Challenges for Baltic Sea Mussel Farming

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AQUAFIMA

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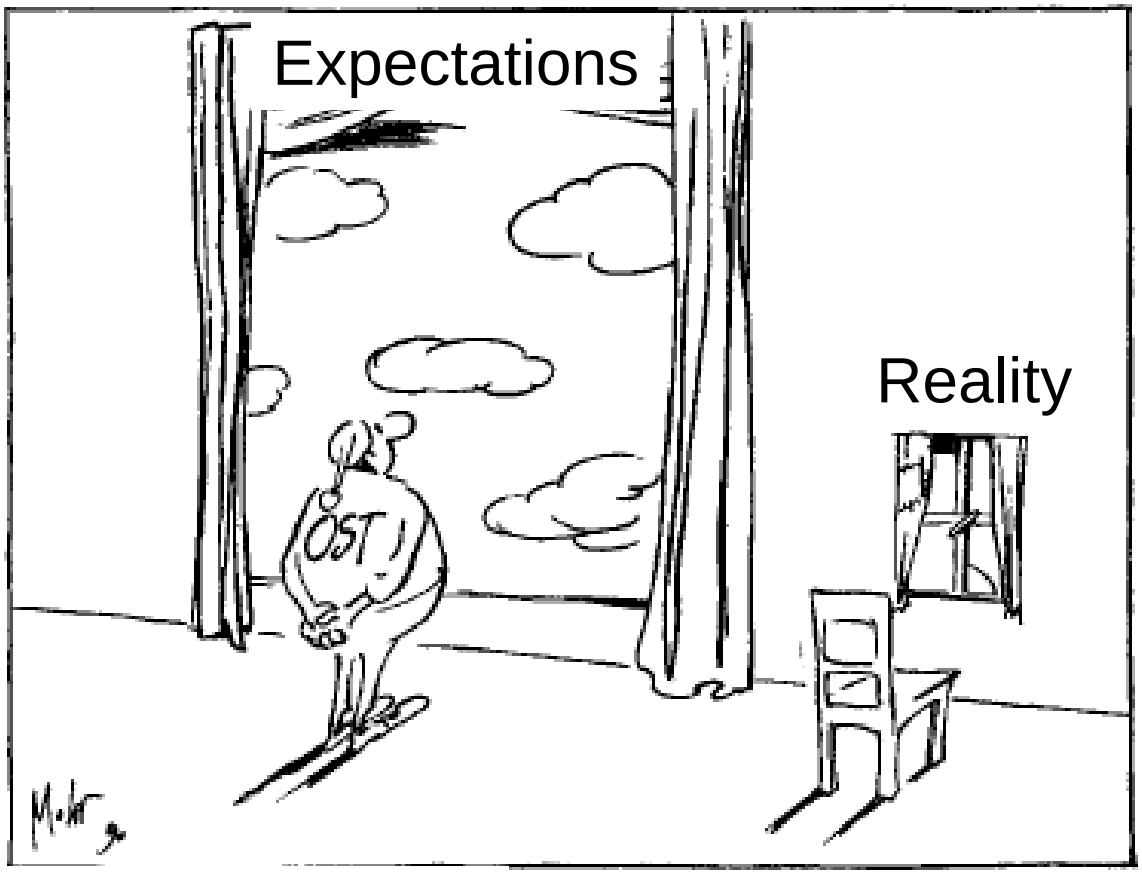
Ambivalence of mussel farming



Zeichnung: Mohr, 1990

Challenges of mussel farming

Biotic factors

- Competition for food
- Changes in benthic communities
- Changes in food web

Physico-chemical factors

- Influence of hydrodynamic regimes
- Concentration and accumulating of organic matter

Socio-economic factors

- Costs and benefits of mussel cultivation
- Spatial use conflicts
- Low acceptance and experiences
- Legal aspects

Biological effects I

Competition for food

- Extensive bivalve aquaculture can lead to intra- and interspecific competition for food between natural and aquacultured bivalves or other suspension feeders

-> growth rates are highest at intermediate mussel densities and with low growth rates at highest densities

