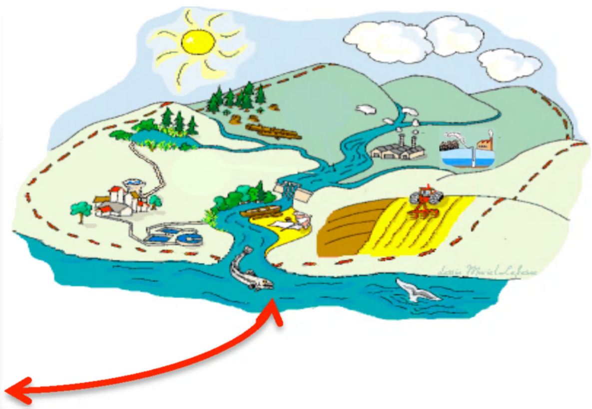
Cultural eutrophication in the Greater North Sea
Cause, symptoms, mitigation



How can science guide ecologically-relevant and economically sustainable decisions ?

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esa

CONTENT

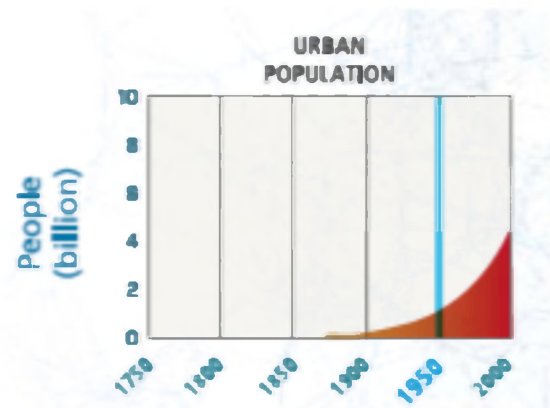
I-The Global Eutrophication Context

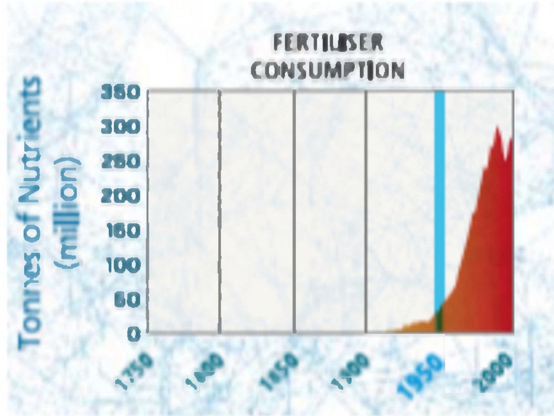
- ✓ Global trends in nutrient loads
- ✓ Mechanisms behind eutrophication
- ✓ Undesirable effects

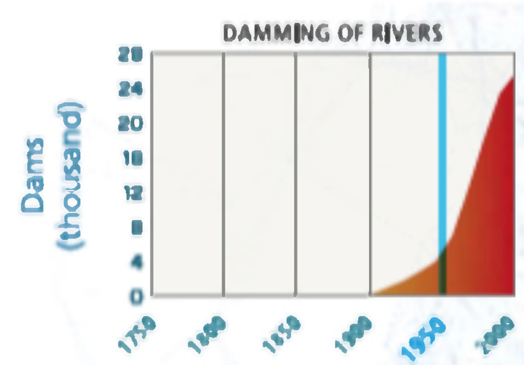
Global Nutrient Loads

Since 1950: the Great Acceleration: a connected global system

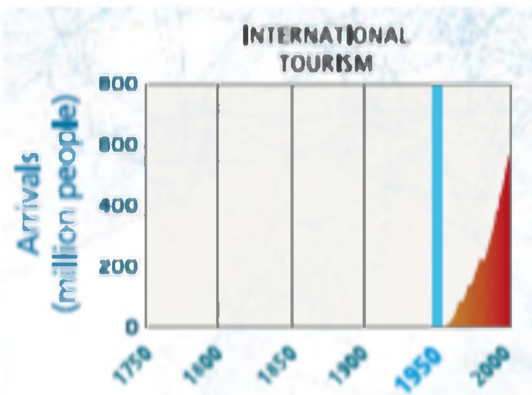
population * socio-economy * green revolution

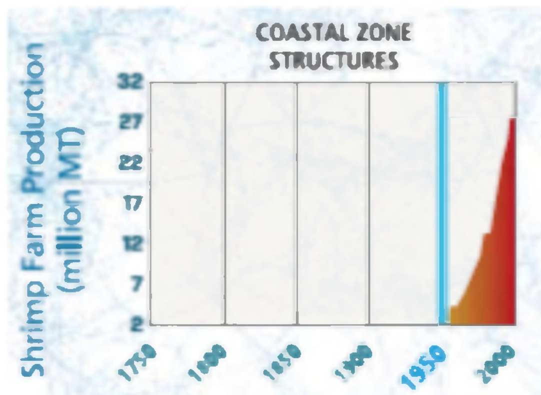


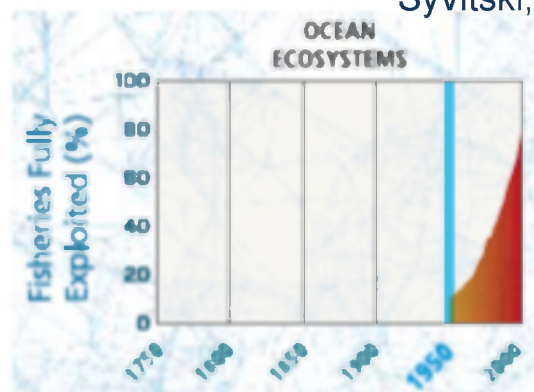




Syvitski, 2012







As a consequence:

Global increase of N (18%), P (13%) river inputs — Seitzinger et al. 2010

Global retention (18%) of Si — Beusen et al., 2009

Exacerbated by release from growing aquaculture, atmospheric and groundwater inputs

