

Mussel Mitigation Farming

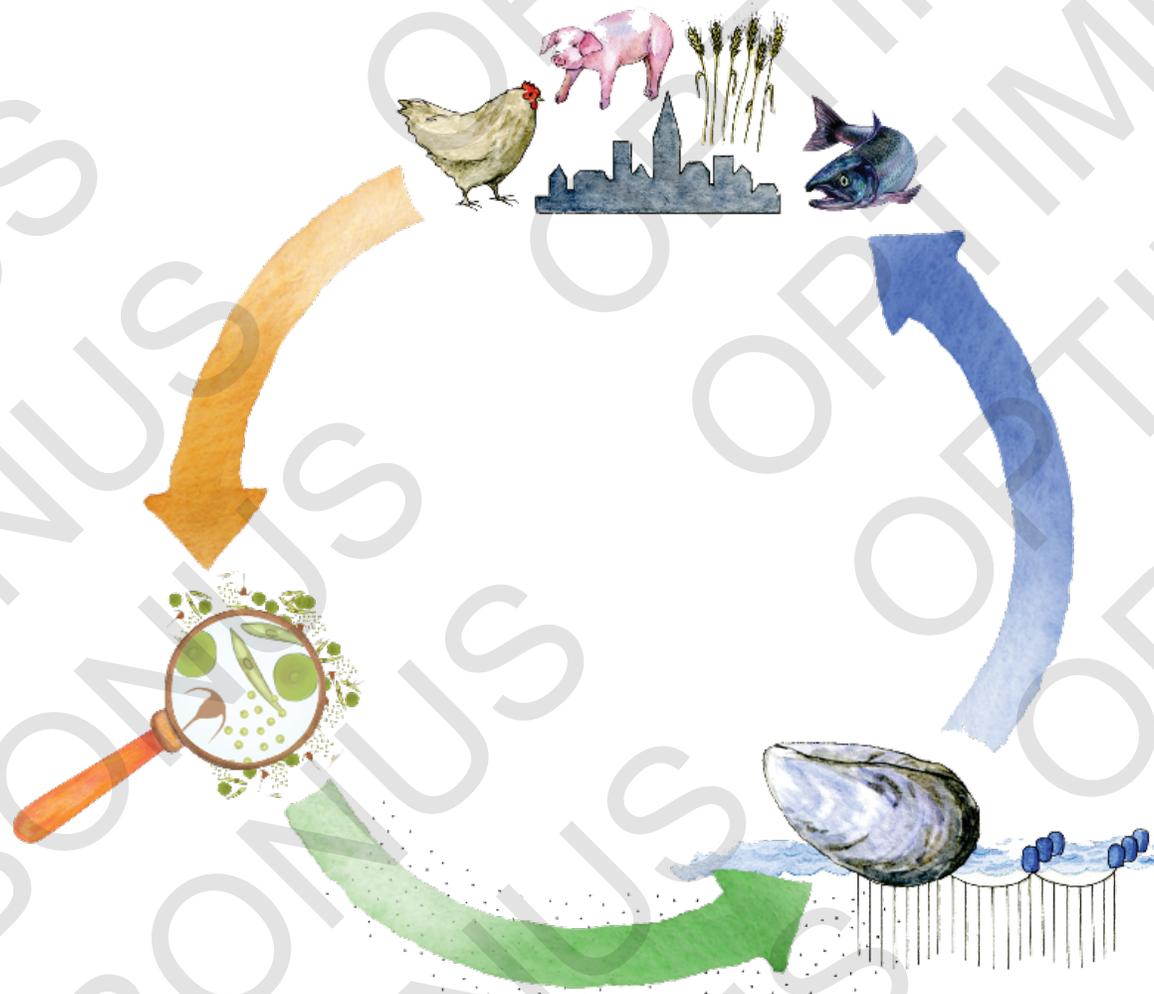
Transforming eutrophication to high quality protein

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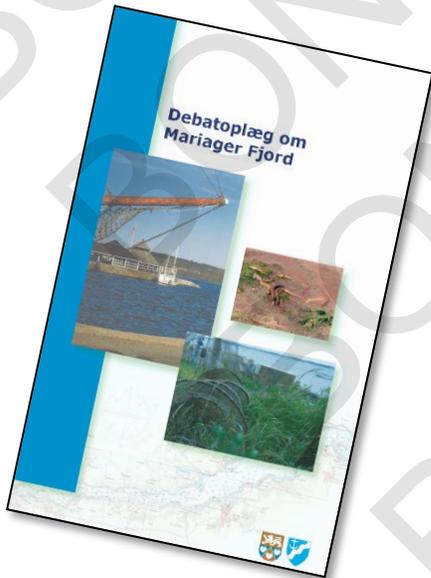
The mussel mitigation farming tool



Prerequisite: *De novo* production, not harvesting standing stock

Mariager Fjord 1997

Historical context



KVÆKVOTER – BEDRE FOR MILJØET I HAVET OG ØKONOMIEN

KVOTEANLEGG FOR OPPÅK AV NITROGEN I LYSKIL

Anøsken fra NORDIC SHELL PRODUCTION AB.

Utarbejdet gjennom Interreg-prosjektet "Blåskjellanlegg og nitrogenkvoter"



frontiers
in Marine Science

Intervention Options to Accelerate Ecosystem Recovery From Coastal Eutrophication

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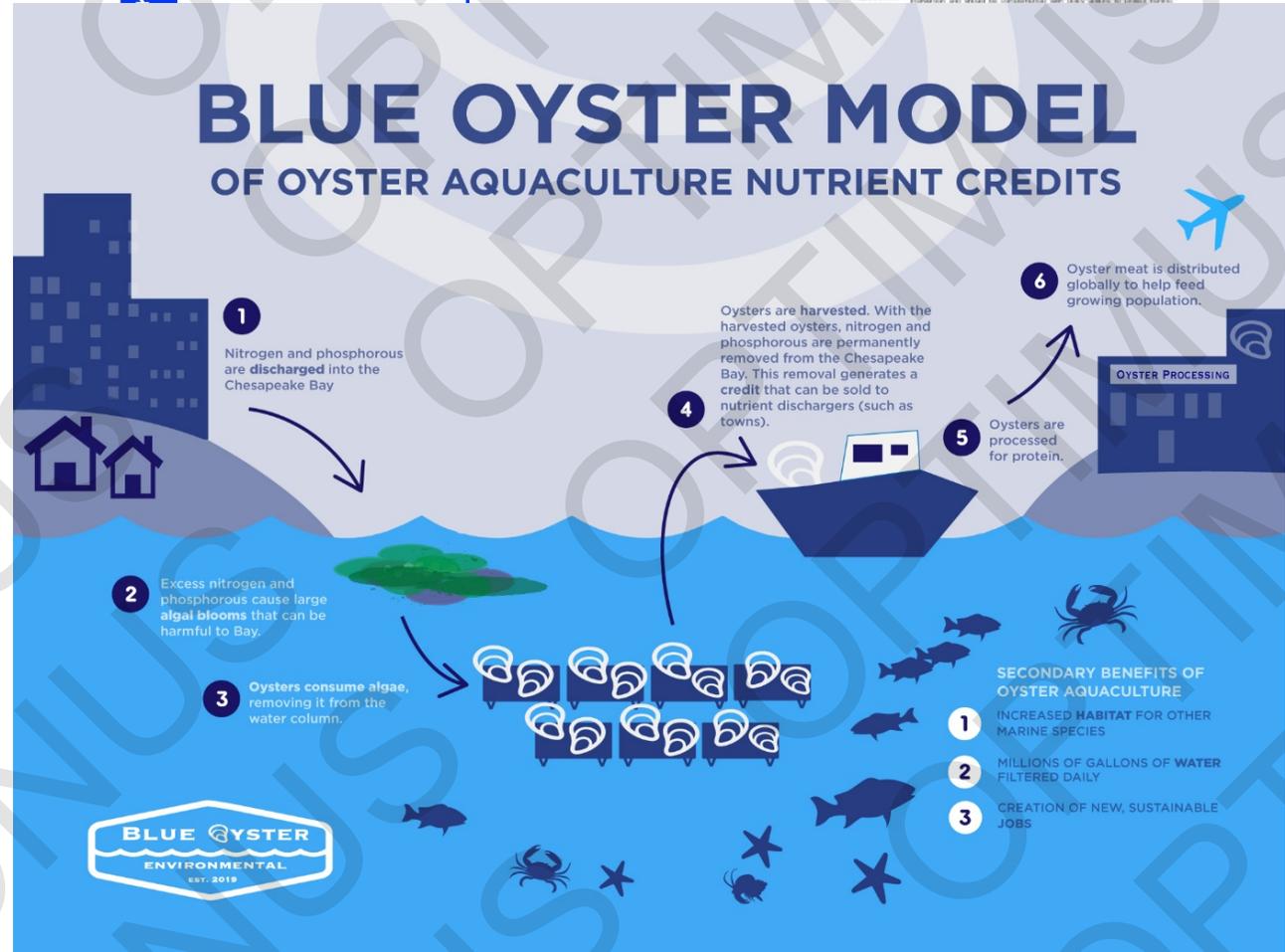
There is growing concern about the state of coastal ecosystems globally. These ecosystems are facing increasing pressure from human activities, including those associated with climate change, such as warming, ocean acidification, and increased runoff. These additional pressures risk counteracting efforts to reduce eutrophication and arrest coastal ecosystems in a state of eutrophication. Despite the efforts and significant resources already invested to meet coastal eutrophication, there is an urgent need for a broader, more comprehensive approach to managing coastal eutrophication. Options for intervention include multiple levers controlling major pathways of nutrient loading of coastal ecosystems, i.e., nutrient inputs, which in the intervention most commonly depend on nutrient export, sequestration in sediments, and removal of nitrogen to the atmosphere as N₂ gas (denitrification). The authors review local-scale hydrological engineering to increase flushing and nutrient export from semi-enclosed coastal systems, biological engineering such as sustainable aquaculture of oysters and mussels to enhance nutrient export and restoration of bivalve habitats to increase denitrification in sediments as well as denitrification and geo-engineering approaches including, with much precaution, aluminum sandbars in sediments. These proposed supplementary management levers to reduce eutrophication involve ecosystem-level interventions and should be complementary with policy actions to protect sources.

