



Challenges for Baltic Sea Mussel Farming

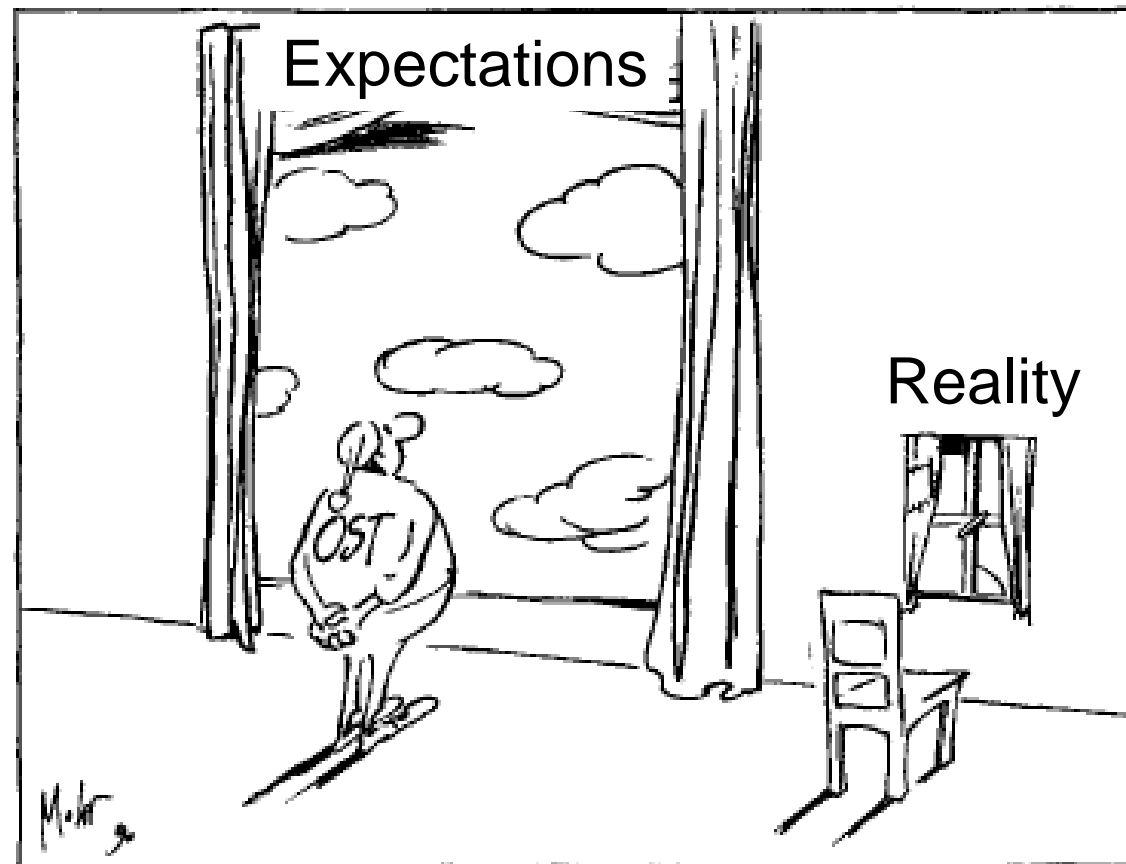
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Leibniz-Institute for Baltic Sea Research**

Mariehamn, 11.10.2012



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.



