Action for Reinforcement of Transitional Waters‘ Environmental Integrity (ARTWEI)
Workshop on 23. June 2010 in Szczecin, Poland

Activities and Perspectives of water quality management in transitional waters

- the Oder/Odra Estuary -

Gerald Schernewski & Nardine Stybel

Leibniz-Institute für Baltic Sea Research Warnemünde
Coastal & Marine Management Group

EUCC – The Coastal Union Germany

Projects & activities

Hydrodynamic & Organism-Transport

1. 2007-2009 KKW Lubmin: Auswirkungen auf den Greifswalder Bodden. Forschungsauftrag des StAUN Stralsund
2. 2008-2011 EU-FP7 Projekt GENESIS (GEneric European Sustainable Information Space for Environment). 19 Partnerinstitute aus 11 Staaten (Gesamtbudget: ca. 10 Mio.) (Partner und Fallstudienkoordinator).

Integrated Coastal Zone Management (ICZM)

3. 2007-2009 UBA-Projekt IKZM: Sparsame und effiziente Flächeninanspruchnahme im deutschen Küstenraum (F&E 3707 16 101) (Unterauftragnehmer).

Eutrophication & Ecosystem-modeling

4. 2007-2010 BMBF-Projekt IKZM-Oder II & III (Forschung für ein integriertes Küstenzonen-management in der Odermündungsregion)' (Gesamt-Budget: ca. 1.200.000 €). Konsortium aus 10 Instituten verschiedener Fachrichtungen in Deutschland (Antragsteller und Projektkoordinator).
5. 2007-2011 EU-FP6 Integrated Project SPICOSA (Science and Policy Integration for COastal System Assessment) Konsortium aus 54 internationalen Partnern (Gesamt-Budget: ca. 12 Mio. €) (Partner und Koordinator der regionalen Fallstudie).
6. 2009-2012 ERA -NET BONUS Projekt AMBER (Assessment and Modeling of Baltic Ecosystem Response) 10 internationale Partnerinstitute (Gesamtbudget: ca 2Mio. €)

Climate Change - Coast & Sea

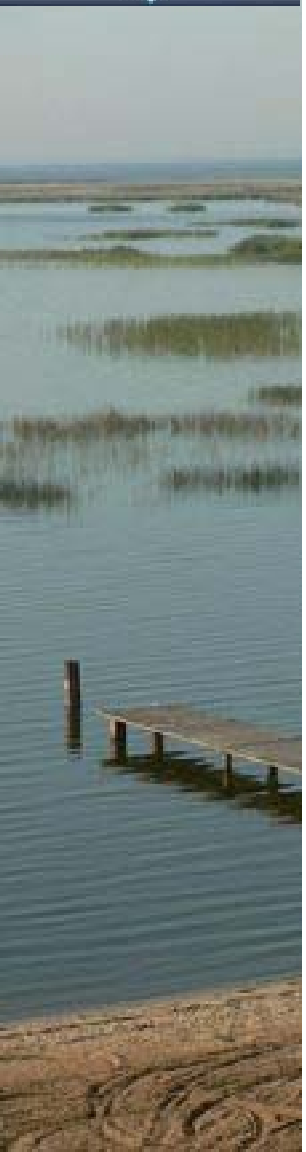
7. 2009-2012 Interreg IV-Projekt BaltCICA (Climate Change: Impacts, Costs and Adaptation in the Baltic Sea Region). 24 Partnerinstitute aus 8 Staaten (Gesamt-Budget: ca. 6 Mio. €).
8. 2009-2014 BMBF-Projekt RADOST (Regionale Anpassungsstrategien für die deutsche Ostseeküste) 11 national Verbundpartner (Gesamt-Budget ca. 9 Mio €) (Koordinator der naturwissenschaftlichen Forschung).

Tourism

Schernewski

Szczecin Lagoon: Eutrophication

Schernewski
(2000, 2001)



GENESIS (EU-FP7)

(GENeric European Sustainable Information Space for Environment)

Objectives

- Development of a model system that allows the spatial and temporal simulation of past and present problems with human-pathogenic organisms as well as scenario-simulations.
- Exemplary application of the model system to show its potential for spatial risk assessment, the analysis and evaluation of spatial water quality problems and as a decision support tool for authorities.
- Provision of this model system for the internet-based GENESIS-Environmental Information System, to allow end-users to carry out own applications.

The model system:

- **General Estuarine Transport Model (GETM)**

  Input: river discharges (Oder, Uecker, Peene); meteorology; boundary conditions
  Output: flow field (and others), **Format:** NetCDF

- **General Individuals Tracking Model (GITM) (off-line Lagrangian particle tracking routine)**

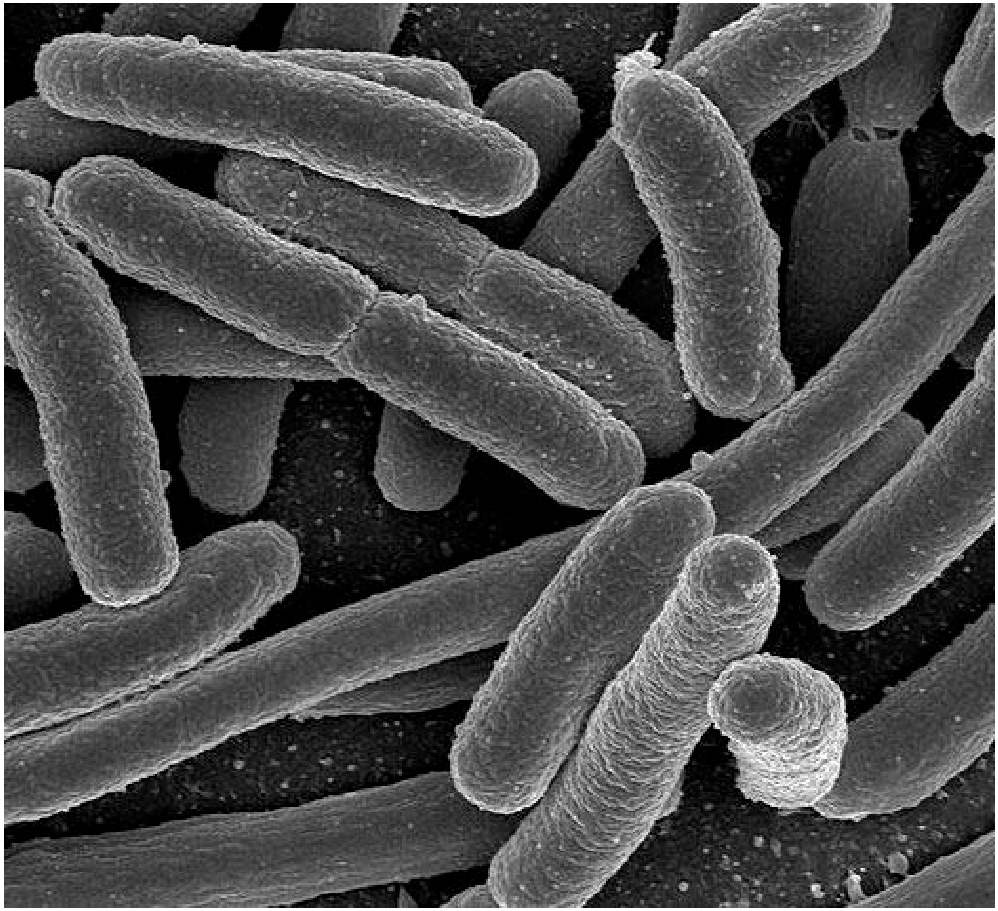
  Input: Flow-fields, number, location and properties of particles
  Output: Trajectories of particles

Challenges: New pathogen stems e.g. *Escherichia coli* bacteria *O157*

Escherichia coli (E. coli), an intestine bacteria, has the ability to survive outside the body for short periods and is an ideal indicator organism for fecal contamination.

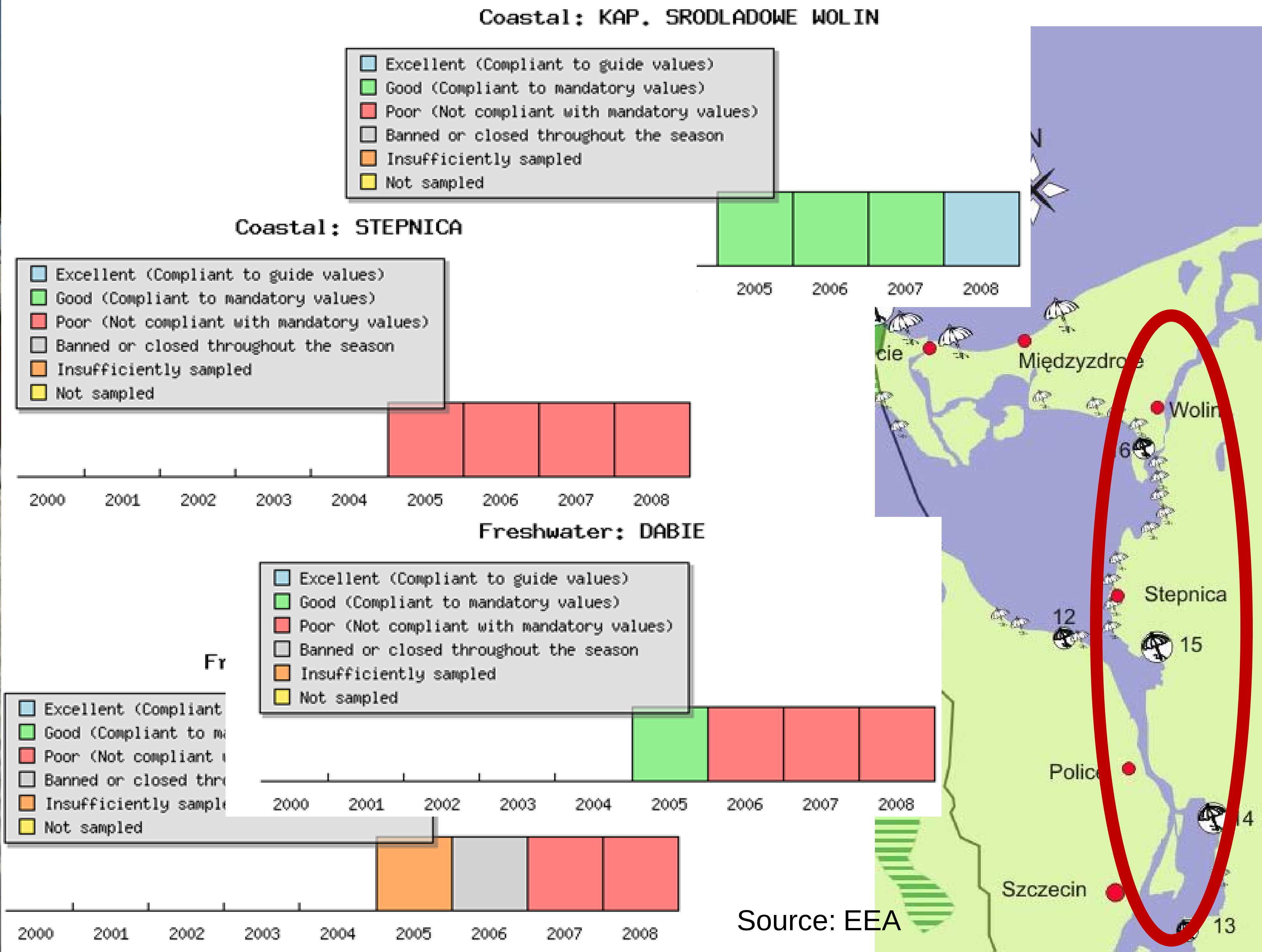
E. coli O157

Emerged in Europe in the 1990's and can produce severe, potentially life-threatening, illness (Coia, 1998).