-> mussel culture can replace copepods as the main pelagic grazing organism

->not clear whether benthic bivalve compete with zooplankton grazers for phytoplankton resource or whether bivalves filter out microzooplankton (Dame, 1996)

Biological effects II

Changes in (benthic) communities

- **Cultures can alter infaunal (benthic) communities through provision of complex habitats / artificial reef (incl. mussels falling to sediment) & input of organically rich material**
- ***Decrease in abundance and biodiversity* of benthic communities possible (Peterson et al. 2011)**
- **Opportunistic enrichment tolerant species become predominant**
- **Provision of new substratum for settlement and growth of beneficial and *unwanted* biota**

Biological effects III

Changes in food web

- **Acting as food attractive devise / competition with predators**

->provision of invasive species by cultivated food

-> e.g. Szczecin Lagoon - round goby (*Neogobius melanostomus*) is invaded. It primarily feeds on zebra mussels (up to 78 mussels / day). Cormorants population could increase. Fishermen fear further loss by cormorants feeding pressure on commercial fish.

Biological effects IV

Changes in pelagic communities

- in Szczecin Lagoon focus of mussel cultivation *(Dreissena polymorpha)* is on improvement of water transparency

->transparency < 50 cm due to algae blooms of cyanobacteria (*Mycrocystis, Anabaena*) in summer

- zebra mussels can filter selectively and may promote cyanobacteria blooms

Physical effects

Influence of hydrodynamic regimes

- **Cultivation structures can modify current velocity and direction of water movements**

-> alters natural patterns of erosion and sedimentation

-> important for sediment oxygen uptake that increases with lower current velocities

Chemical effects I

Concentration and accumulation of organic matter

- **faeces, pseudofaeces & dead mussels on the bottom**

-> decomposes under oxygen consumption and affects biogeochemical cycles

-> e.g. mussel culture on Swedish West coast (2800 m², 100t in 18 mth) sedimentation rates 2.4-3.3 gC/m²/d – 3times higher than at reference station (Dahlbäck & Gunnarson 1981)

- **Oxygen depletion events can follow (in western Baltic sea area if average water currents are less than 0.82 cm/s below a mussel farm (Carlsson et al. 2009))**
- **Decreased rates of denitrification and increase of ammonium production possible underneath intensive farms**

Chemical effects II

Critical reflection of German Federal Environmental Agency *(UBA)*

- **well-oxygenated sediments as prerequisite for positiv ecosystem effects of bivalve**
- **anoxic sediments recycle and release N & P as well as NOx as potent greenhouse gas**

-> lead to impacts on benthic fauna and in case of hazardous substances stored in the sediments these can be released under anoxia

