NETHERLANDS INSTITUTE OF ECOLOGY

Coastal ecology in a changing world: can we provide the answers we promised?

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Promises, promises, problems?

- ‘Ecological quality’ as a yardstick for management
- Reference conditions
- Conflicting management goals
- Scientific problems in setting goals
- Where to go from here in coastal ecology?

Global constraints

- (LOICZ..)>Coastal ecological processes are high-intensity, biologically mediated transformers
  - -> determining (part of) global budgets (C, nutrients, sediment, water)
  - -> determining (part of) anthropogenic impact on global change
- Reverse: Global change (climate, sealevel,..) becomes important boundary condition for coastal ecological processes

Concerns at local-regional scale

- 70's: oxygen, chlorophyll, ammonium
- 80's: heavy metals, org. Contaminants
- 90's: Birds, habitats, 'goods and services'
- 00's: 'Good ecological quality'/ biodiversity
  + new substances

-> ecology evolved from 'understanding' to 'prescribing'

In quest of 'quality indicators'

- 1970's: eutrophication affects species composition

Species typology

- 1980's: estimate environmental pressure from communities

Community statistics

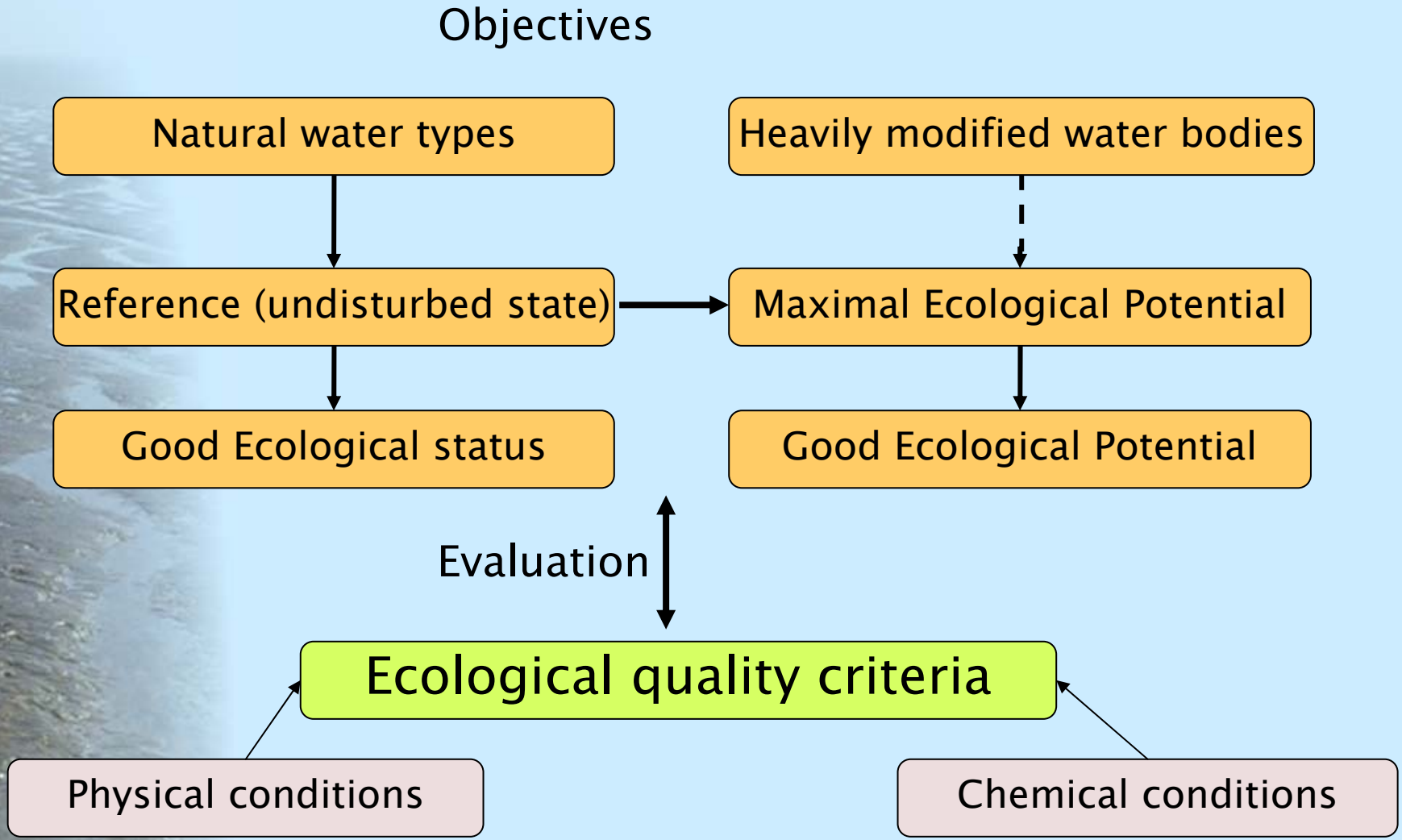
- 1990's: measure 'ecosystem health' ~ 'goods & services'

Biodiversity indicators

- 2000's: legislative and normative use of indicators

Complex normative indicator systems

Example: EU Water Framework Directive



Problems. I. ‘Reference conditions’

- ‘pristine conditions’ — Goethe
  - Romantic view
  - Mythical ‘nature without man’
  - Subject seeking to be overwhelmed by nature
- ‘optimally functioning ecosystem’ — Descartes
  - Mechanistic view
  - Nature as a ‘clockwork’, a complex adaptive system
  - Subject standing outside, observing, fostering
- ‘goods and services’ — Hume
  - Utilitarian view
  - Nature as a resource for human society
  - Subject as part of the system, with exploiting role

The romantic view – 'pristine' conditions

Once destroyed, pristine conditions are:

- Often undefinable
- Usually irrelevant for today's society
- Always out of reach (boundary conditions, global change)

BUT

- Attaches 'existence' and 'naturalness' values to habitats and ecosystems
- Provides room for the unexpected

The mechanistic view – optimal functioning

- Based on incomplete and changing concepts of ecosystem functioning
- Moving target with changing and unmanageable boundary conditions
- Complex and unsure

BUT

- Rational and (in principle) consistent
- Emphasis on autonomous functioning
- Distinction between target (ecosystem development) and management (boundary conditions)

The utilitarian view – 'goods and services'

- Difficult to value resources that have no value – i.e. no market value
- Goods and services only delivered by *exploited* systems
- Some goods and services delivered much better by 'the worst of ecosystems' (e.g. nutrient cycling in anoxic muds / fish by destroyed deep corals)

BUT

- System consistent with human societal values
- Multi-criteria optimisation possible
- Appealing currency

Problems. II. Indices

- Aiming to measure the distance between ‘reference’ and actual condition
- Need validation against real or modeled reference conditions
- Literature abounds with technical problems (algorithms, statistical properties, temporal variability,…)