Source: Wikipedia

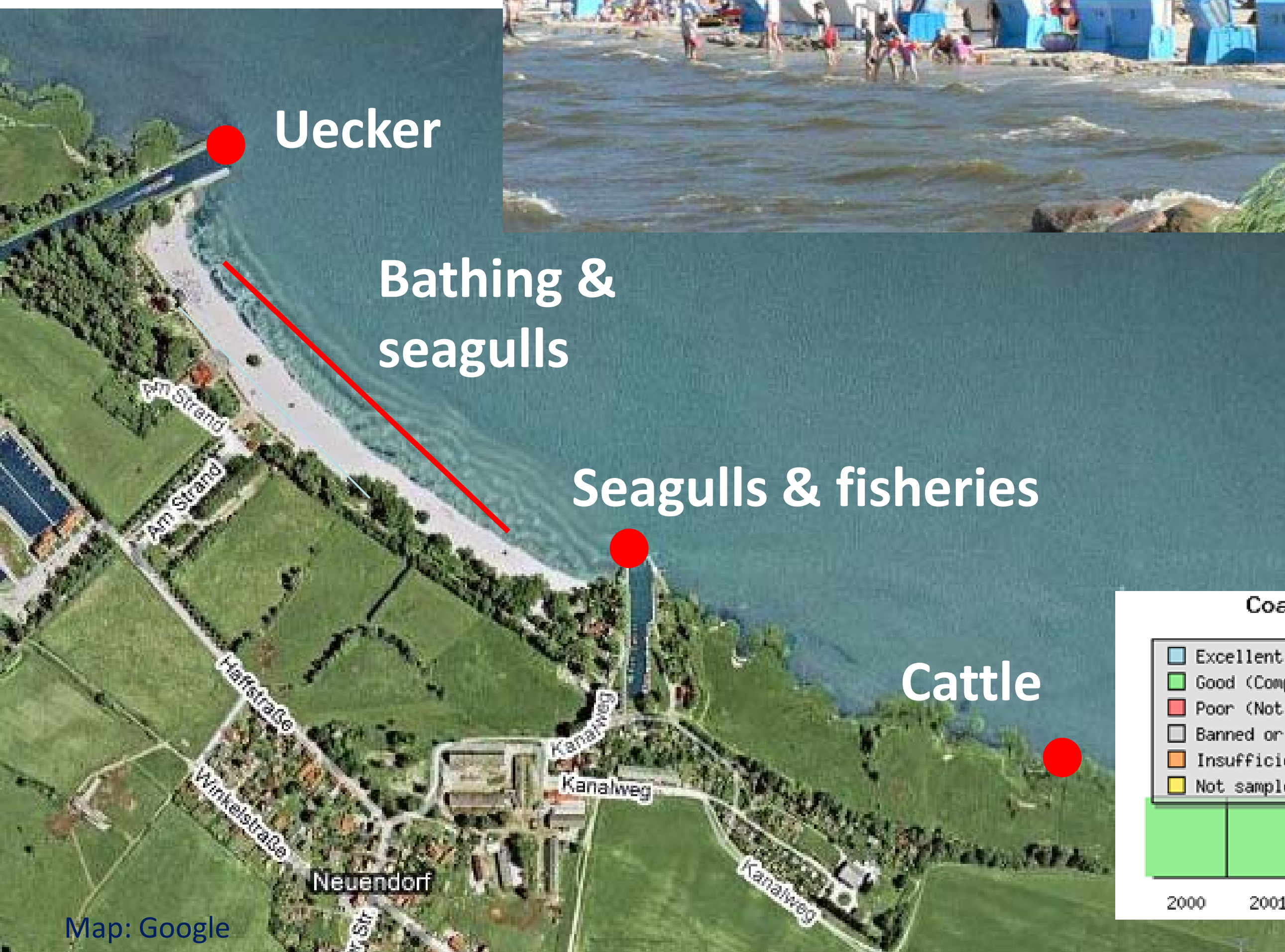
Bathing water quality:
Beach evaluations and closures