1.Too much threats! – Too little long-term experiences

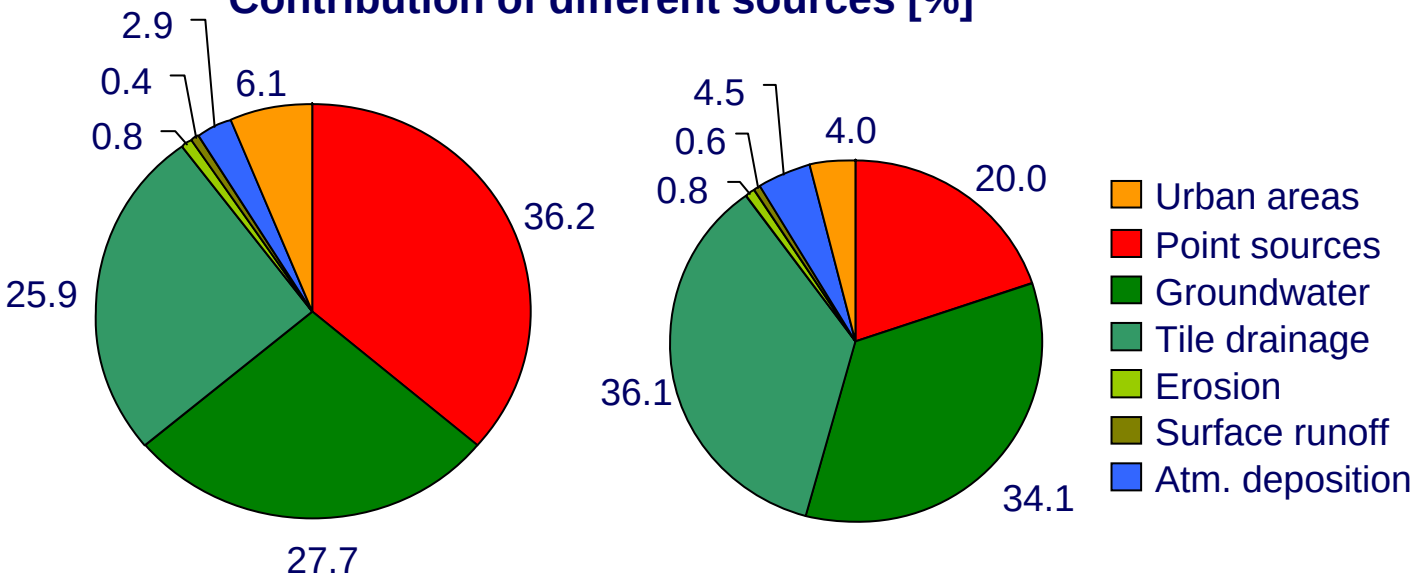
2. Nutrient inputs must be remediated at source / as close to the source as possible

-> Agency is against using large-scale mussel farming !

Reduction of nitrogen loads in the river Oder

Average 1993–1997 **Optimal scenario**

Contribution of different sources [%]



