

Phosphorus and phytoplankton development in Årungen

Workshop 5th November 2008

Aleksandra Trnic Romarheim

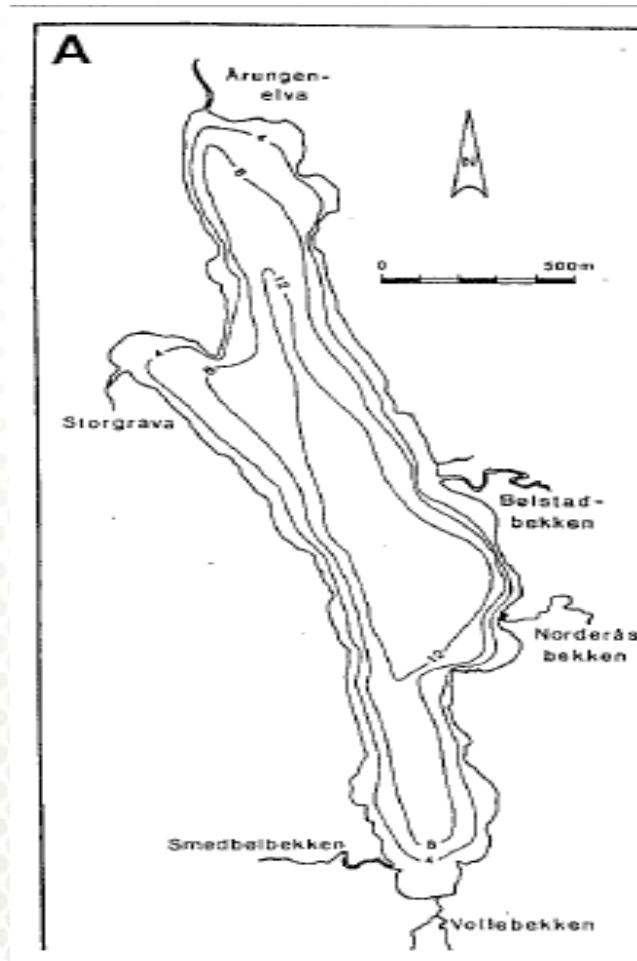


Outline

- Årungen
- Research in Årungen - historically
- Phosphorus - long term trend
- Phytoplankton - long term trend
- Phosphorus and phytoplankton seasonal variation
- UMBs research in Årungen



ÅRUNGEN



- Catchment area: 52 km²
 - Lake surface area : 1.2 km²
 - Agriculture: 53 %
 - Forest: 34 %
 - Settlement: 10 %
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- Max depth: 13 m
 - Mean depth: 8 m
 - Water retention time: 4.5 months

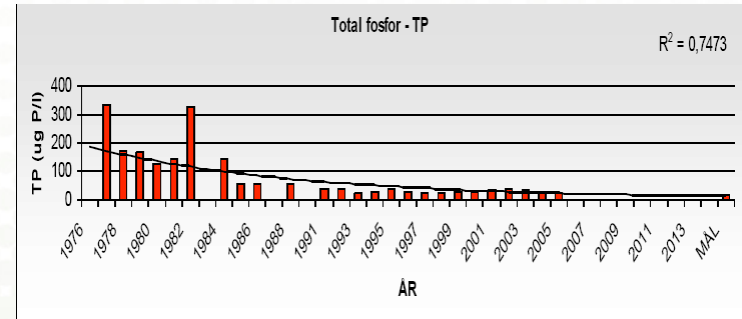
The state of Årungen

- Improvement in agriculture practices
- Improvement in sewage systems
- Constructed wetlands
- Biomanipulation

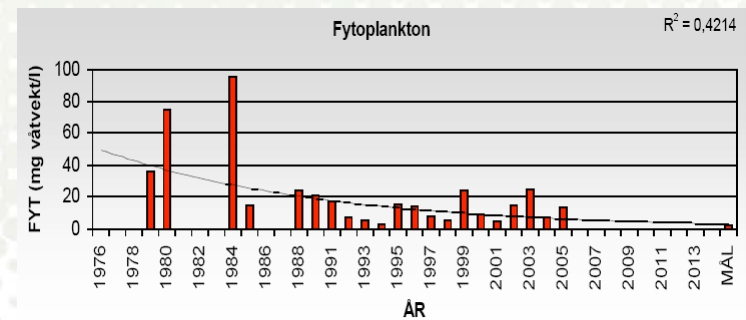


- **Challenges:**
- High phosphorus and nitrogen concentration
- High primary production
- Low Secchi depth
- Algae bloom (blue – green algae)

