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UNIVERSITY
OF OSLO



**Watershed EUTROphication
management
through system oriented
process modelling
of Pressures, Impacts and Abatement
actions**

Funded NRC project 2009 - 2013

EUs Water Framework directive

- Requires a **good surface water status** and that the condition of all water reserves should not have large deviations from their natural condition by the year **2015**



- Scientists and environmental managers are required to **assess the original- and present-state of the environment, and to predict future trends**
 - Need to select cost-efficient and sustainable **management practices**
 - Assess expected **lag time** between abatement measures and expected chemical and ecological response in the lake

 **Eutrophication** is usually the main cause for not fulfilling the requirements for good ecological quality in agricultural districts

- In South-Eastern Norway > **30%** of the water bodies are characterized as being at risk or possibly at risk
 - ▶ 45% of the anthropogenic P input to Norwegian surface water originates from **agricultural areas**
 - ▶ P is mainly transported in the rivers adsorbed to **clay particles**
 - ▶ The **natural background** flux of P to western Vansjø is estimated to be 20-25% in the form of dissolved natural organic matter

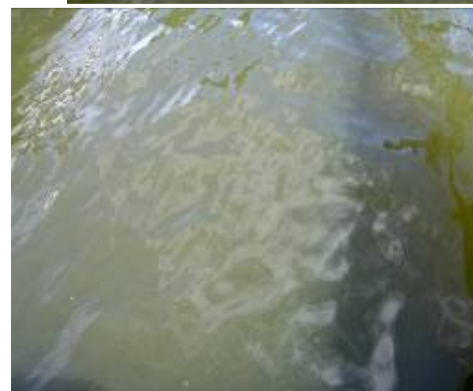


500 MNOK is used on abatement measures in the case study watershed Morsa

-  No apparent improvement are made
-  The processes that govern the P fluxes are influenced by several environmental factors
 - ▶ Without the implemented measures the situation would likely been worse



Toxic cyanobacterial blooms as a problem

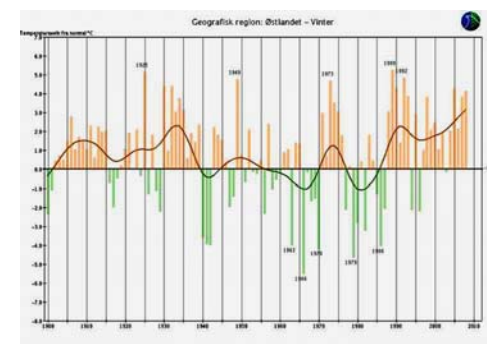
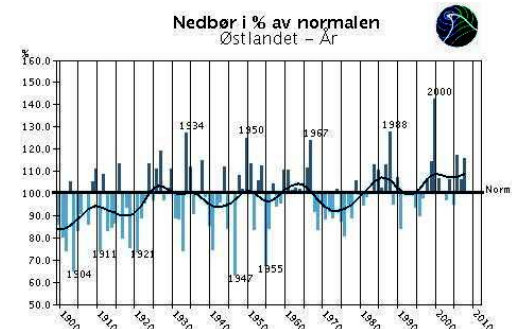