Total N emissions

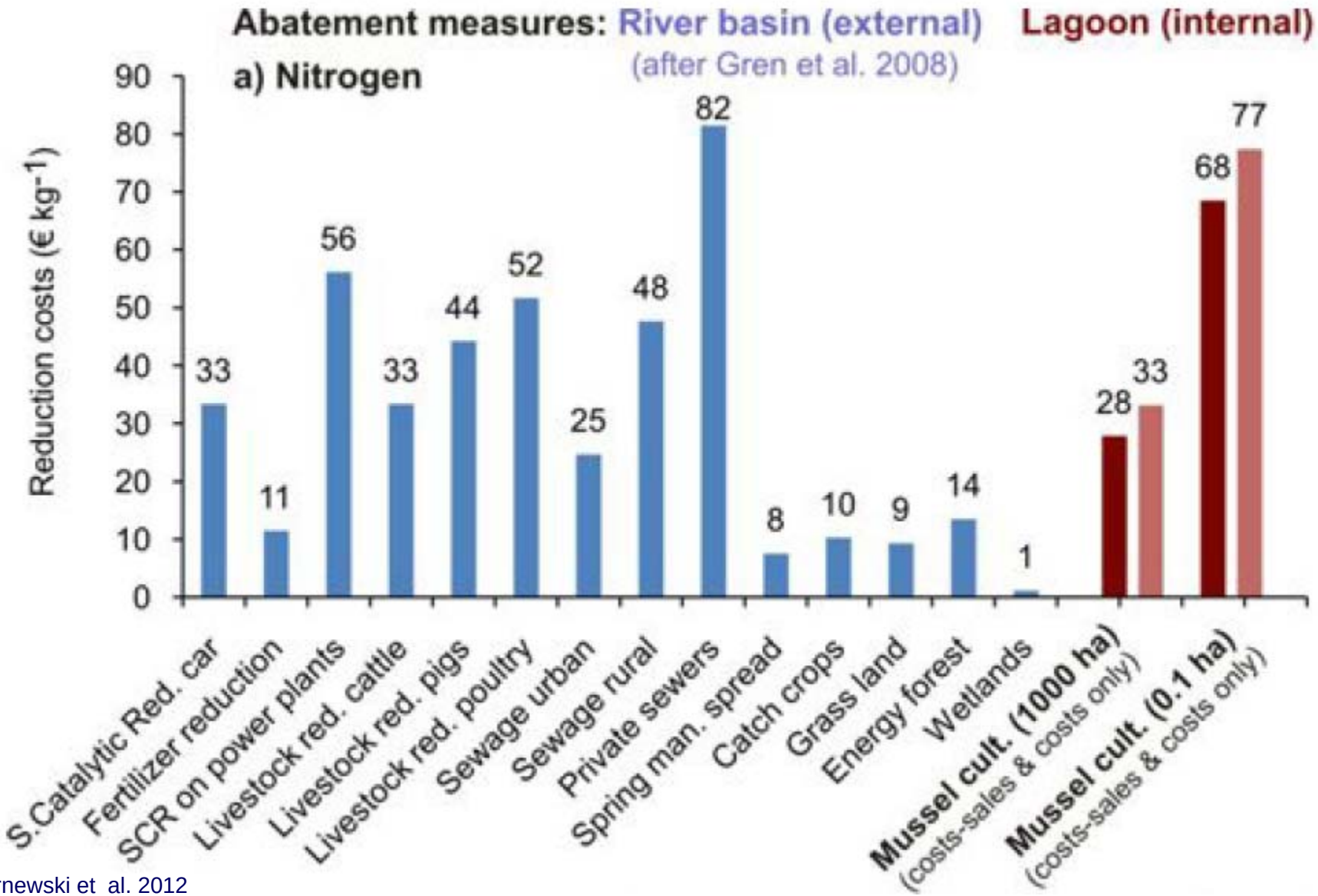
118,400 [t/a] **77,600 [t/a]**

Average annual total nitrogen emissions in the Oder river during the period 1993-1997 (left) and according to the scenario (optimal load reduction scenario, right)

= 35 % reduced N-load in the scenario; further reduction with high marginal costs

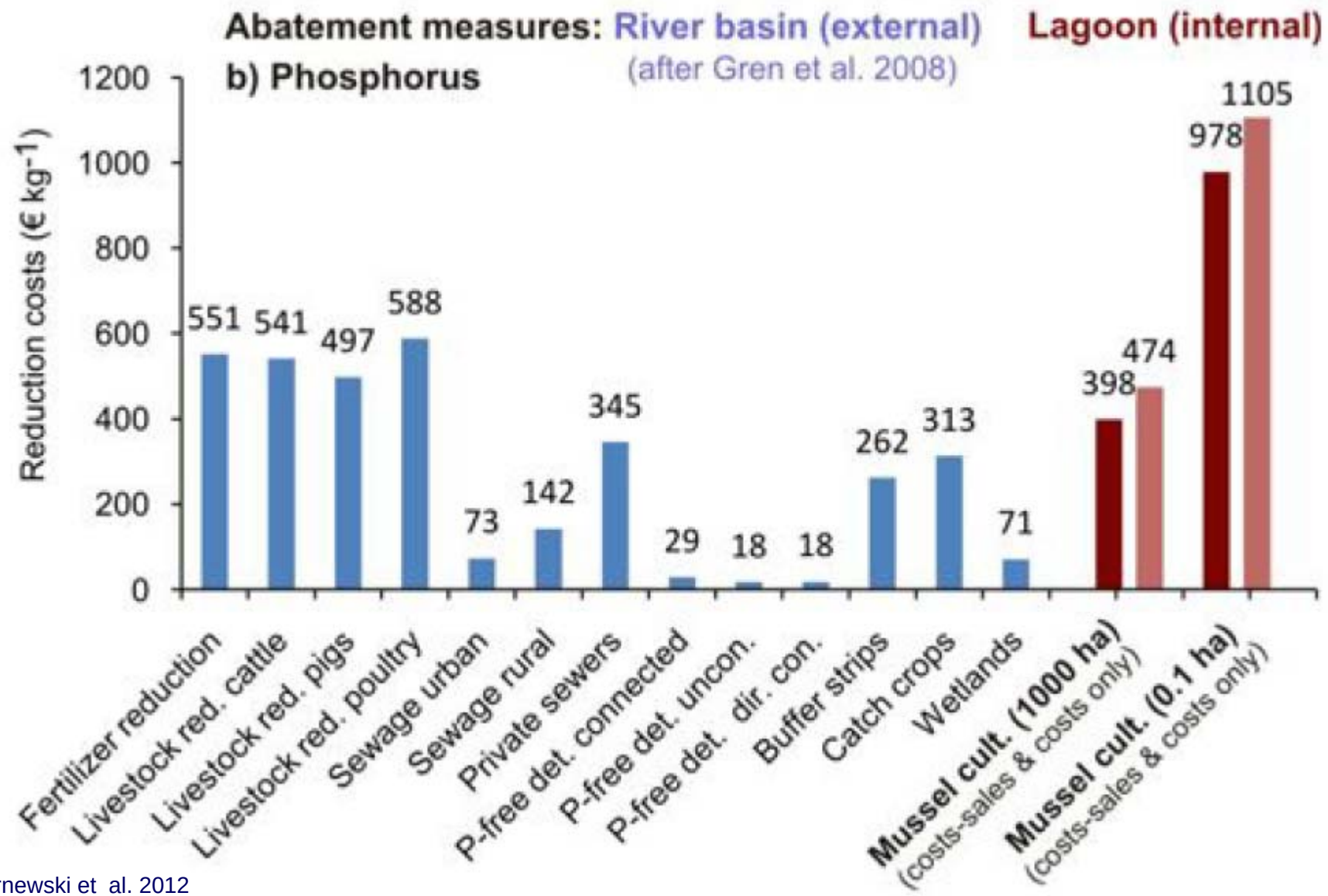
Behrendt et al. (2005) in Schernewski et al. 2008