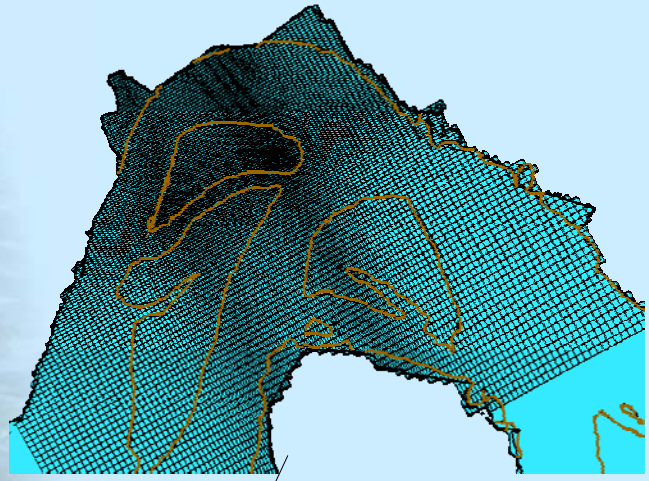
BUT

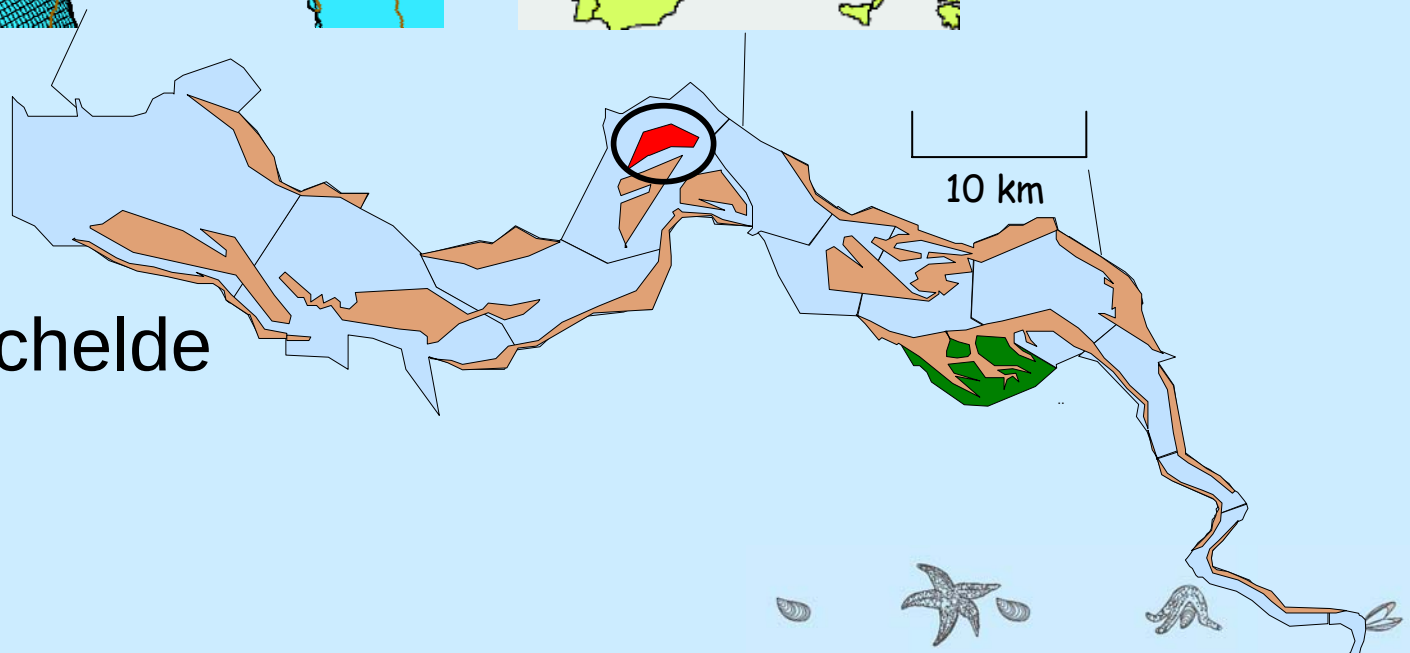
- Inherit problems from definition of reference conditions
- *Identification problem* is more important than validation/calibration problem

Problems. II. Indices

- Biodiversity and the 'precious wonders of nature'
  - Indices of diversity and species richness
  - Lists of rare and endangered species – carved in stone!
- Managing boundary conditions needed for 'ecosystem integrity'
  - Focus on ecosystem processes
  - Water quality indicators, functional groups, spatial structure
- Optimising values for human society
  - Centred on valuation of goods and services
  - Measures distance from actual condition to scenario optimising wealth creation *(sensu lato)*

Compatibility problems
ex. Molenplaat, Westerschelde

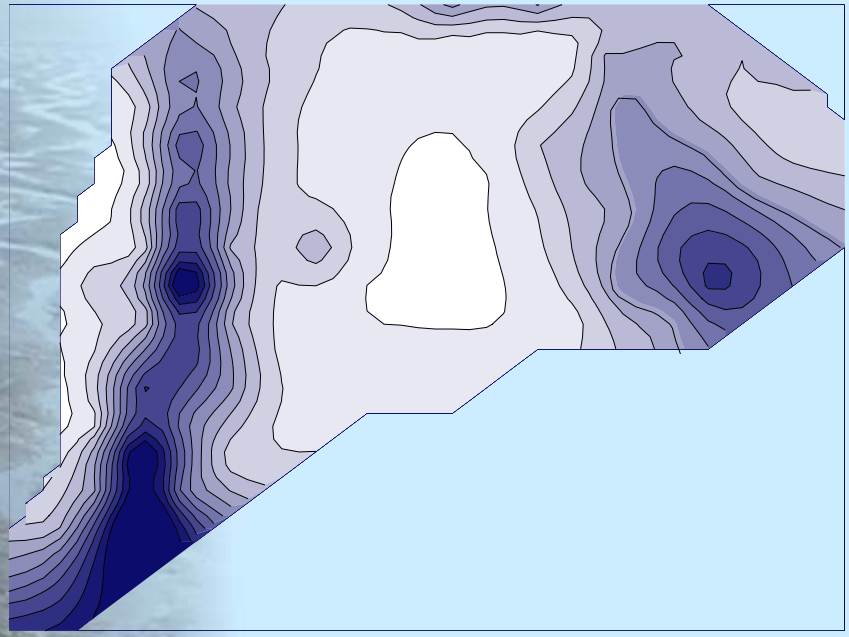




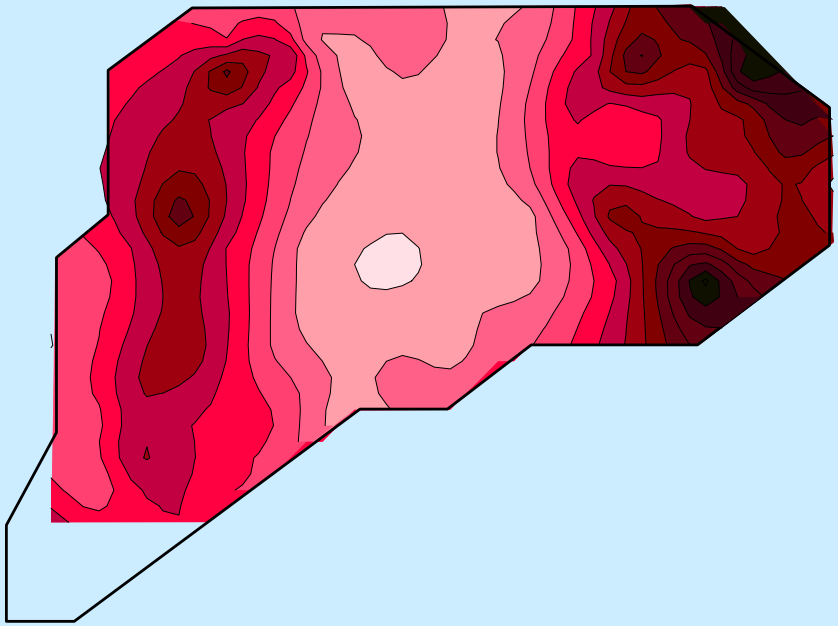
Westerschelde

Physics determine macrobenthos

Shear stress



Scores first axis CA

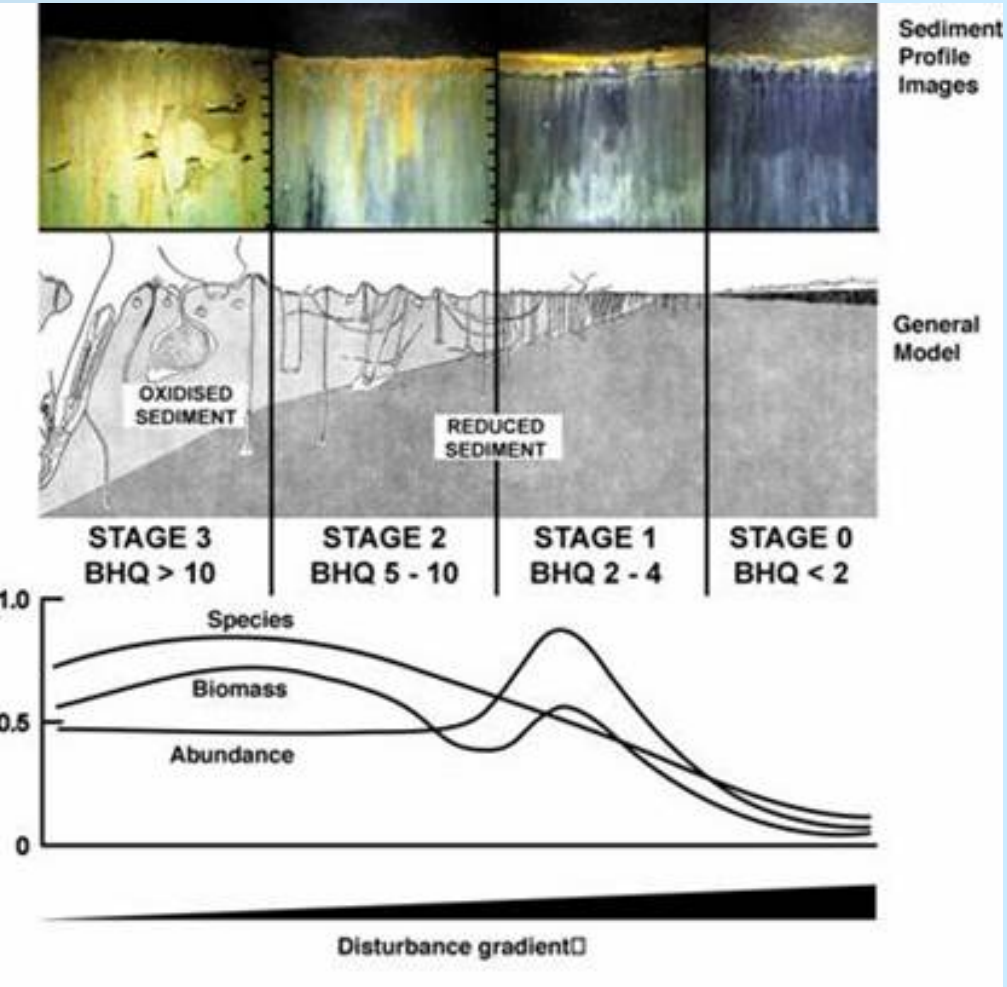


Dredging management

-> great emphasis placed on ‘physical integrity’