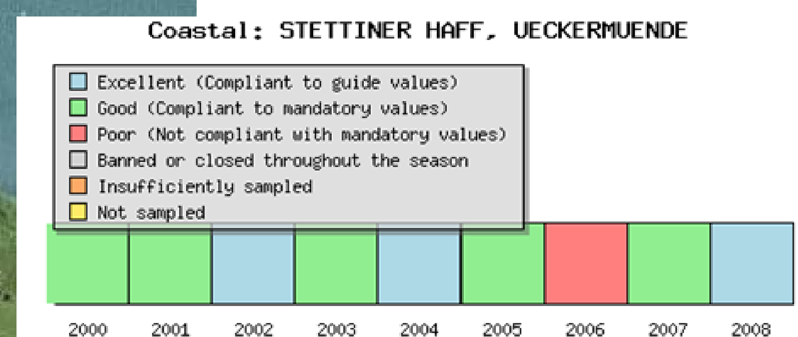


Source: EEA

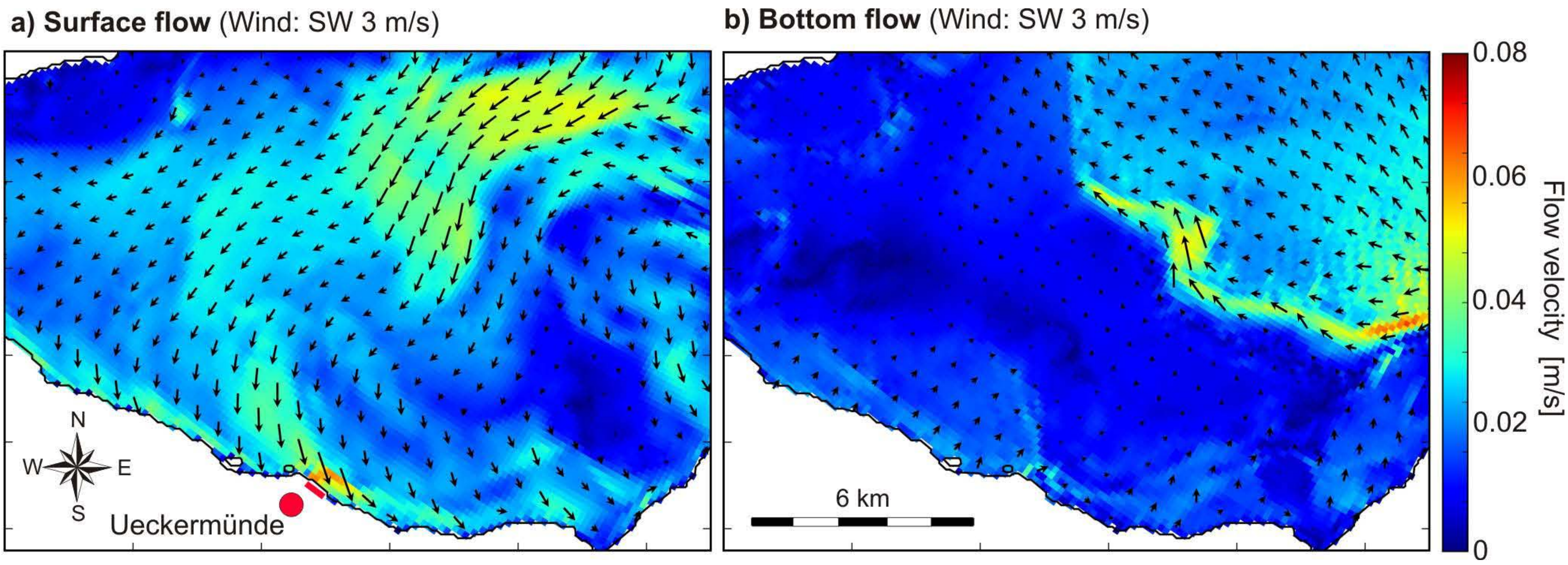
Case study Ueckermünde beach

1. Allocation and quantification of *E.coli* sources



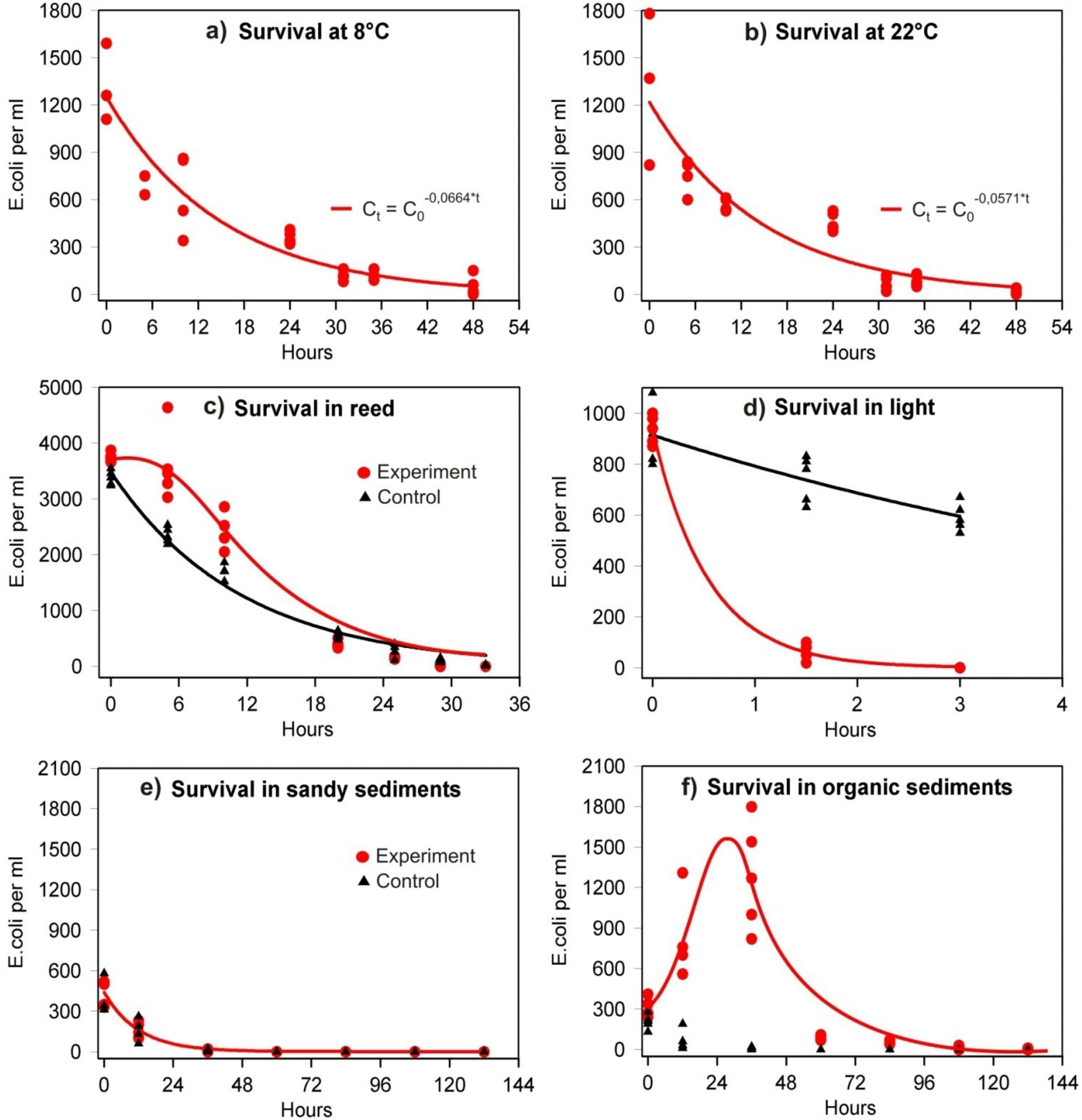


Case study Ueckermünde beach
2. Flow field simulations

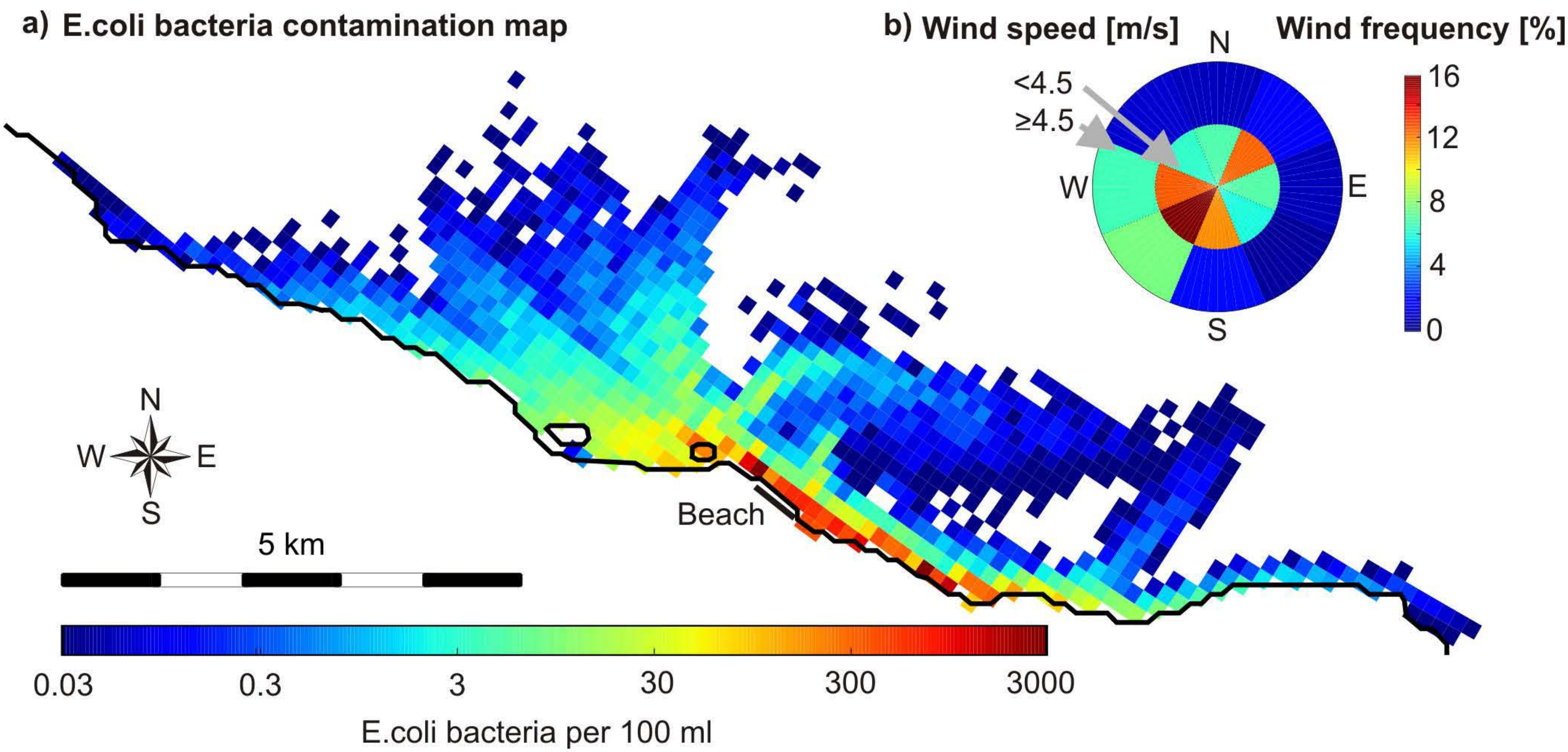


Case study Ueckermünde beach:

4. E.coli survival experiments

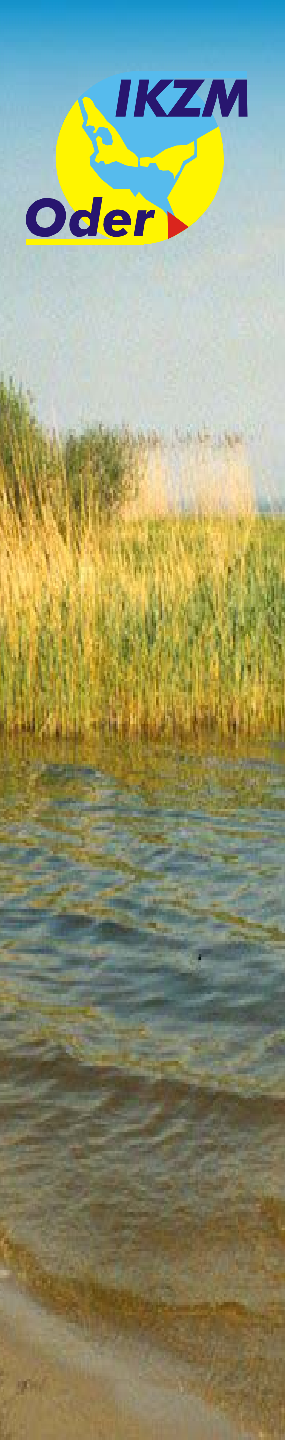


Case study Ueckermünde beach:
7. *E.coli* average pollution map



Perspectives

- Model applications in the Odra river mouth and the coastal Baltic Sea
- Simulations with other problematic organisms: Salmonella, Vibrions



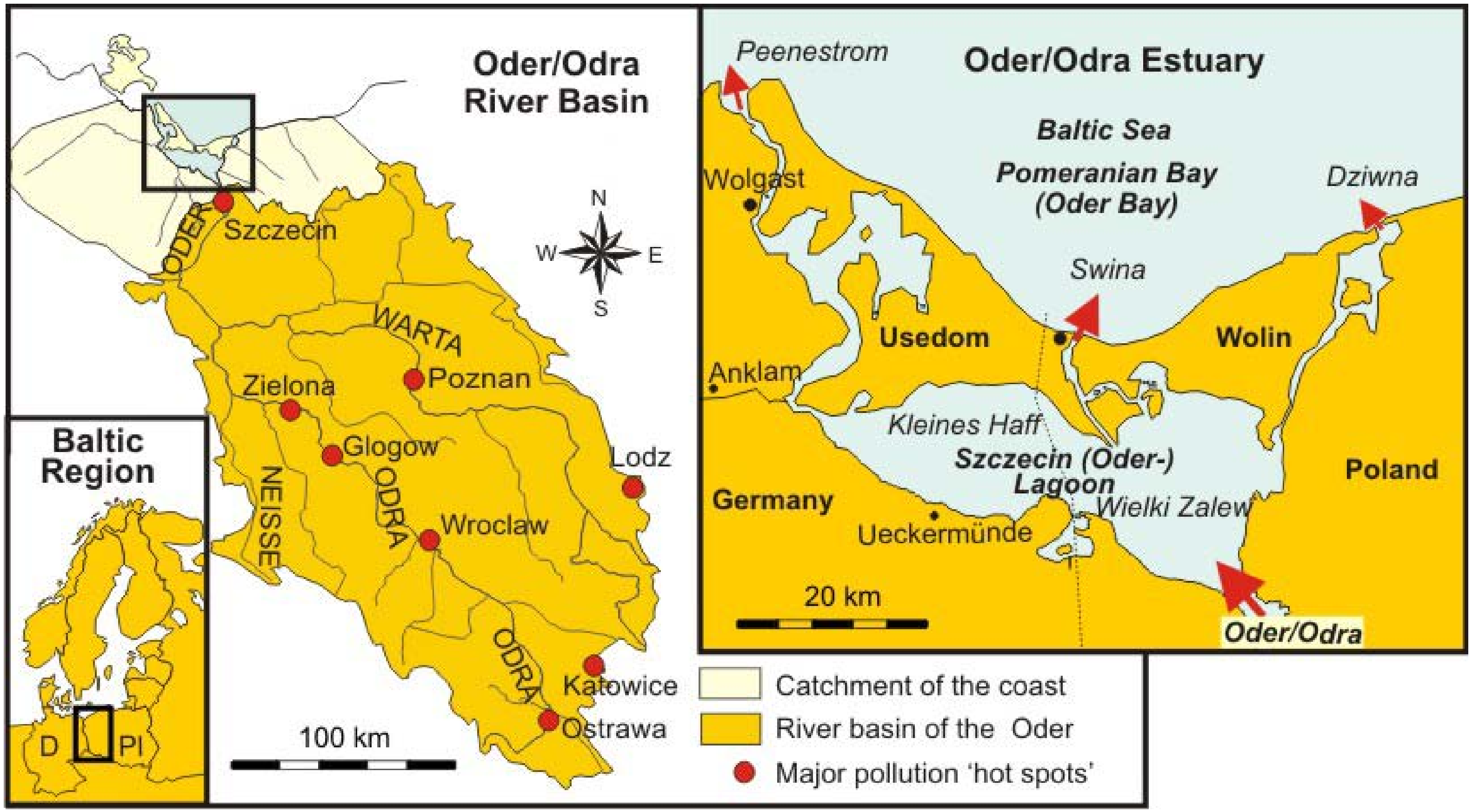
IKZM-Oder (BMBF)
(Integrated Coastal Zone Management in the Oder estuary region)

AMBER (ERA-NET BONUS)
(Assessment and Modeling of Baltic Ecosystem Response)

Some questions

- How did the long-term eutrophication history look like?
- To what extent can the nutrient load in the Oder River be reduced?
- Can we reach a good water quality status according to the EU Water Framework Directive in the river, in the lagoon and in the coastal Baltic Sea?
- How could a cost-effective nutrient load reduction look like?
- What is the role of coastal waters in nutrient retention and transformation?

The Oder/Odra estuary



A coastal region

- characterized by a complex pattern of land, lagoons and sea
- divided between Germany and Poland and
- dominated by the Oder/Odra river basin

Managing eutrophication

Approach

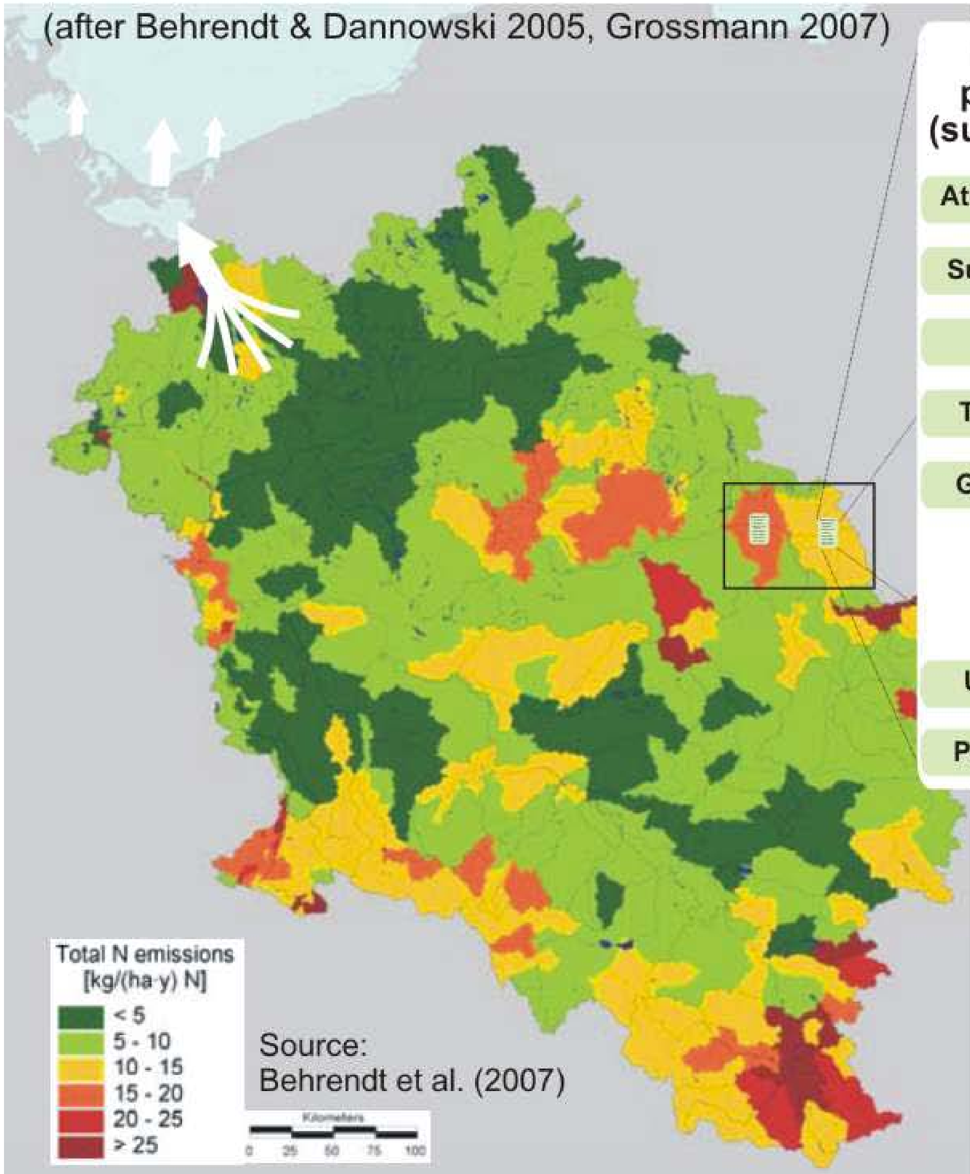
- Development of scenarios – visions what will or could happen in the river basin and how management could look like
- Application of models (MONERIS, a river basin water and nutrient flux model and ERGOM, a 3D hydrodynamic model with an ecological module)