Cultural Eutrophication

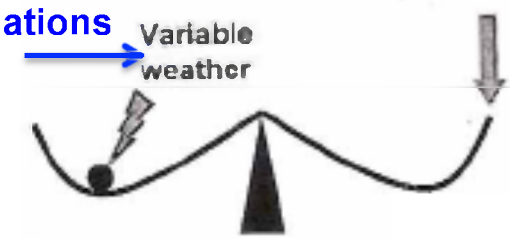
Modification of the natural N:P:Si balance of coastal waters towards N and P excess ➔primary production ↗

Undesirable if this nutrient excess appreciably degrades ecosystem health and/or the provision of goods and services

MSD-TG5 report 2010; Fereira et al. 2011

DESIRABLE

Interannual variations



Nutrient loads

Total N, P: ↗

Si: ≈ or ↘

Change in coastal N:P:Si nutrient status

UNDESIRABLE

HABs (high-biomass, toxic…)

Hypoxia/anoxia

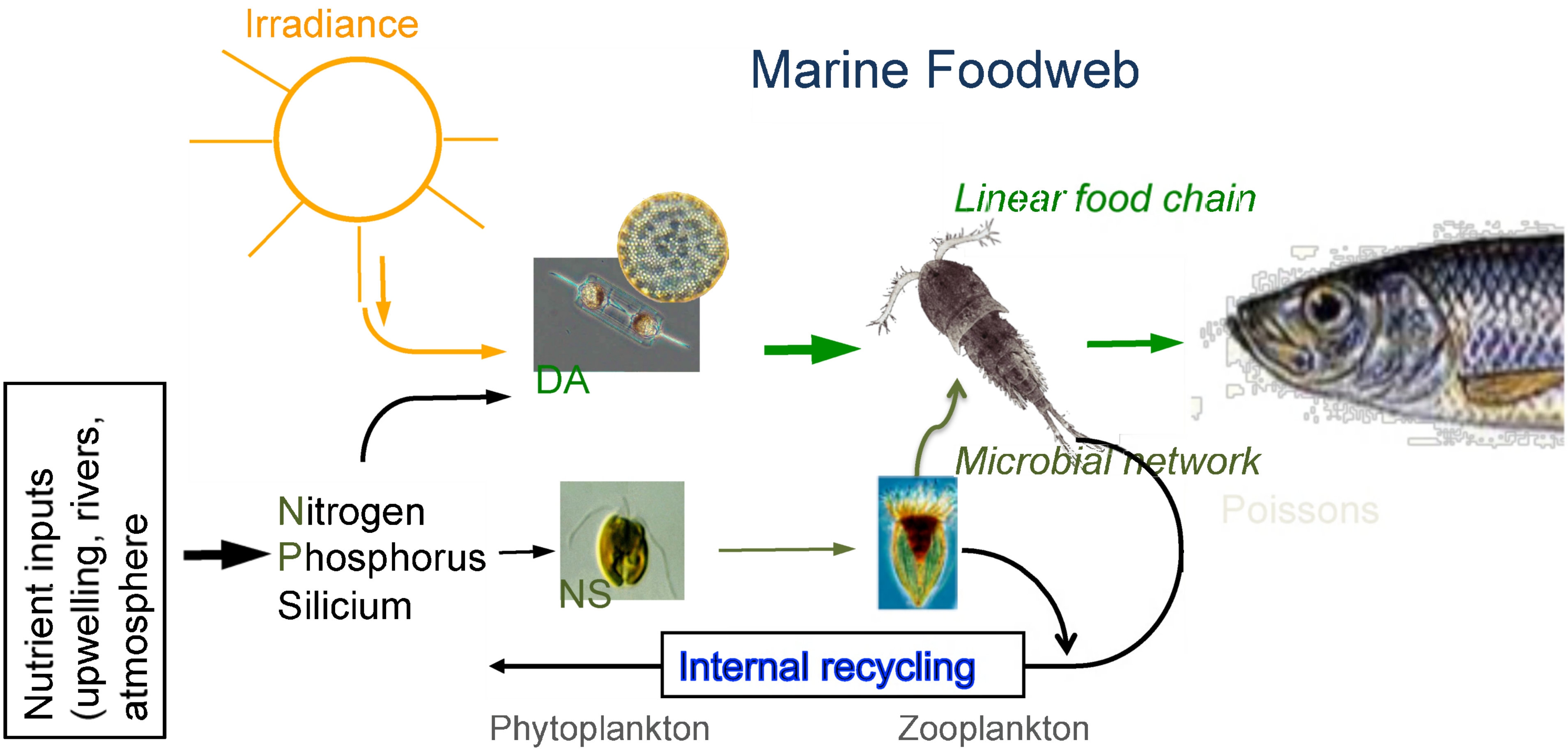
Benthic/pelagic species shifts

…

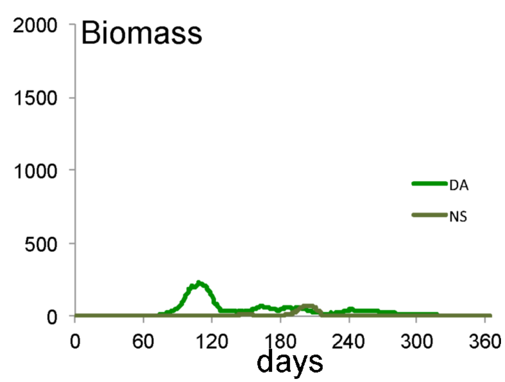
Different symptoms !