Long term trend – Total phosphorus

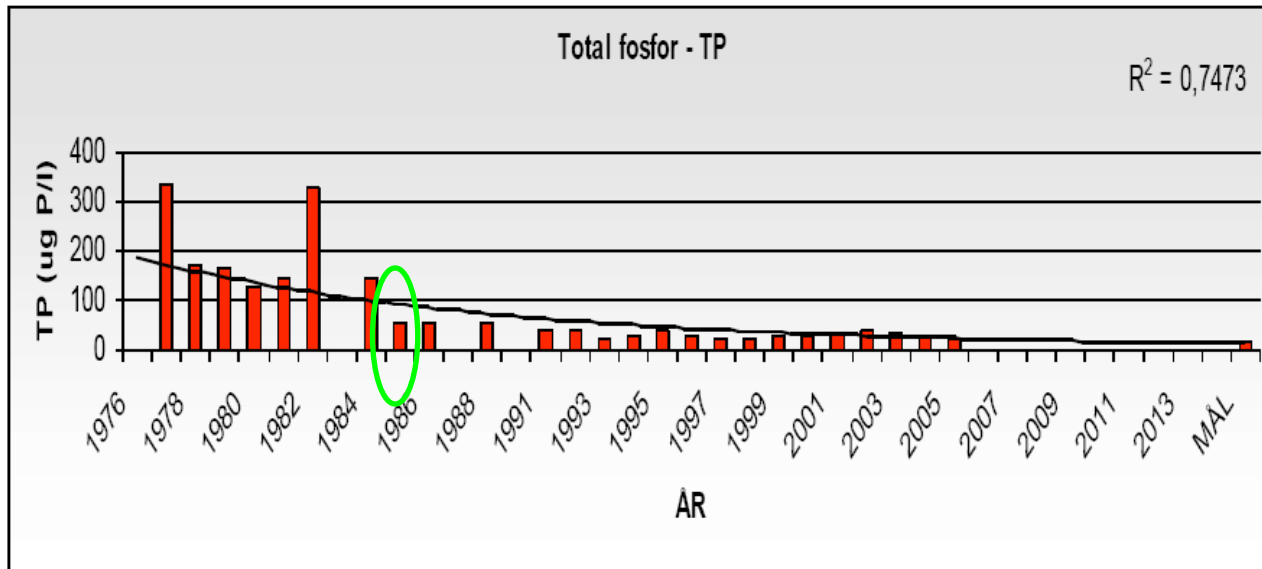


Long term trend - Phytoplankton



Phosphorus in Årungen: year to year variation

Long term trend – Total P



Research in Årungen

	Natural state	Brettum et al., 1975	NLVF 1979-1981	Løvstad and Krogstad. 1991	2008
TP, µg/l	7-8	160-250	150-400	30-70	37-148
TN, µg/l	-	1700-5200	1640-3977	1400- 3700	1850- 3520
Secchi depth, m	-	0,1-1,6	0,2-1,8	0,25-2	0,2-1,4
Chl <i>a</i> , µg/l	-	-	-	-	107*
SFT class	II	V	V	V	V

* The highest concentration of Chl *a* measured

Tabell 23 : SFTs verditabell for klassifisering av ferskvann

Virkninger av	Parametre	I <i>Meget god</i>	II God	III Mindre god	IV Dårlig	V Meget dårlig
Næringssalter	Totalt fosfor (µg/l)	<7	7 - 11	11 - 20	20 - 50	>50
	Klorofyll <i>a</i> (µg/l)	<2	2 - 4	4 - 8	8 - 20	>20
	Total nitrogen (µg/l)	<300	300 - 400	400 - 600	600 - 1200	>1200
Partikler	Turbiditet (FTU)	<0,5	0,5 - 1	1 - 2	2 - 5	>5
	Susp. stoff (mg/l)	<1,5	1,5 - 3	3 - 5	5 - 10	>10
	Siktedyp (m)	>6	4 - 6	2 - 4	1 - 2	<1 0,5m