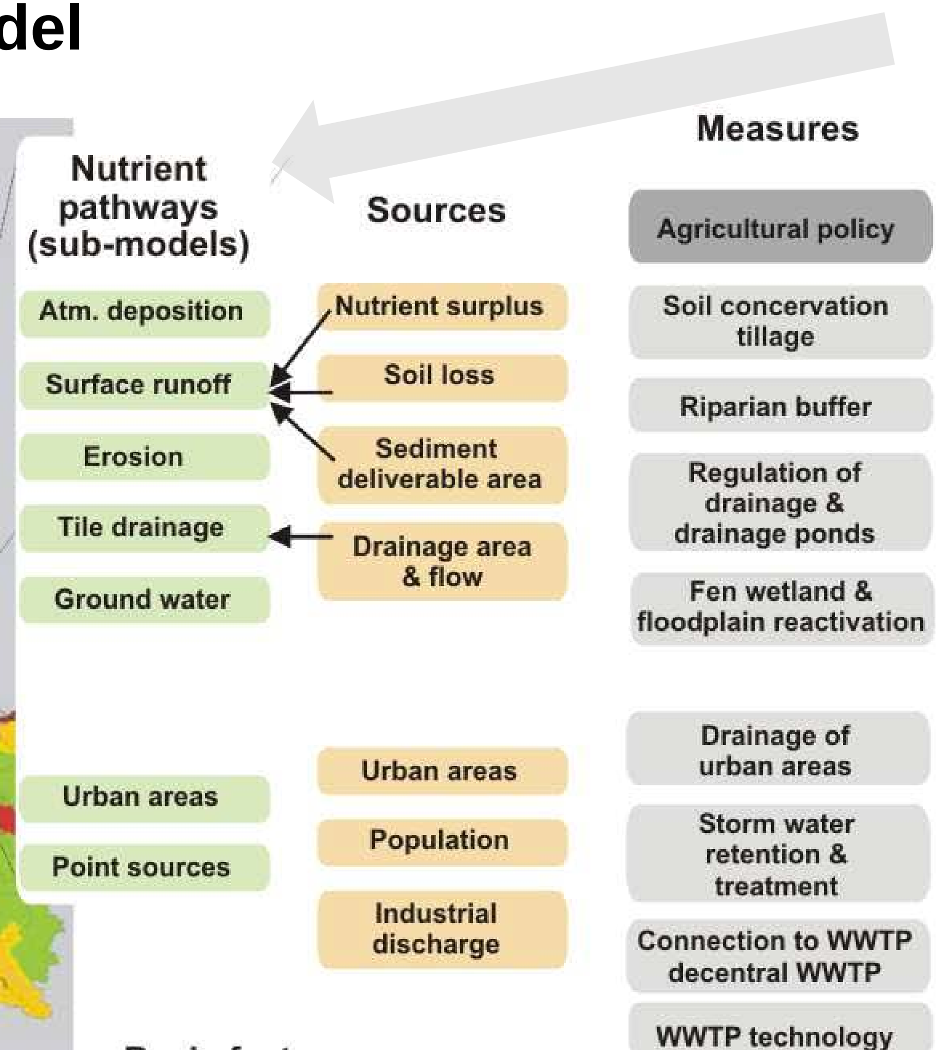
Scenario 1:
Optimal nutrient load reduction

(implemention until 2015, cost-effective measures, realistic policy)

- The **emissions from point sources** in the entire river basin meet the requirements of the Urban Waste Water Treatment Directive (91/271/EEC). The following thresholds shall not be exceeded: BOD = 25 mg O2/l, COD = 125 mg O2/l, SS = 35 mg/l, P = 2 mg/l, N = 15 mg/l for municipalities with a population ranging between 10,000 and 100,000; 1 mg P/l and 10 mg N/l for municipalities with more than 100,000 inhabitants.
- **Phosphorus free detergents** are standard in Poland and Czech Republic.
- **Best management practices** on arable land are implemented to reduce the load from diffuse sources.
- **Soil erosion** is strongly reduced. Conservation tillage is applied on all arable land in the Oder basin.
- The **nitrogen surplus** (difference between nitrogen fertilization and uptake by plants) is decreased by 20-30 %.

MONERIS: A nutrient flux model



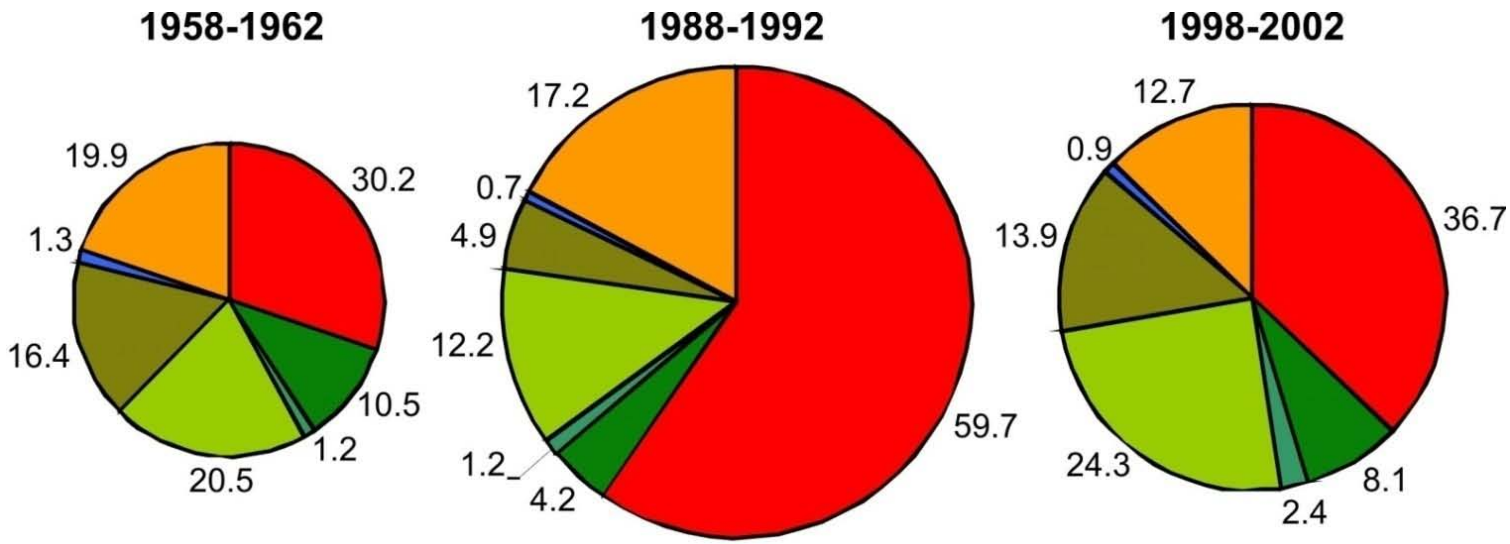


Basic features:

- Spatial coverage 120,000 km²
- 484 sub-basins, average size 326 km²
- Annual load calculation
- Monthly load extrapolations

Schernewski (2007)

Optimal nutrient load reduction: Phosphorus



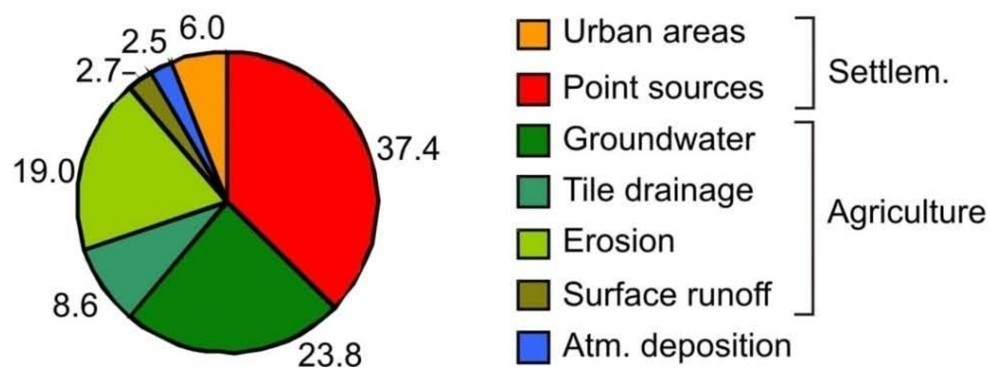
5966 t/a P
Agriculture: 2901 t/a
Settlements: 2989 t/a

15488 t/a P
Agriculture: 3484 t/a
Settlements: 11900 t/a

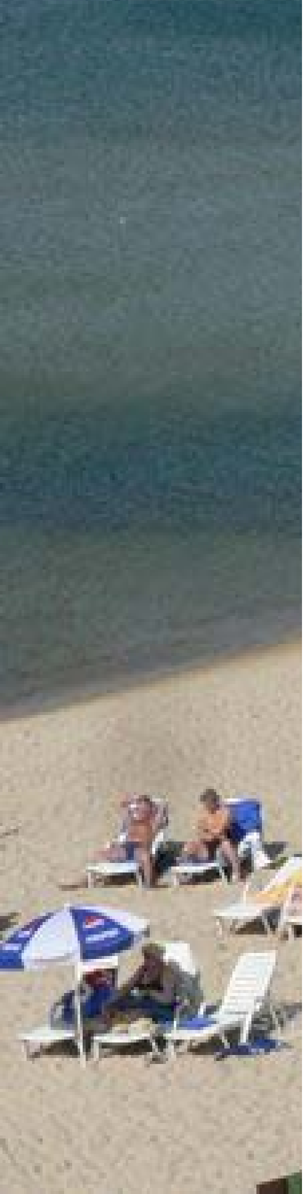
9360 t/a P
Agriculture: 4237 t/a
Settlements: 4380 t/a

Max. emission reduction scenario

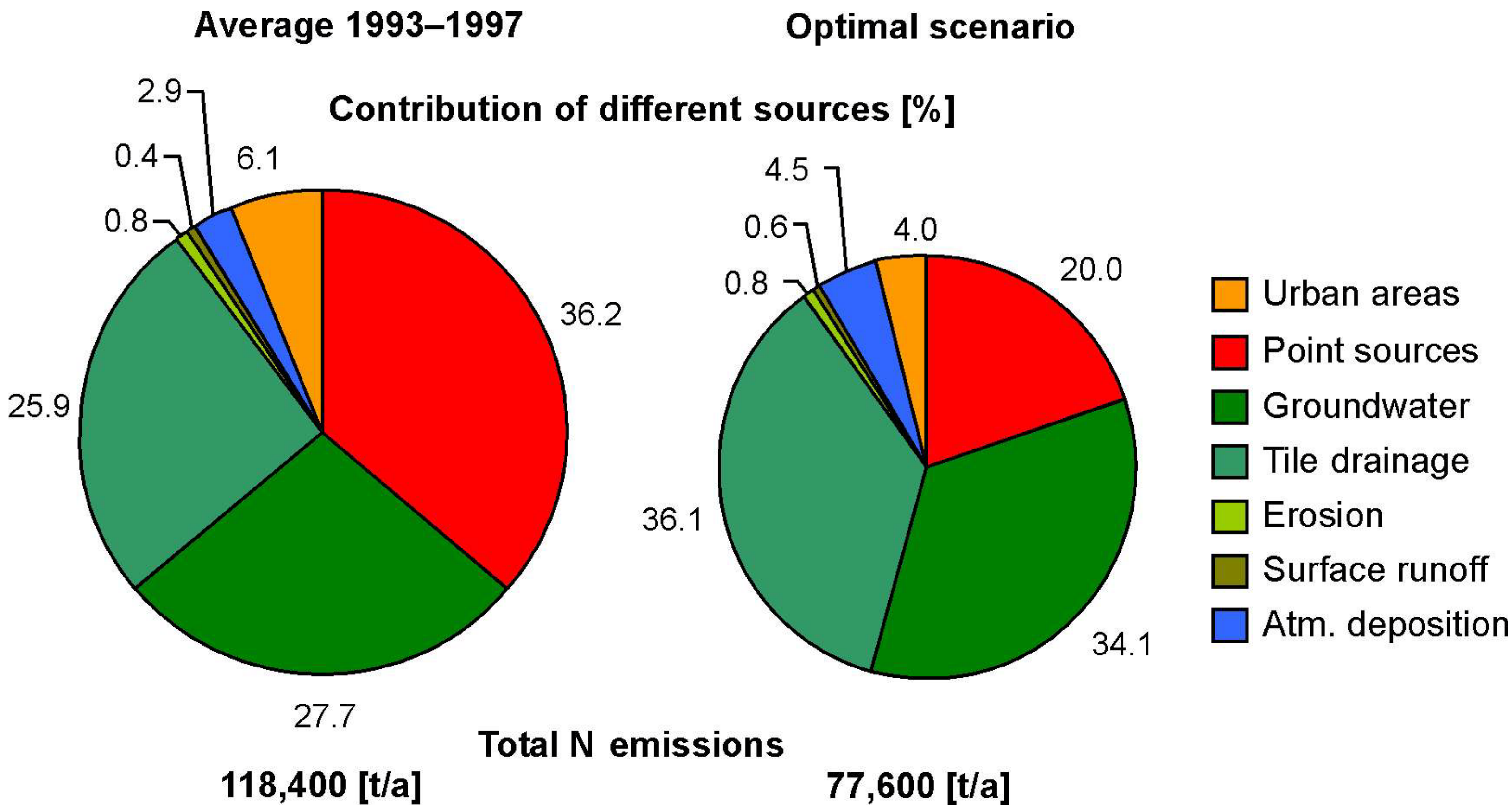
4900 t/a P
Agriculture: 2127 t/a
Settlements: 2161 t/a