Costs of measures to reduce 1 kg N



Schernewski et al. 2012

Costs of measures to reduce 1 kg P



Schernewski et al. 2012

Socio-economic effects

Costs and benefits of mussel cultivation

- few studies about cost-benefit available

-> marginal costs per kg nutrient removed: 0-10 € N and 0-100 € P (Gren et al. 2009)

- no costs when mussels could be used as seafood – unlikely because of meat content, concentration of heavy metals, toxins and pathogenic microbes
- use as feedstuff and fertilizer depends also on quality of harvested mussels!
- **Critique:** Comparison of costs is not possible as long as only harvested N & P by mussels is taken into account - enhanced release rates of N & P from sediments + potential loss of denitrification must be considered as well

Socio-economic aspects

Acceptance of local population

- Aesthetic problems by visual intrusion (buoyage on surface)
- Drifting of torned off cultivating structures due to storm events, ice-drift

-> creates marine litter

-> dangerous for ecosystem (entanglement for large vertebrates – mammals, birds) and visual disturbance

Interviews of fishermen

First results

- **Small part of fishermen can imagine to carry out aquaculture, but just additionally and when cost-effectiveness is assured.**
- **Problems named by opponents:**
  - **aquaculture technically not feasible in lagoon**
  - **competition with traditional fishery**
  - **spatial use conflicts**

