Map-based screening to achieve cost-effective spatially targeted WFD river basin action programmes

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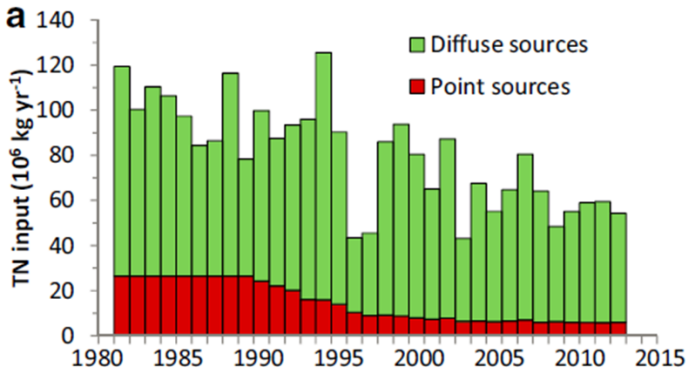
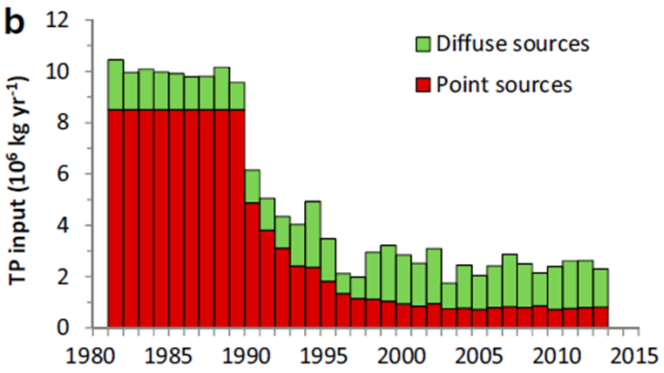
The Danish Case – a success story