- About 45 % reduction compared to 2000
- Loads like in the late 1950‘s

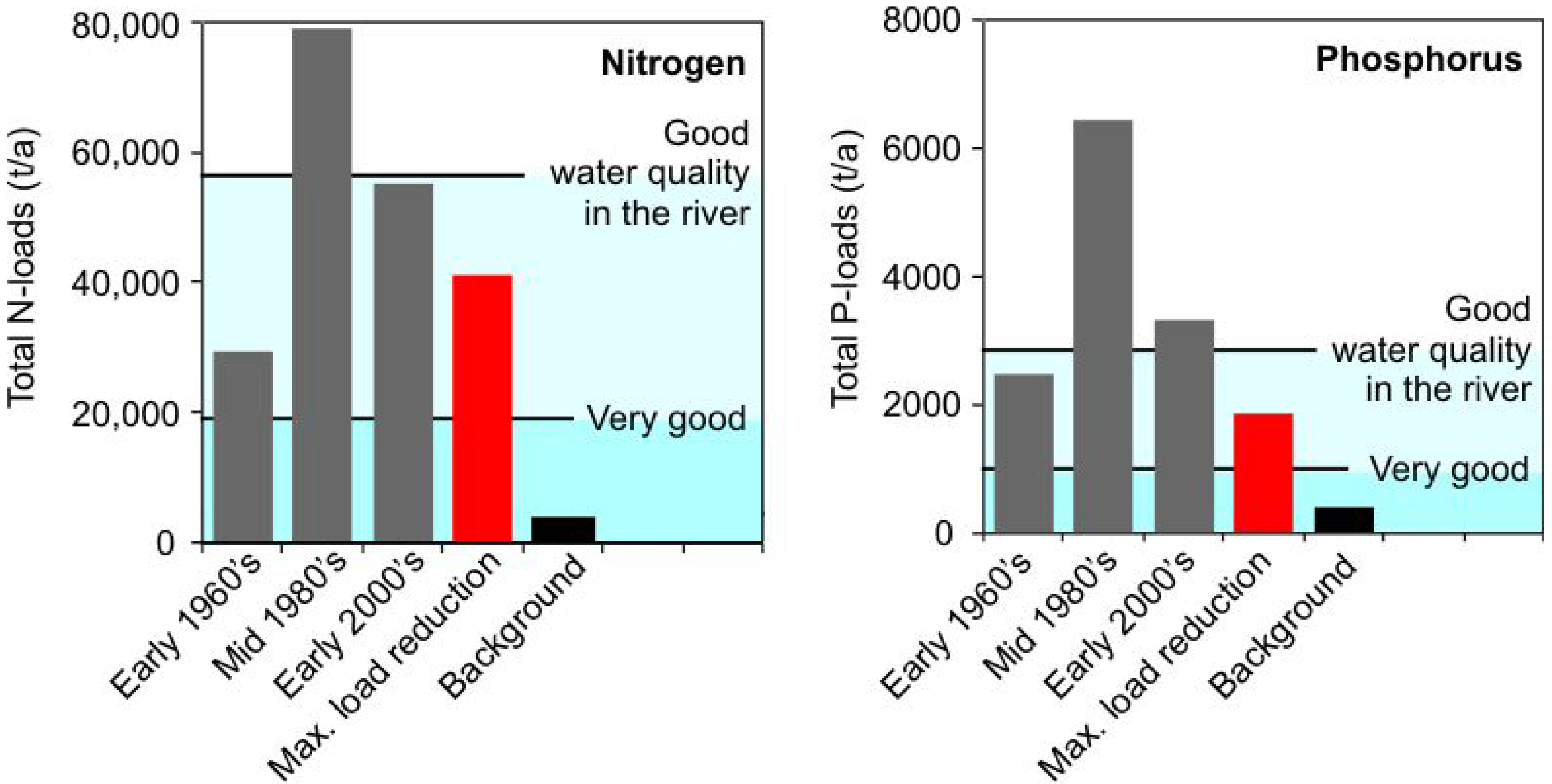


Optimal nutrient load reduction: Nitrogen



- About 35 % compared to 1995
- Loads like in the late 1960‘s

Water quality objectives in the river



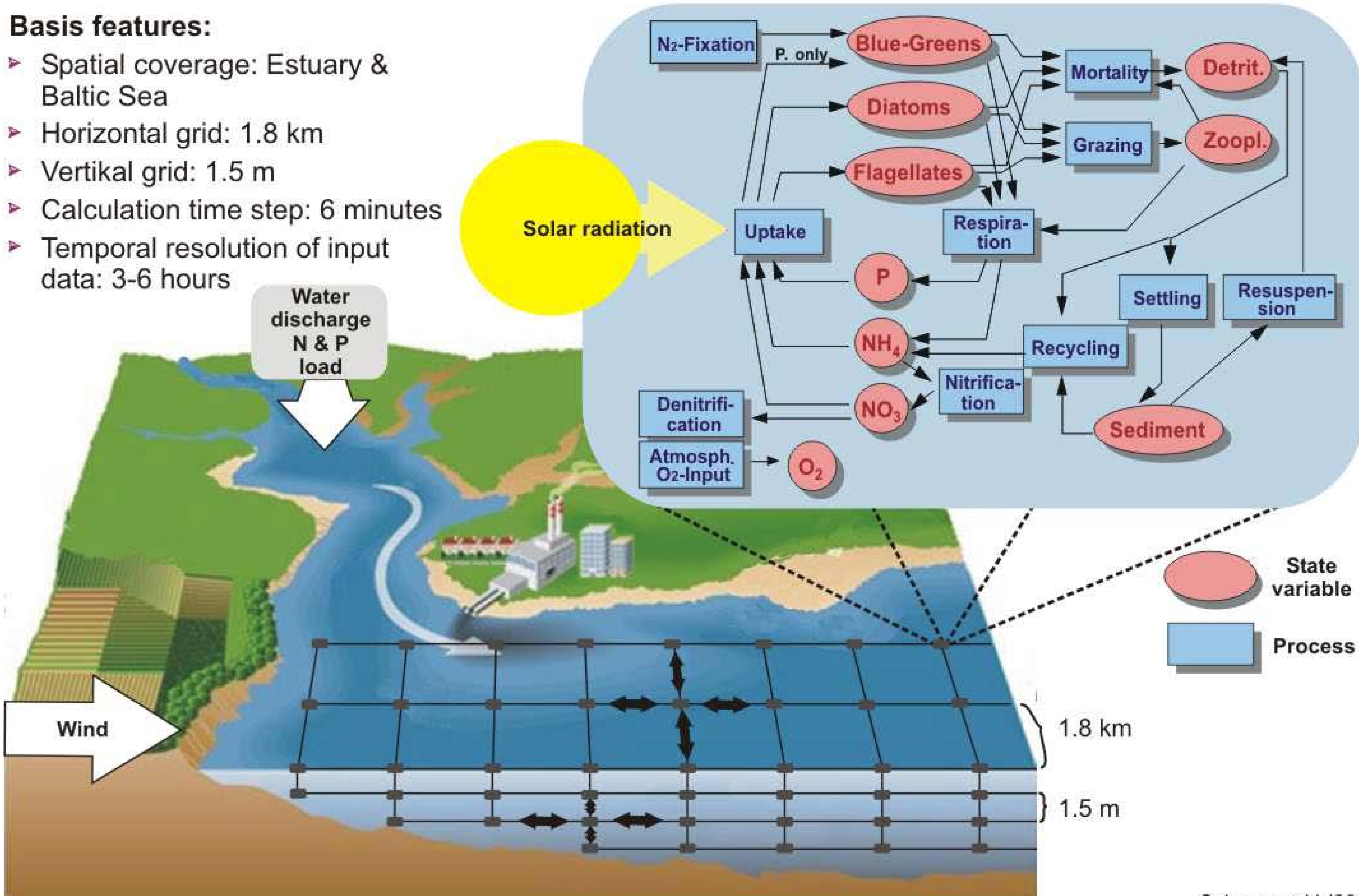
- A „good water quality“ in the river is a realistic objective, but will this cause a good status in coastal waters as well?

ERGOM – a 3D hydrodynamic & ecosystem model

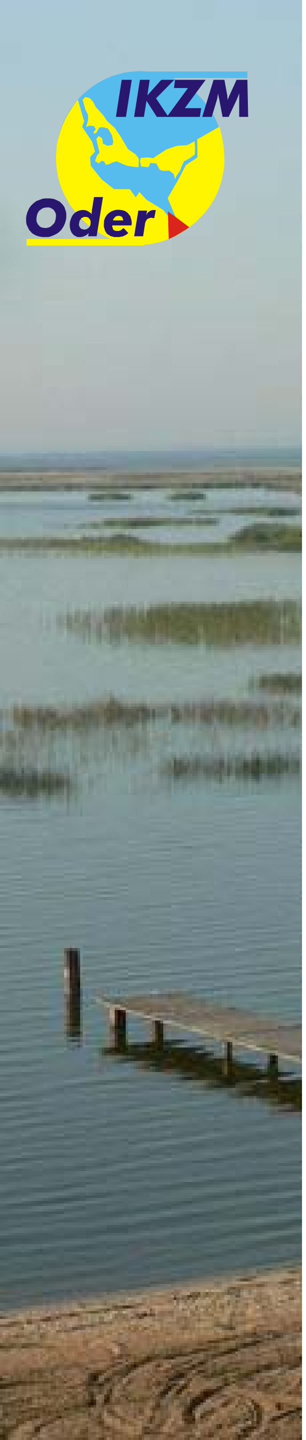
(after Neumann et al. 2002)

Basis features:

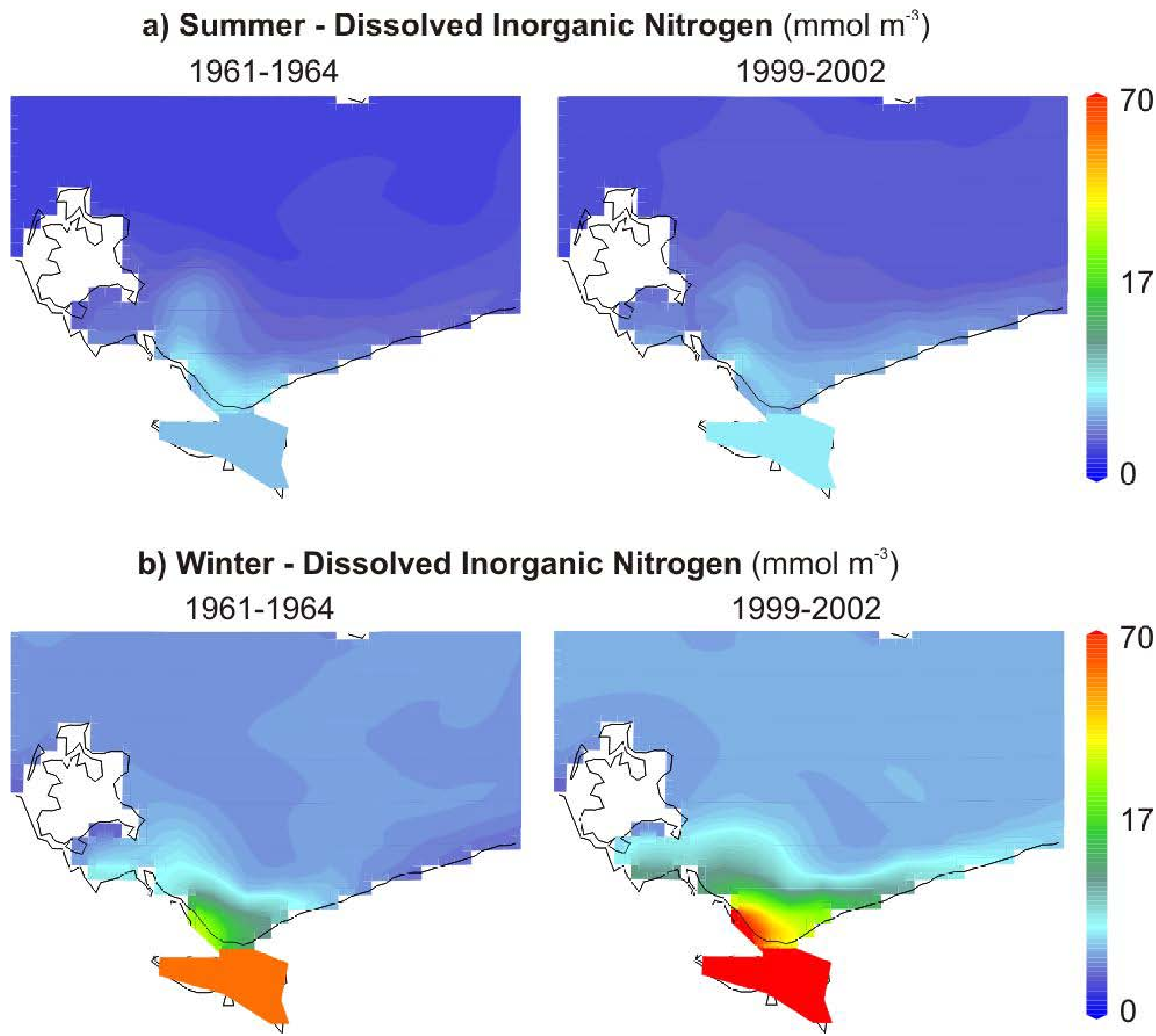
- Spatial coverage: Estuary & Baltic Sea
- Horizontal grid: 1.8 km
- Vertikal grid: 1.5 m
- Calculation time step: 6 minutes
- Temporal resolution of input data: 3-6 hours