Effects of warming on phosphorus dynamic in lakes

- Change stratification in the lake (summer period)
- Increased annual load of P from land to the lake (winter period)

Winter episode (Øygarden, 2000)

January 30

Runoff: 25 mm

Soil loss: 2 kg ha⁻¹



January 31

Runoff: 77 mm

Soil loss: 3 050 kg ha⁻¹



Effect of climate on phytoplankton in lakes

- Extended algae growth season (Wiedner et al., 2007)
- Increased phytoplankton biomass
- Changed phytoplankton composition

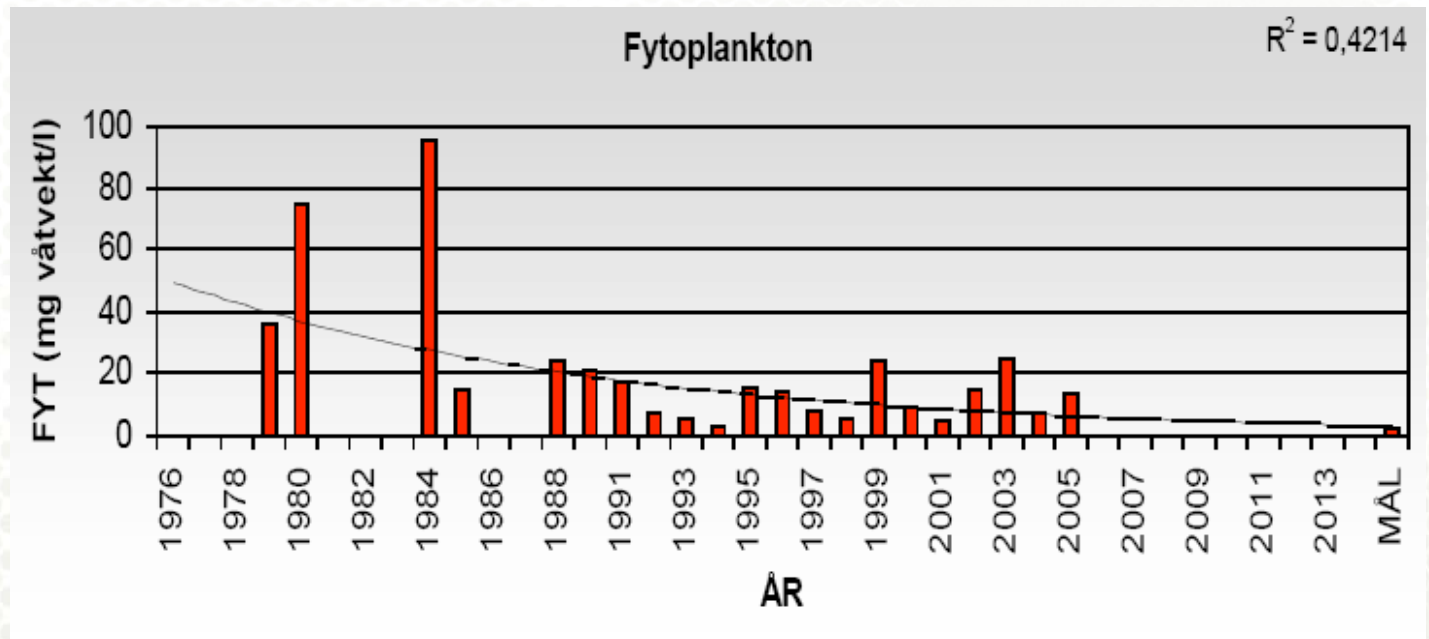
Effects of increased precipitation on phosphorus in lakes