N inputs to coastal waters

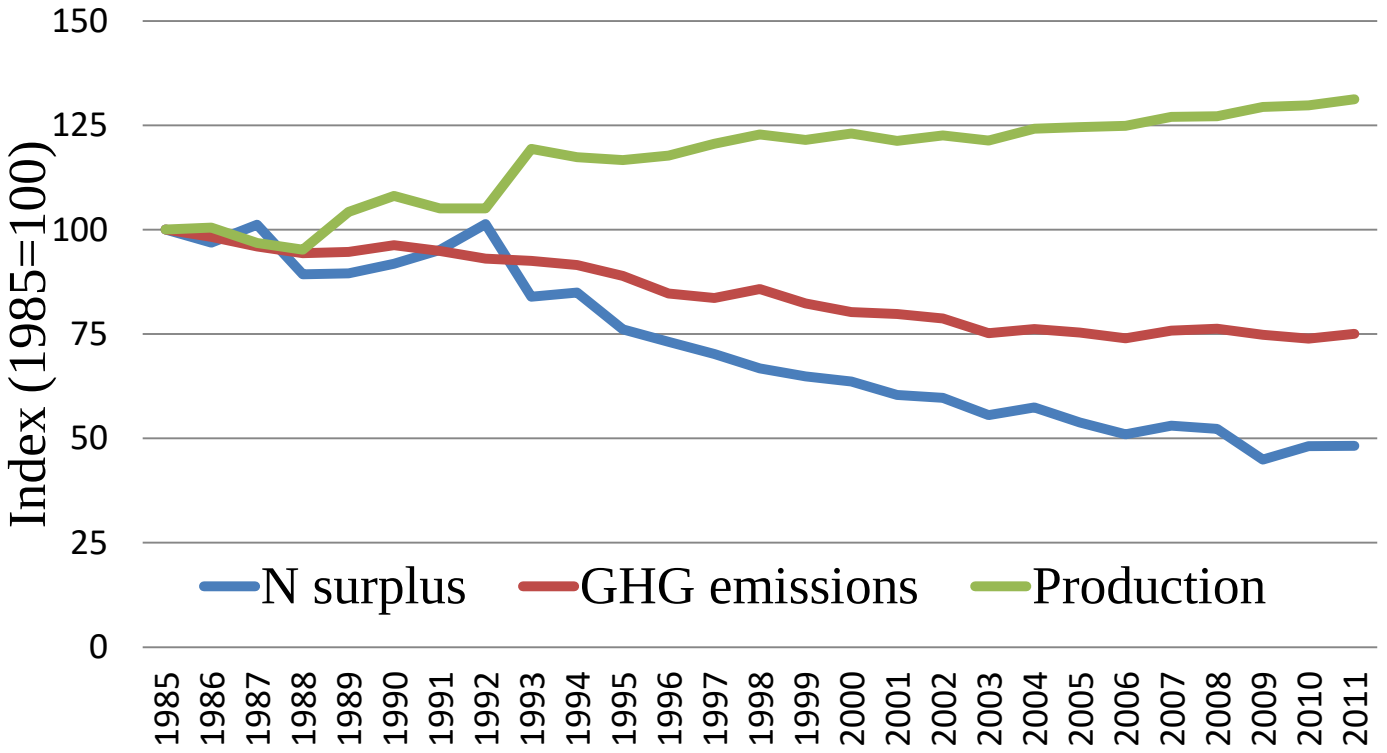


P inputs to coastal waters



Based on data from Riemann et al (2015)

Decoupling environmental impacts



Based on Blicher-Mathiesen et al. (2012), Danish Agriculture and Food Council (2013), Nielsen et al. (2013)

The challenge in Denmark - and Northwestern Europe

- Nutrient loads have been reduced during the past 30 years
- Ecosystems have not yet fully recovered and do not (yet) comply with EU WFD
- 2. generation water plans requires **significant additional nutrient load reductions**

- **Economical losses due to lower crop yields and protein contents of cereals**
- Denmark has been applying less fertilizers than other European countries

Commission for Agriculture and Environment, 2013 report on the way forward

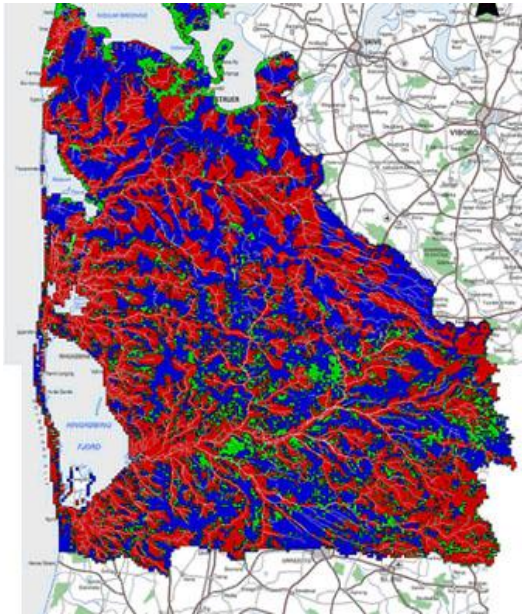
- It is possible to both increase agricultural production value and protect the environment
- Vulnerable versus robust agricultural land– **differentiation in use of measures is needed !**

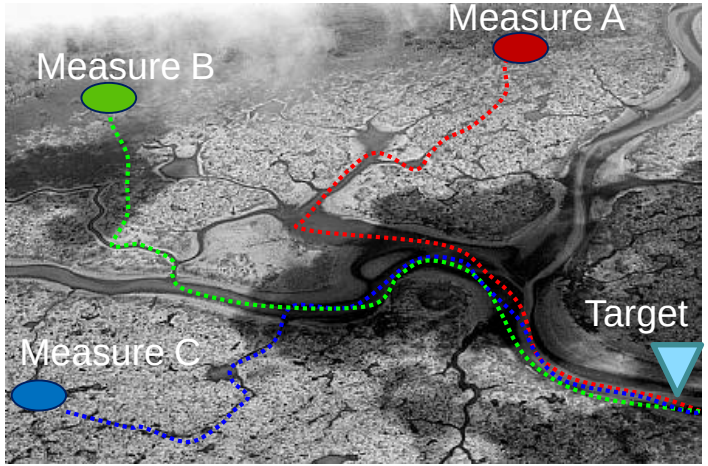
Political decision, implementation of targeted management (2018)