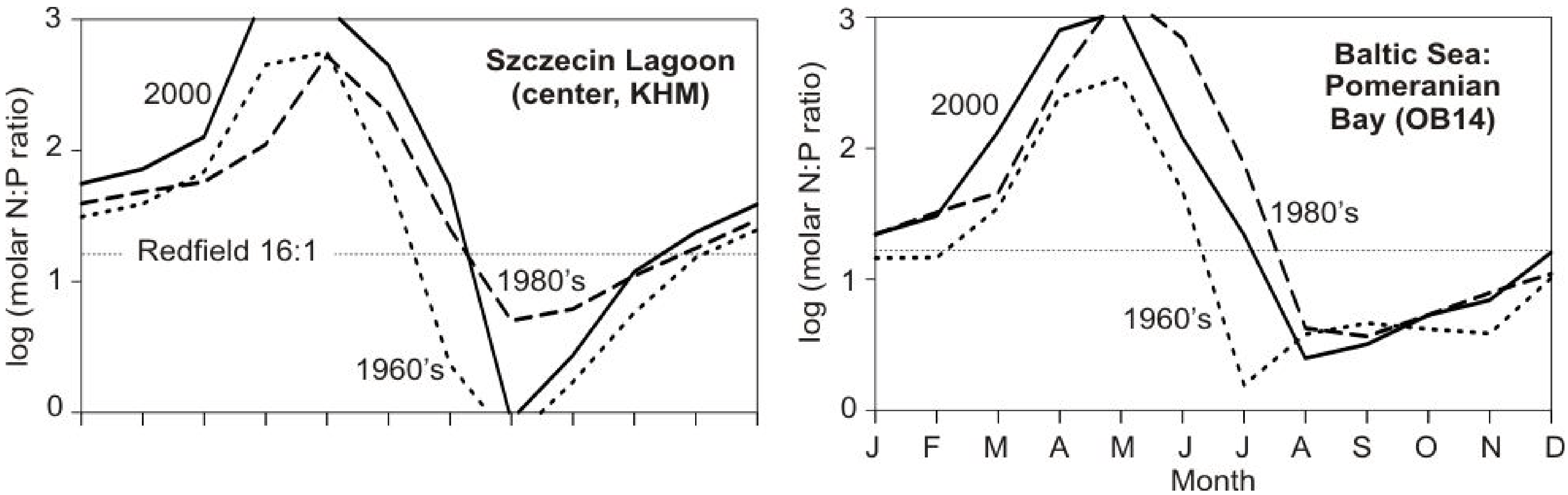
Schernewski (2007)



Eutrophication history: Comparison 1960 to 2000



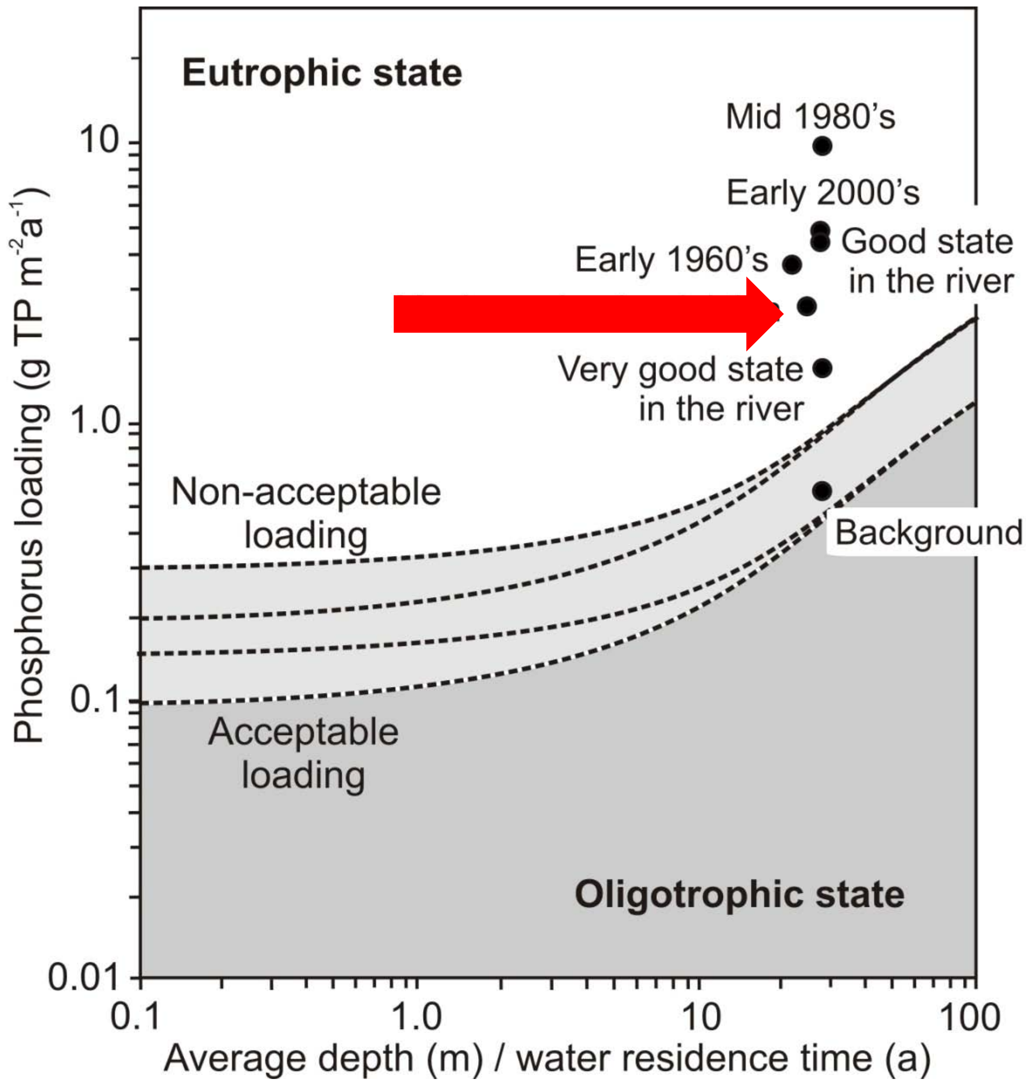
Eutrophication history: Comparison 1960 to 2000



Some results

- Nutrient removal in the lagoon via **denitrifikation** is reduced from 26 % (1960's) to 15 % (1999-2002). An increase of denitrification in the coastal Baltic Sea took place.
- **N-Fixation** does not play an important role in the lagoon. It was higher in the 1960's. Heavy blue-green blooms can contribute up to 30% of the monthly river load.
- **Limitation**: A temporal shift and changes in nutrient availability took place. However, a lasting nutrient limitation can not be assumed.

Water quality in the lagoon



Adapted after Vollenweider (1976)

BaltCICA (Baltic Sea Region Programme)
(Climate Change: Impacts, Costs and Adaptation in the Baltic Sea Region)

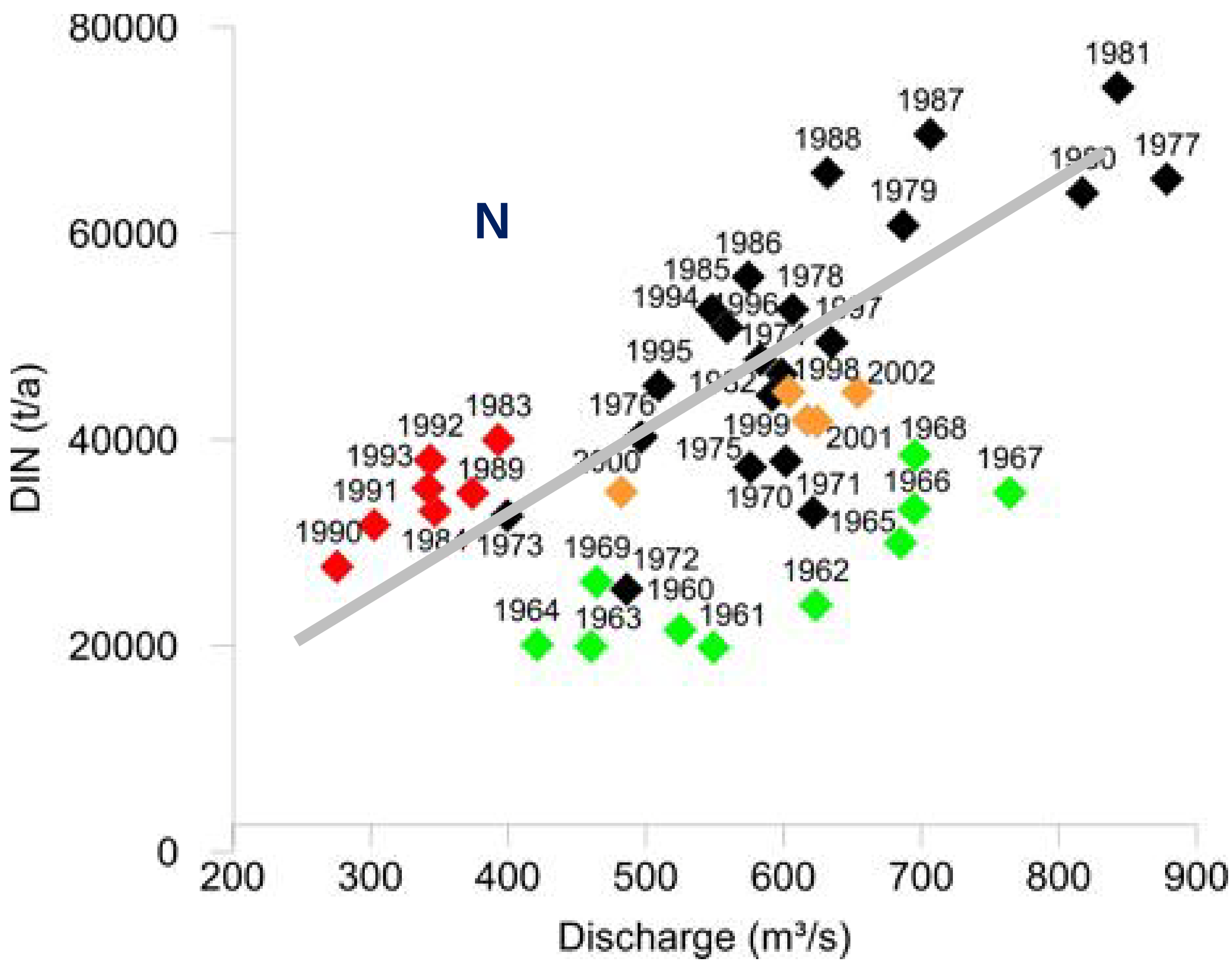
BaltCICA

RADOST (BMBF-Procekt)
(Regional Adaptation Strategies for the German Baltic Coast)