Drivers - Changing environment

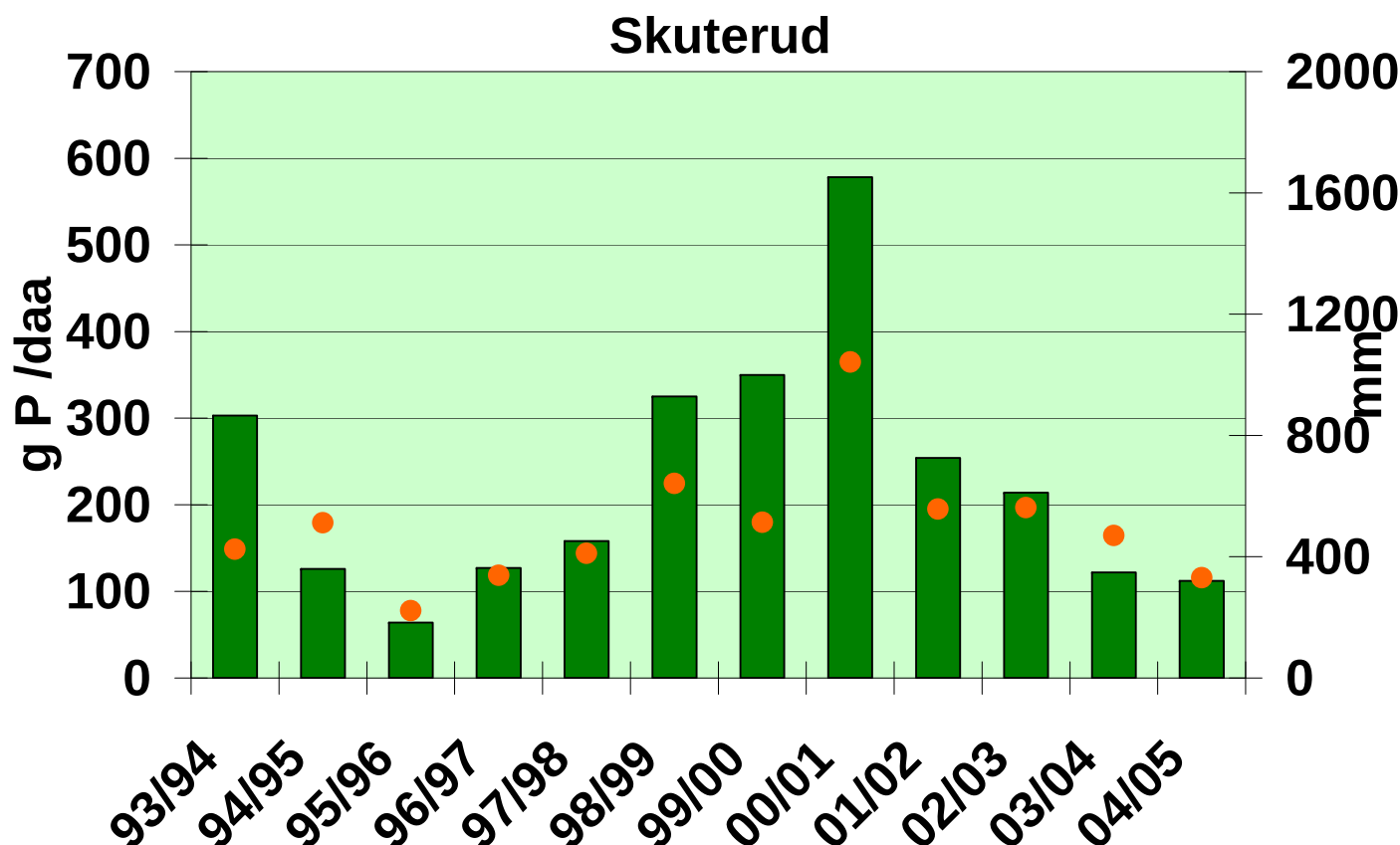


Climate:

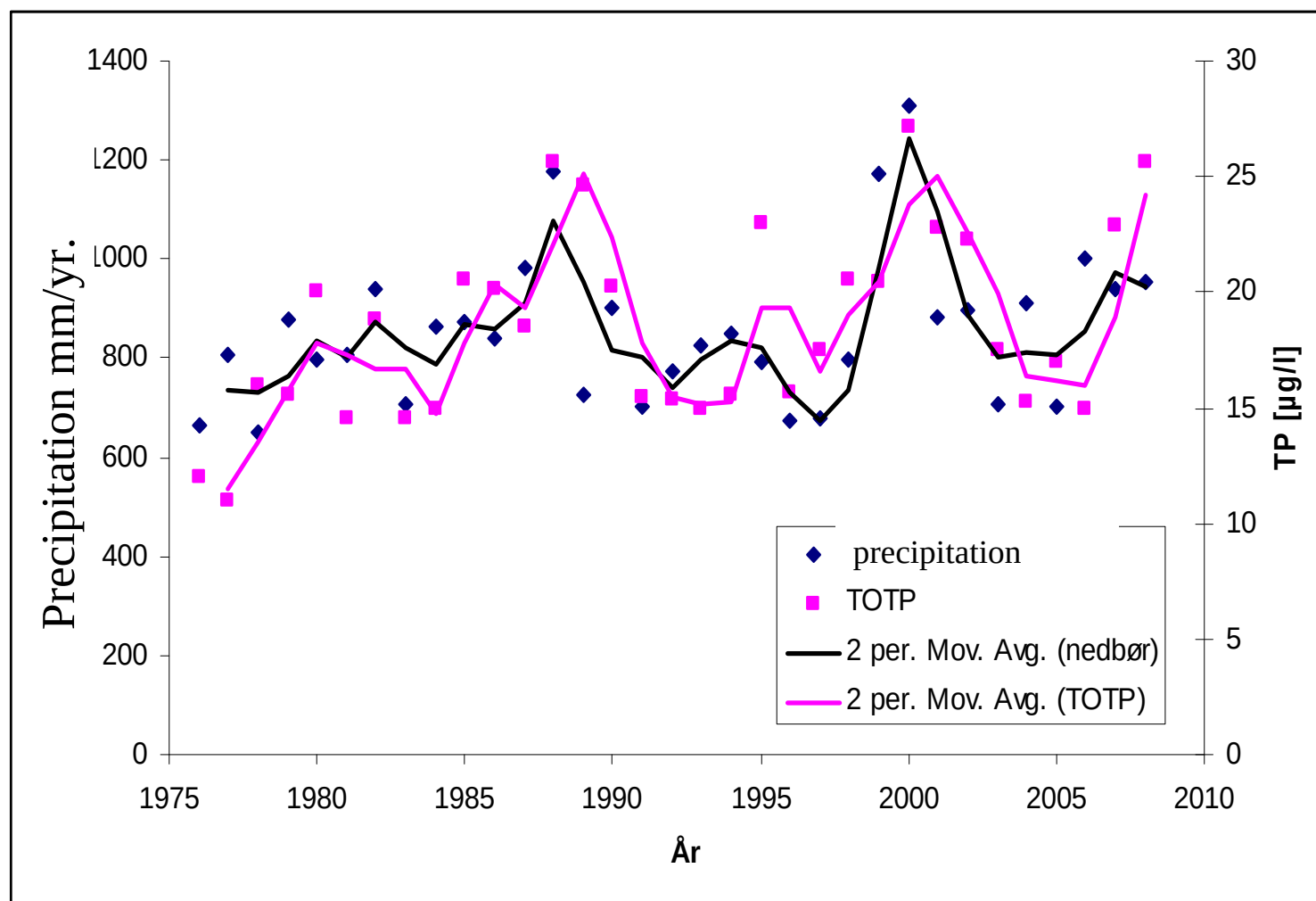
- Increase in **amount and intensity of precipitation** and a 2°C increase in the average **winter temperature** in the Oslo region
- Increased **surface runoff** causes soil erosion and Increased winter temperature causes more frequent **freeze-thawing** cycles leading to
 - ▶ more **soil erosion** and thereby greater influx of nutrients adsorbed to the soil



Effect of precipitation on total P-loss



Effect of precipitation on P in Vansjø



Drivers - Changing environment



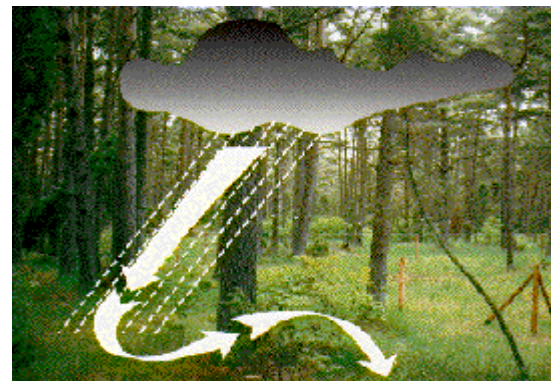
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Landuse:

- **Urbanization**, deforestation, draining of wetlands and removal of riverbank vegetation, as well as encroachments such as modification of meandering streams to straight canals and piping of open brooks.
- Changes in **agriculture**



Atmospheric deposition:

- Reduced S emission, which in acid lakes in southern Norway constitutes the dominant anion charges, has **decreased by about 60%**.
 - The background **amount of DOC** has increased and **characteristics** of DNOM have changed radically in Northern Europe
 - ▶ causing an increased natural flux of nutrients and energy for heterotrophic micro-organisms in surface waters.

