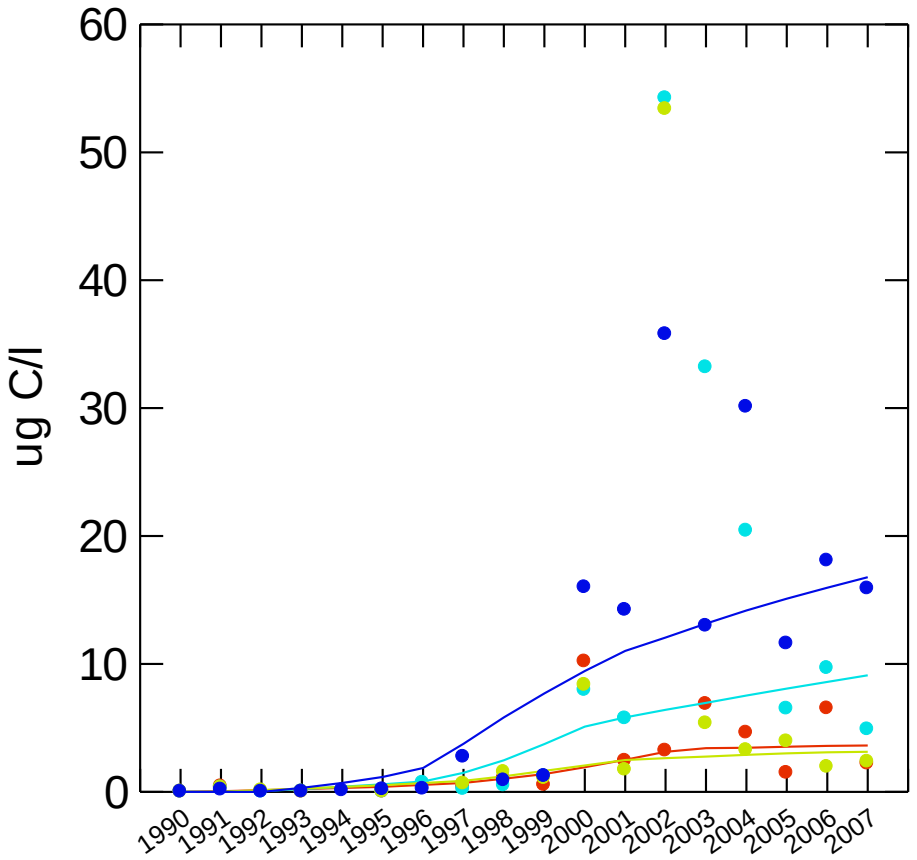
West: increase **

North Sea: no trend

Prins, Desmit & Baretta-Bekker, in press

Deltares

Nannoflagellate (< 4 um) biomass



Trend analysis: 1990-2011

North: increase ***

East:increase ***

Central: increase **

West: increase **

North Sea: no trend

Prins, Desmit & Baretta-Bekker, in press

Deltares

Conclusions

Despite changes in nutrient loadings

- No clear changes in nutrient availability
  - Role of internal nutrient cycling / shellfish populations?

- Shift in phytoplankton composition
  - Higher biomass of flagellates
    > Si limitation of diatoms?
  - Higher biomass of nanoflagellates
    > Overgrazing?

- Improve the carrying capacity of the Oosterschelde
  - Reduce stocks or increase nutrient loads?