OPEN ACCESS

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US nutrient credit trading

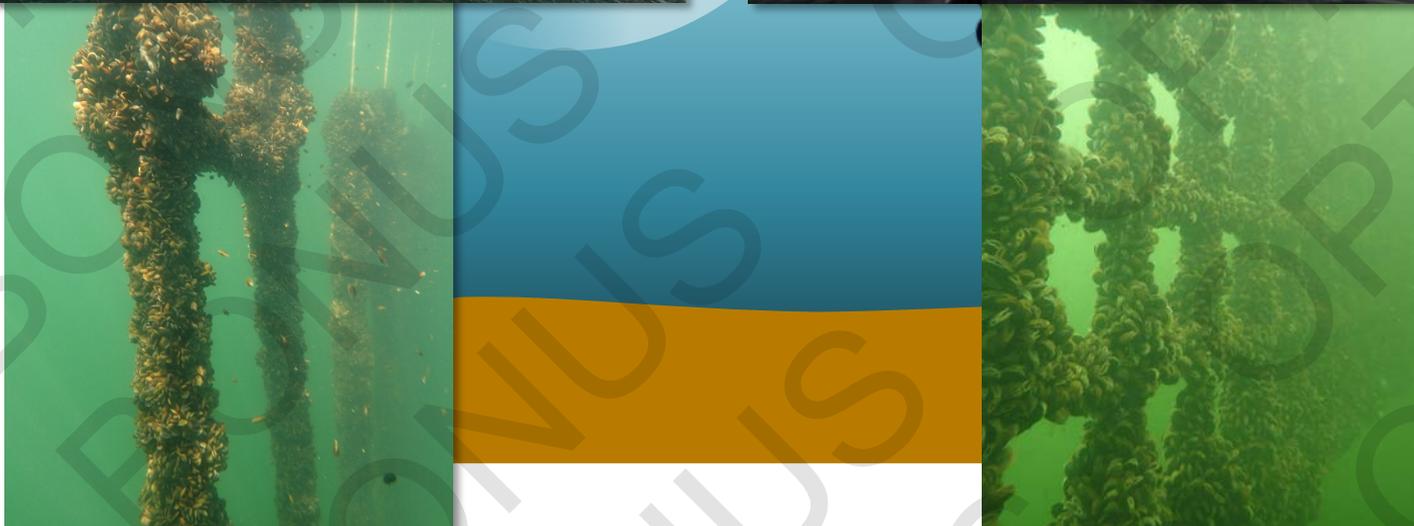
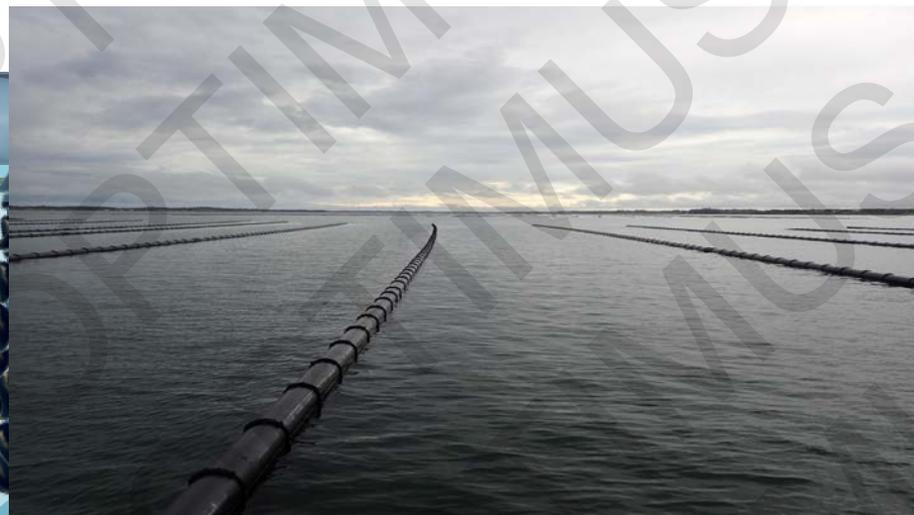
How is it done?



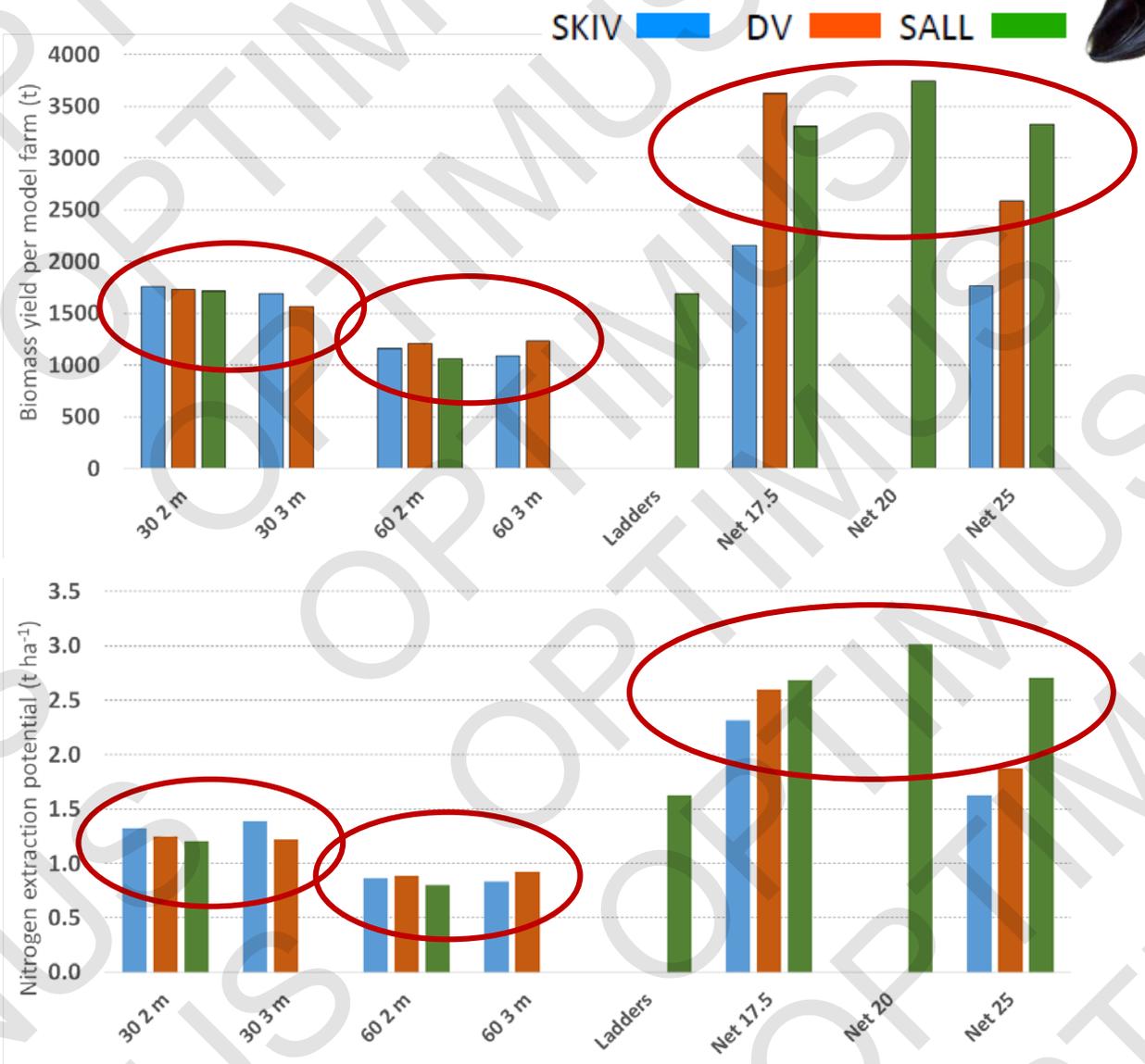
Longlines



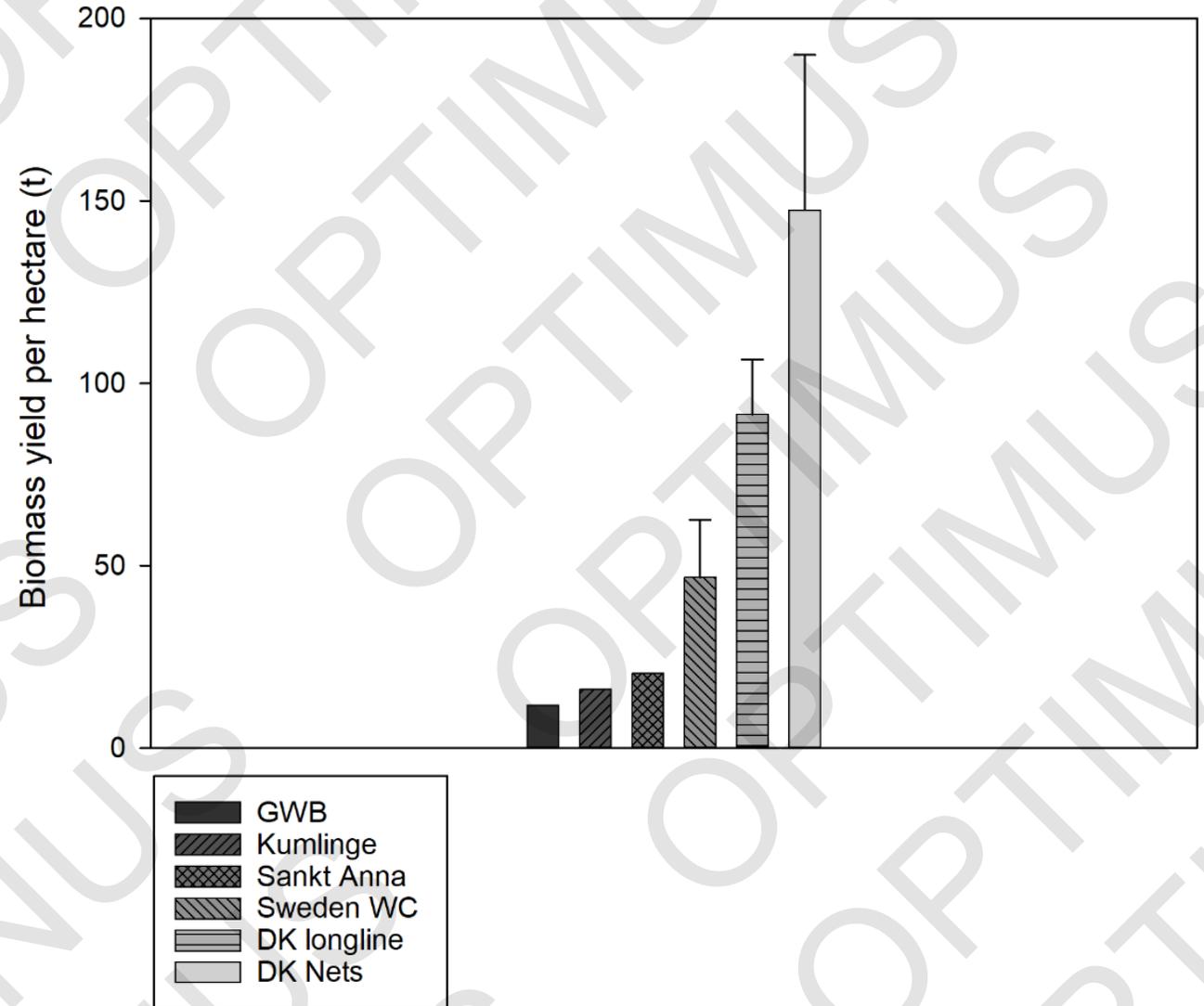
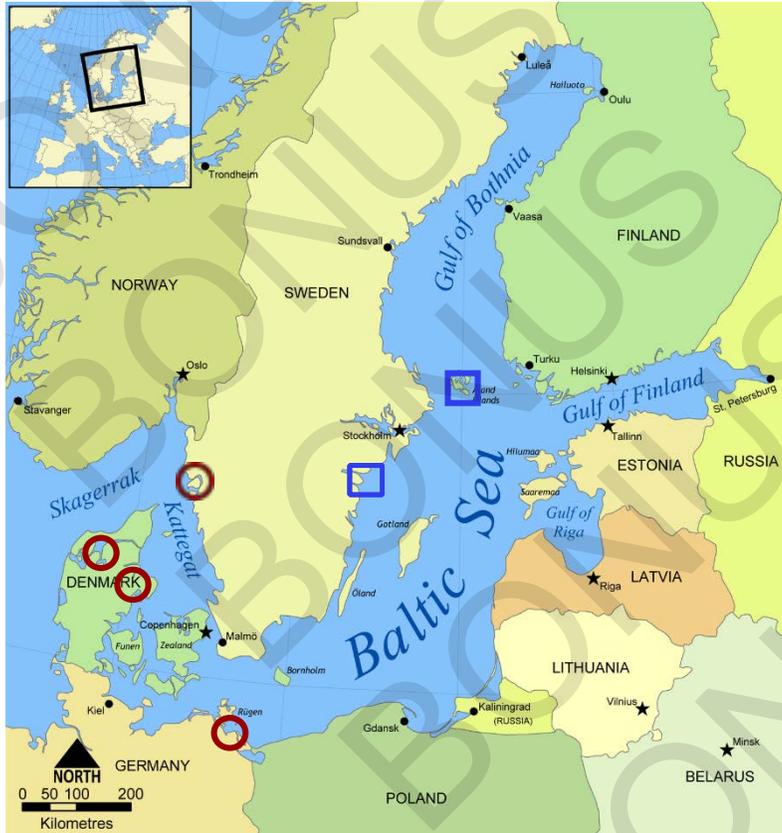
Nets+Pipes