-> existence of spatial gradients essential for ecosystem functioning

Use of indicator species for sediment quality



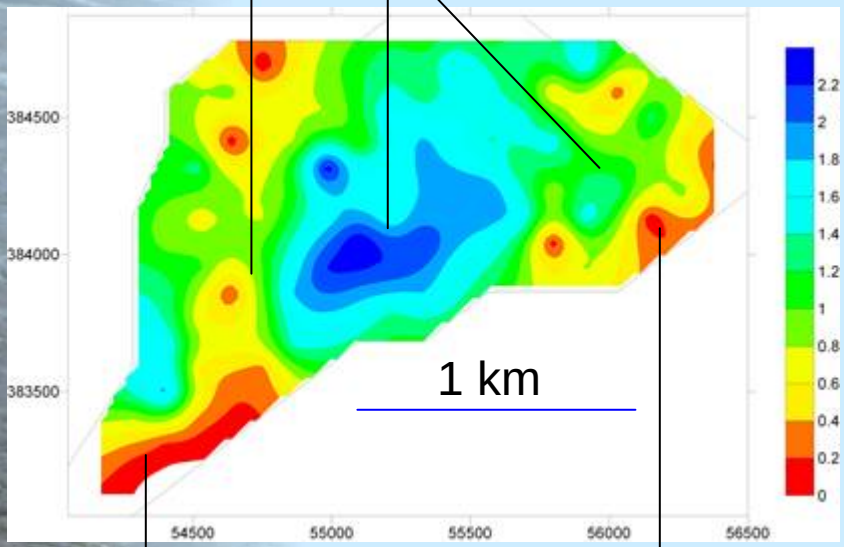
- Validated concept (Pearson & Rosenberg, Rhoads, ...) refers to r/K strategies
- REMOTS monitoring
- ABC method
- biodiversity-based methods
- response databasing methods

Nilsson & Rosenberg (2000)

Stress, biomass and biodiversity-based quality

sand ridges
mobile sediment
some Arenicola,..

high biomass
silty sand sediment
cockle, Macoma, Nerei

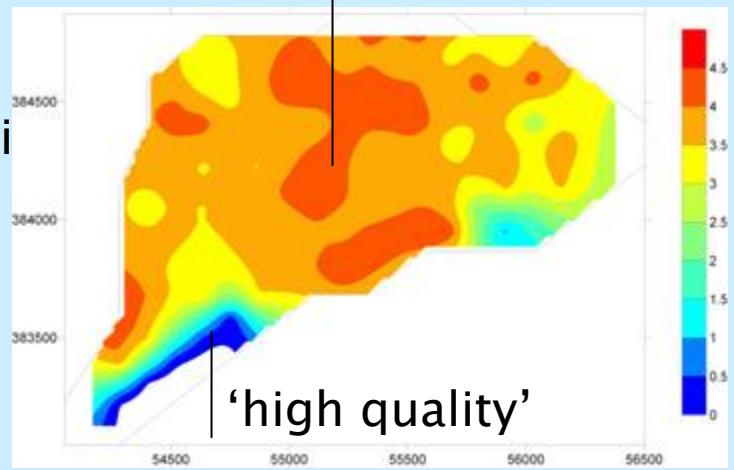


sand megaripples
very low biomass
Haustoriids, some
lost animals

(log) biomass

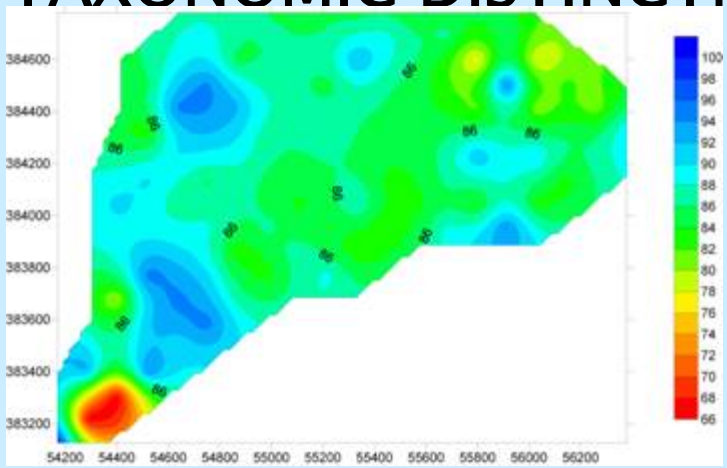
AMBI

'meanly polluted'



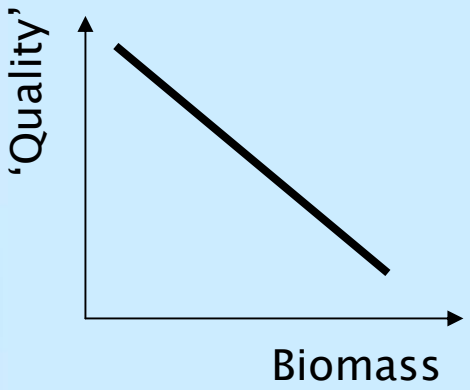
'high quality'