The functioning of Marine Ecosystems

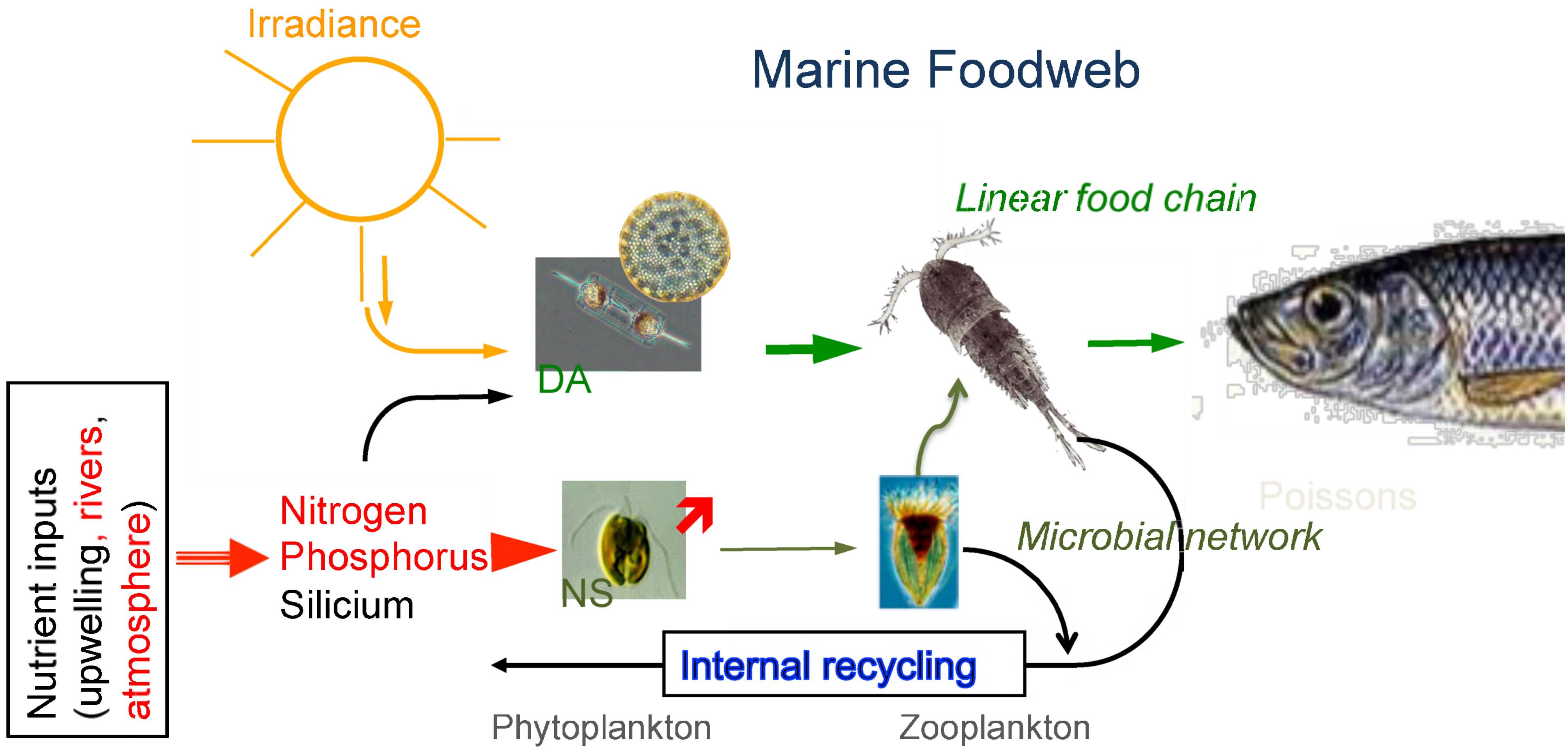
Marine Ecosystem: Generic Process



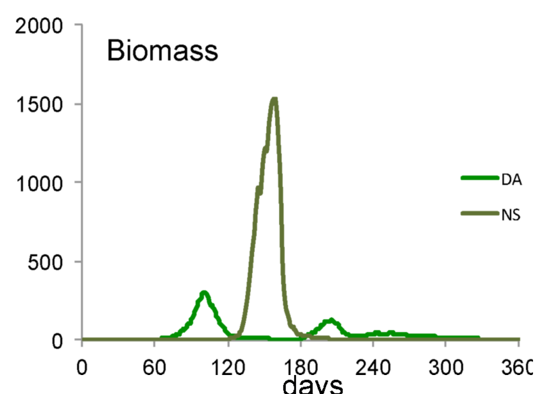
<u>Pristine</u>
N:Si:P=16:16:1
phytoplankton pattern
Dominated by DA