From general regulation to differentiated and cost-efficient water plans

Differentiated application of measures

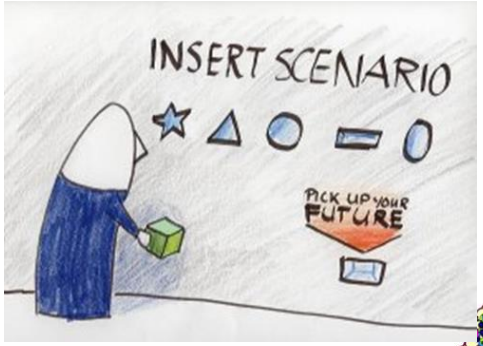
Unique pathway, N/P-retention & the environmental impact





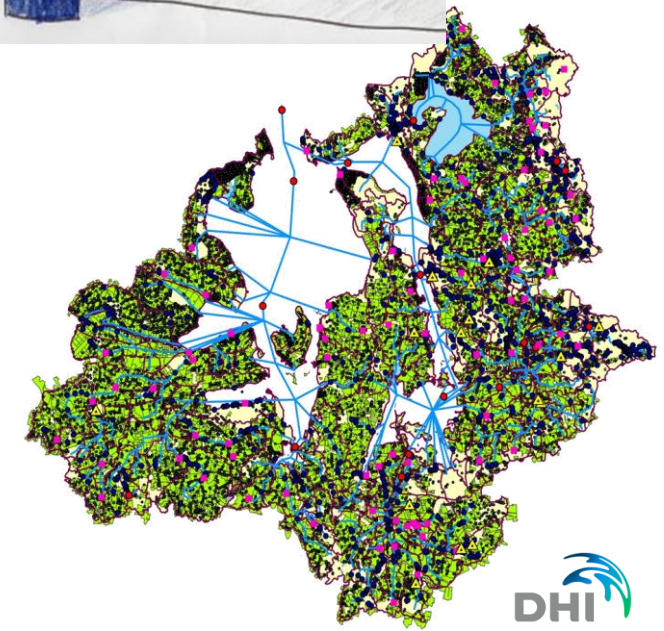
0-100 % reduction
0-100 % cost-effectiveness

Programme of Measures (POM) tool – what is it?