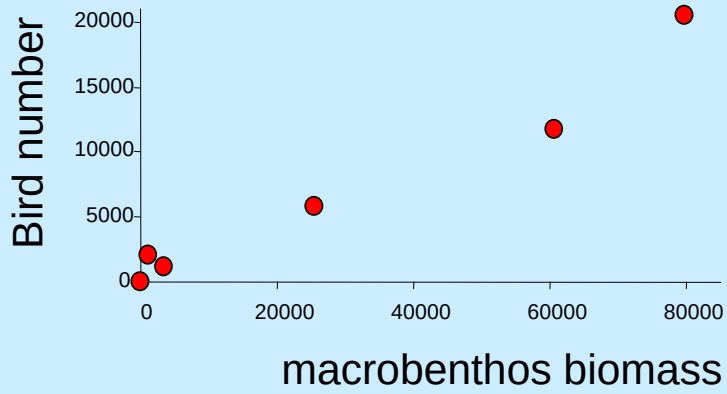
TAXONOMIC DISTINCTNESS



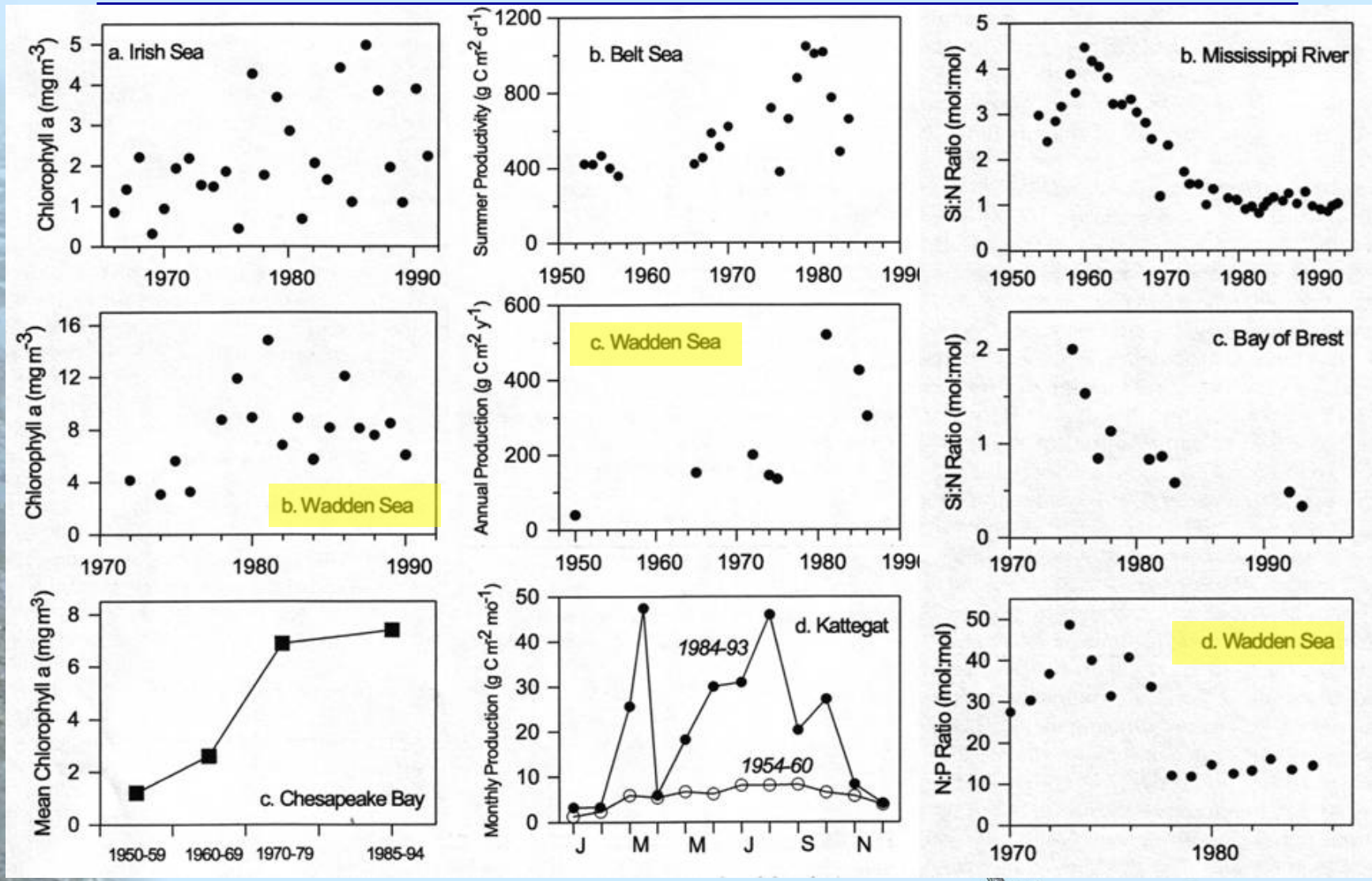
Incompatibility problems

- Biodiversity <> autonomous physical functioning
- Biodiversity <> Biodiversity



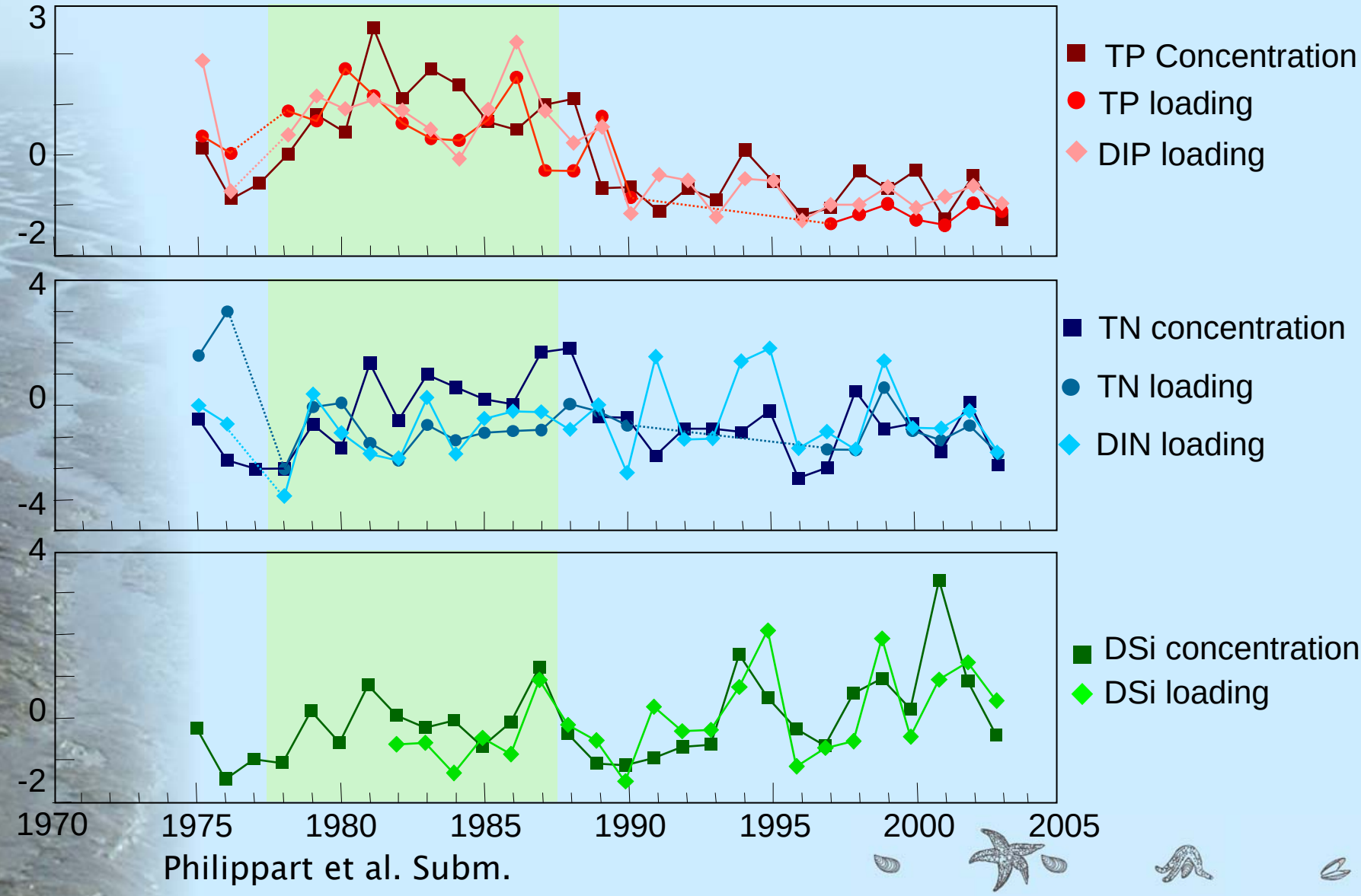


Biodiversity vs. Water quality indicators

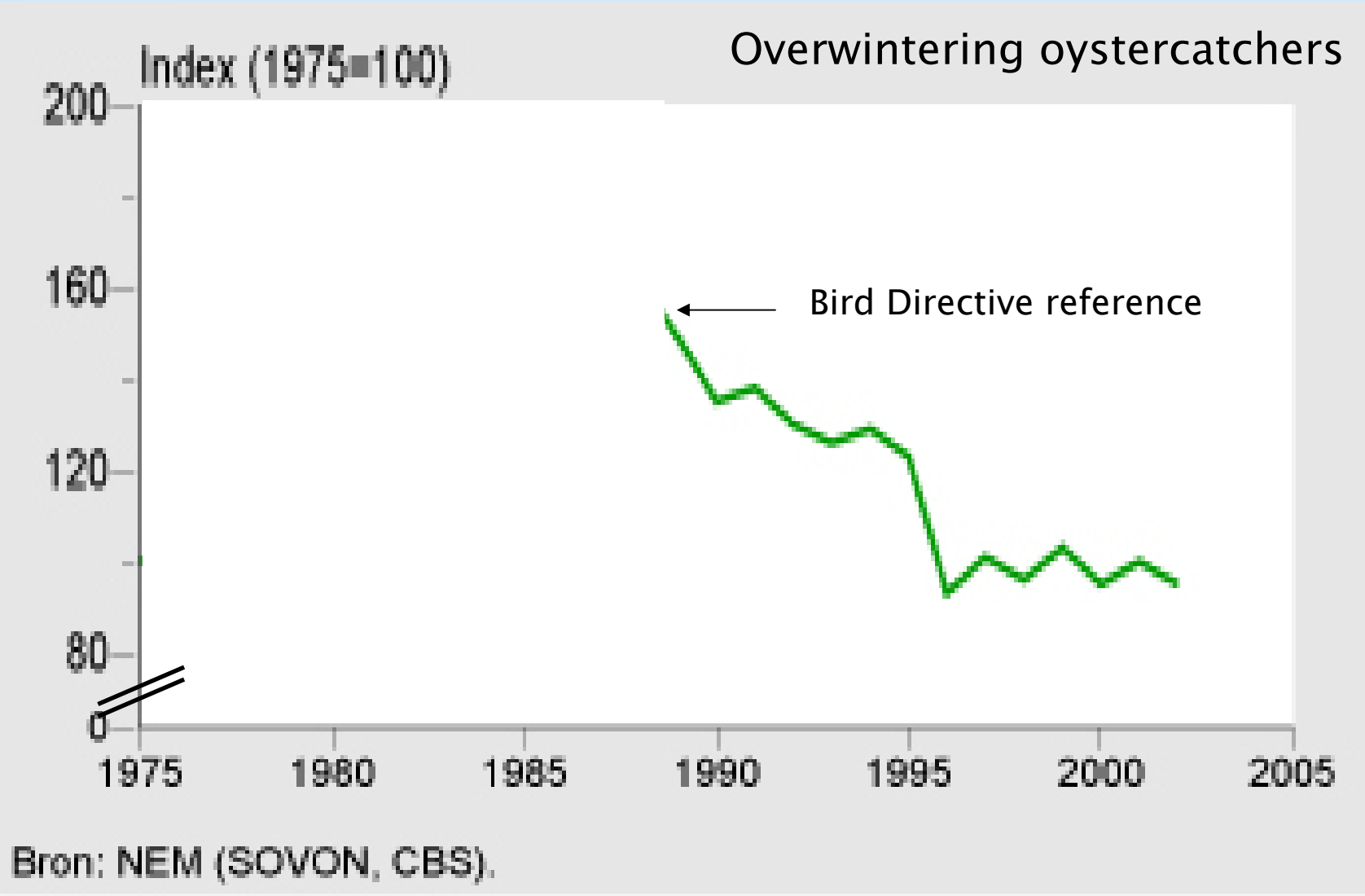


Cloern, 2001