The research needs



Goal:

Increase the models ability to **predict the effects** of changes in the environment and effect of abatement measures



Need:

Improve the underlying models **reliability**



Strategy:

Specifically targeting the **bioavailable** P-fraction and supplement empirical assessments with conceptual knowledge based **process understanding**



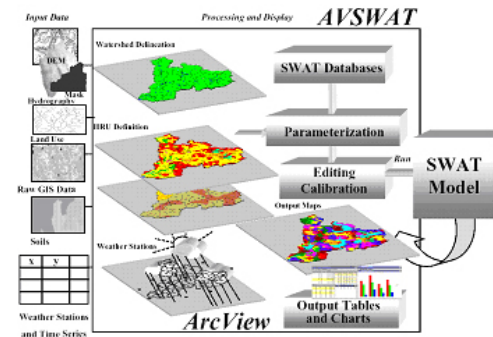
Prerequisite:

Need to **link** geochemical and physio-hydrological processes in the **catchment** with the limnological and **in-lake** biochemical processes controlling the level of nutrients (P, N, C) and its effect on water quality

Modelling

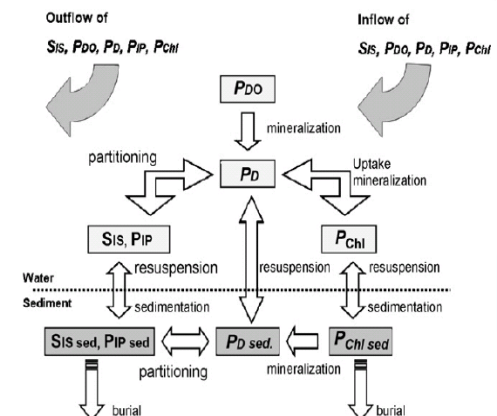
 The SWAT and MyLake models will be adapted and applied for hypothesis testing as well as to identify knowledge gaps

- SWAT is a **river basin** model developed to quantify the impact of land management practices in large, complex watersheds



SWAT; www.brc.tamus.edu/swat/

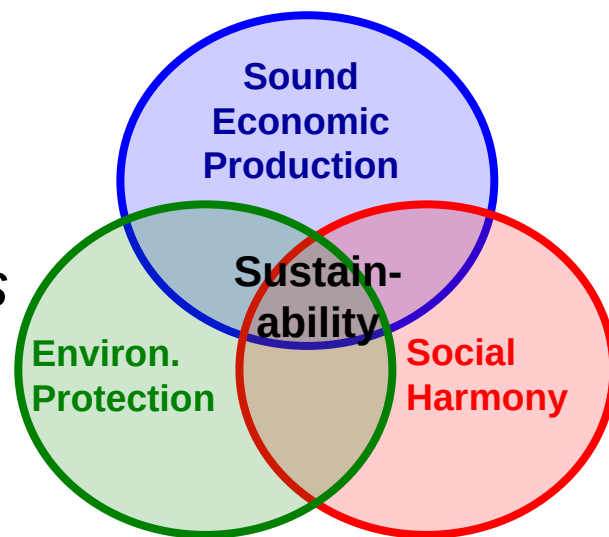
- The MyLake (Multi-year Lake) is a process-based **lake water** model for simulating vertical distribution of lake water temperature, sediment-water interactions, and phosphorus-phytoplankton dynamics



Saloranta & Andersen, 2007

Sustainable management

 *Abatement measures need to be assessed in regards to **cost-effectiveness** and an analysis of land **users'/farmers'** **response** to the these measures*