Ecosystem service: N (& P) removal



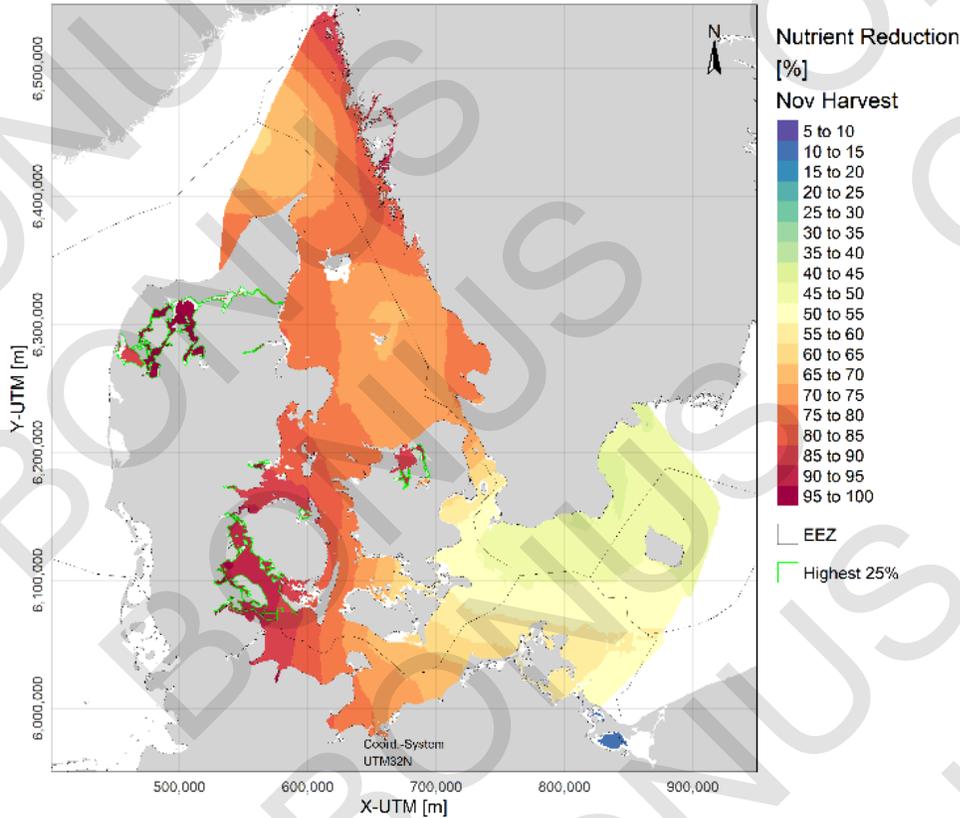
Baltic perspective



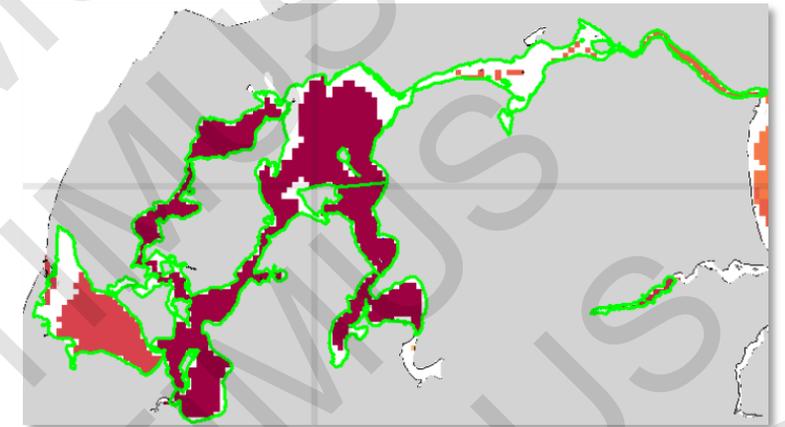
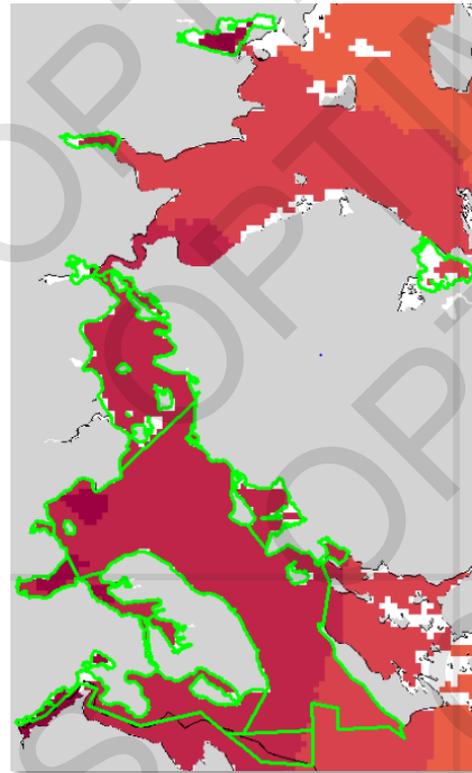
Western Baltic removal potential



Relative Nutrient Reduction

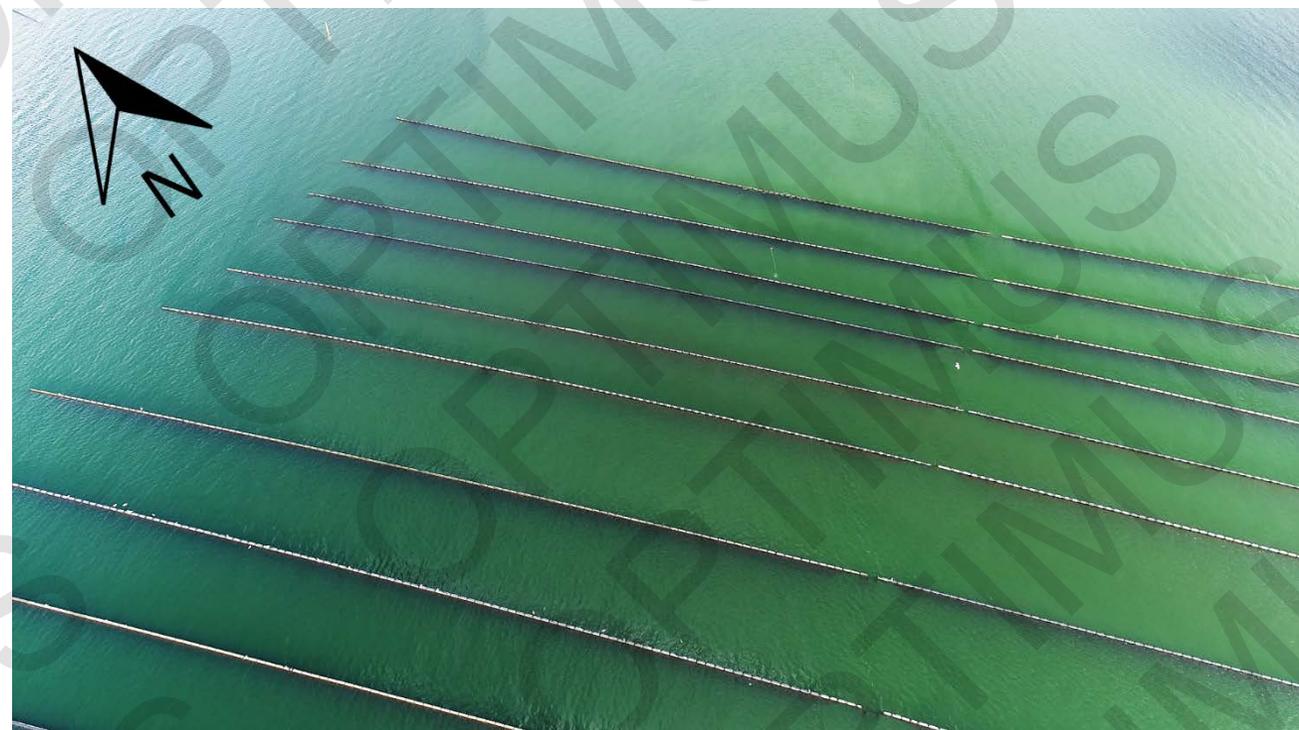
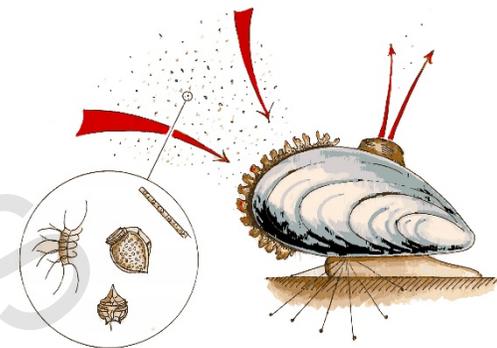


100/red indicates:
Longlines: 0.7-1.4 t N/ha
Net+pipes: 1.6-3.0 t N/ha



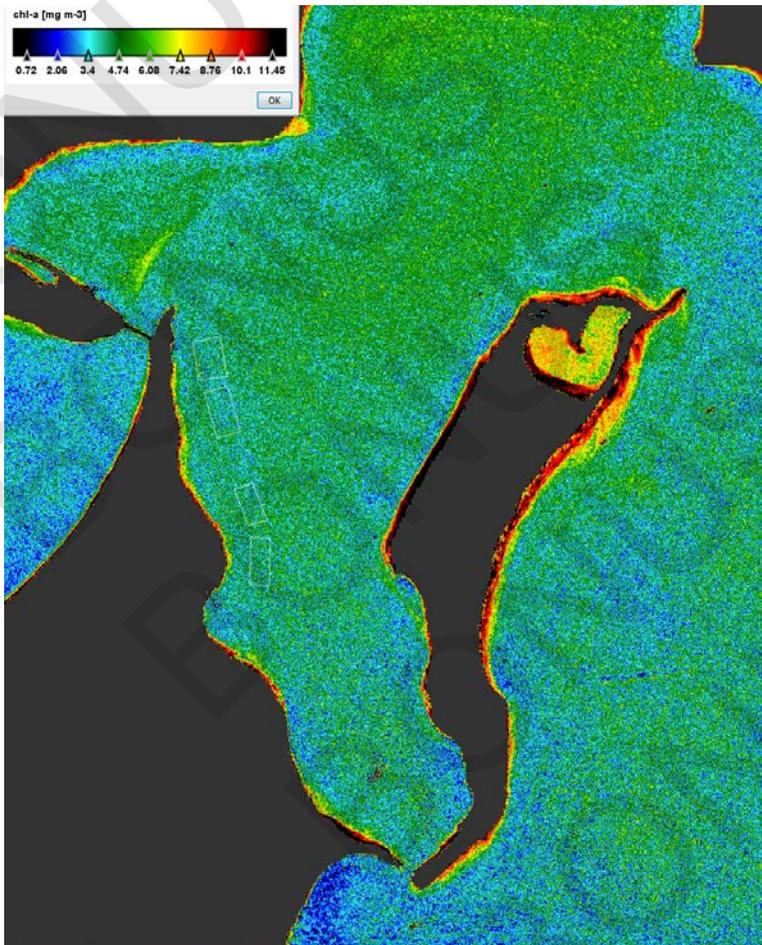
- Mussels can be produced in most Western Baltic waters
- Potential N removal depends on salinity, phytoplankton, cultivation technique, and water depth
- Relatively broad spatial variability
- Greatest relative removal potential in DK waters