Increase runoff and input of nutrients to the lake



Phytoplankton biomass in Årungen: year-to-year variation

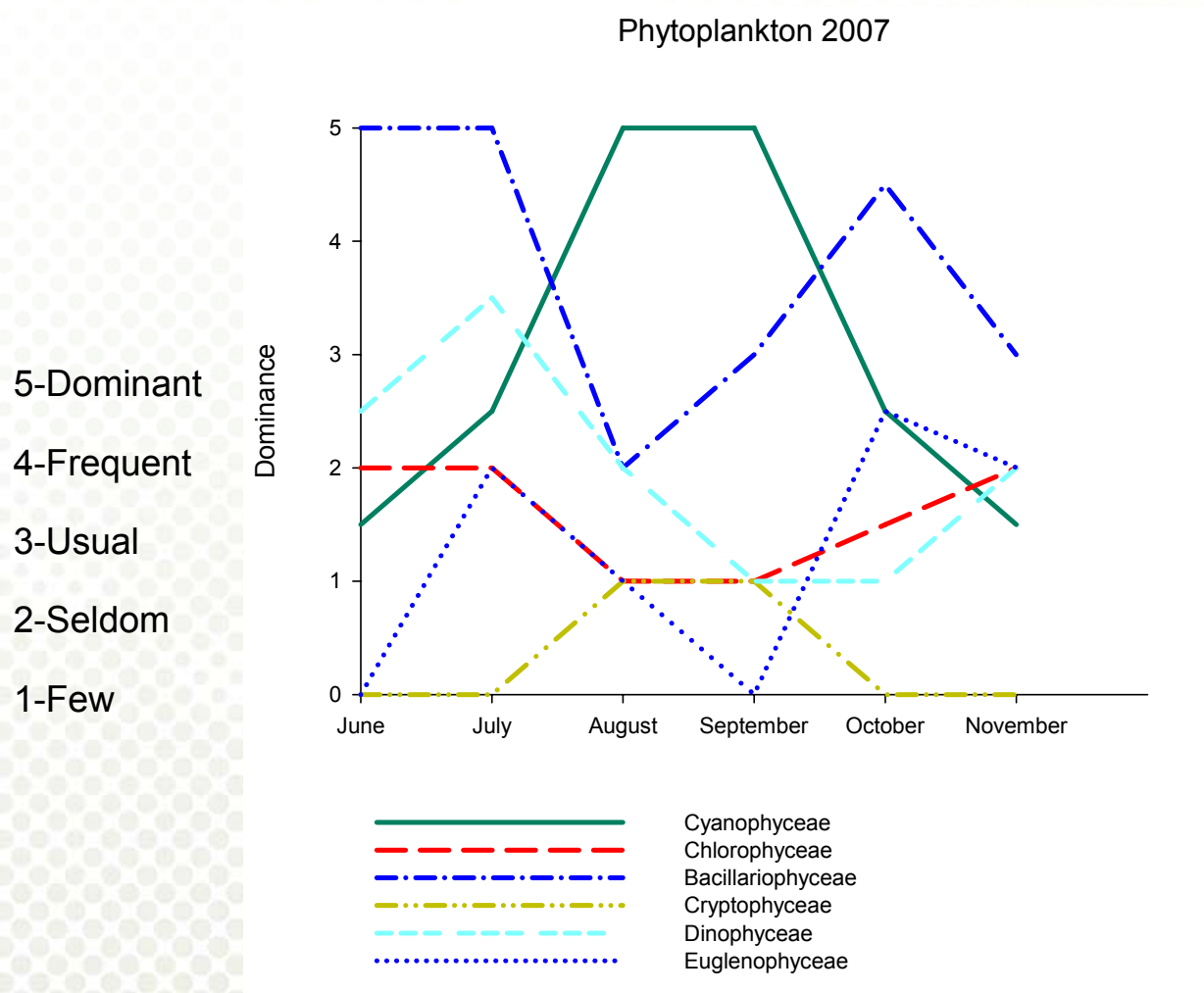
Long term trend - phytoplankton



Dominant phytoplankton in Årungen

	Brettum et al, 1975	NLVF, 1979-1981	Løvstad and Krogstad, 1991	2007
Spring	<p>Chlamydomonas Oocystis lacustris Chrysomonadae Cryptomonas spp. Cyclotella stelligera Nitzschiapalea Stephanediscus astrea</p>	<p>Dominant of cyanobacteria, mostly Oscillatoria (Planktothrix) agardhii and Microcystis aegerinosa</p>	<p>Synechococcus sp. Diatoma elongata Stephanodiscus hantzschii Oscillatoria (Planktothrix) agardhii</p>	<p>Planktothrix cf. agardhii</p> <p>Fragilaria ulna (morfortyp"ulna")</p> <p>Fragilaria crotonensis</p> <p>Peridiniopsis elpatiewskyi</p> <p>Peridinium sp.</p>
Summer	<p>Mycrocystis flos-aquae Osmarim ornatum Chrysomonadae Cryptomonas spp. Gloeococcus schroeteri</p>		<p>Synechococcus sp. Aphanothece clathrata Oscillatoria (Planktothrix) agardhii Microcystis sp. Aphanizomenon flos-aquae Anabaena solitaria</p>	<p>Microcystis sp. Anabaena planctonica Aphanizomenon sp. Asterionella formosa Fragilaria crotonensis Aulacoseira italica v.tenissima</p>