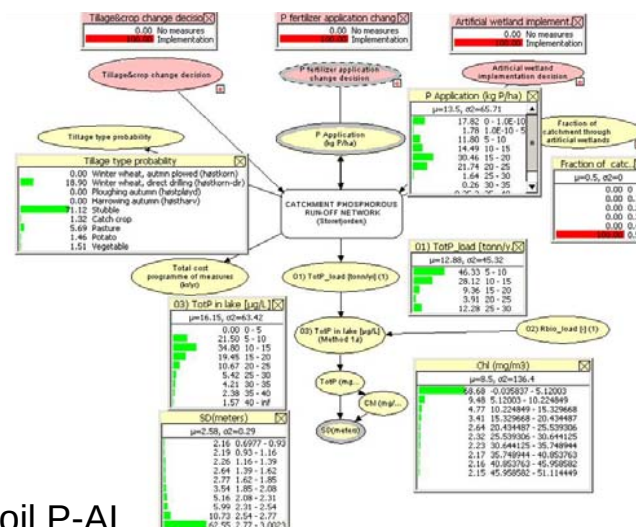


- Especially an assessment of **probability** of implementation is lacking from previous assessments of measures

Bayesian Belief Network

Common **framework** for combining (uncertainty) information from different sources

Utilizes **probabilistic**, rather than deterministic, expressions to describe relationships among variables



It will be used to;

- I. Include sub-catchment of **Western Vansjø**
- II. Effect of fertilizer reduction in “**hot spots**”
- III. Assess impacts of **long-term** leaching of on soil P-AL
- IV. Assess impacts of **reduced ploughing** on the contributions from gully erosion
- V. Consider non-agronomical factors affecting **farmer participation** in implementation of abatement measures
- VI. Address water quality indicators predicted by lake water quality model (e.g. sight depth) in the assessment of **willingness to pay** for improved recreational water quality
- VII. Model **interaction** between the Western Vansjø and Storefjorden
- VIII. Assess the effect on **joint uncertainty** of correlated probability distributions across run-off and lake models in the integrated uncertainty analysis

The societal response

 There are many conflicting interests

- Agricultural productivity, leisure time activities, general environmental concerns, public drinking water provision

 Focus mainly on *farmers and the public authorities*

- Farmers because they are one of the immediate source of emissions, and
- Public authorities because they will be responsible for regulating emissions and thereby the pollution level.

 According to **game theory** it might be rational not to cooperate to implement measures as long as one does not know whether others intend to comply..

- **Knowledge** is a prerequisite for collective action between stakeholders

		Henry	
		Not Guilty	Guilty
Dave	Not Guilty	 2 Years	 5 Years 1 Yr.
	Guilty	 5 Years 1 Yr.	 3 Years

Study site – Western Vansjø



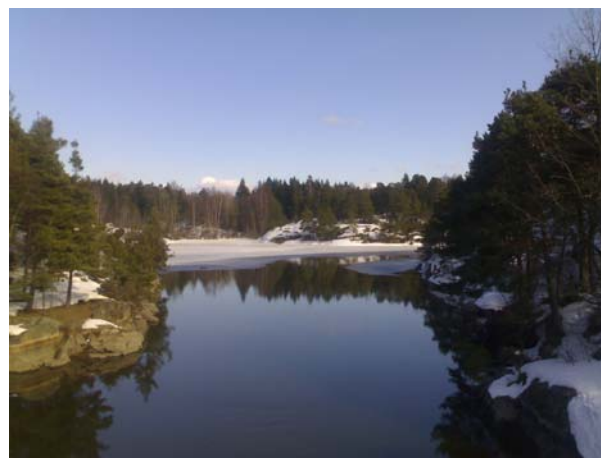
The Morsa watershed and its catchments have received significant attention due to eutrophication causing frequent blooms of cyanobacteria.