A map-based screening and POM scenario tool

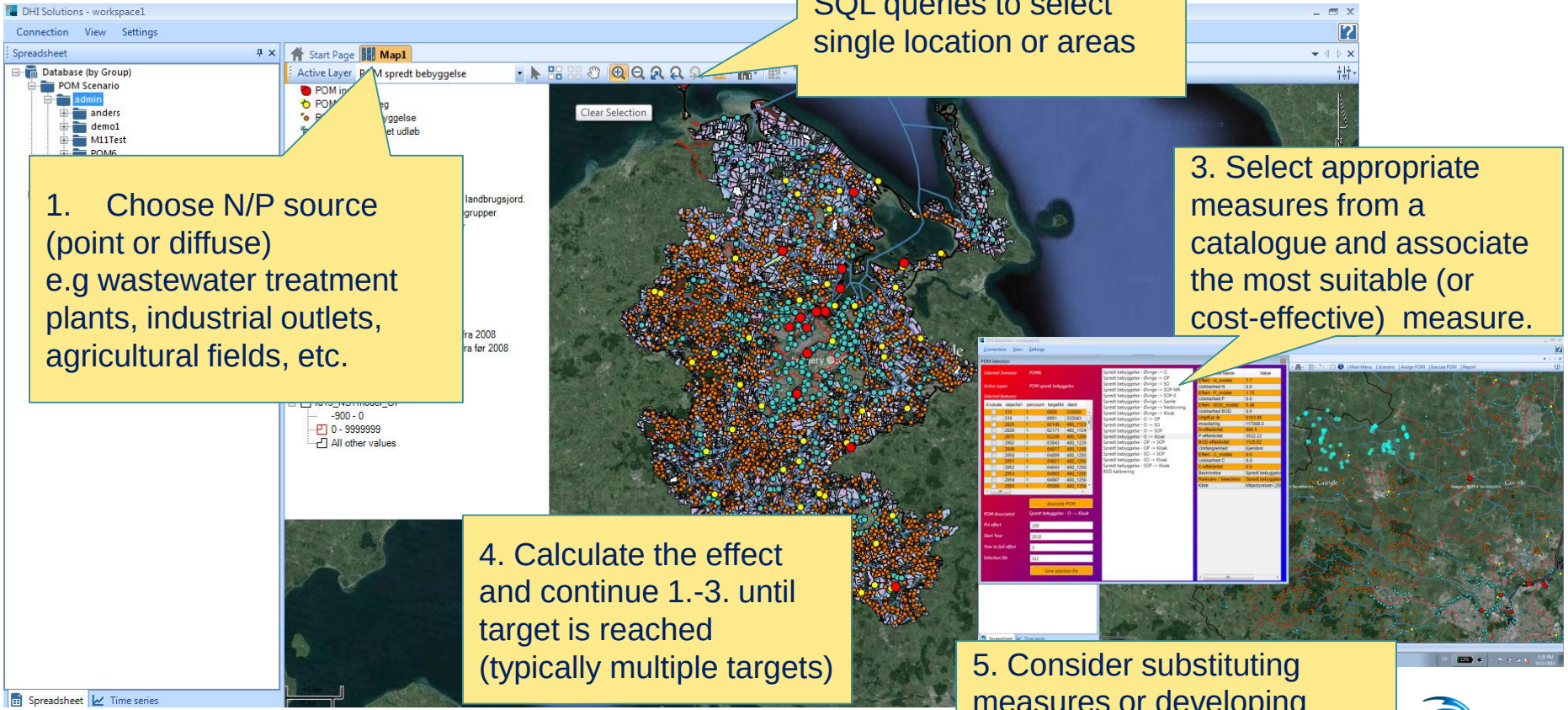
Simple calculation scheme for the accumulated effect of a set of individual measures within a catchment using the river network, subcatchments & GIS information



Provides the net effect and cost in any number of points within the catchment and downstream e.g at the outlet to a fjord

- No differential equations !
- Can be used independently or together with advanced catchment N/P models