Wikipedia

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



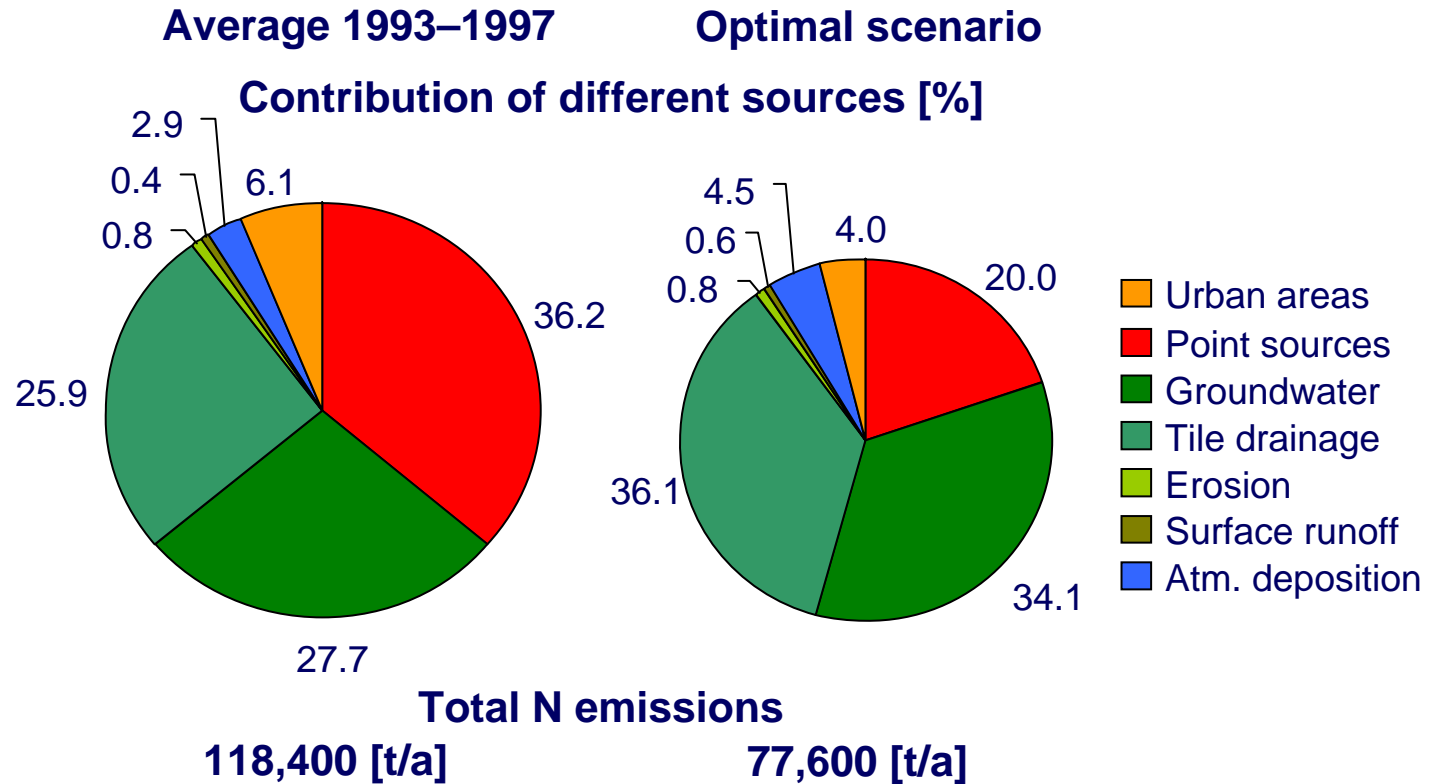
Chemical effects II

Critical reflection of German Federal Environmental Agency (UBA)

- well-oxygenated sediments as prerequisite for positive ecosystem effects of bivalve
 - anoxic sediments recycle and release N & P as well as NO_x 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 !