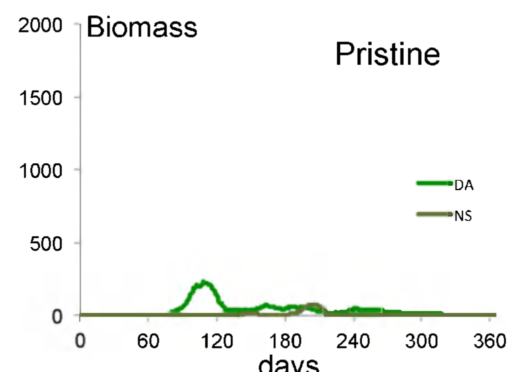


Cultural eutrophication: Generic Process



Eutrophied phytoplankton pattern





Undesirable symptoms of eutrophication: HABs

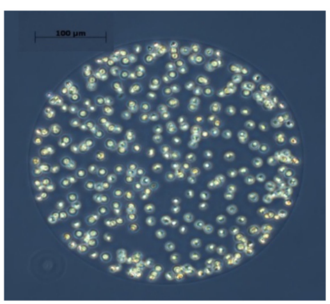
Foam deposits

Algal deposit & H_2S release

Fish mortality

Shellfish poisening

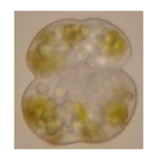
High-biomass HABs



Phaeocystis globosa

Ulva

Toxic HABS

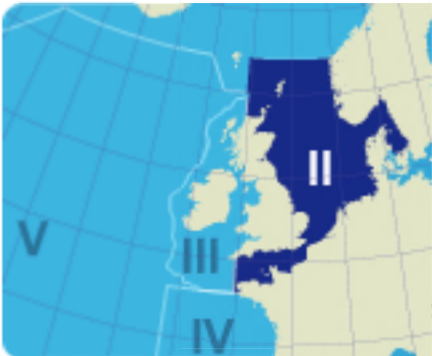


Karenia mikimotoï

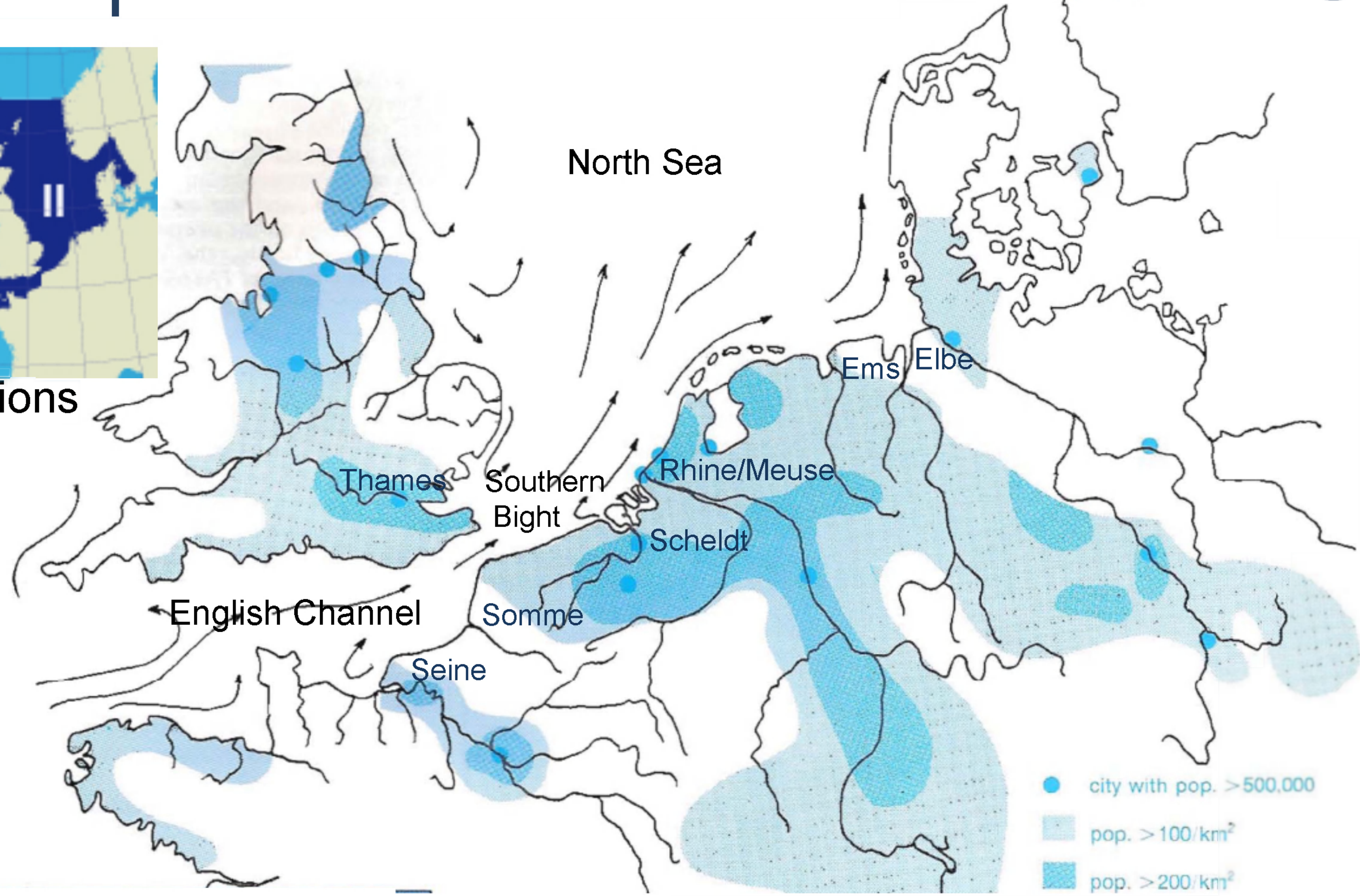
Pseudo-Nitzschia

Dinophysis

II-Eutrophication in the Greater North Sea



OSPAR regions



- ✓ Historical key dates
- ✓ Nutrient sources today
- ✓ Eutrophication symptoms

Eutrophication in the greater North Sea: key dates

✓ 1950-1970

Great Acceleration

✓ After 1970

Eutrophication symptoms

Environmental awareness

✓ 1975-1991

Governance (OSPAR, HELCOM)

Combination of professional judgment and political art :e.g. 50% ➘1985 N and P loads