Seasonal variation in phytoplankton composition

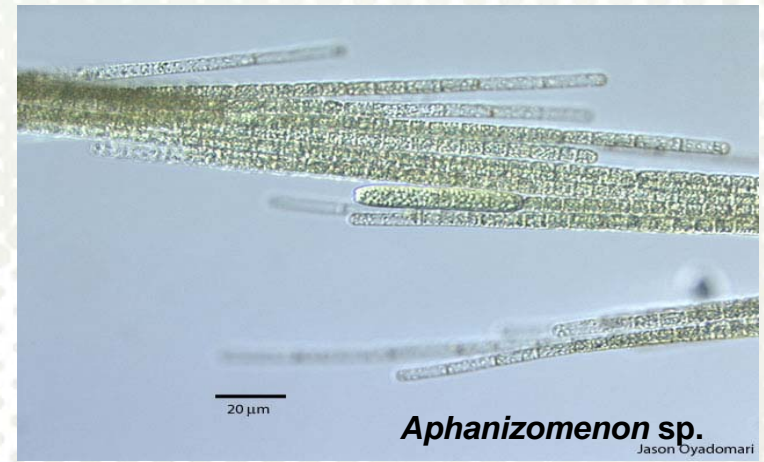
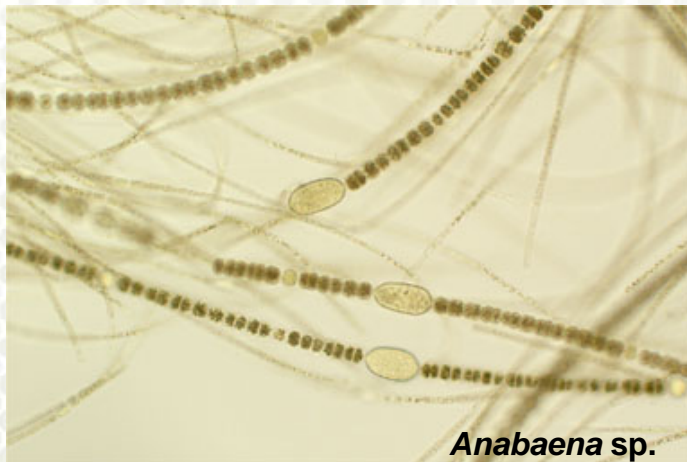
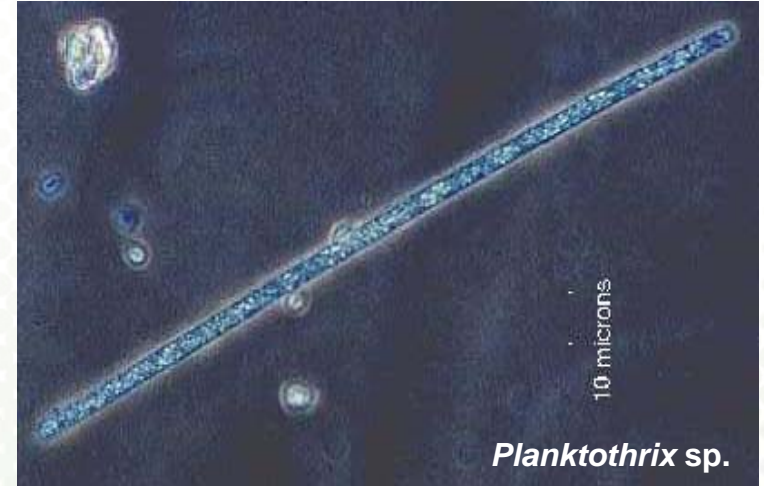
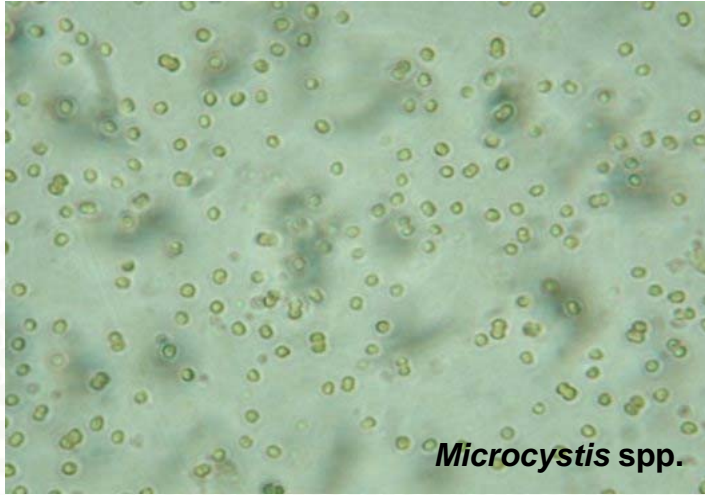