Morsa is selected as pilot case study area for the implementation of the Water framework directive by the ministry of Environment



Western Vansjø is the part of the watershed with the greatest problems



Hypothesis



Methods

- Improved **P-fractionation** monitoring methods will enhance our ability to identify the processes governing fluxes of bioactive P-fractions and thereby algal growth



Processes

- It is possible to **assess the processes** governing mobilization and transport of nutrient (P, N and C) from soil and sediments by determining their phosphate pools and water chemistry
- More frequent intensive **rain episodes** enhance eutrophication through increased erosion and leaching of nutrients
- Continued flux of P from over fertilized soils and sediments will **maintain** eutrophication of lakes in agricultural regions despite appropriate abatement measures



Models

- It is possible to adequately **parameterize** processes governing nutrient fluxes to improve performance of the conceptual models



Bayesian Belief Network

- Joint uncertainty** regarding the cost-effectiveness of abatement measures will be reduced by accounting for correlation between drivers common to two or more sub-models
- Uncertainty will be increased by accounting for **behavioural responses** as implementation uncertainty



Societal response

- Knowledge of **stakeholder interests** will be essential for the success of the overall public policies

Research Strategy

 The hypotheses will be tested through works packages in an integrated project framework dealing with

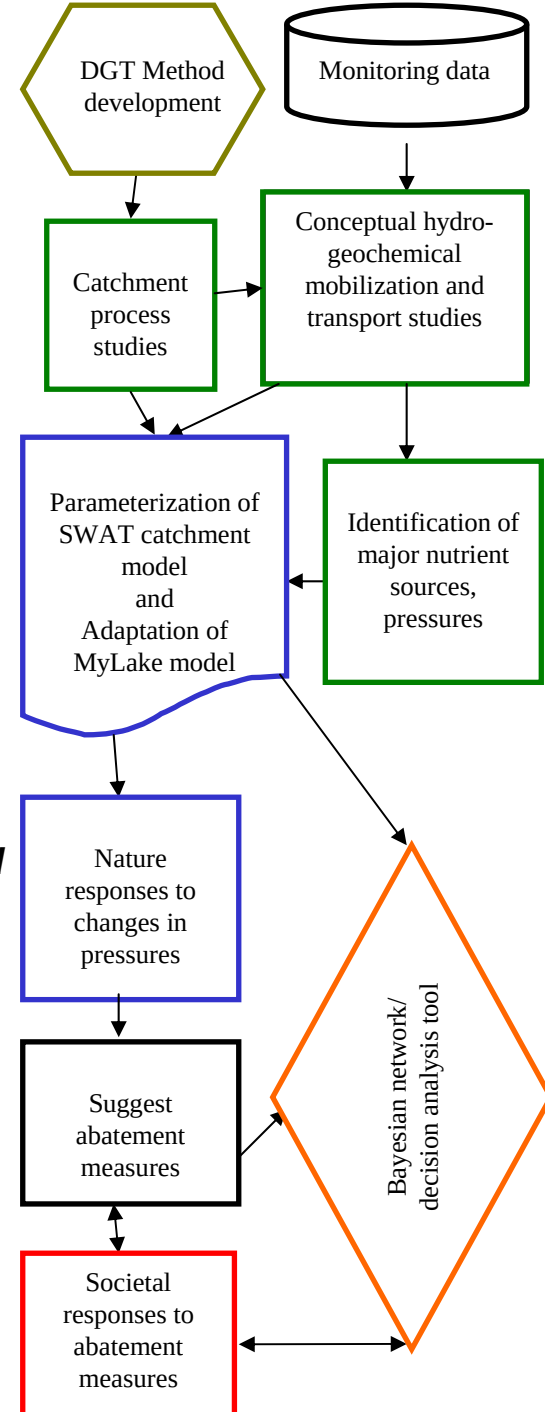
WP1 *Development of sampling and laboratory methods for P fractionation*

WP2 *Catchment processes - the influence of climate and land-use on nutrient fluxes into aquatic systems*

WP3 *Modelling of catchment and lake processes*

WP4 *Integrated uncertainty analysis of cost-effectiveness of measures using Bayesian belief network methodology*