Ecosystem service: Water quality improvement

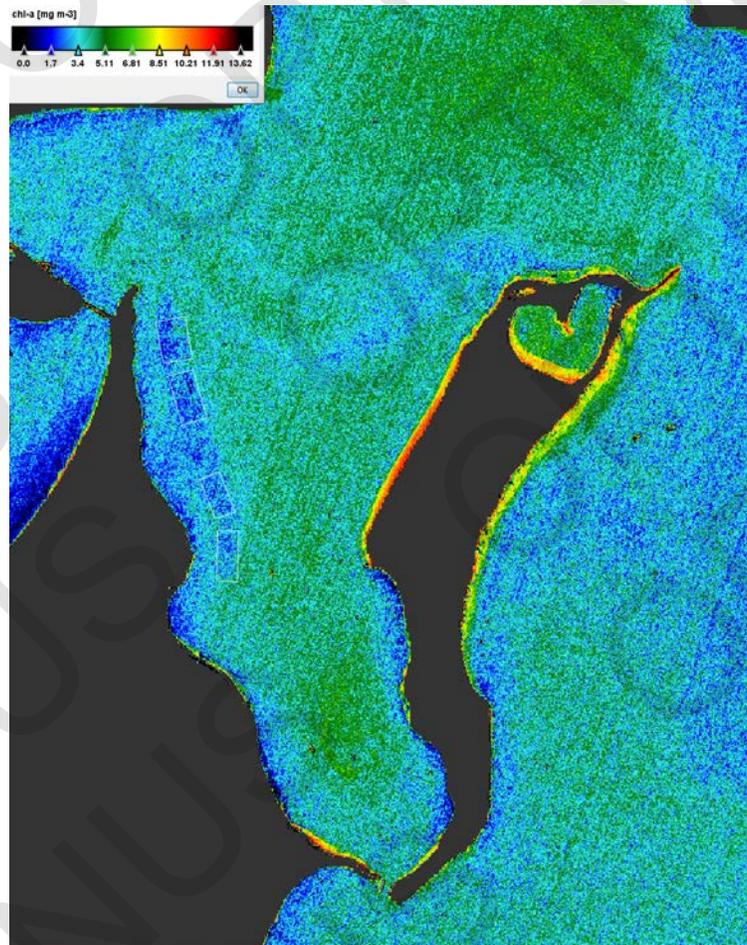


→ 3-7 km³ daily per farm

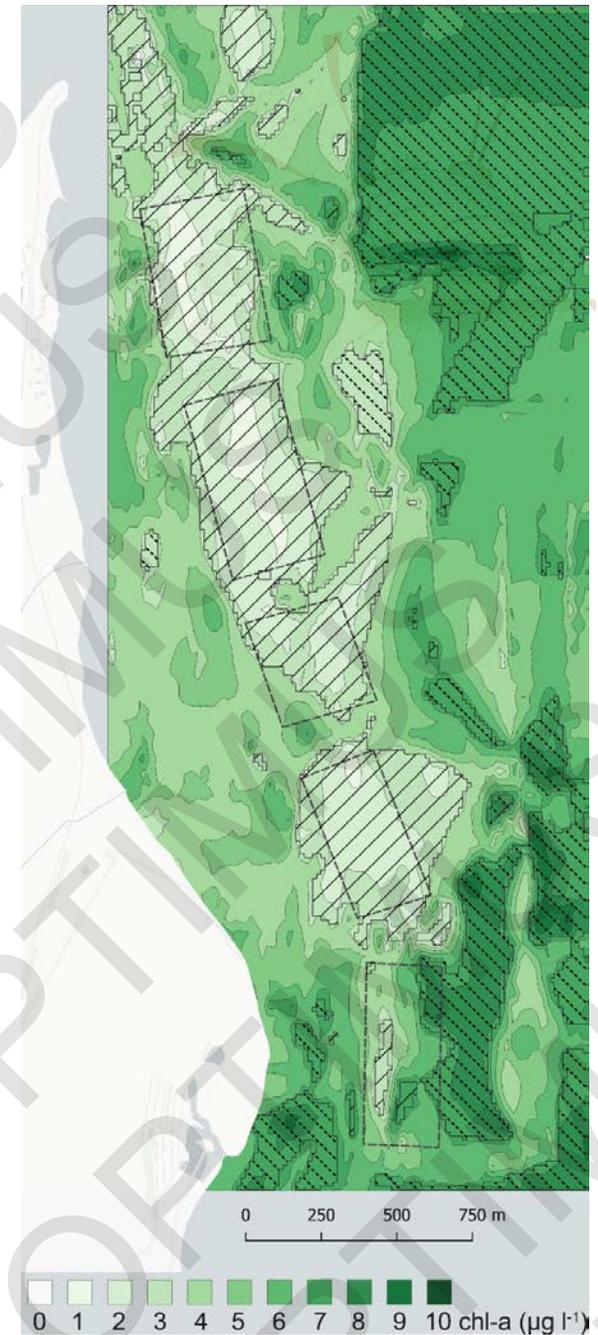
Effect of filtration on water quality



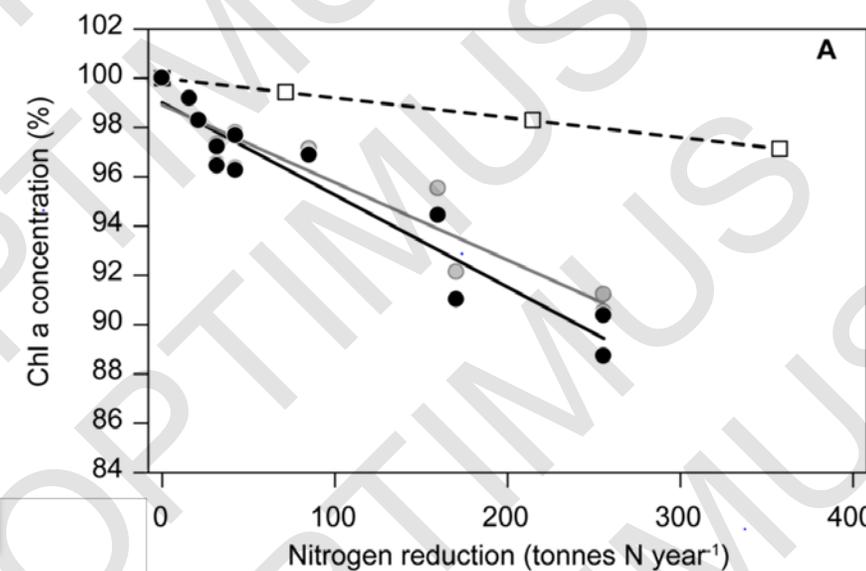
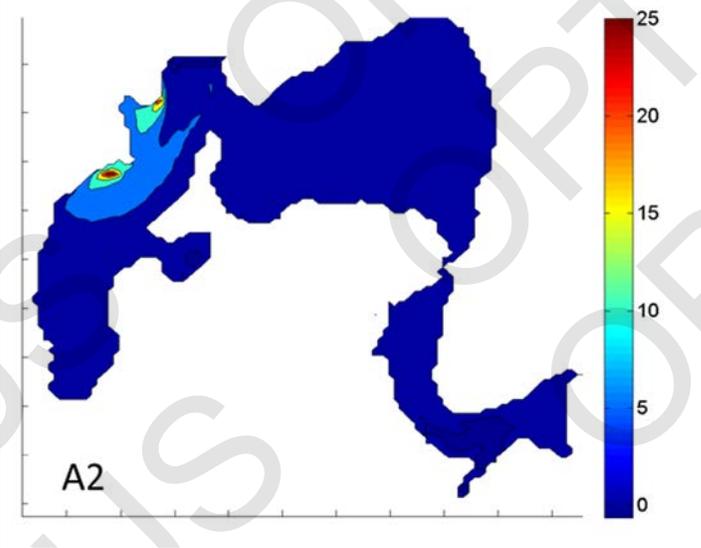
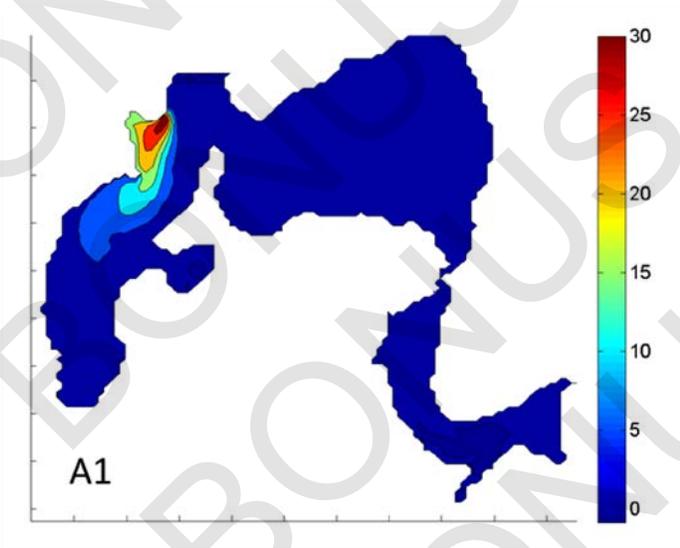
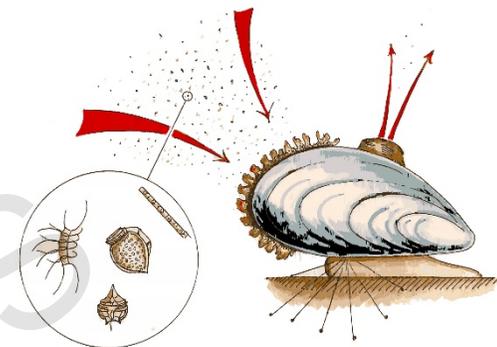
2018 – farm not operational



2019 – farm operational

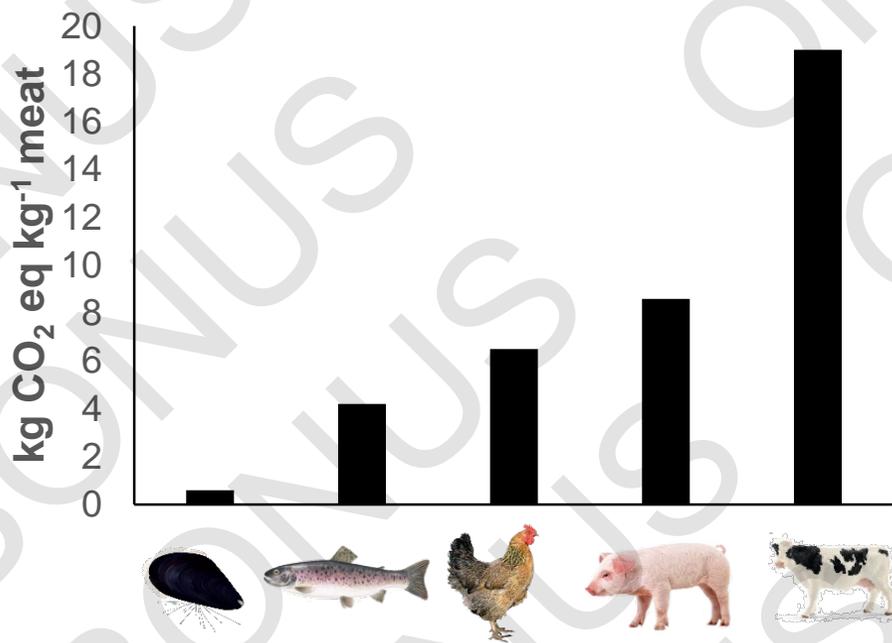


Effect of filtration on water quality



→ Chlorophyll concentration is significantly reduced around the farm and improves basin-scale water quality