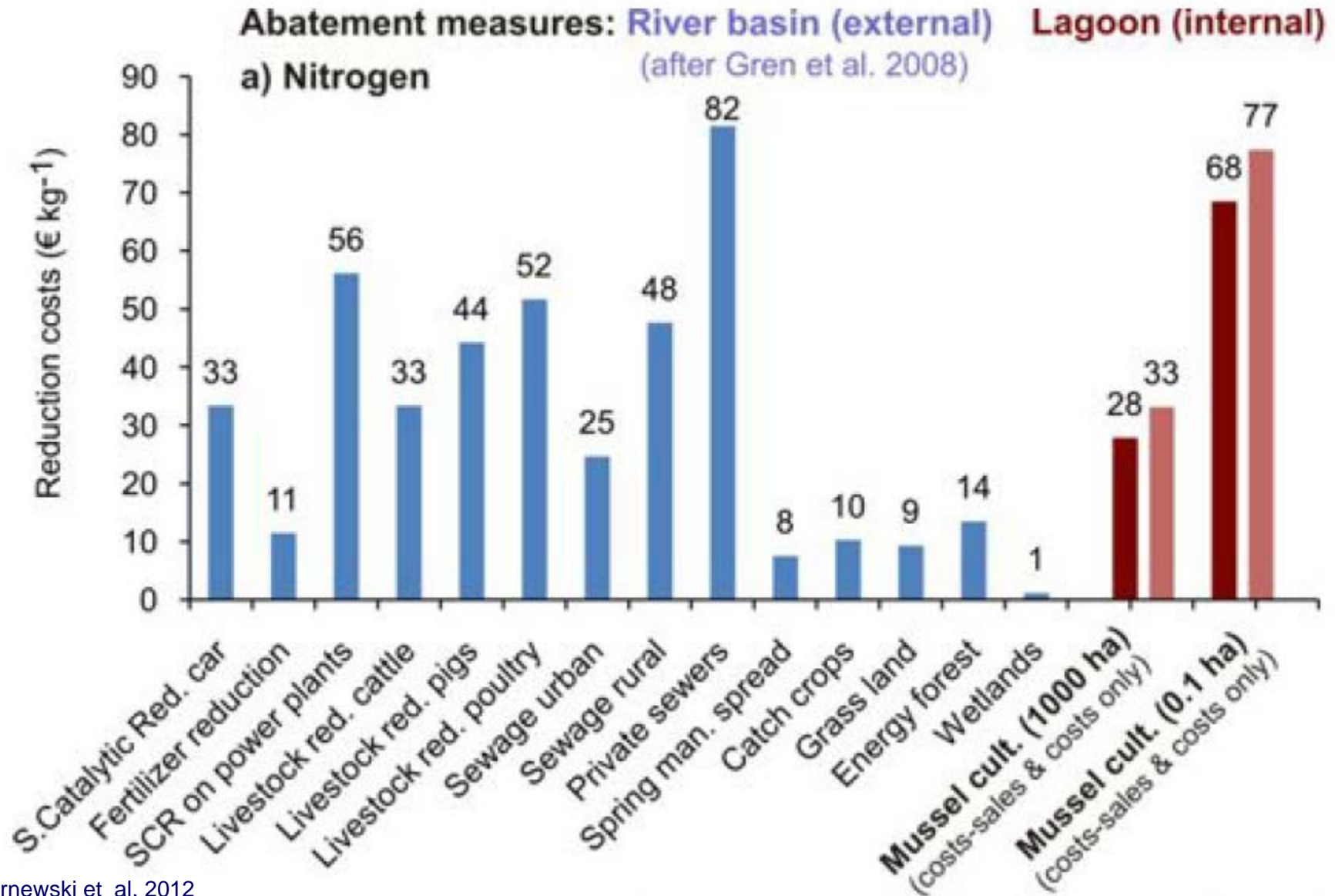


Reduction of nitrogen loads in the river Oder

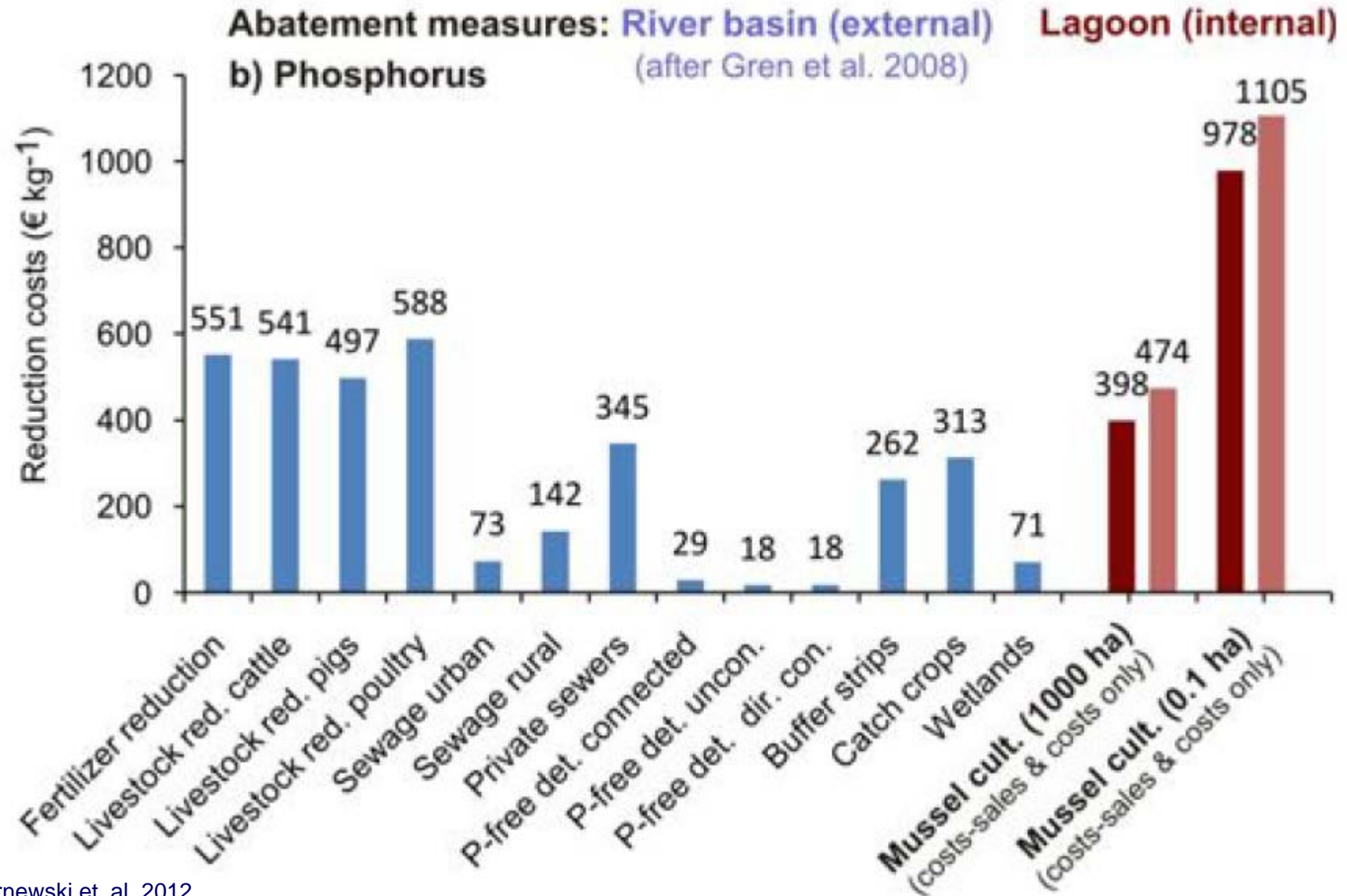


Average annual total nitrogen emissions in the Oder river during the period 1993-1997 (left) and according to the scenario (optimal load reduction scenario, right)
= 35 % reduced N-load in the scenario; further reduction with high marginal costs

Costs of measures to reduce 1 kg N