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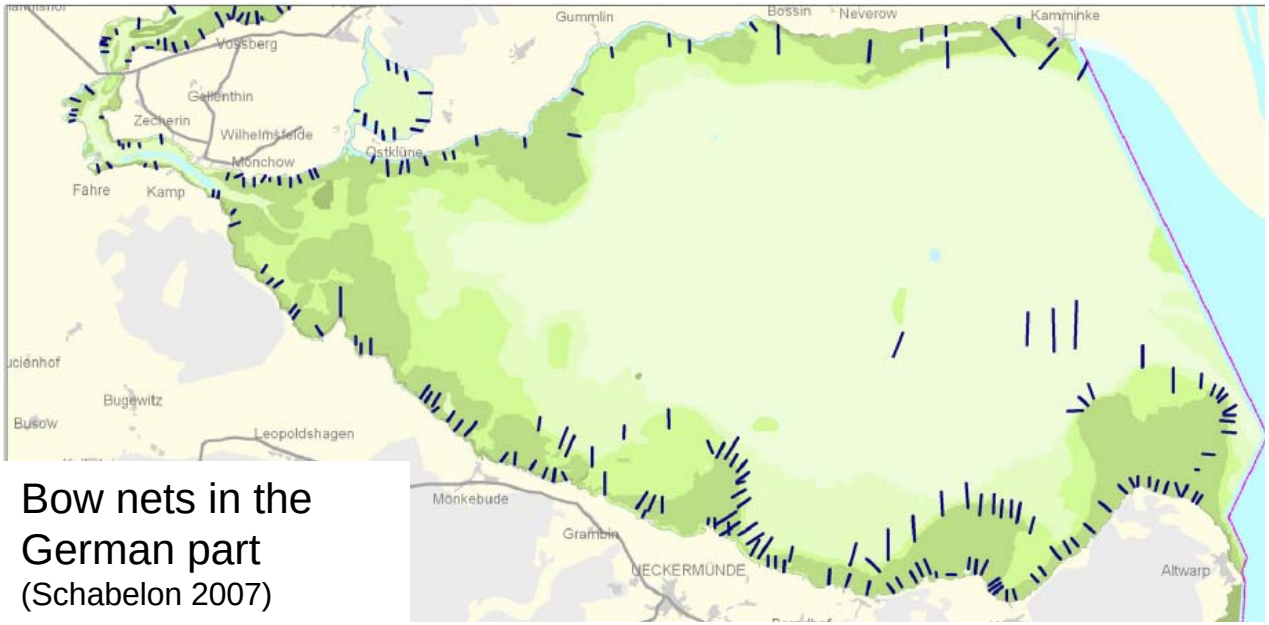


Bow nets in the German part
(Schabelon 2007)

SWOT-Analysis

Mussel cultivation in the Szczecin Lagoon

Strenghts	Weaknesses	Opportunities	Threats
• **Environmentally friendly**, „native“ species • **Removal of nutrients** by periodic harvest • **Improvement of ecosystem quality** by increased biodiversity • **Low limitation by spatfall** in comparison with bottom cultures	• **Uncertain commercial use** because of slow growth and small harvest size • **Increased concentration of heavy metals** affects mussel use for animal husbandry • **Reduction of mussel biomass** by predators (fish, waterfowl) or lack of food • **No tradition and experiences** in mussel cultivation • **Uncertain legal and planning situation**	• **Resettlement of macrophytes** by improved water transparency • **Altered food web interactions,** more benthic feeding fish and expanded fishery • **New regional jobs** in harvesting and processing of mussels • **Higher number of tourists and overnight stays in summer season** by improved water transparency	• **Local anoxic surface sediment** by deposited organic material • **Bothered tourists** by mussel shells washed ashore • **Material damage** by fouling of boats, gillnets etc. • **Damage of net structures** by ice cover in winter

Legal aspects

Lack of appropriate legislation

Germany: Little experiences with mussel aquaculture.
No aquaculture law!

Permission depends on:
- **structure, size and place of construction**
- **method of cultivation (e.g. nutrient input, risk of anoxia)**

Szczecin Lagoon:
- **Definition as fishery method or method for water protection determines implementation**
  ->fishery method would be easier to implement
- **Environmental Impact Assessment required**
- **whole lagoon is part of NATURA 2000 network - permission under environmental law possible?**
- **biofilter deployment adds bureaucracy**

Legal aspects

Lack of incentives

- **potential farmers tend to have a narrow short-term view focussed on immediate profits**
- **current aquaculture operations do not recognise economic value of bioremediation**
- **lack of tools and incentives to support bivalve farming for bioremediation**
- **polluter-pay principle is missing**

->if implemented costs of biofilters could be added to production costs and would constitute additional income to farmer

Bivalve carrying capacities

Sustainable shellfish farming

- **Importance of selecting an appropriate site – with a high demand for water quality improvement (not related to highest profit)**
- **Ensuring stocking densities and biomass remain in accordance with assimilative and dispersive capacity of surrounding environment**
- **Combination of mussel cultivation (+ algae cultivation) and fish farms to excess nutrients and wastes**