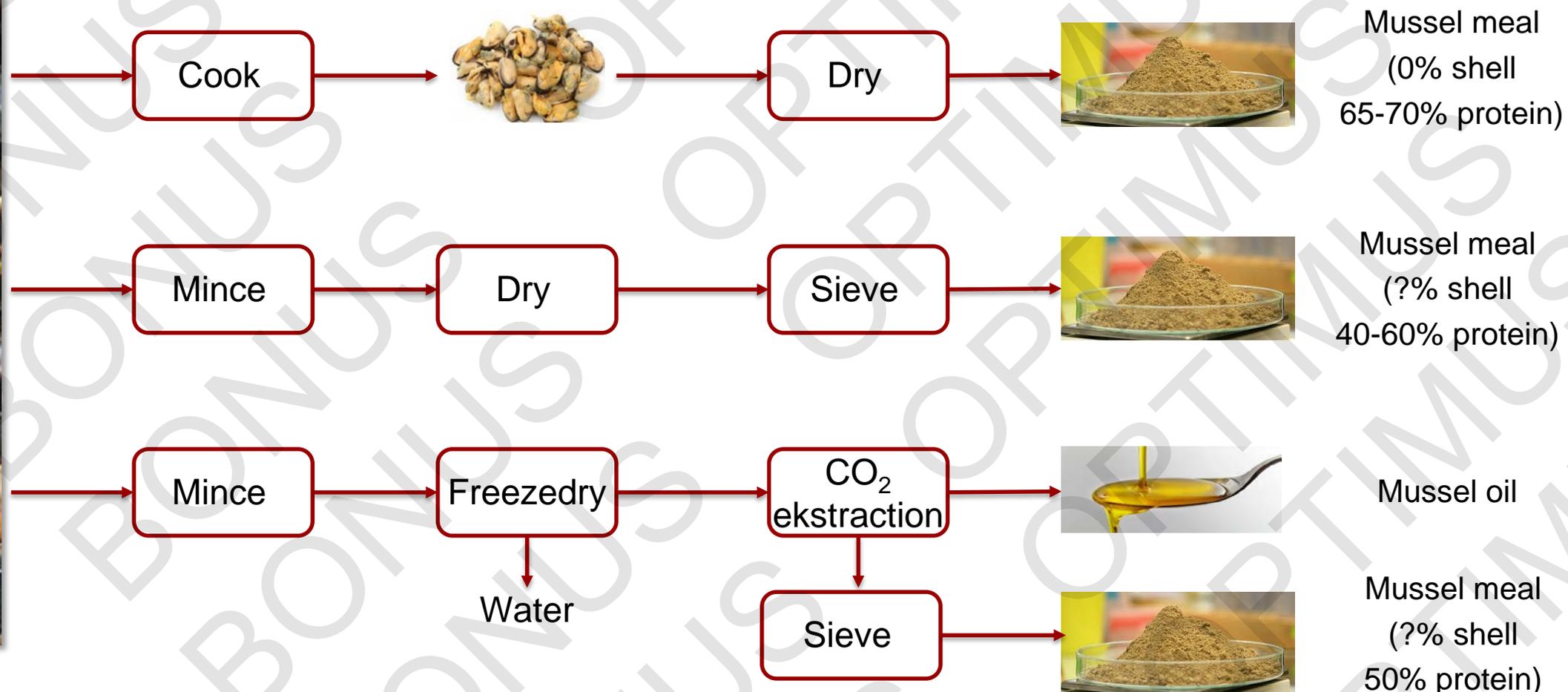
Ecosystem service: Provisioning



	Indhold/100 gr
Protein	17,8 gr
Carbohydrate	4,1 gr
Lipids	2,8 gr
Water	73,7 gr

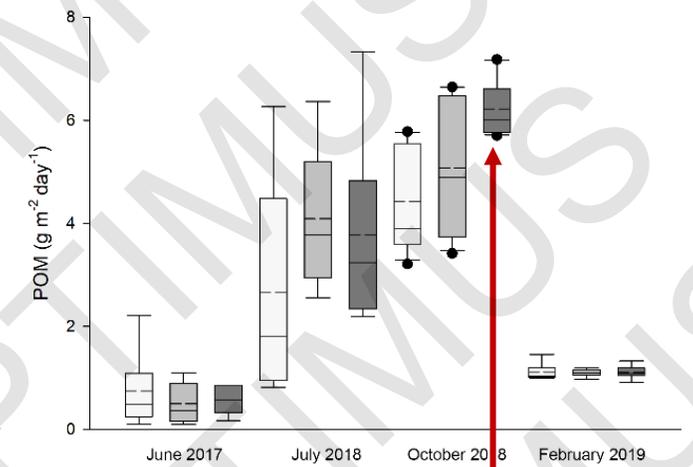
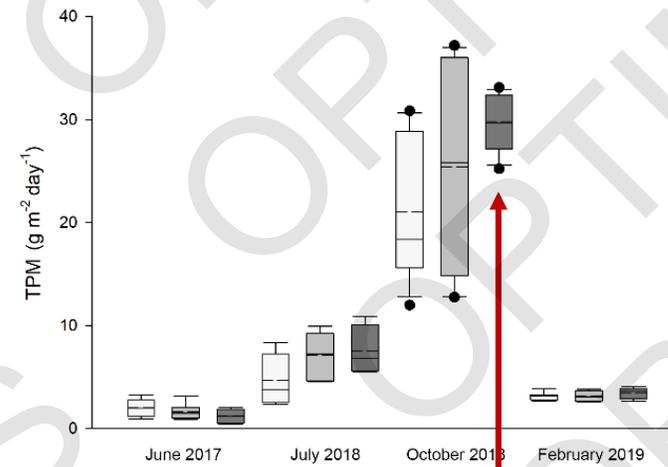
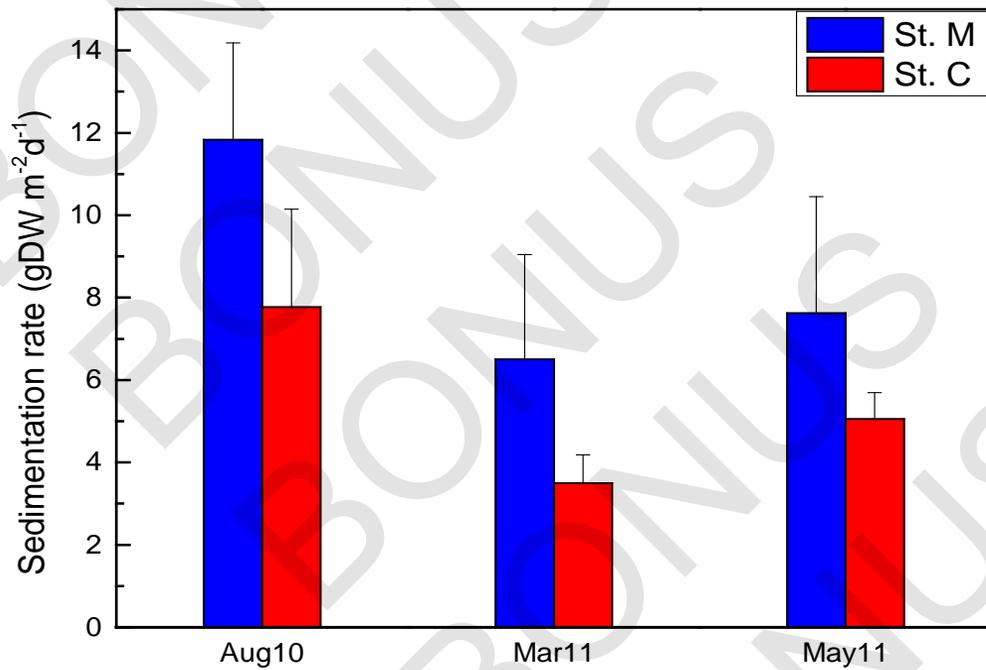