Costs of measures to reduce 1 kg P





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

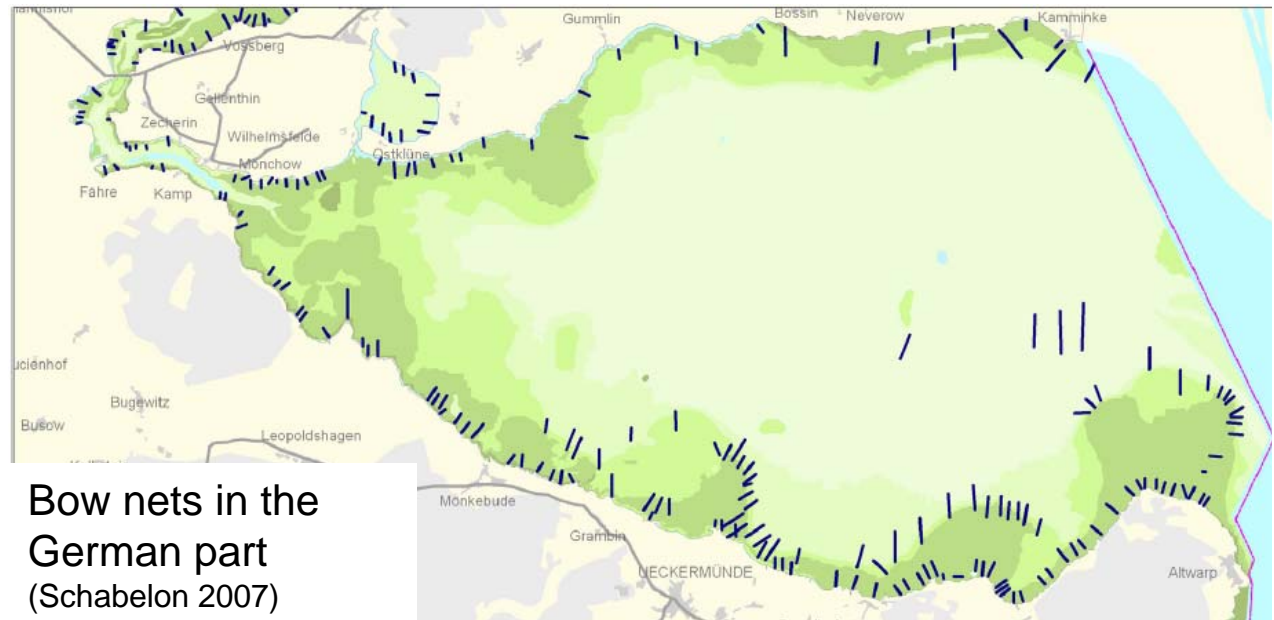
- Small part of fishermen can imagine to carry out aquaculture, but just additionally and when cost-effectiveness is assured.
- Problems named by opponents:
 - aquaculture technically not feasible in lagoon
 - competition with traditional fishery
 - spatial use conflicts