RA:dOst
Regionale Anpassungsstrategien für die deutsche Ostseeküste

- Modell simulations on regional Climate Change impact
- Analysis of ecological and practical consequences
- Development of adaptation strategies

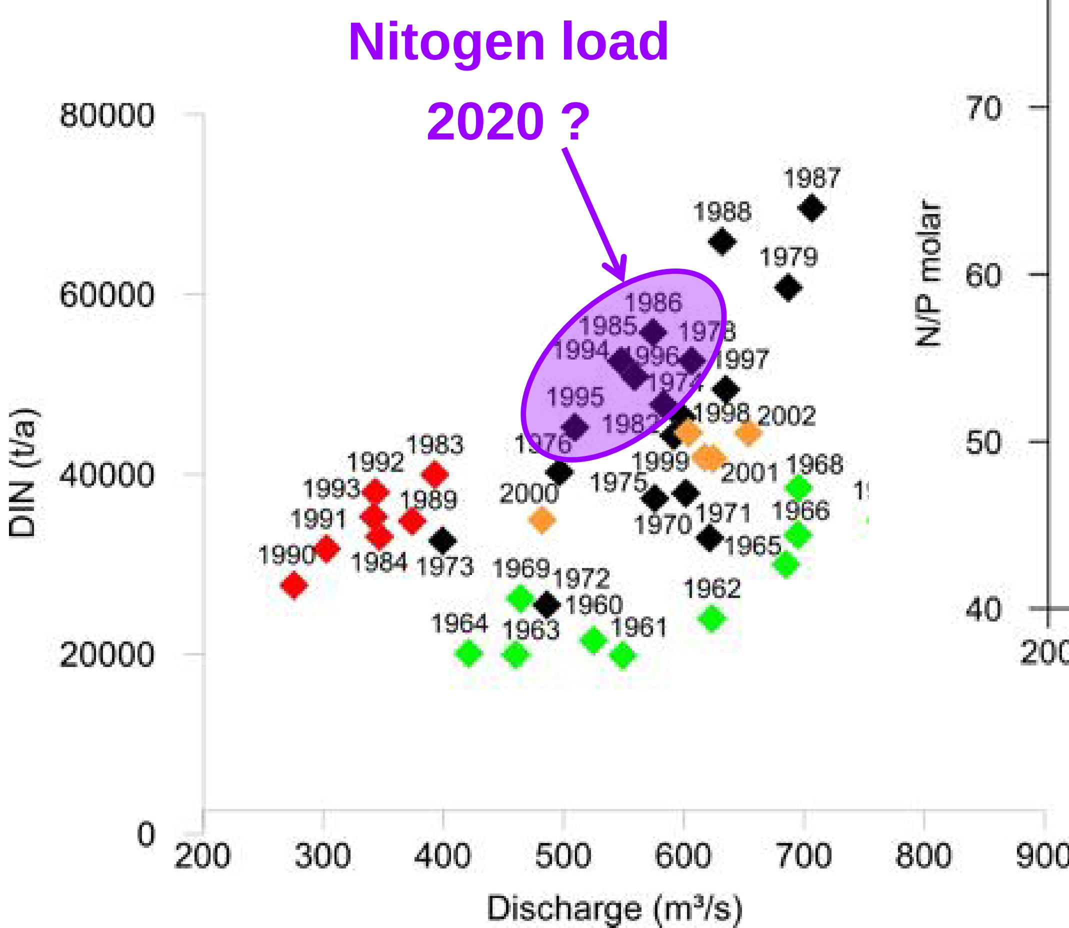
Example: Climate Change effect on the Szczecin Lagoon

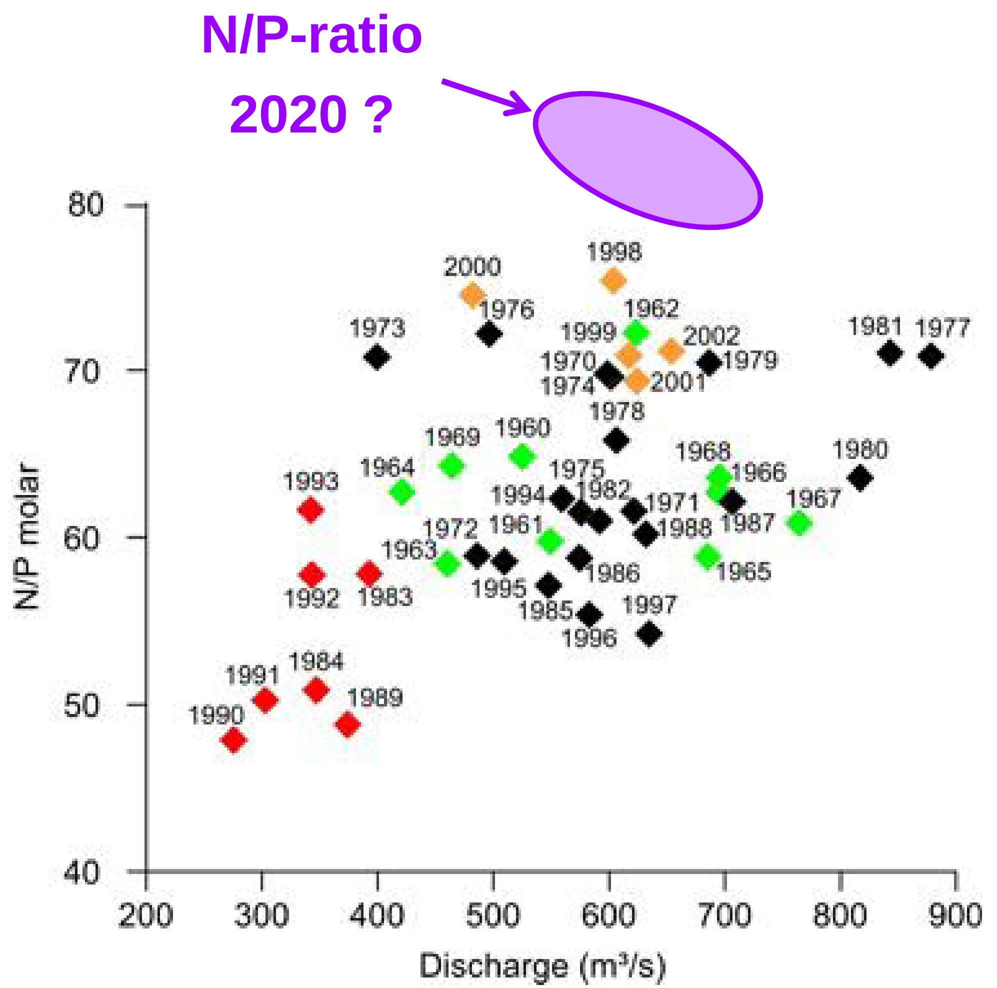


- Discharge is most important for nutrient loads. Climate Change projections show shifts between seasons but minor changes in annual precipitation
- Climate Change will have an effect on internal processes in the lagoon

Example: Effects of future land-use changes

Perspectives based on scenarios „business as usual“ and „subsidized agriculture“.

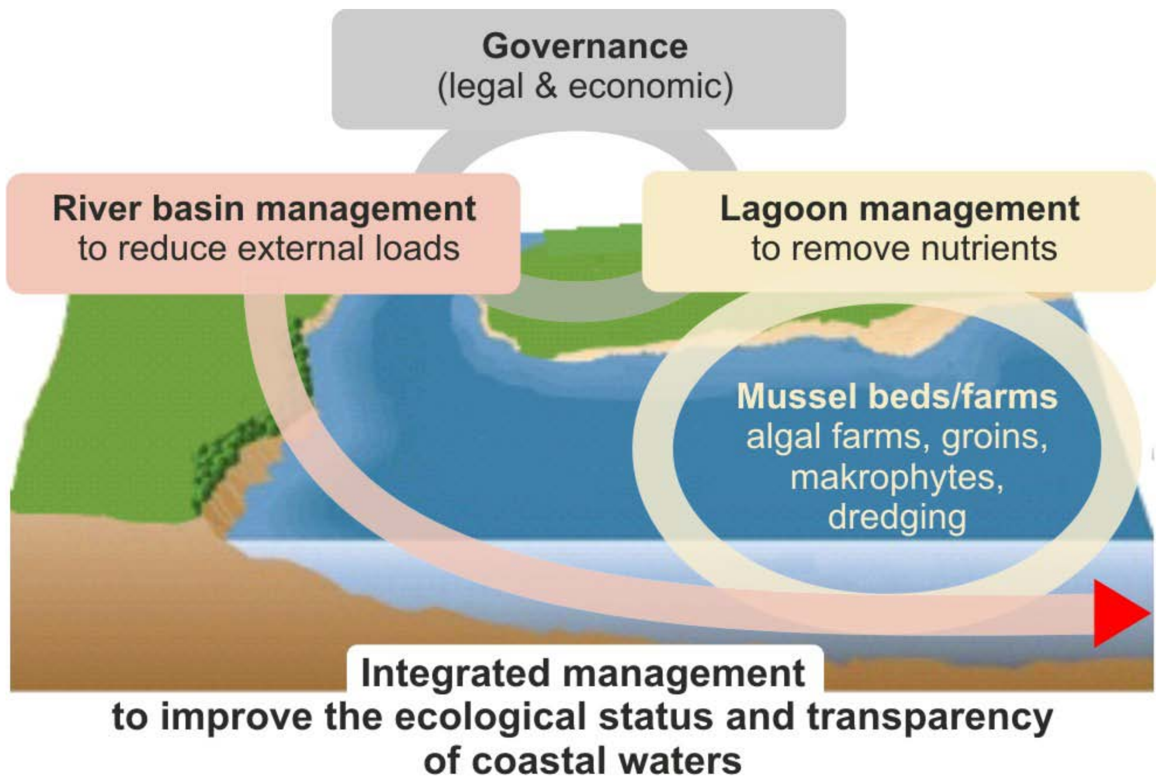




SPICOSA (EU-FP6)

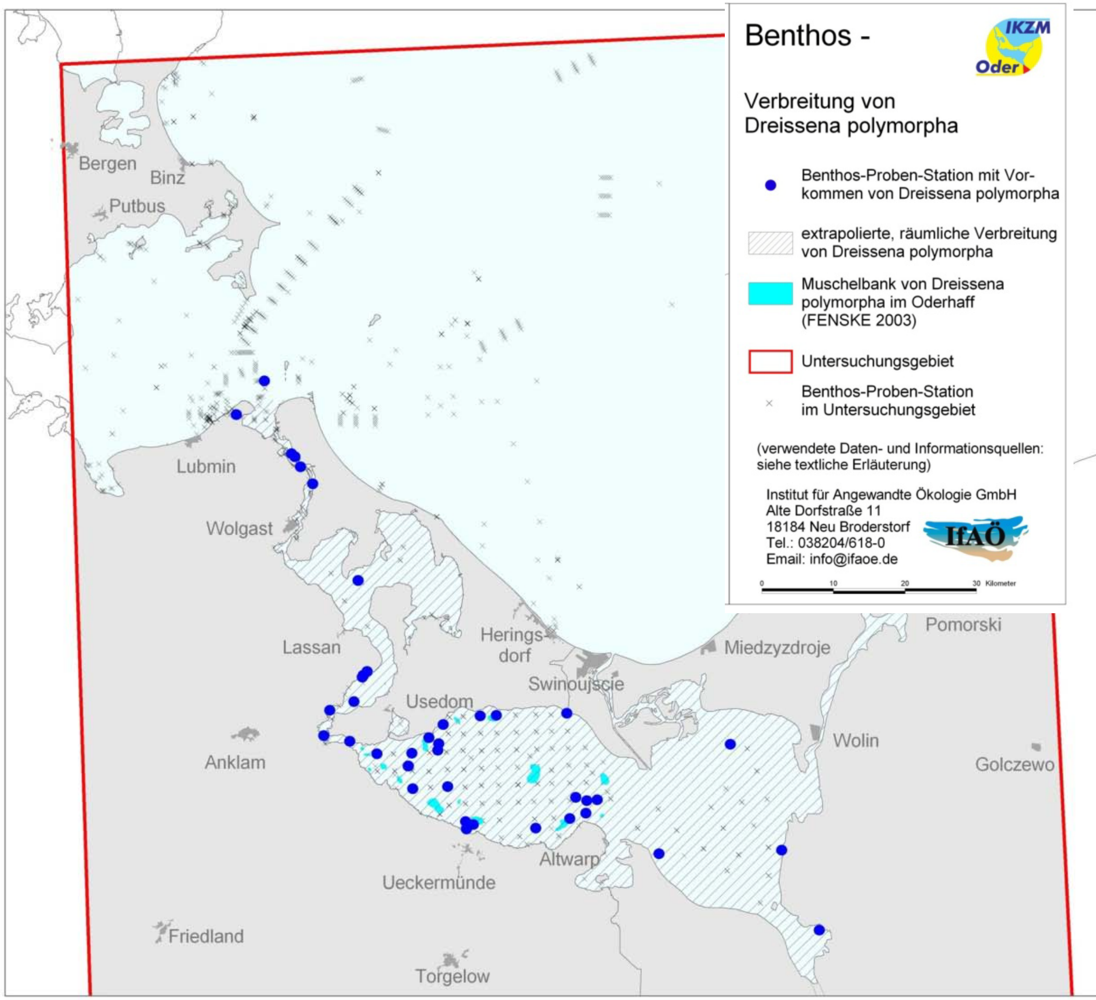
(Science and Policy Integration for COastal System Assessment)