Processing options - focus on meals





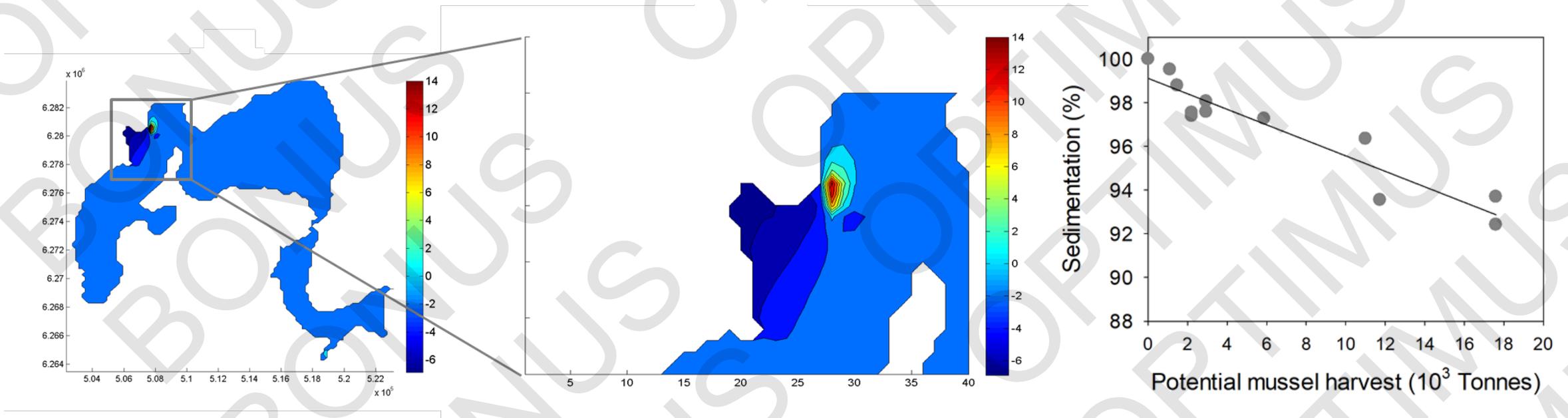
Challenge: Sedimentation



Reference site
Mid-farm
Net

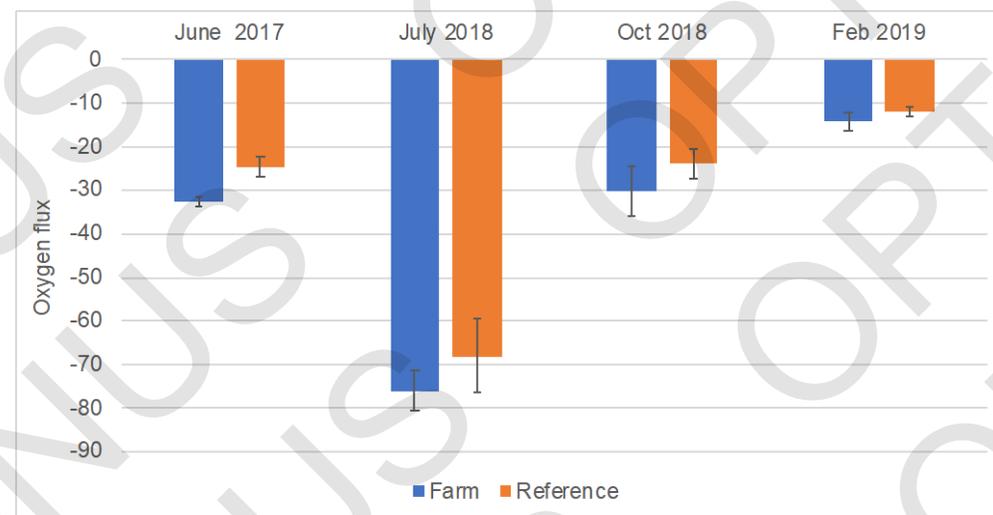
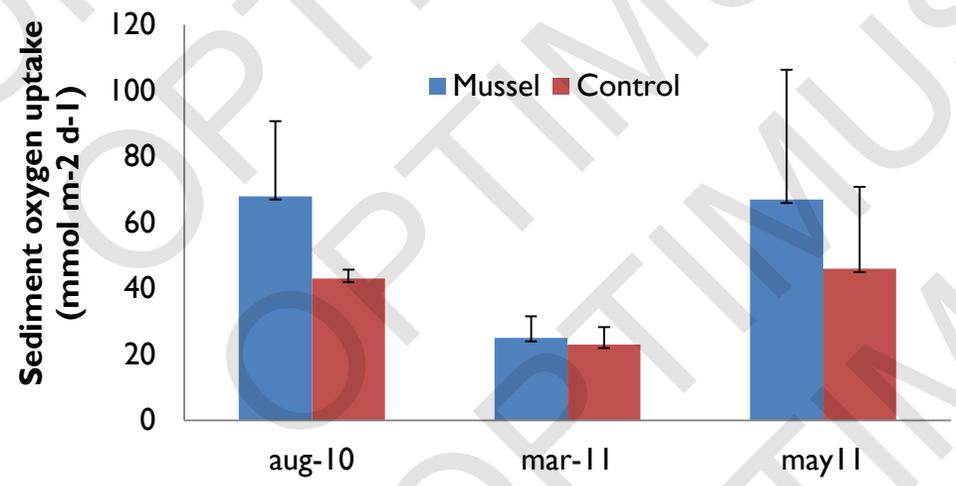
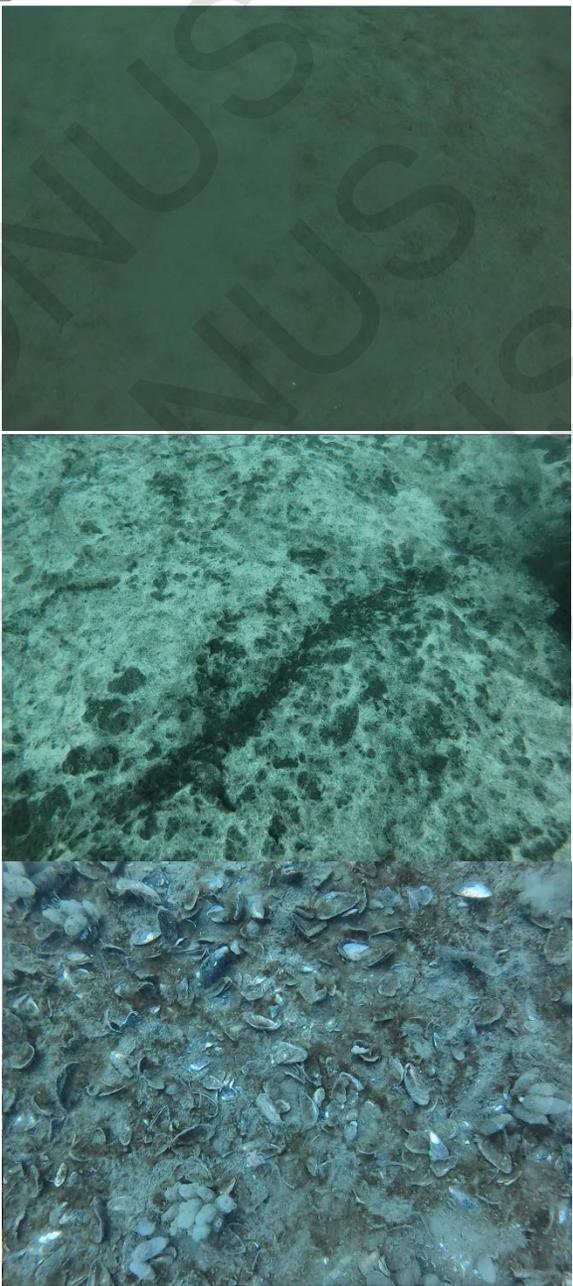


Bigger picture on sedimentation



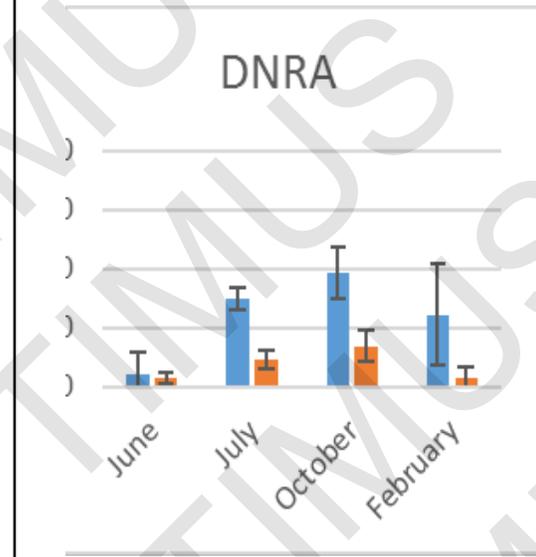
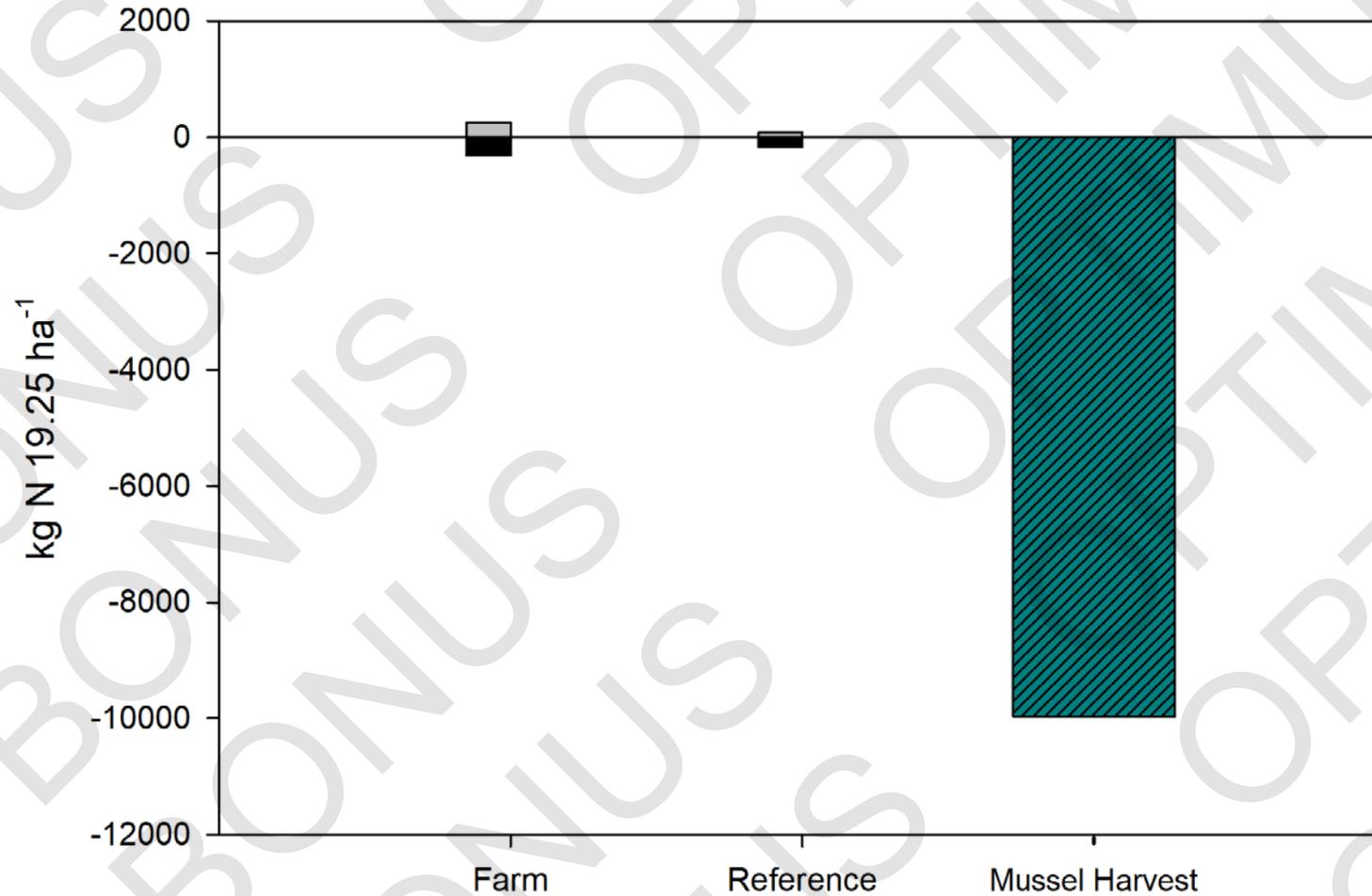
→ Although there is increased sedimentation under a farm, it decreases on a basin scale

Effect of sedimentation - oxygen



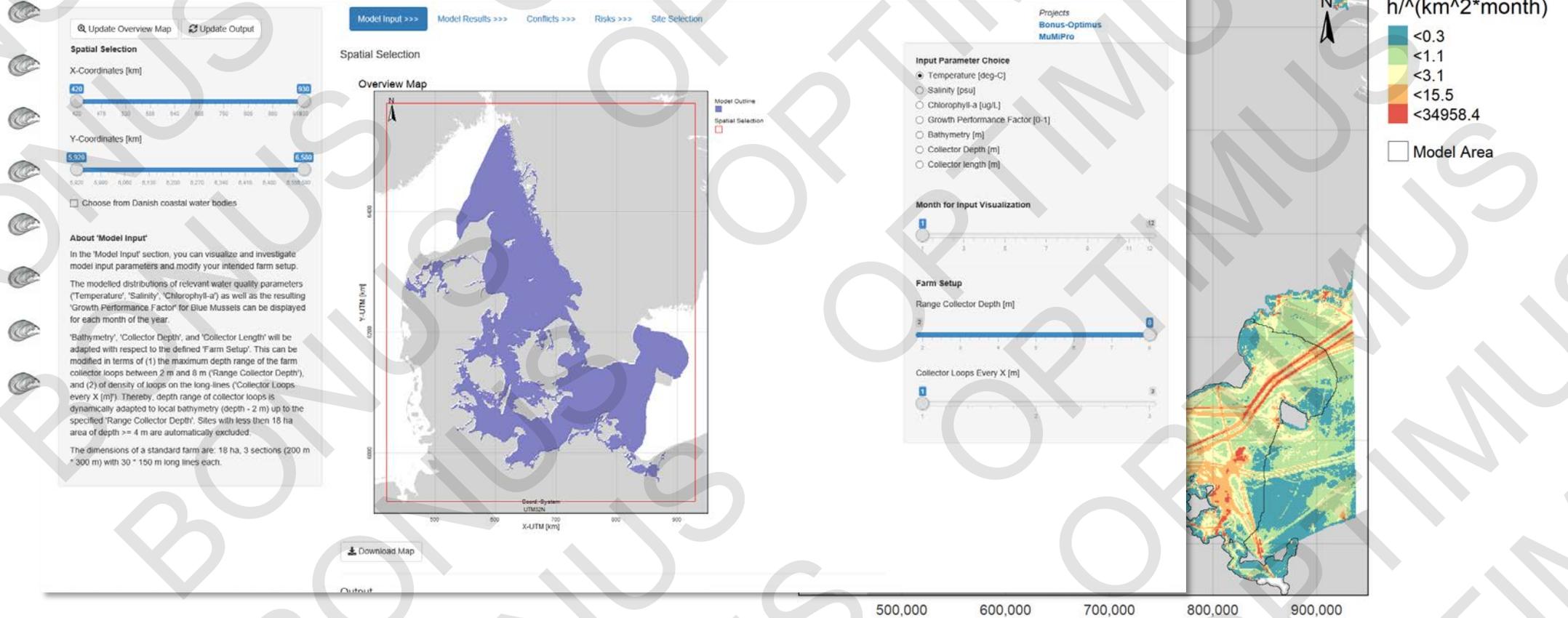


Effect of increased sedimentation - nitrogen



Challenge: Site selection

Multi-Criteria Tool for Optimized Site Selection of Blue Mussel Mitigation Farms in the Western Baltic Sea