WP5 *Societal response*



Tasks



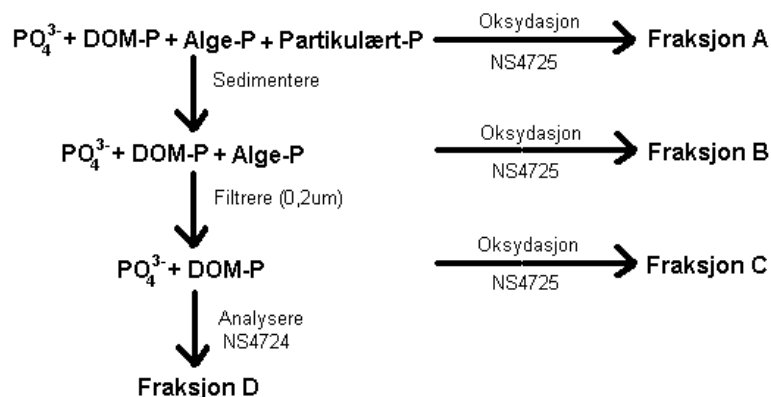
WP1 Develop monitoring methods

- Determination of P-fractions
- Diffusive Gradients in Thin films (DGT)



WP2

- Study
- Study
- Proce
- Syno
- hydro



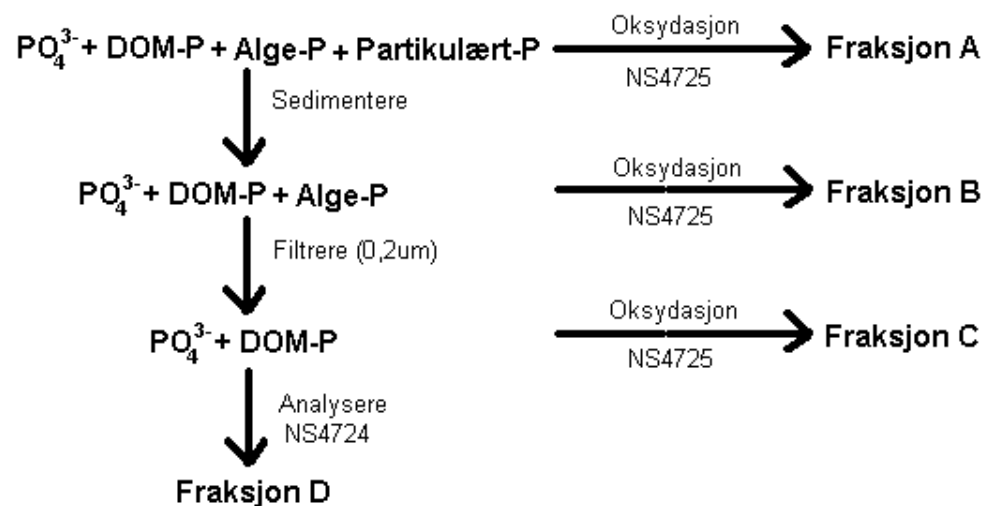
WP3

Fraksjon A = Tot-P

- The S Fraksjon A - Fraksjon B = Partikulært-P
 - MyLa Fraksjon B - Fraksjon C = Alge-P
 - Mark Fraksjon C - Fraksjon D = DOM-P
- Fraksjon D = PO₄³⁻

jø
run on the uncertainties

P fractionation



Fraksjon A = Tot-P

Fraksjon A - Fraksjon B = Partikulært-P

Fraksjon B - Fraksjon C = Alge-P

Fraksjon C - Fraksjon D = DOM-P

Fraksjon D = PO_4^{3-}

Tasks



WP4 Bayesian network

- *Reduce uncertainty*
 - Including **conceptual process** and
 - **Calibrate** against new monitoring data
- *Assess farmer response*
 - Conduct a farm-level **survey**
 - Develop a **new model** of farmer response to abatement measures
- *Assess the effectiveness of abatement measures*
 - Adapt the Bayesian network to **MCMC** simulation results
- *Use the Bayesian network methodology to integrate project activities*



WP5 Societal response

- *Conduct a baseline study of the **policy process** of dealing with eutrophication*
- *Carry out an analysis of the political/administrative **decision-making process***
- *Assessment of the **relevance and legitimacy** of probability modelling (Bayesian network modelling)*
- *Develop and improve the **DPSIR model***

欢迎指导!

Thank You

谢谢!