Cyanobacteria in general

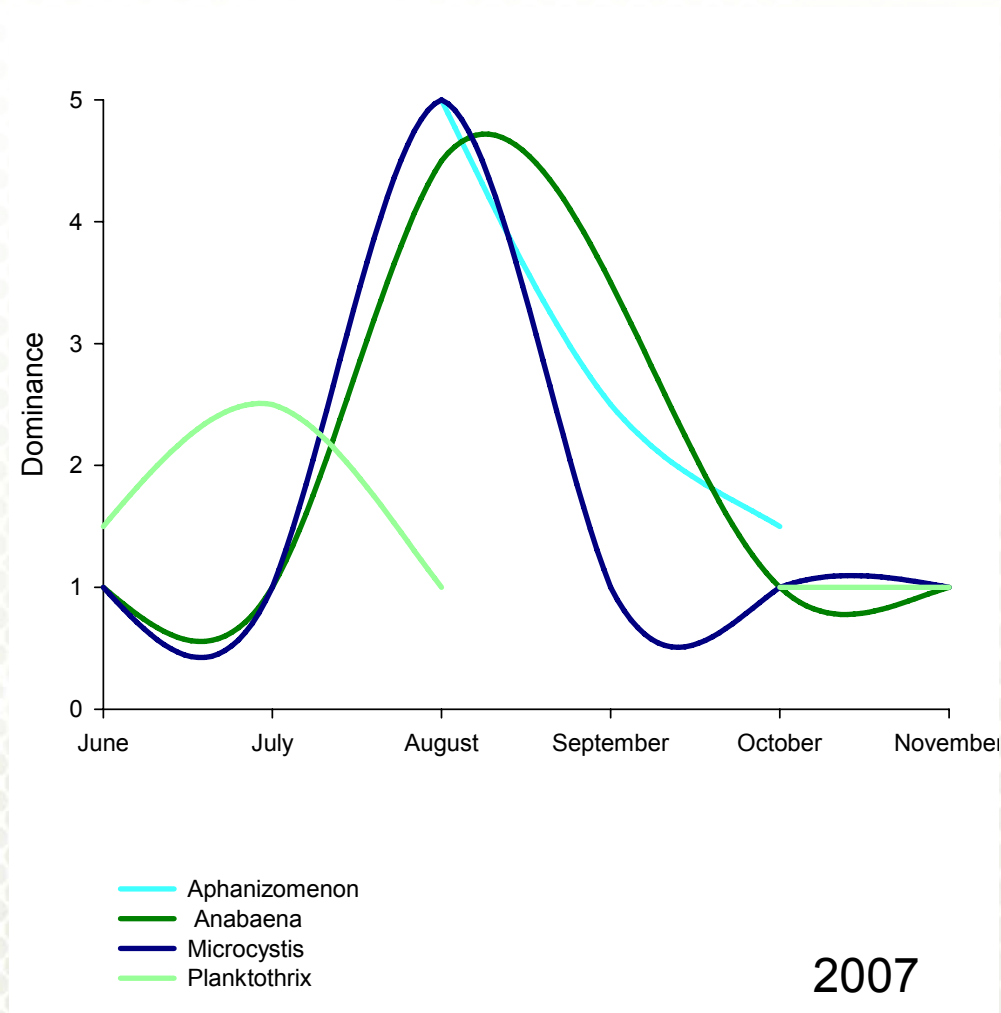
- High affinity for nutrients
- Have storage capacity for phosphate
- Thrive in warmer water
- Less edible
- Some are toxic