Conclusion

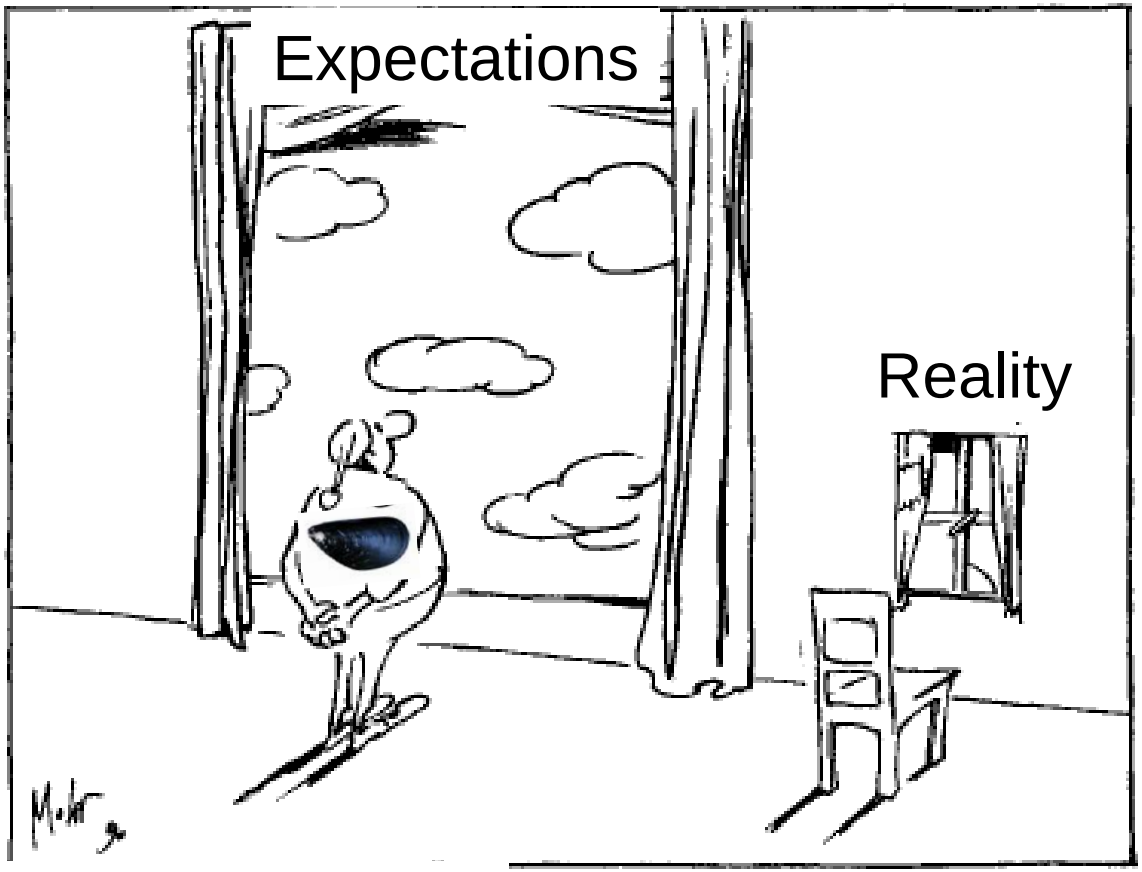
Knowledge gaps:

- **What is the cumulative ecological impact of an increased bivalve population?**
- **What can we learn from advanced mussel cultivating countries? Can we transfer your knowledge to our less saline coastal regions?**

Need for more:

- **Experiences in small-scale pilot measures and modelling of ecological carrying capacity**
- **Awareness and co-operation between stakeholders**

Thank you for your attention !



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Stybel, N., Fenske, C., Schernewski, G. (2009): Mussel cultivation to improve water quality in the Szczecin Lagoon. Journal of Coastal Research 56, 1459-1463

Schernewski, G., N. Stybel, and T. Neumann (2012): Zebra mussel farming in the Szczecin (Oder) Lagoon: water-quality objectives and cost-effectiveness. Ecology and Society 17(2): 4.