Eider ducks - a special challenge



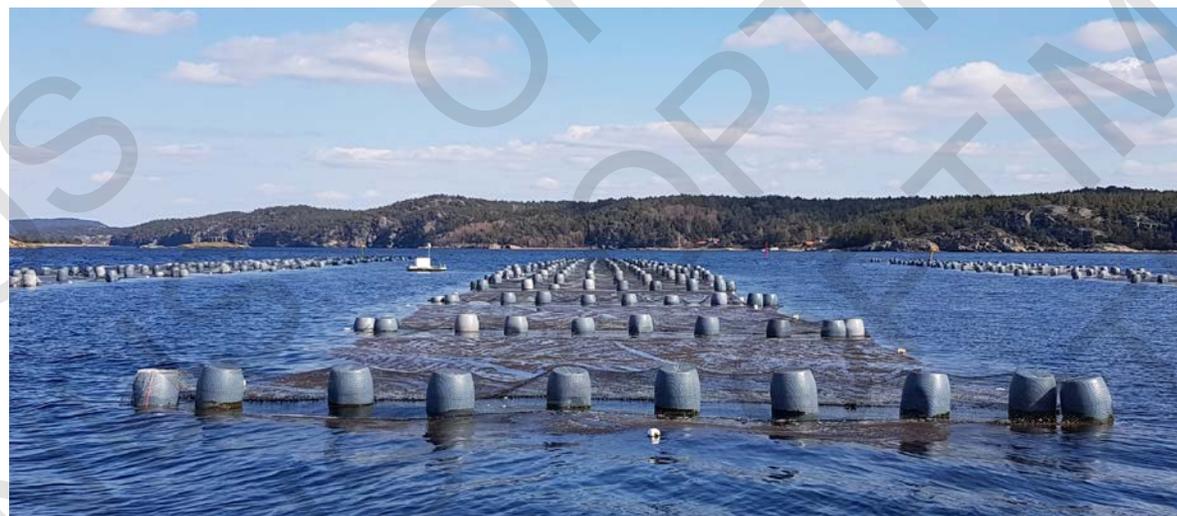
August



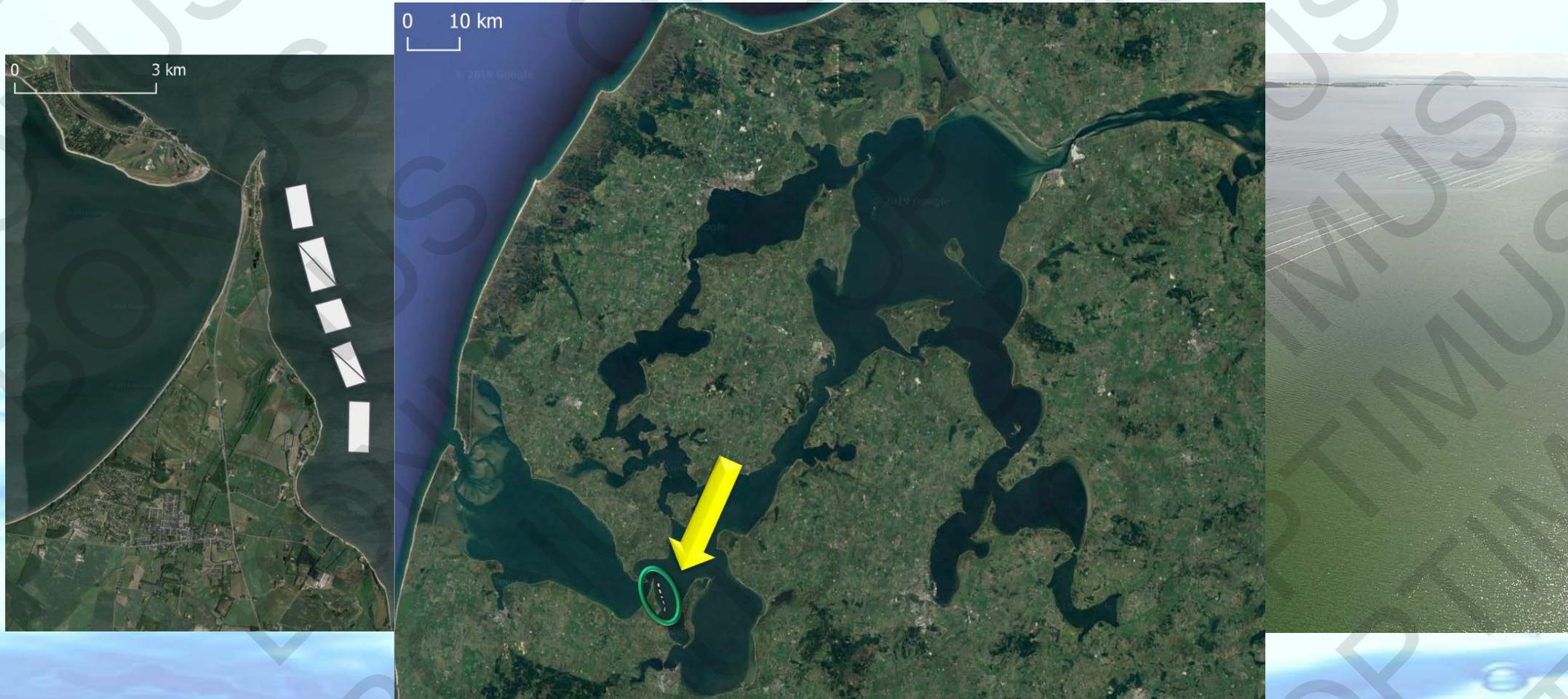
September

Measures:

- Harvest timing
- Protection net
- Deterrents



Challenge: Visual disturbance and social acceptance



→ Present annual removal capacity 100-150 t N

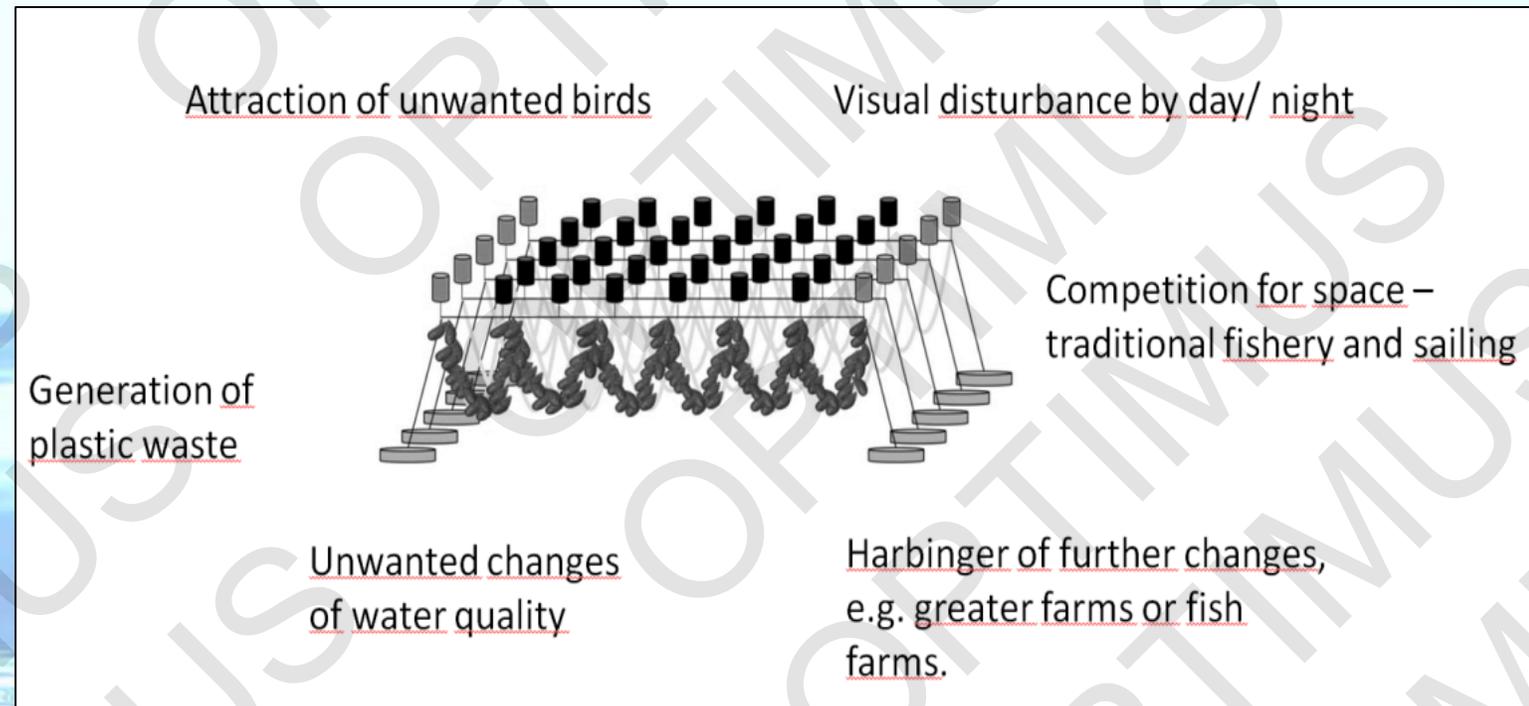
Social acceptance - main concerns

Fish farming is coupled to mussel farming

Space matters

Longing for undisturbed scenery/nature

Lack of proper regulation and management



Sources of social acceptance

Mussel cultivation in accordance with local values

- Sustainability
- Local identity

Stimulates local development

- Good to be frontrunner

Prevents unwanted measures on land



Summary

- 🐚 Mussel cultivation can be an area-efficient tool that can remove 1.4-3.0 t N / ha in the top 25% most suitable areas.
- 🐚 Net+pipe is the most efficient method for mitigation cultivation.
- 🐚 Mussel cultivation provides other ecosystem services in the form of better water quality and sustainable protein sources that can be used for food or feed.
- 🐚 Ecosystem services provided will require compensation to the operator.
- 🐚 Implementation of the instrument requires local dialogue in relation to the use of the water areas.
- 🐚 Social acceptance will depend on information on goods and services provided, dialogue with local stakeholders and firm control with the operation
- 🐚 Placement of mussels as a tool will always depend on a specific assessment in the relevant water areas and can take advantage of expert knowledge.
- 🐚 Further research and development is primarily necessary for optimization of farming practice in the central Baltic.