Cyanobacteria in Årungen



Cyanobacteria in Årungen



Our research

- The effect of climatic conditions on in-lake phosphorus dynamics
- The relationship between the lake phosphorus and lake primary production under different climatic conditions

Cyanobacteria in Årungen

- **Place of sampling:** outlet

the deepest place (13 m)

Vollebekken



- **Sampling material:** water, phytoplankton, sediments
- **Type of water samples:** whole water samples on 1 m, 3 m , 5 m, 8 m, 12 m and 13 m
- **Time of sampling:** Monthly and weekly/biweekly sampling



Measuring *in situ*

Temperature (MultiLine P4, YSI 600XLM, YSI 6920V2)

Dissolved oxygen concentration (MultiLine P4, YSI 600XLM, YSI 6920V2)

Conductivity (MultiLine P4, YSI 600XLM, YSI 6920V2)

pH (YSI 650XLM, YSI 6920V2)

Chl *a* (YSI 6920V2)

Secchi depth



MultiLine P4



YSI 600XLM



YSI6920V2

Chemical analyses

- Total phosphorus and nitrogen
- Phosphate, nitrate and ammonia
- Total and dissolved organic carbon
- pH
- Alkalinity
- Turbidity
- Suspended matter



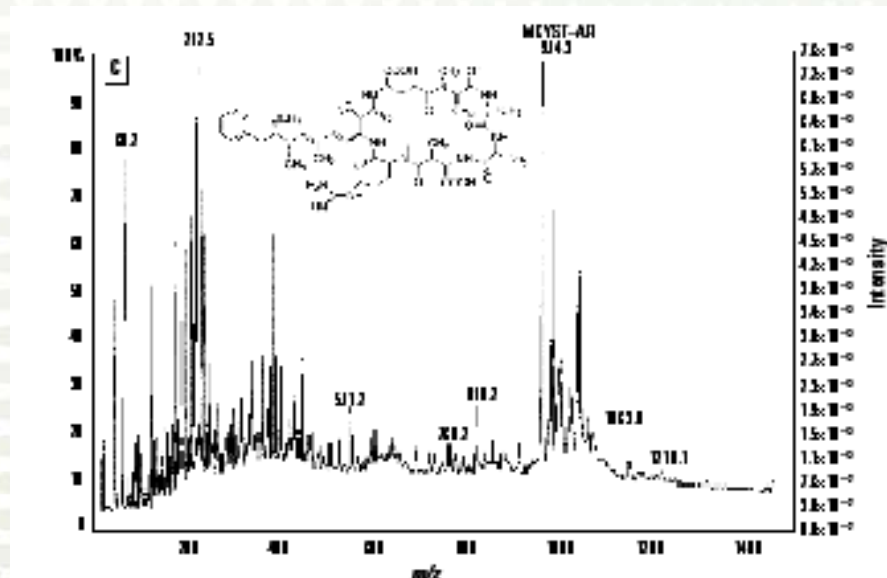
Phytoplankton analyses

- Qualitative; presence/absence, dominance
- Quantitative, but indirect; measuring chlorophyll concentration
- Quantitative, direct; biomass, cell density



Analyses of cyanotoxins

- The qualitative and quantitative analyses of toxins from the cyanobacteria (HPLC, MALDI- TOF MS)



My-Lake Model: A multi-year lake simulation model

● Input:

- Daily meteorological data from weather station
- Monthly mean inflow of water, Tot-P and SS
- P_{do} (diss. org. phosphorus) in the inflow
- Chl a in inflow
- Sediment-related parameters
- S_d (mean summer water transparency)

● Output (Model state variables):