ARTWEI



AQUAFIMA



Bow nets in the German part (Schabelon 2007)

SWOT-Analysis

Mussel cultivation in the Szczecin Lagoon

Strenghts	Weaknesses	Opportunities	Threats
<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• 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

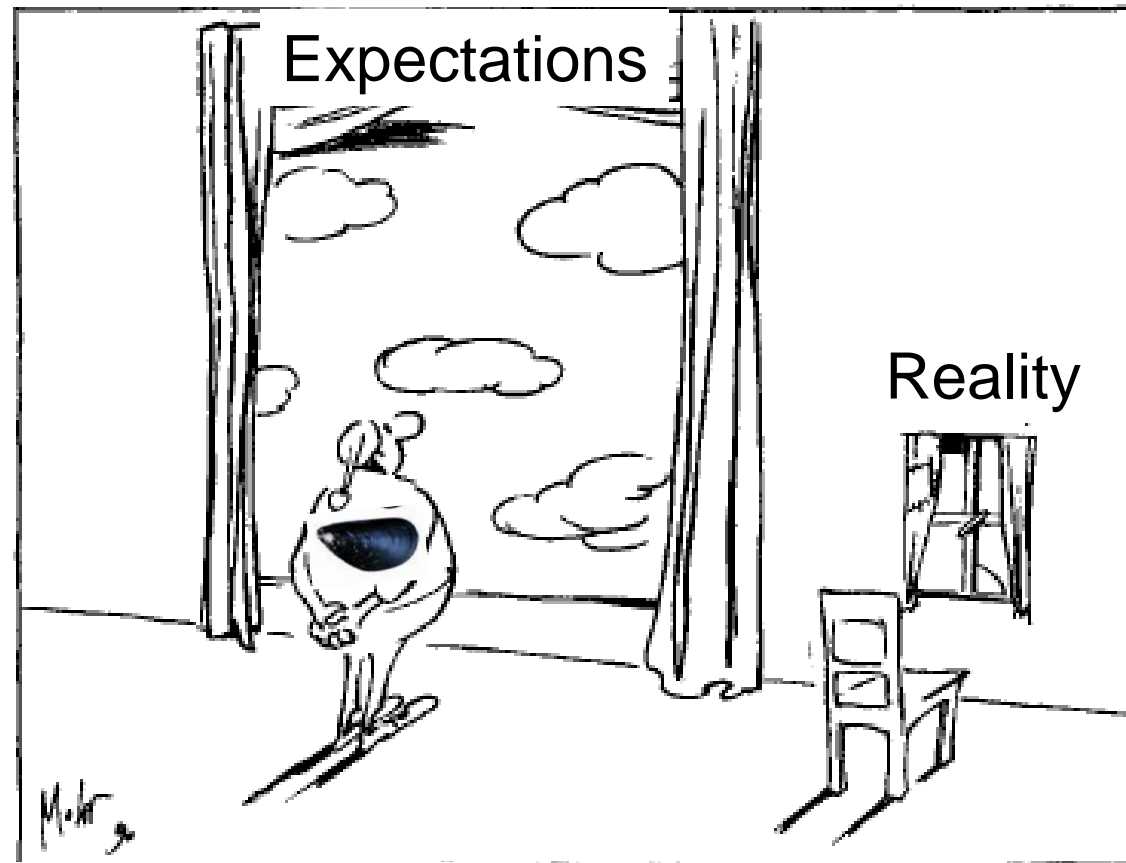
Knowledge gaps:

- 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 !



Zeichnung: Mohr, 1990

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.