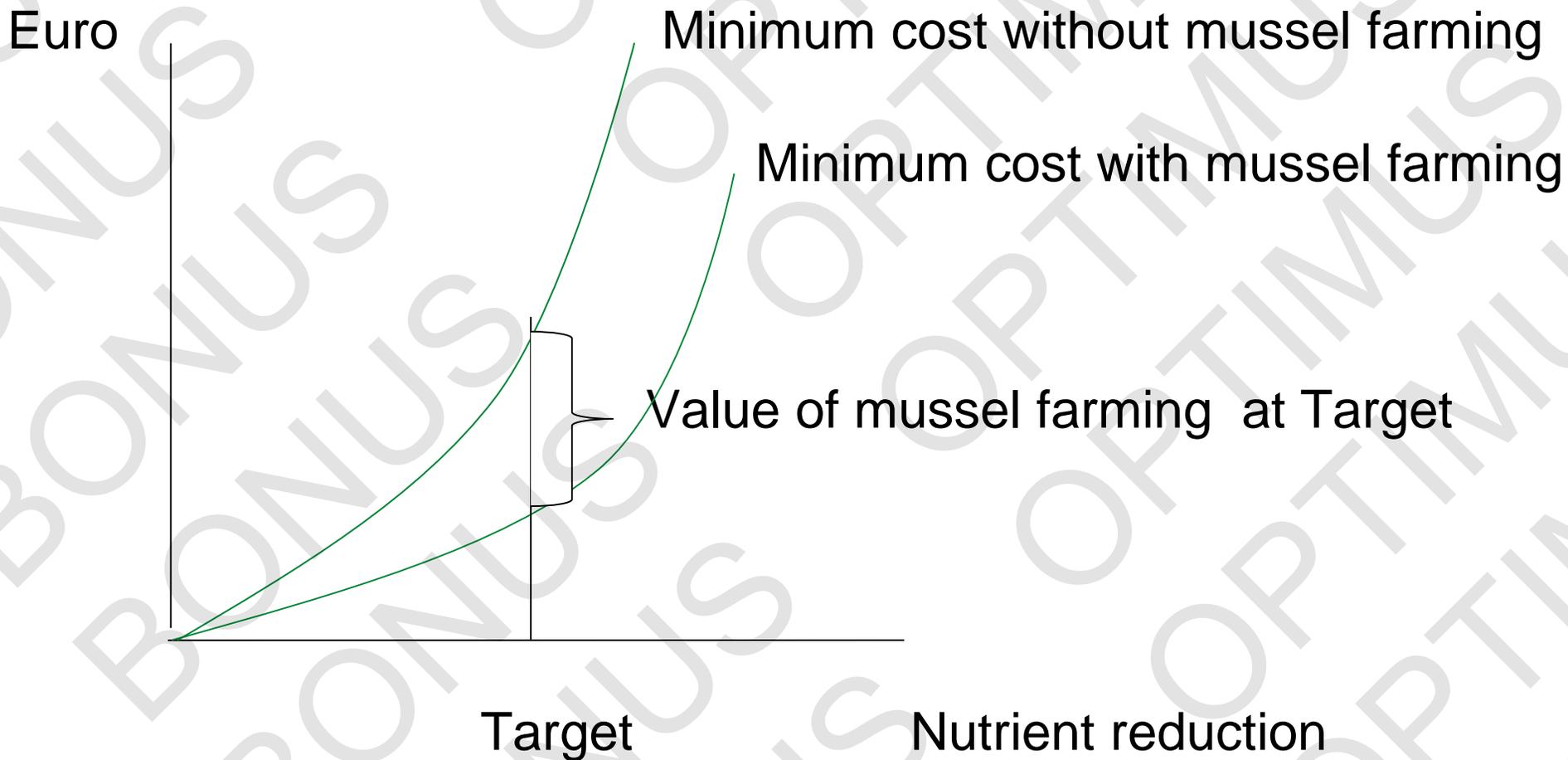
Economic value of mussel farming for nutrient removal

- Principle for value calculation
- Value of mussel farming for reaching HELCOM targets in the Baltic Sea Action Plan (BSAP)
- Local scale; nitrogen reductions in Limfjorden in Denmark
- Alternative policies





Principles for calculating value of mussel farming for nutrient removal



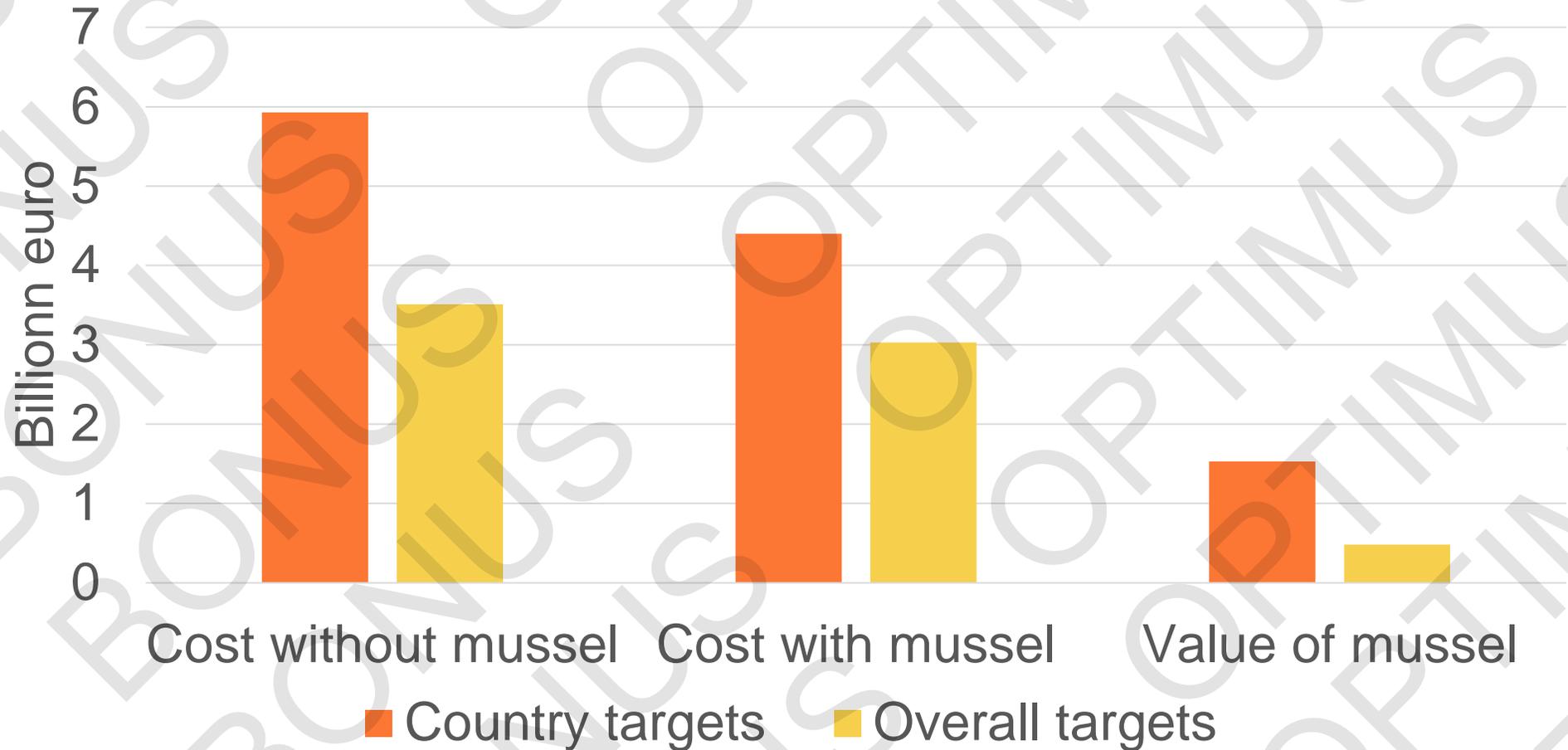


Value of mussel farming for BSAP

- **Costs and impacts on the Baltic Sea from:**
 - agriculture (livestock and fertilizers reductions, catch crops, increased grassland, construction of wetlands)
 - Improved cleaning at sewage treatment plants and industry
 - Reductions in air born nitrogen emissions
- **Targets**
 - BSAP country targets
 - Overall nitrogen and phosphorus reductions by 13 % and 48 %



Value of mussel farming in the BSAP under two target regimes, billion Euro





Allocation of values of mussel farming among mussel farmers and land based measures under two target regimes, billion Euro





Local scale: nitrogen reductions in Limfjorden, Denmark, Euro/kg nitrogen removal

	Location 1 with long line	Location 2 with nets+pipe
Cost of mussel farming	12.64	6.4
Cost of land based measures	16.75	23.85
Value of mussel farming	4.11	17.45

Policies for mussel farming: principle issues

- *Payments for nutrient removals, mussel farming as an offset:*
 - gives incentives for technological development
 - stacking (i.e. payment for both N and P reductions)
 - additionality
 - uncertainty in predicting nutrient removal
- *Payment for costs of mussel farming:*
 - no incentives for technology development
 - simple to measure (but, risk of misreporting costs)
- *Transaction costs from implementation, monitoring and verification*



Policies for mussel farming: examples from practice

- Mussel farming as an offset for increased cleaning at sewage treatment in Lysekil at the Swedish West coast (2007-2010). 3900 ton biomass to compensate for 39 ton N load from the plant.
- Oyster as an offset for point sources in Virginia and Maryland with caps on emissions of N and P (2020 -)



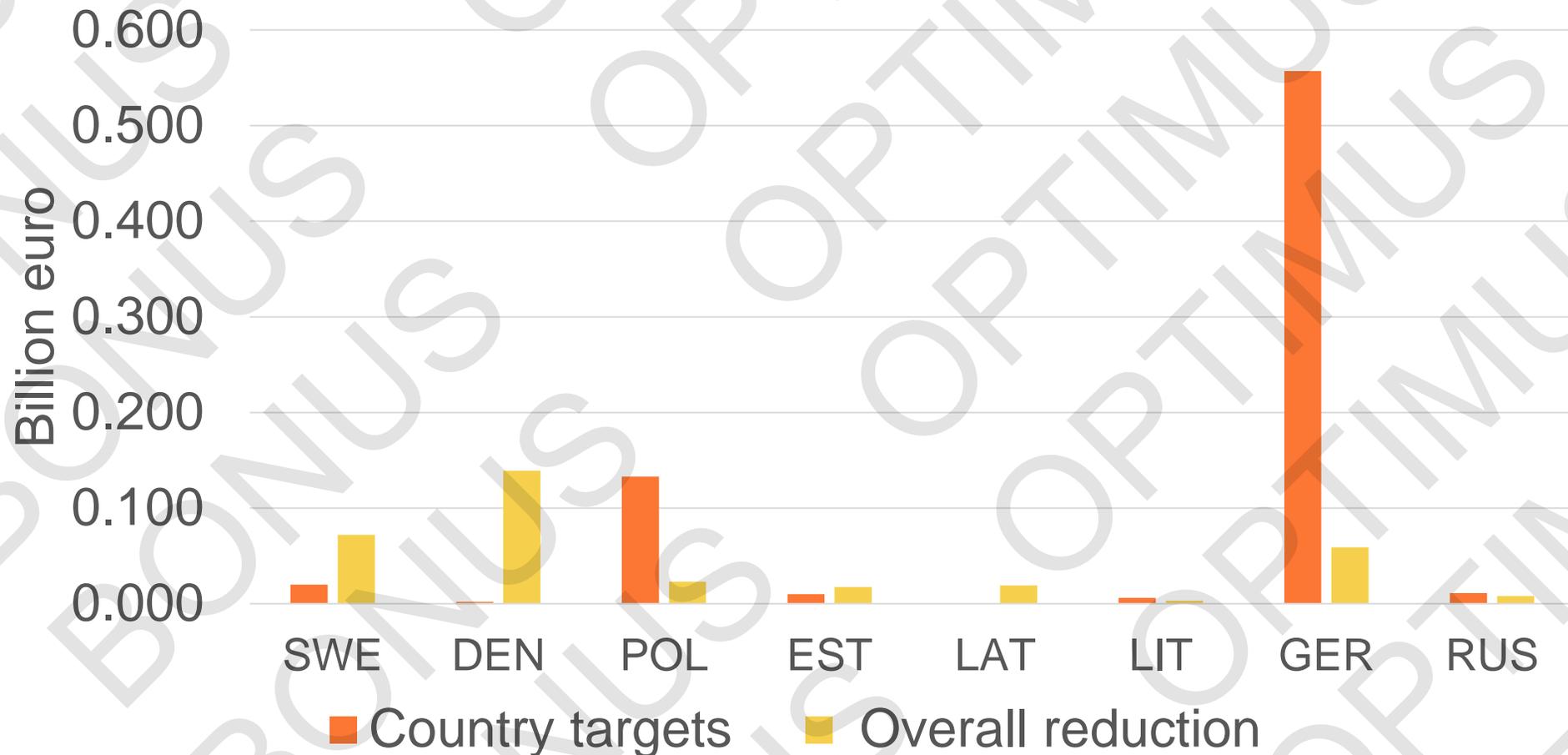
Conclusions

- The potential economic value of mussel farming for nutrient removal is positive and can be high
- More focus needed on how to implement mussel farming (payment mode, additionality, stacking, monitoring and verification)





Profits for mussel farmers in a offset system for BSAP under two target regimes, billion euro



Questions