Improvement in external nutrient loading

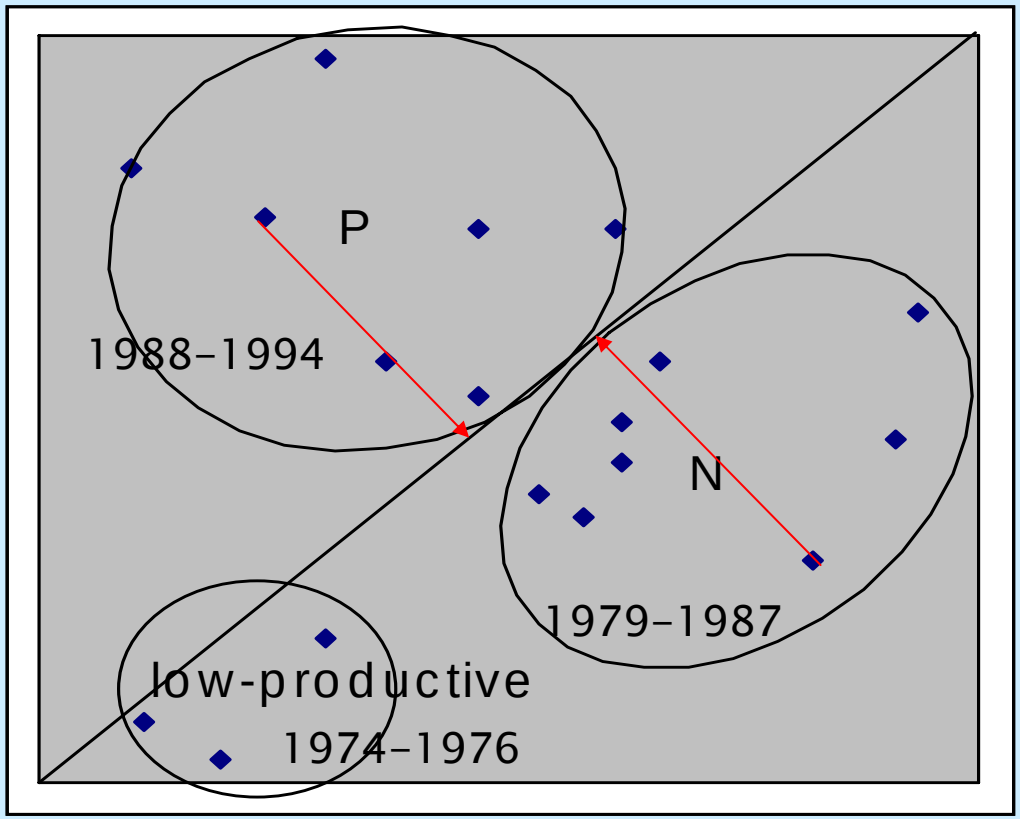


Dramatic decreases in bird numbers



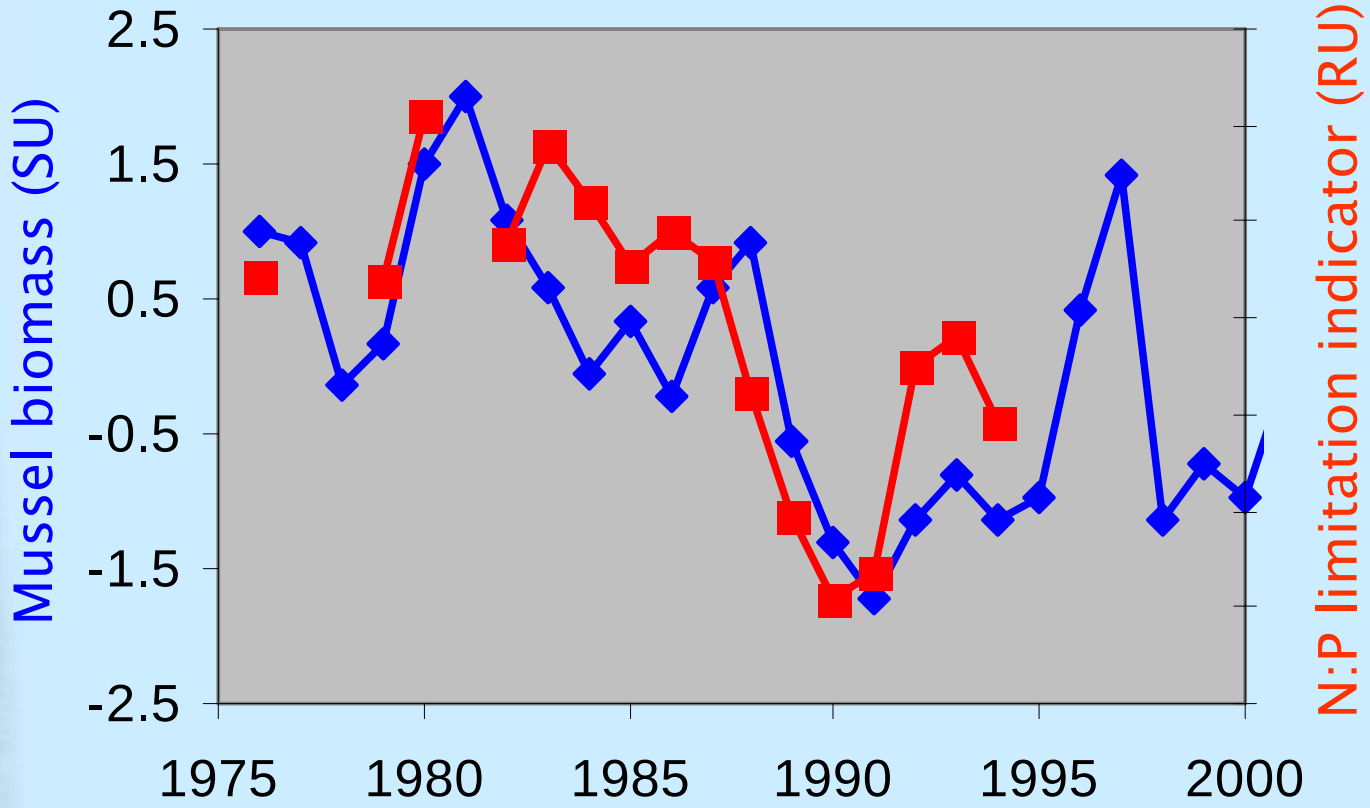
Changes in phytoplankton community

PCA of summer phytoplankton species composition
1976 – 1994



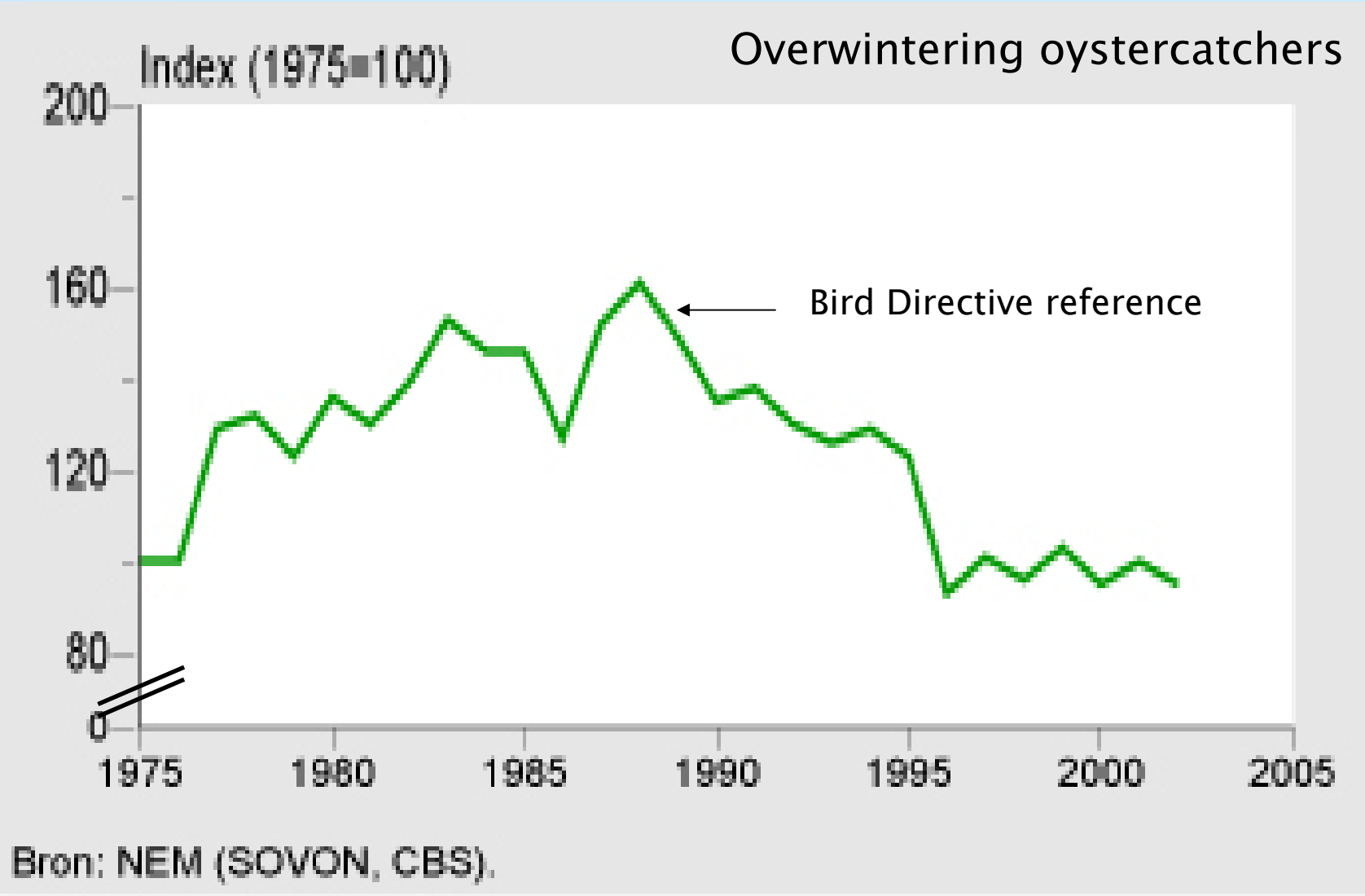
Philippart et al., 2000, L&O

Link: phytoplankton – mussels – birds ?