POM tool



2. Use graphical tools or SQL queries to select single location or areas

1. Choose N/P source (point or diffuse) e.g wastewater treatment plants, industrial outlets, agricultural fields, etc.

3. Select appropriate measures from a catalogue and associate the most suitable (or cost-effective) measure.

4. Calculate the effect and continue 1.-3. until target is reached (typically multiple targets)

5. Consider substituting measures or developing alternative scenarios

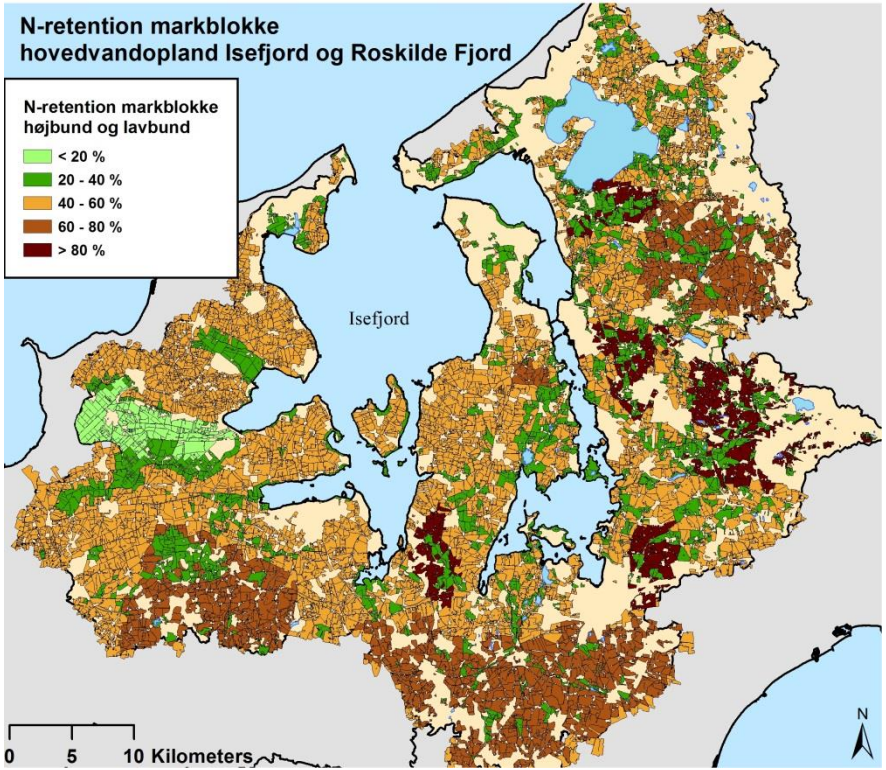
Roskilde Fjord

Isefjord and Roskilde Fjord catchments features two fjords, 52 lakes and 682 km streams and 19 GW bodies.

Reductions relative to baseline 2015:
Isefjord : 281 t N/year
Roskilde fjord : 348 t N/year

Potential for increasing cost-efficiency by targeting:

- Catch crops (60 %)
- Stream buffer strips
- Restored wetlands



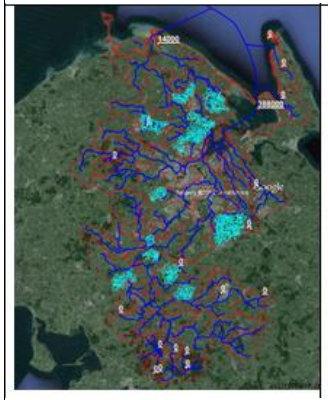
Bjarke Kaspersen

- Adding CO2- eqv. to N and P load reduction measures
- Demonstrating effects of other measures, biogas plants

Odense River Basin POM analysis

Buffer strips

Wetlands



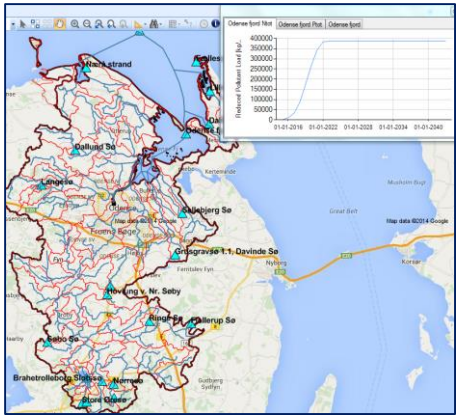
Catch crops

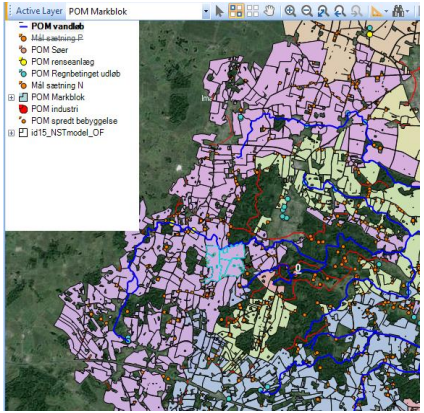
Energy crops

Objective : To set up a realistic and cost-efficient program of measures for Odense River basin reducing N-loads to the coast by 370 t/year and P-loads to lakes.