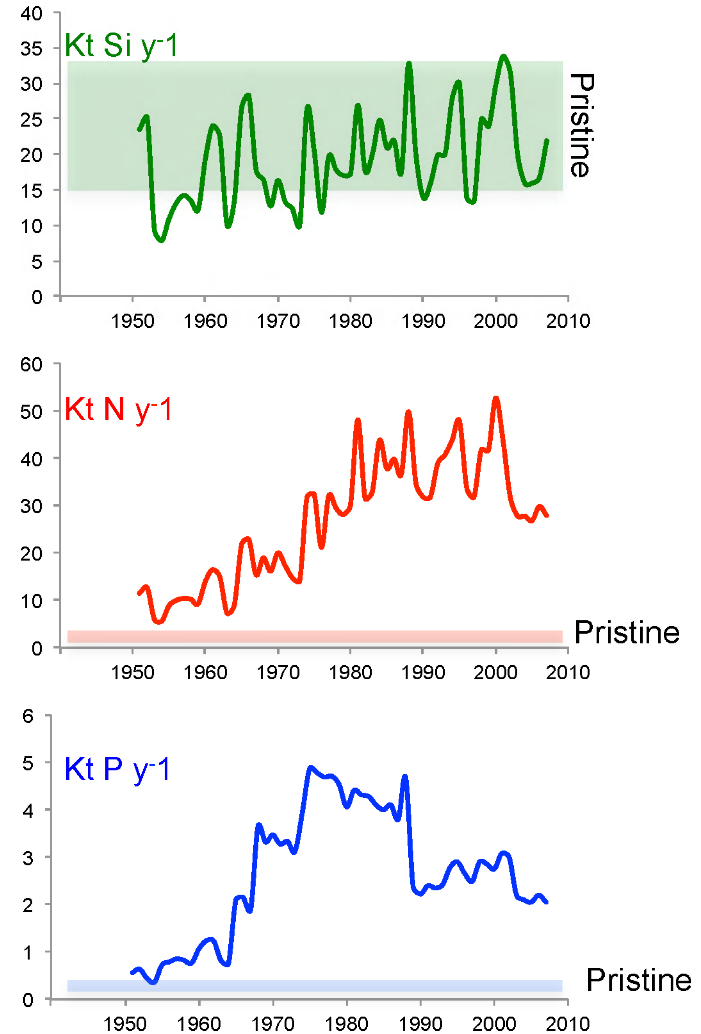
First EU Directives (WWT, Nitrate)

✓ Since 2000 (WFD and MSD)

Awareness of the 'land-sea' connectivity, regime shifts, thresholds, points of non-return ➔ Ecological Quality Objectives.

Sustainable coastal sea.

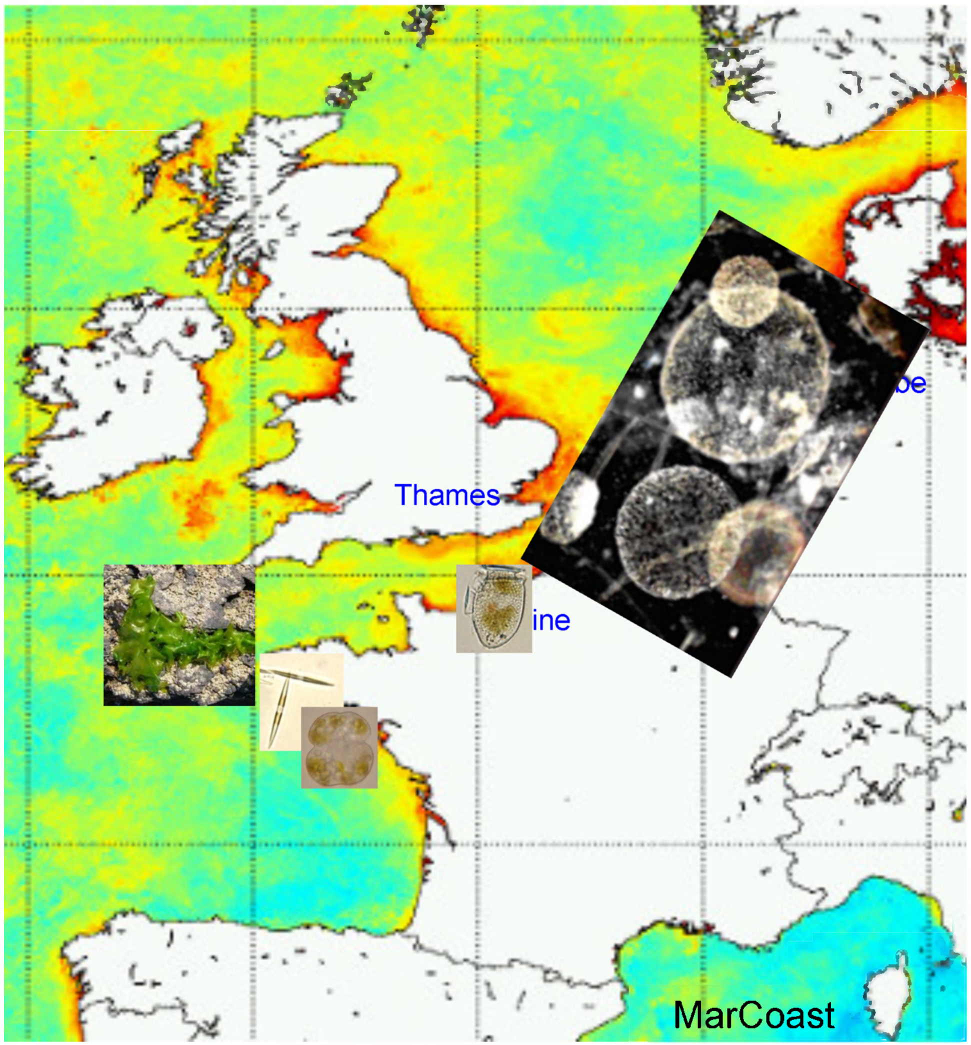
Nutrient river load
e.g. River Scheldt



Model reconstruction after Lancelot et al., 2007; Passy et al., 2013

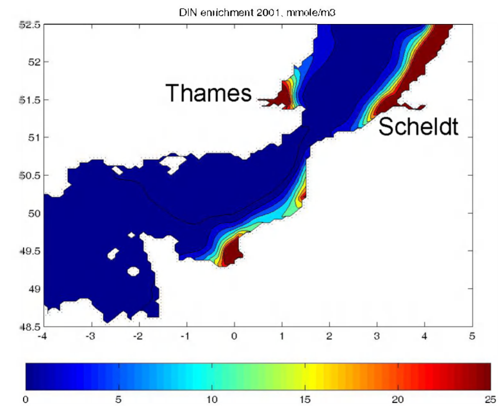
Eutrophication in the greater North Sea: current status