Based on: Brinkman & Smaal (EVA II report) and Philippart et al. 2000

Dramatic decreases in bird numbers



Biodiversity vs. Water quality vs. economic indicators

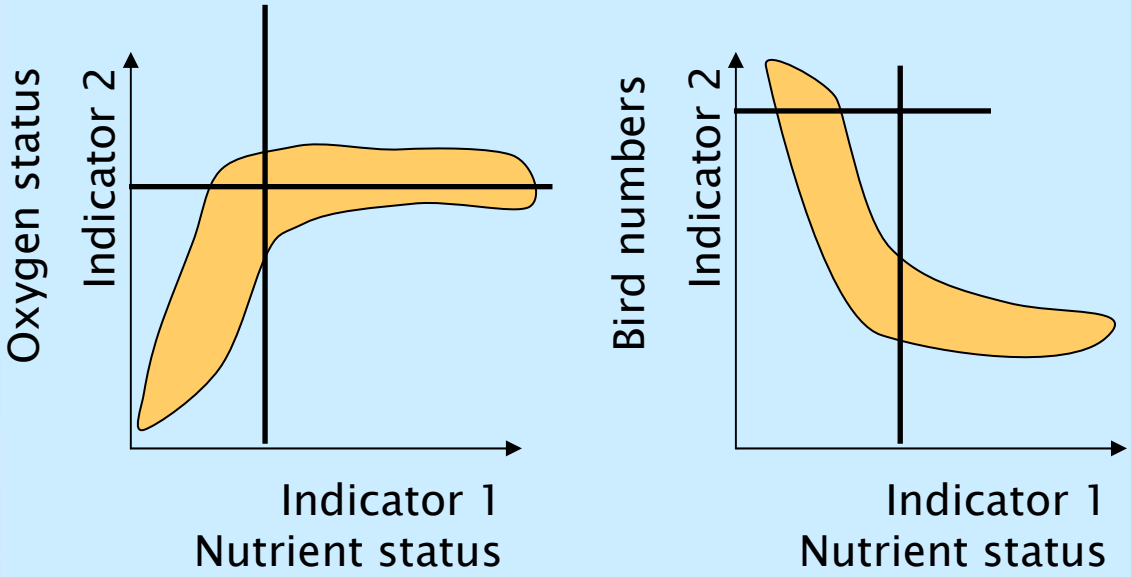
- Cockle fisheries has stopped (‘threat for ecosystem’, ‘harvest food of birds’)
- Mussel fisheries has declined (but profits OK), but is under pressure to disappear (same reasons)
- Gas exploitation has been proven harmless, but not approved (‘spoiling last Dutch wilderness’) – may be traded against shellfisheries
- Nutrient reduction policy is maintained

Some preliminary conclusions

- Targets and indices in current use are an implicit mix based on different ‘world views’
- This mix is *within* legislation, but also within the minds of people involved
- Consistency problems are conceptual and cultural – what about the rest of the world?
- It is easy to average out differences in targets and indicators, difficult to use them constructively

‘Feasibility space’

- Question: given ecosystem functioning, what are achievable states in indicator-indicator space?



+ how can external conditions change these spaces ?

Problems. 1. How to treat unfeasible targets?

1. Deny the problem
   - Average out so many criteria that the law of large numbers takes over
   - Delete or add criteria to keep consistency (usually also with a preconceived management scheme)
2. Adjust ‘free’ parameters to reshape the feasibility space
   - E.g. delete fishing so as to hopefully increase nutrient-bird efficiency
3. Readjust targets by ignoring some aspects of ‘good ecological status’) and keeping others
4. Regionalise targets
   - Prioritize different targets differently for different areas in a region

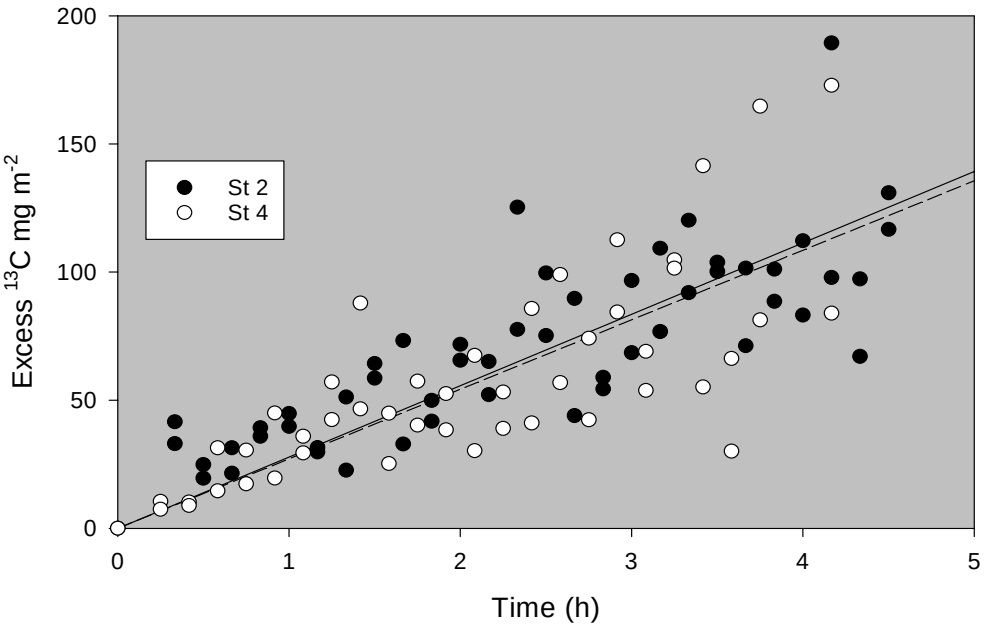
Problems. 2. How to scientifically describe 'feasibility space' ?

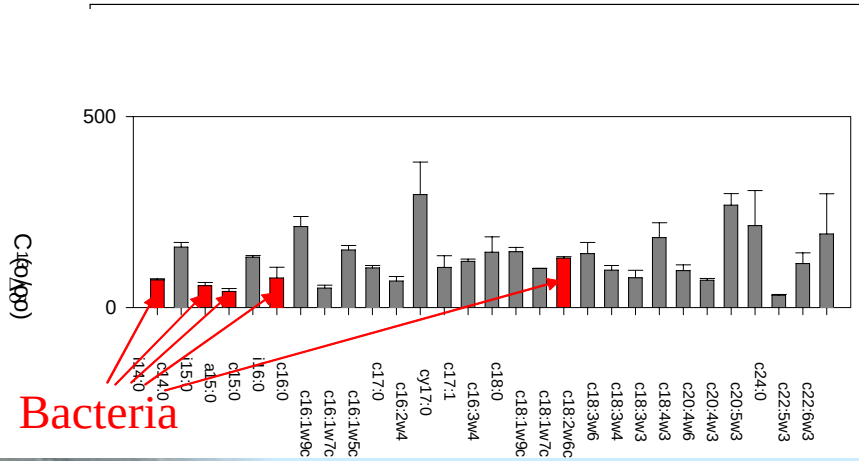
- Biogeochemical correlations are much better known than the ones involving biodiversity
- Effects of structural variables (e.g. stoichiometry, phytoplankton composition) often poorly known
- Erratic events with great impact (storms, toxic blooms, anoxia events) difficult to account for

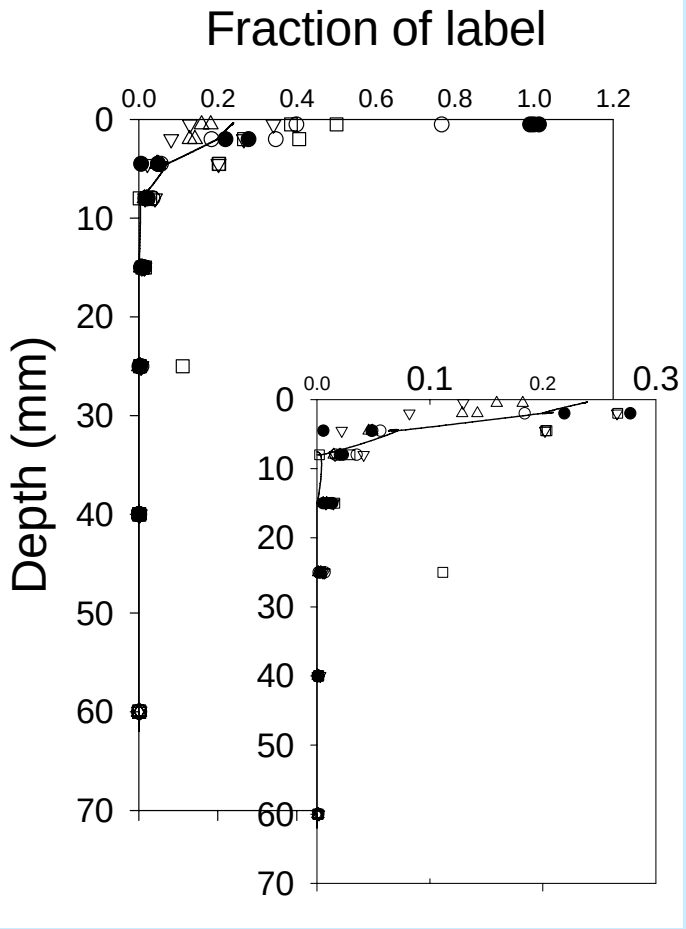
Challenges for ecology

- Past ten years: dramatic increase in 'microscopic resolution' for study of ecological processes
  - Biogeochemistry: stable isotopes, advanced chemical analyses, process modeling
  - Microbiology and molecular biology: diversity assessment, genomics, proteomics -> functional genes linked to ecological conditions
  - Field observation and experimental methods: increasingly fine spatio-temporal resolution / long high-resolution *in situ* series

Enhanced understanding...