Cost efficiency: Minimize costs of measures (e.g Euro/kg N) and maximize environmental effects (lakes, coast)

Targeted: Demonstrate the benefit of adopting targeted, site specific managment measures as opposed to previous generalised pollution control rules





Selected key POM tool results, Odense

Measure type	Extent	Units	Costs kEuro/year	Marine load reduction (T N/year)
Late catch crops	2842	ha field blocks	130	54,5
Early catch crops	4697	ha field blocks	227	35,2
Energy crops	1218	ha field blocks	241	39,1
Fallow land	604	ha field blocks	408	21,9
Early sowing	8035	ha field blocks	107	37,5
Storm water detention	7770	m3 storage	108	0.1
Water treatment upgr.	16	no. households	13	0.1
Buffer strips	116	km stream	58	6,7
Restored wetlands	383	ha wetland	253	59,4
Mini-wetlands	67	ha wetland	1,733	134,0
Total			3,279	388,3

Ranking of measures by cost-efficiency

Replace lower ranking measures ?

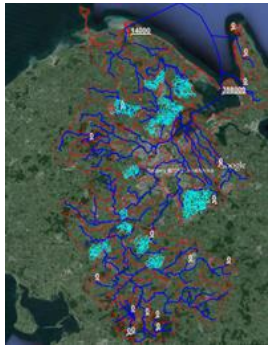
Kilde type	Dosering [Enheder]	Enheds-effekt [kg/enhed/år]	Effekt Ved kilde [kg/år]	Omk.effekt. ved kilde [kr/kg]	Reduktion Ved fjord 2021 [kg/år]	Omk.effekt. Ved fjord 2021 [kr/kg]
Efterafgrøder (G2) : Odense fjord - POM Markblok_Marker_Hedebaekken_EAfgr	322.57	28.50	9193	12.00	7618.57	14.48
Efterafgrøder (G2) : Odense fjord - POM Markblok_Marker_HolmehaveBaek_nedst_EAfgr	117.39	28.50	3345	12.00	2317.30	17.33
Efterafgrøder (G2) : Odense fjord - POM Markblok_Marker_SallingeLunde_EAfgr	517.22	28.50	14741	12.00	10172.29	17.39
Randzoner 10 m (på hver side) : Odense fjord - POM vandløb_RandzonerVandloeb_Pilebaekken	6.30	96.00	605	17.72	604.56	17.72
Spredt bebyggelse - O -> Kloak : Odense fjord - POM spredt bebyggelse_SB_DallundSø_O-Kloak	16.00	7.70	123	800.50	123.20	800.50
Regnvand - infiltrationsbassin : Odense fjord - POM Regnbetinget udløb_RBU_DallundSø_1	7.77	15.60	121	6706.98	99.45	8174.62

Water plan implementation costs reduced from 4,0 to 3,3 mill euro/year by targeting measures

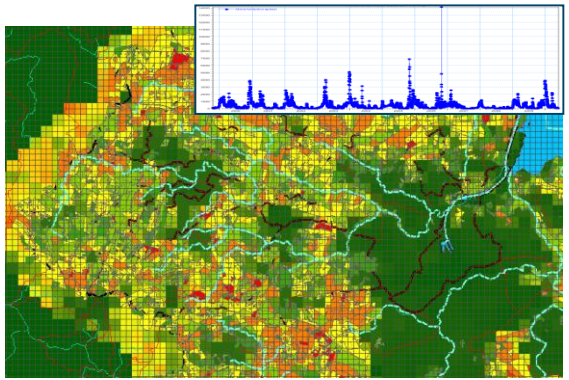
Export to MIKE SHE – MIKE11 – EcoLab basin WQ model

Going from screening level POM analysis to full, integrated proces based WQ model
Requires 1:1 correspondence of point and diffuse sources in POM tool and MIKE model