Ocean color 2011



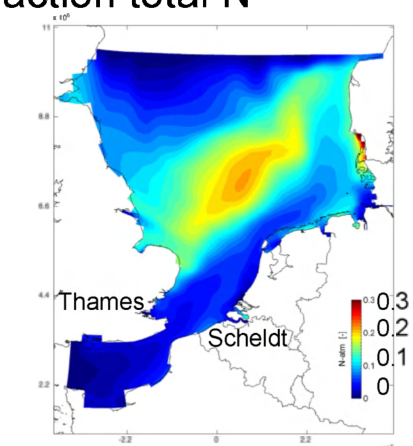
Nutrient enrichment

Winter nitrate concentration



Lancelot et al., 2014

Atmospheric deposition fraction total N



Troost et al., 2013

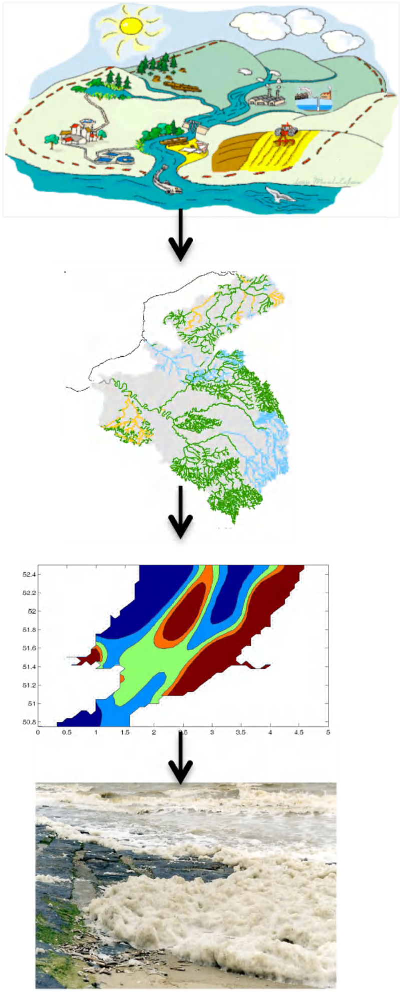
Same causes but distinct blooms

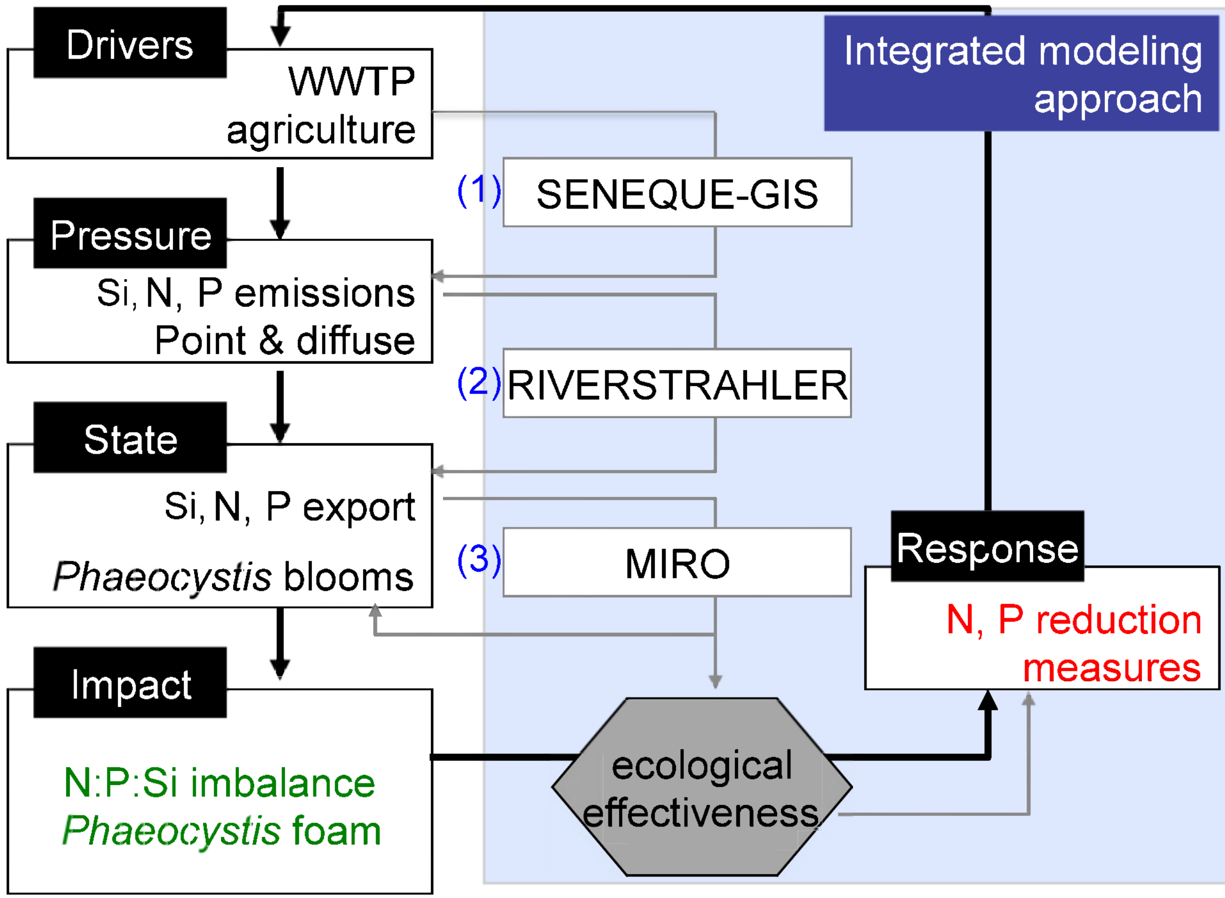
III-Science Support to Combat Eutrophication

What can be done to improve the situation and how can we appraise mitigation actions ?