Middelburg et al. 2000, L&O

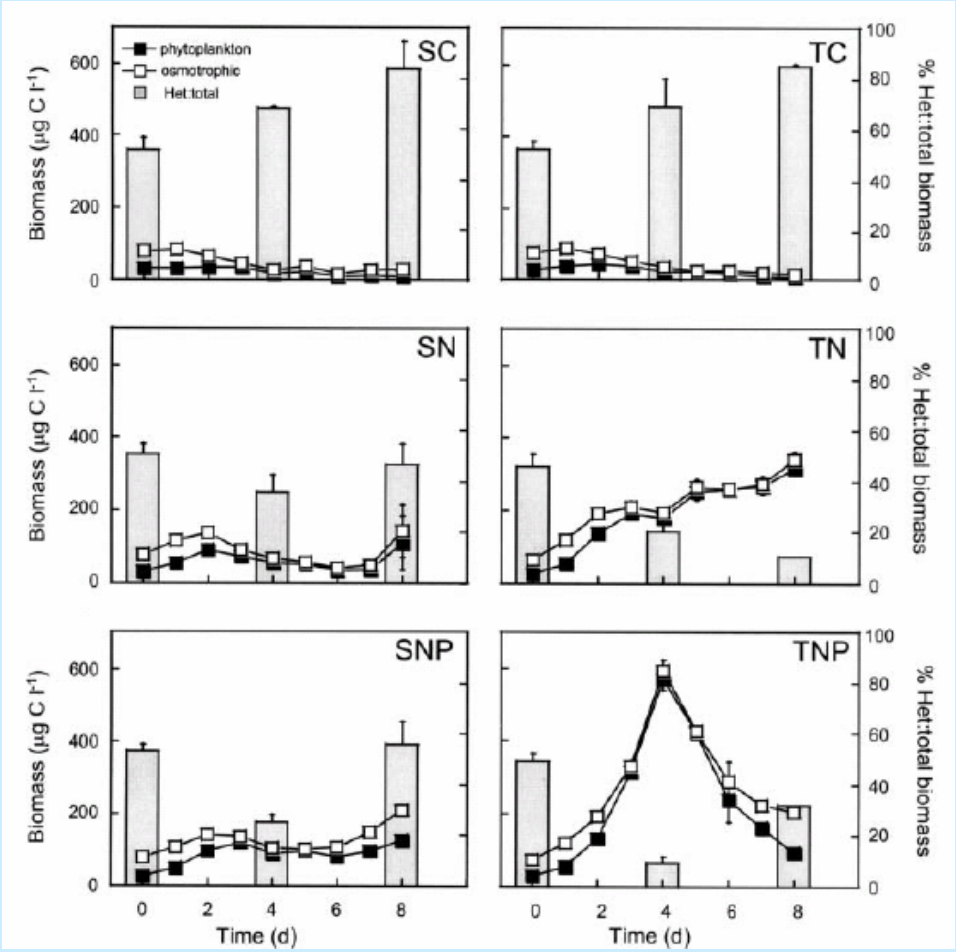
And better resolution...

Non-turbulent Turbulent

Control

N excess

Redfield enriched



Maar et al., 2002. AME

... increase scale gap between process studies and large-scale budgets...

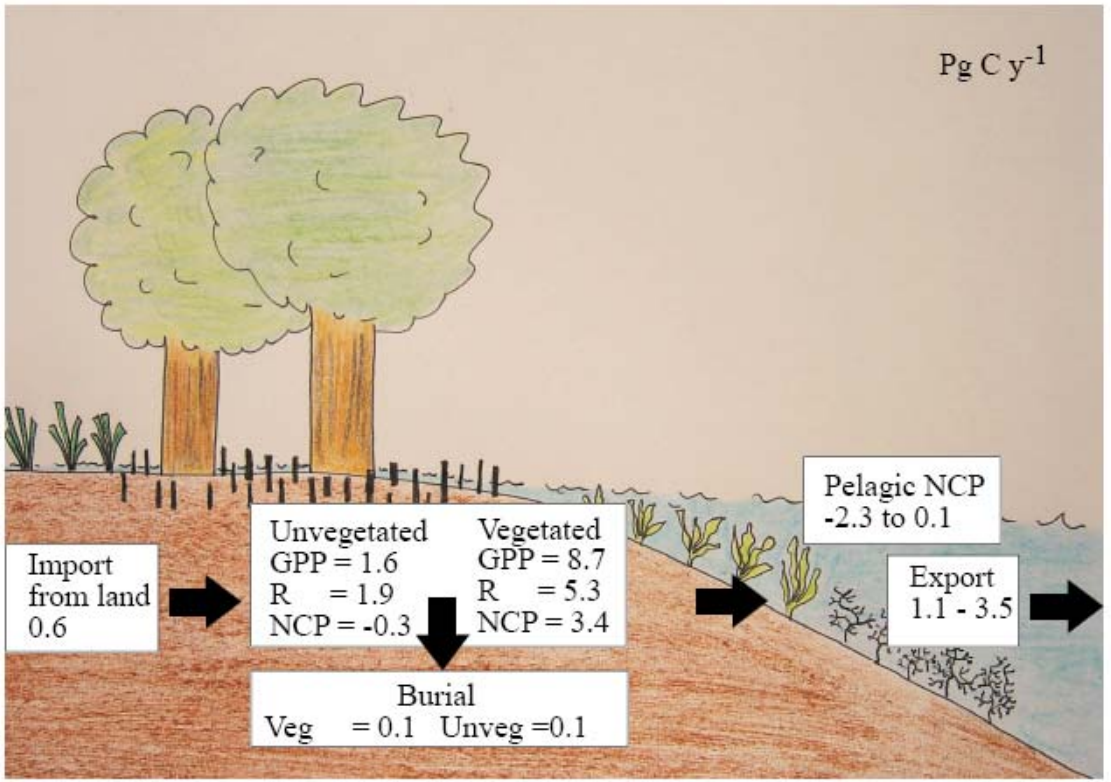
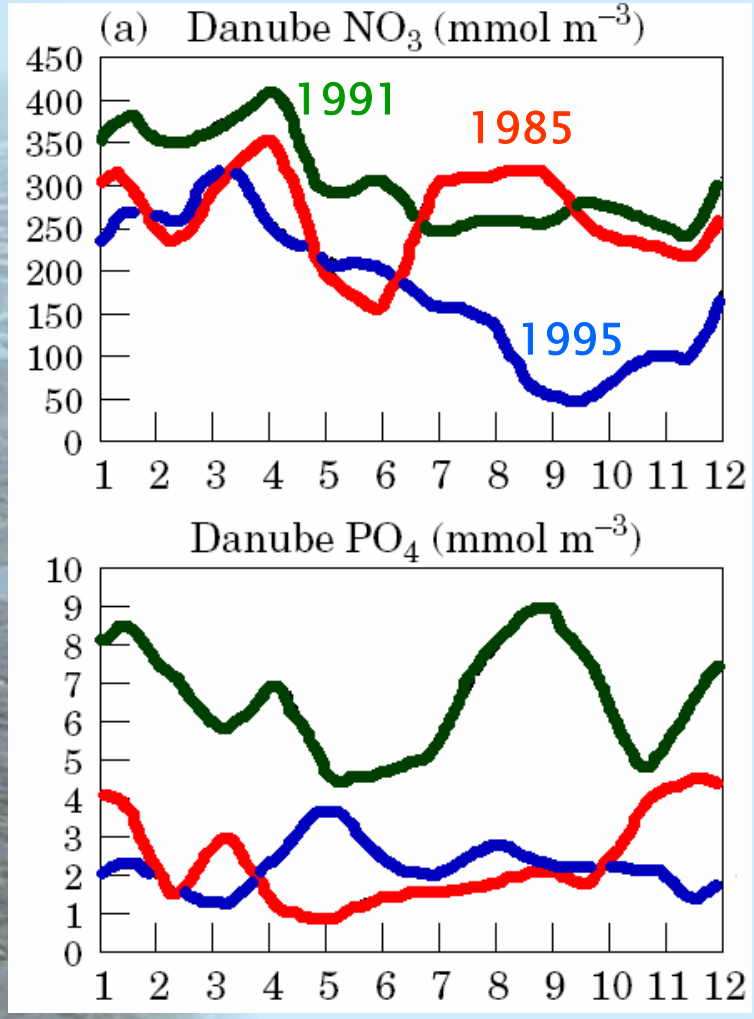
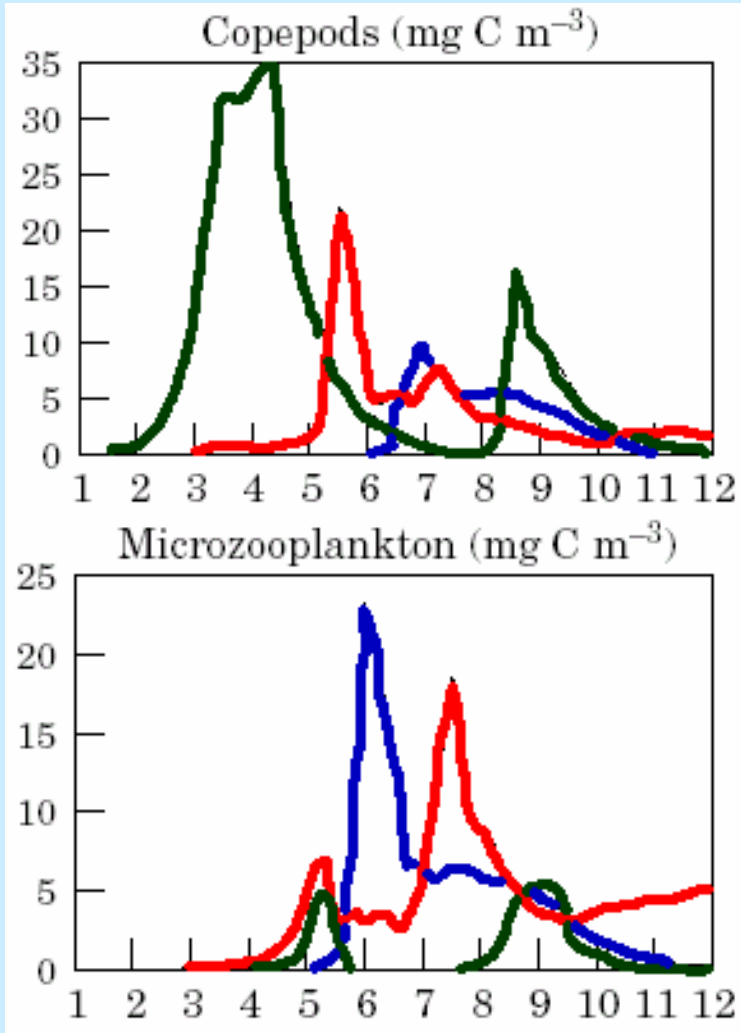