- Development of a self-evolving, operational research approach framework for the assessment of policy options for the sustainable management of coastal zone systems
- Application to eutrophication management in the Oder/Odra river basin - coastal zone system with focus on internal measures in the Szczecin Lagoon



Lagoon management: Zebra mussels

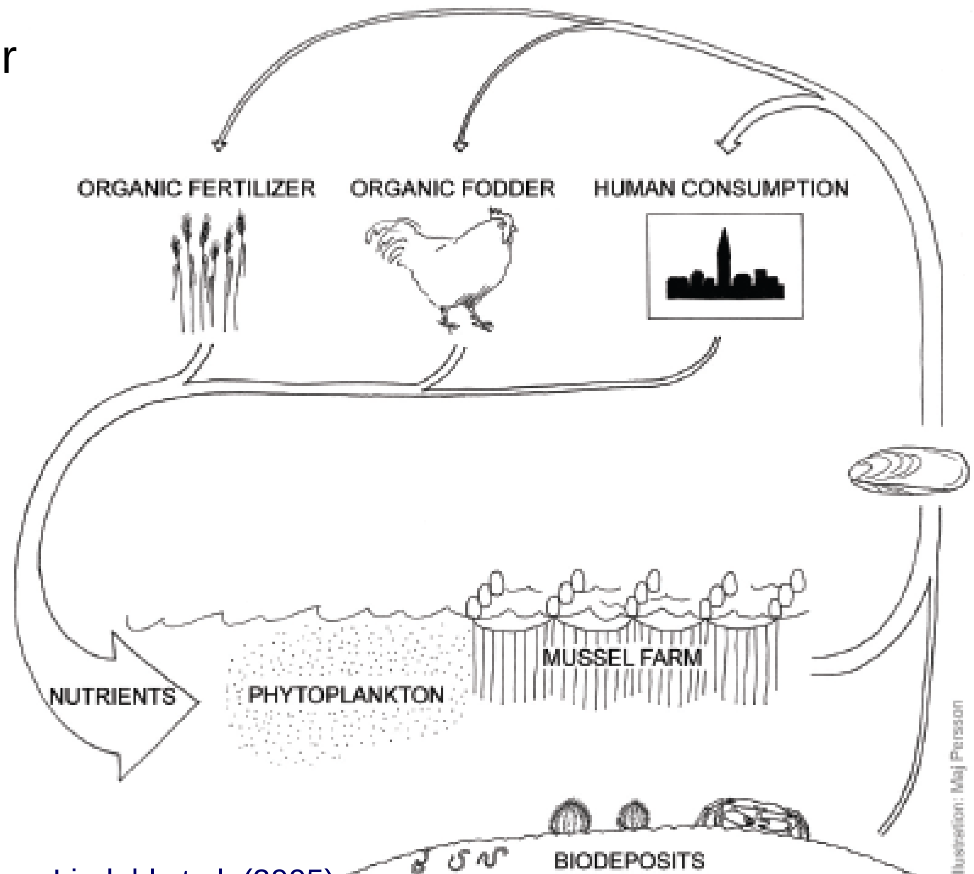
- Biomass: 68,000 t
- Coverage in the German part: 2.4 %
- Average abundance on beds: 4000 mussels per m²
- Filtration rate: 1083 l m^{-2} d^{-1}
- After 2 years
  - size: 12 - 14 mm (max. 30)
  - weight: 0.5 - 1 g (max. 2.5 g)



(Data after Fenske, unpubl.; Woźniczka & Wolnomiejski unpubl.)

Water quality improvement by mussel cultivation

- Enhancement of filtration capacity by cultivating on long lines or nets (increase of mussels from 4000 - 6400 per m²)
- Improved water transparency by higher filtration capacity
- Harvesting of 6.4 kg mussels per m² every 2 years
- Removing of 1% N
  per mussel (64 g N per m²)
- Mussels / mussel shells
  could be used for:
  human food, animal feed and fertilizer



Lindahl et al. (2005)

Lagoon Management

Questions

- To what extent can internal management measures in the lagoon increase nutrient retention and improve water quality (transparency)?
- How efficient are mussel farming and mussel beds (compared to other measures like dredging, makrophyte belts or algals)?

Scenarios

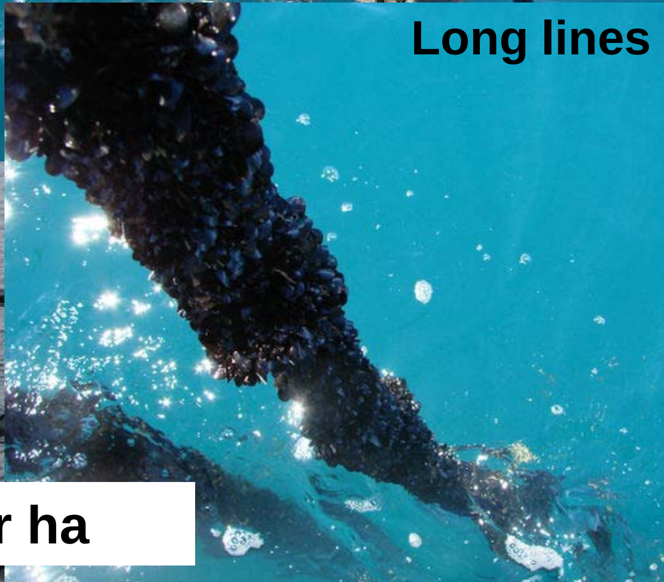
a) Maximum coverage with mussel (*Dreissena*) farms (2-4 m water depth)

b) Coverage to reduce the N-river loads by 10 %

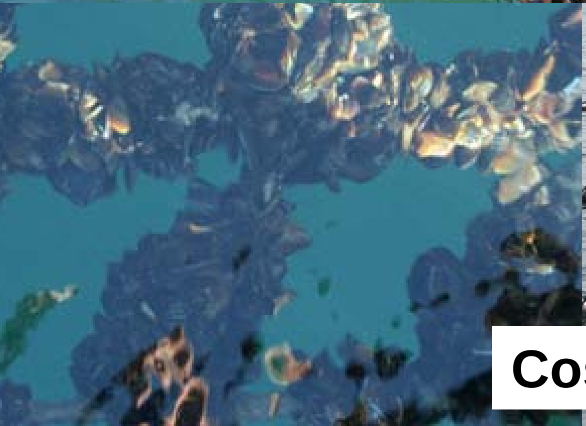
c) Existing mussel beds

Methods of mussel farming

Smartfarm

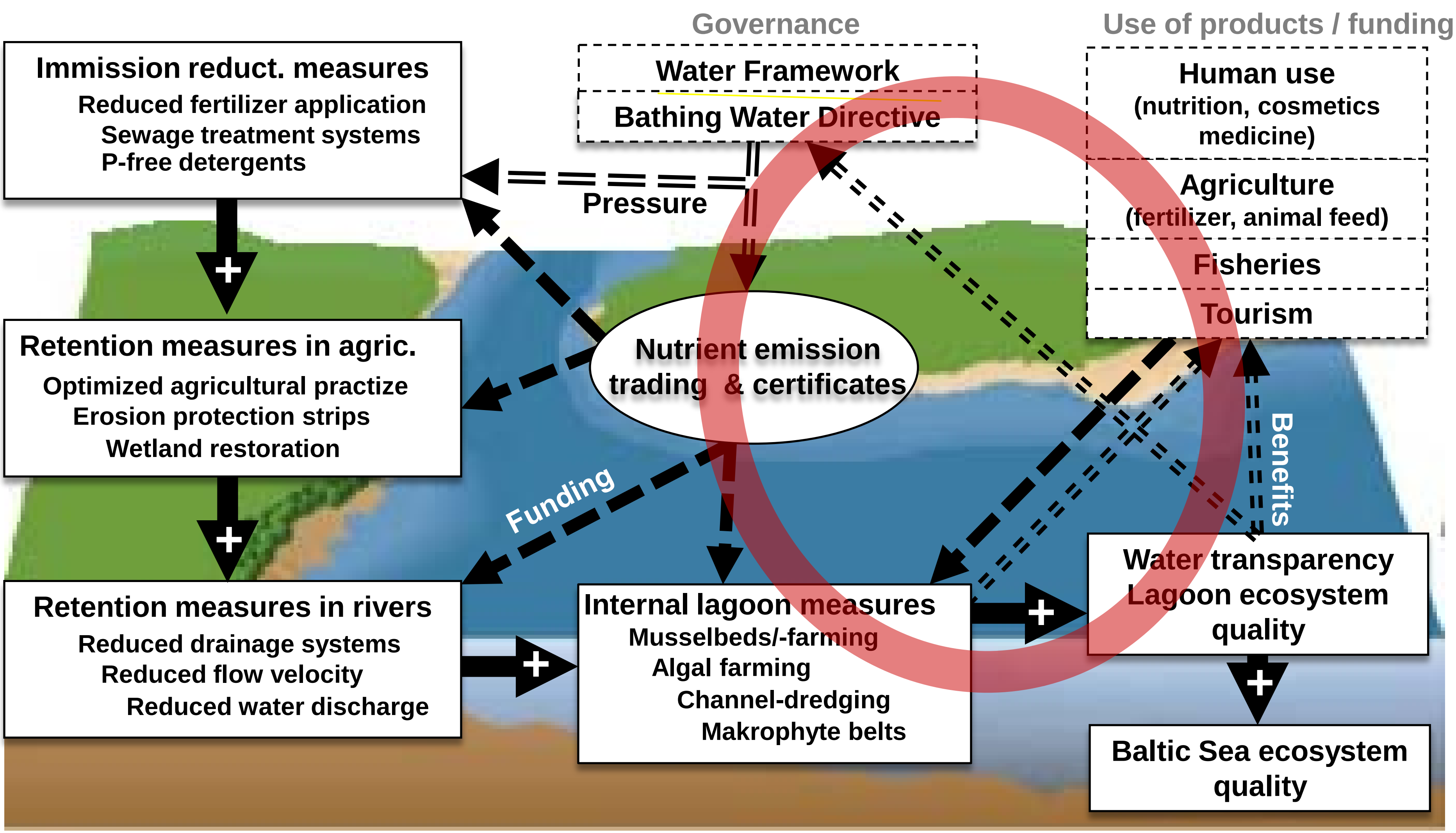


Long lines



Costs: 30,000-38,000 Euro per ha

New management-frameworks are needed



Thank you for your attention !!

Some recent publications

Schernewski, G., Behrendt, H., Neumann, T. (2008): An integrated river basin-coast-sea modelling scenario for nitrogen management in coastal waters. J Coast Conserv, DOI: 10.1007/s11852-008-0035-6, 12: 53-66.

Schernewski G., T. Neumann, S. Maack & M. Venohr (in press): Gewässereutrophierung. Fränzle, Müller & Schröder (Hrsg.) Handbuch der Umweltwissenschaften,Wiley –VCH Verlag.

Schernewski G., T. Neumann & H. Behrendt (in press): Sources, dynamics and management of phosphorus in a southern Baltic estuary. In: J. Harff, S. Björck & P. Hoth : The Baltic Sea Basin as a natural Laboratory. Springer

Schernewski, G., T. Neumann, Dieter Opitz & Markus Venohr (submitted): Long-term eutrophication history and functional changes in a large Baltic river basin - estuarine system. Estuaries and Coasts

Stybel, N., Fenske, C., Schernewski, G.. (2009): Mussel cultivation to improve water quality in the Szczecin Lagoon. Journal of Coastal Research, SI 56

Voss, M., Dippner, Korth, Neumann, Opitz, Schernewski, Venohr (submitted): History and future development of Baltic Sea eutrophication. Estuarine, Coastal and Shelf Science