- Temperature (°C)
- Dissolved tracer
- Suspended inorganic particulate matter (can also be utilised as a sedimenting tracer) (kg m^{-3})
- Dissolved inorganic phosphorus (algal-available phosphorus, phosphate) ($\text{g l}^{-1} = \text{mg m}^{-3}$)
- Phosphorus bound to inorganic particles ($\text{g l}^{-1} = \text{mg m}^{-3}$)
- Dissolved organic phosphorus ($\text{g l}^{-1} = \text{mg m}^{-3}$)
- Chlorophyll ($\text{g l}^{-1} = \text{mg m}^{-3}$)

MyLake model application in the Lake Vansjø-Storefjorden

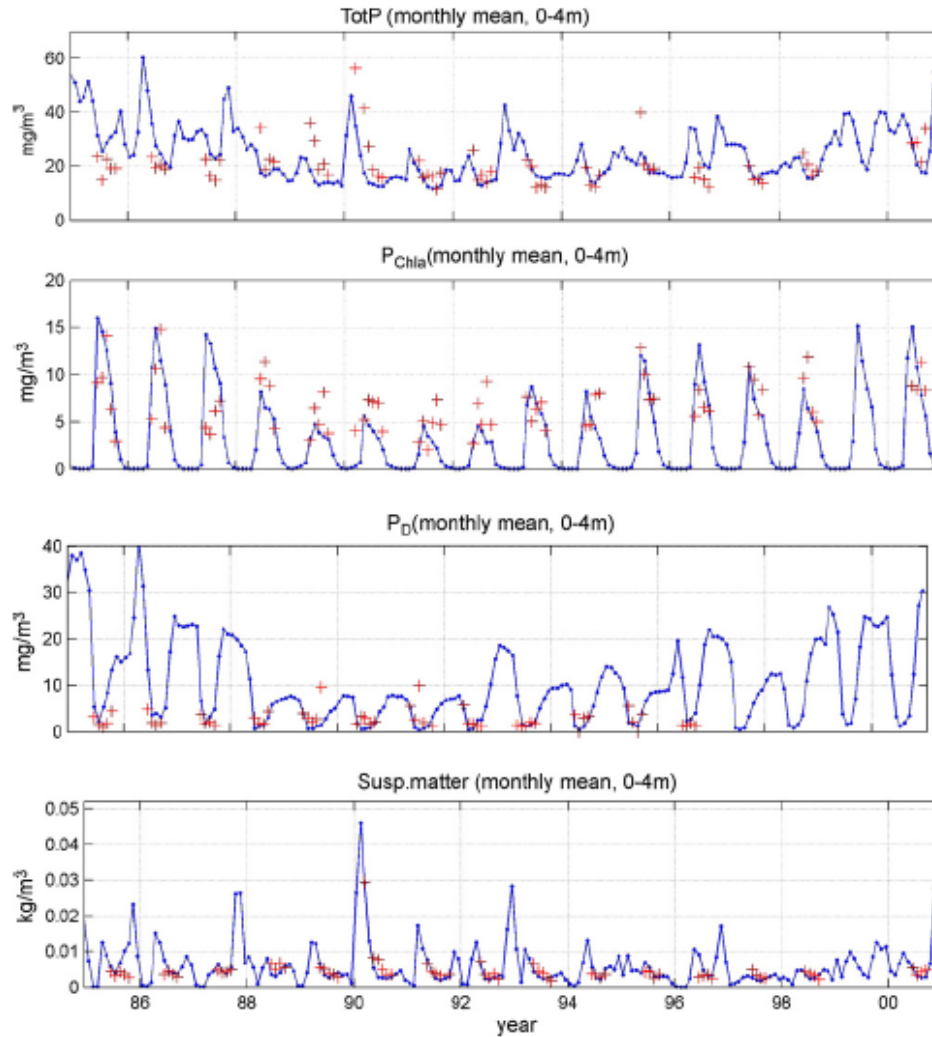


Fig. 5 – Simulated (solid lines) vs. observed (+) surface layer (0-4 m) monthly mean time series of total P (TotP), chlorophyll (P_{Chl}), dissolved inorganic P (P_D), and suspended particulate matter (algae + S_{IS}) in Lake Vansjø-Storefjorden, Norway.

Saloranta and Andersen, 2007



Conclusion

- Further reduction of external loading of phosphorus
- Registration of water and nutrient inputs to Årungen
- Better connection between monitoring and management
- Evaluation of countermeasures
- Estimation of sediments as internal source of phosphorus
- Study the effects of climate variation on eutrophication