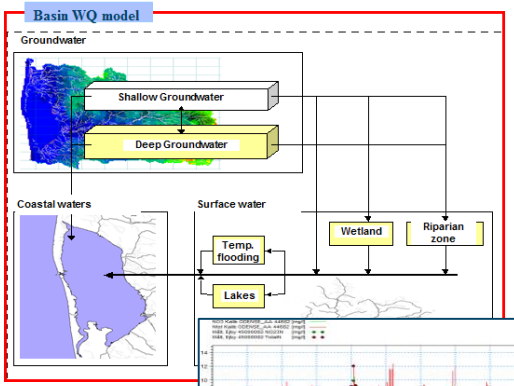
Diffuse sources



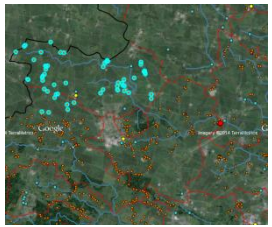
Diffuse POM measures



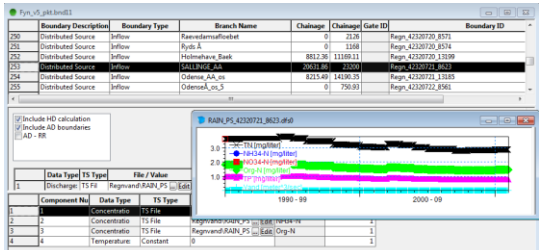
MIKE SHE .dfs2 input of nitrate leakage



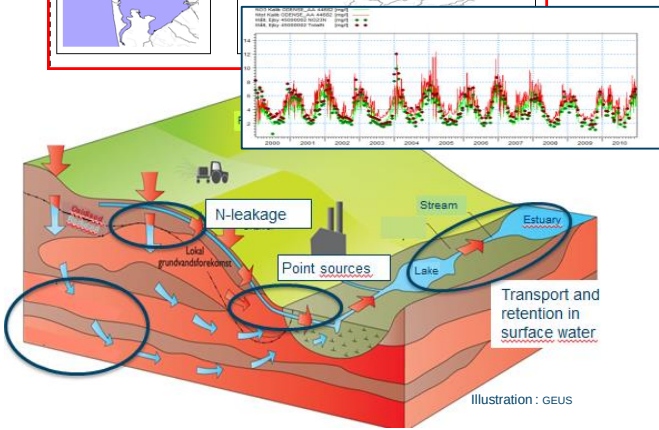
Point sources



Point POM measures



MIKE11.dfs0 input (.bnd11)



Concluding Remarks

- The PoM's assessment tool can support the development of spatially targeted and cost-effective action programmes at the river basin level
- Strengths:
  - Easy to use
  - Based on the data for river basin plans
  - Estimates the effect of measures on environmental targets
  - Contains cost-effectiveness for the analysis of alterative measures
  - Web user-interface & professional software package
  - Covers N, P, & CO_2
- Provides digital, transparent and accessible version of programme of measures in the river basin plans well-suited for engaging stakeholders and decision-makers

For more information

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Stoltze Kaspersen, B., T.V. Jacobsen, M.B. Butts, N.H. Jensen; E. Boegh, L.P. Seaby, H.G. Müller; T. Kjaer (2016) **Using a map-based assessment tool for the development of cost-effective WFD river basin action programmes in a changing climate.** Journal of Environmental Management 08/2016; 178:70-82. DOI:10.1016/j.jenvman.2016.04.043.

Stoltze Kaspersen, B., T.V. Jacobsen, M.B. Butts, E. Boegh, H.G. Müller, M. Stutter, A.M. Fredenslund, T. Kjaer (2016) **Integrating climate change mitigation into river basin management planning for the Water Framework Directive - A Danish case.** Environmental Science & Policy 01/2016; 55:141-150. DOI:10.1016/j.envsci.2015.10.002

Stoltze Kaspersen, B., T.B. Christensen, A.M. Fredenslund, H.B. Møller, M.B. Butts, N.H. Jensen, T. Kjaer (2016) **Linking climate change mitigation and coastal eutrophication management through biogas technology: Evidence from a new Danish bioenergy concept.** Science of The Total Environment 01/2016; 541:1124-1131. DOI:10.1016/j.scitotenv.2015.10.015