Fig. 3. Summary of the organic carbon budget (units Gt C y^{-1}) of the global coastal ocean. NCP=Net community production. GPP=Gross Primary Production. R=Respiration.

Duarte et al. 2005, Biogeosciences

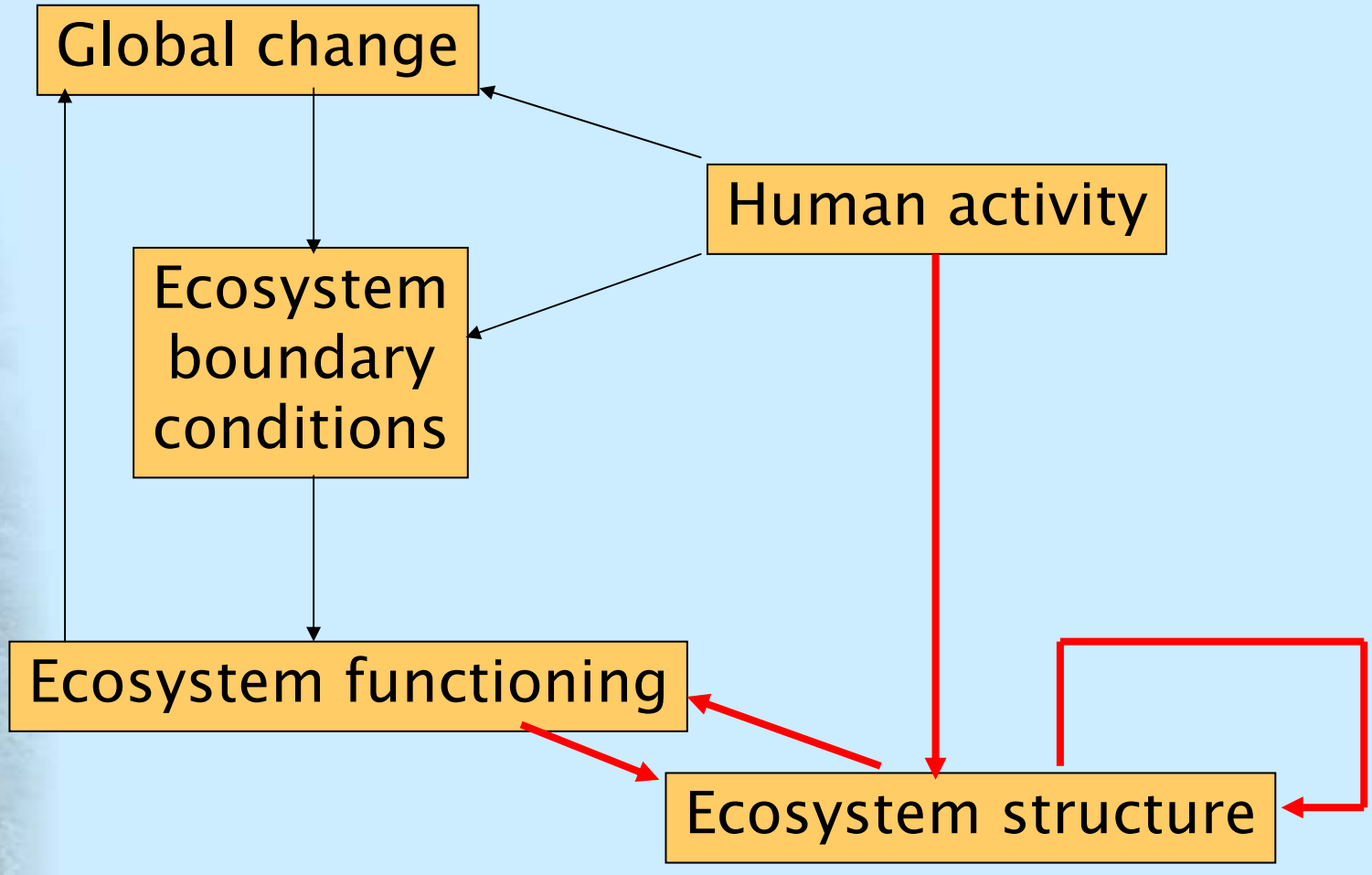
… and increase need for upscaling and modeling



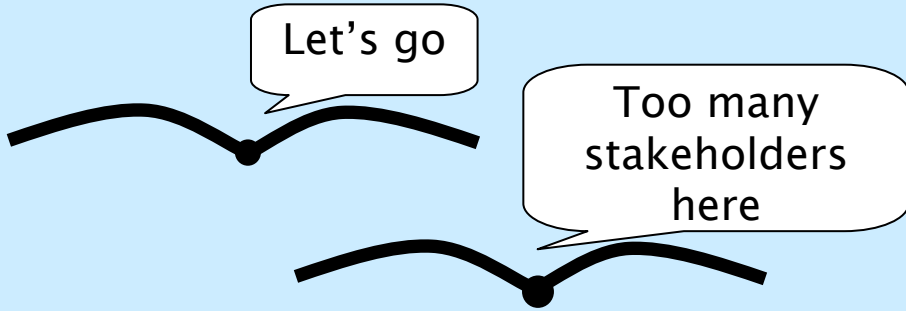


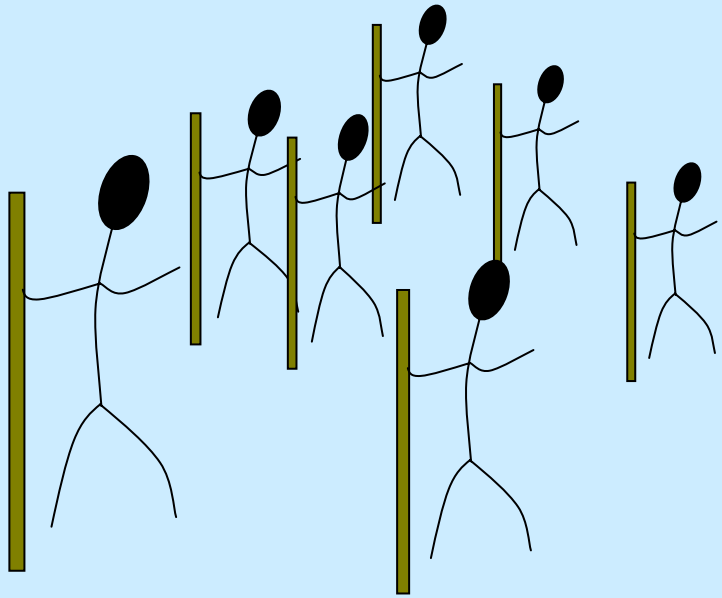
Lancelot et al. 2002

Main problems for coastal ecology



So: back to the lab and field !
And as for social sciences...





The stakeholder

But

- There is probably no unique system to evaluate, manage or protect the coast
- There is probably a deep but implicit link between philosophy, ethics, value systems and ‘coastal dreams’
- More may be gained by a diverse and regionalised value system than by ‘imposed’ criteria and methods

So…

Tell us what we want, why we want it, what else we want and why we want this too, what we could also want and why we should want what we don't know yet we really want !