- ✓ Integrated Impact Assessment Pathway/toolkit
- ✓ Case study: *Phaeocystis* blooms

Impact Assessment Pathway:integration of coupled biogeochemical models in a DPSIR loop

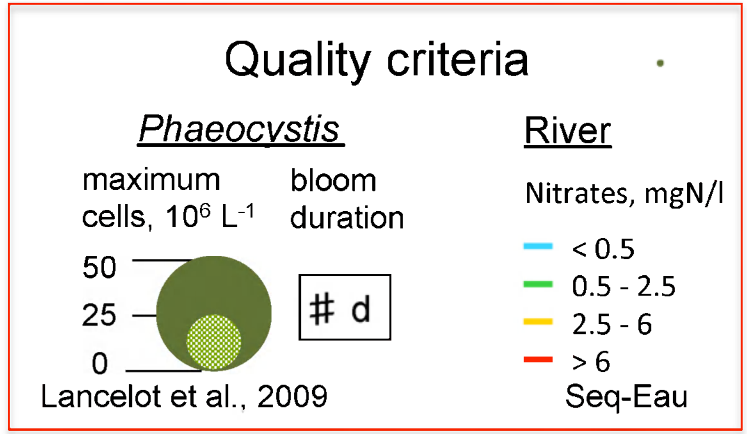




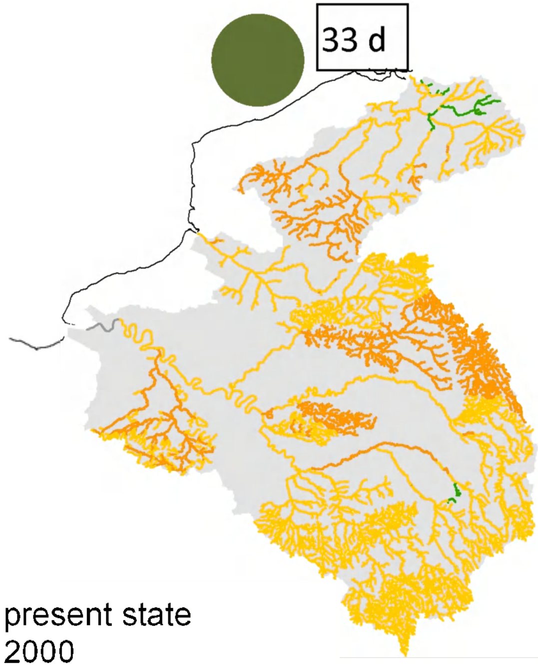
Lancelot et al., 2011

(1) Ruelland et al. 2007; (2) Billen and Garnier 1999; (3) Lancelot et al., 2005

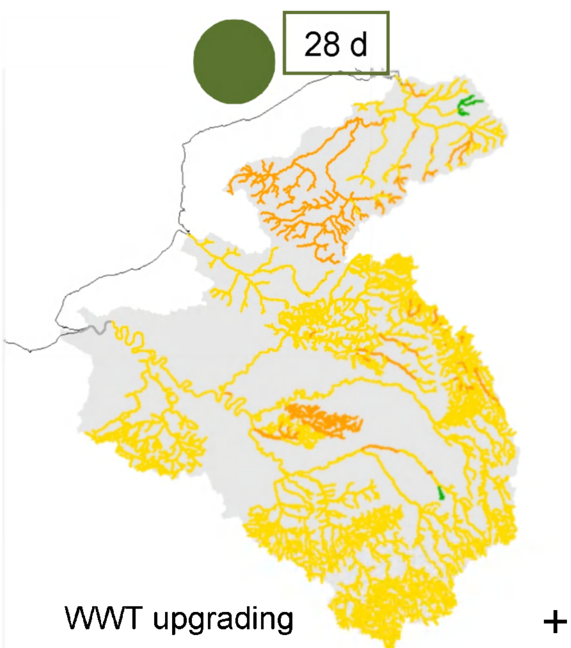
Some possible scenarios



Garnier et al., 2012

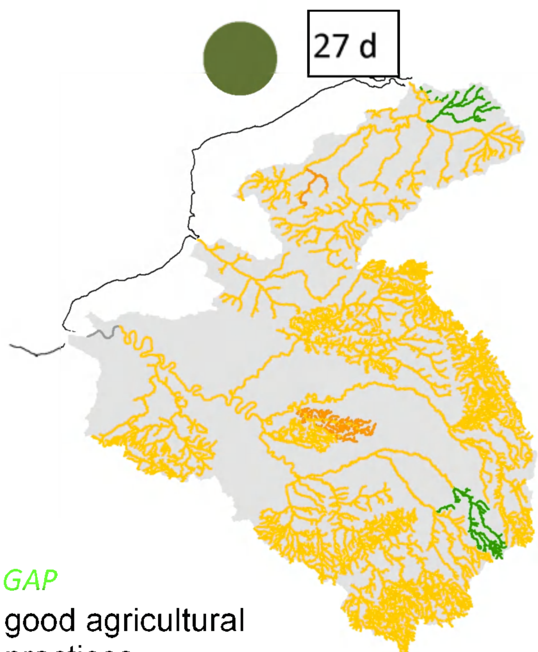


present state
2000



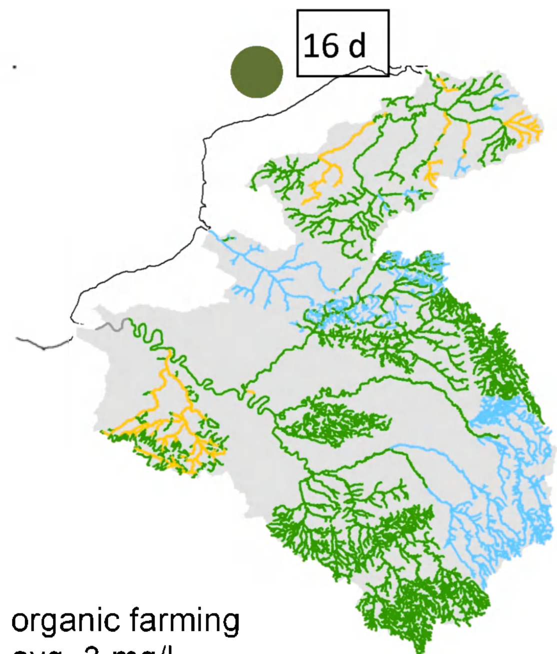
WWT upgrading

+



GAP
good agricultural practices

+



organic farming
avg. 3 mg/l

Overall conclusion and futuring

The fact

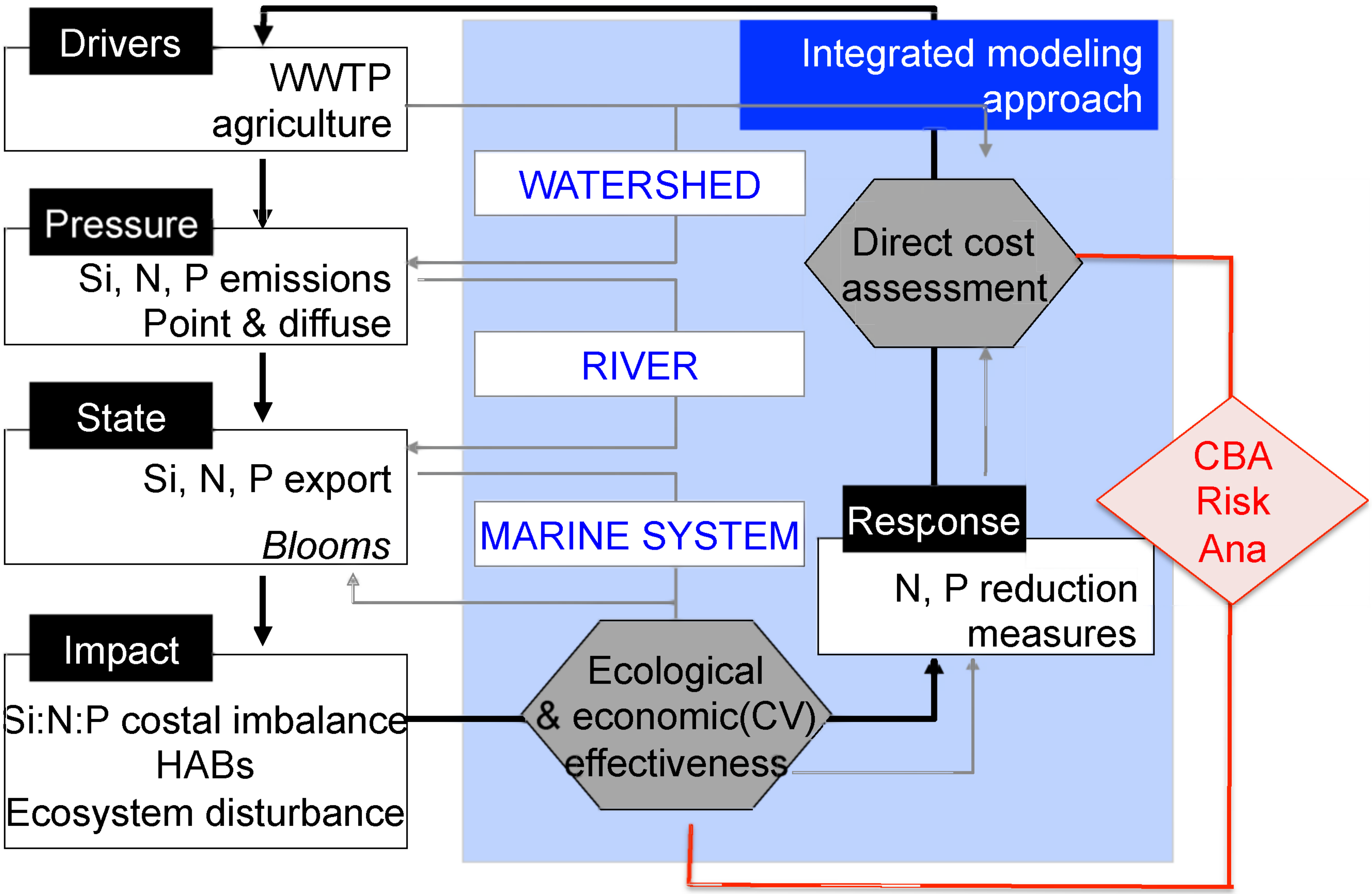
Human activity is modifying the quantity and quality of nutrients (N, P, Si) delivered to the coastal sea;

This N & P enrichment has boosted non-diatom species often undesirable/harmful;

Most attempts to reducing N & P loads have not decrease coastal problems because of end-of-pipe solution choice rather than acting on the NUE (nutrient use efficiency) process.

Towards solutions: de-eutrophication toolkit

- ✓ Interlinked suite of ecological and socio-economic models
- ✓ Scenario-driven approach: dialogue between science and society



Acknowledgements

EU FP6
Thresholds of Environmental sustainability

IAP TIMOTHY (**T**racing and **I**ntegrated **Mo**deling of Natural and Anthropogenic Effec**t**s on **Hy**drosystems (TIMOTHY) Case study:The Scheldt River Basin and Adjacent Coastal North Sea

AMORE (**A**dvanced **Mo**delling and **R**esearch on **E**utrophication)

EU FP7
AWARE
Adaptative management: Increased connectivity between politic, science, public

Ecosystem **Mo**dels as **S**upport to **E**utrophication **M**anagement In the North Atlantic Ocean

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