

Bør vi fokusere på nitrogen i tillegg til fosfor for å redusere eutrofi fra innsjø til kyst?

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Eutrofiering reduserer vannkvalitet, økosystemenes integritet og verdiene av tjenestene de gir oss

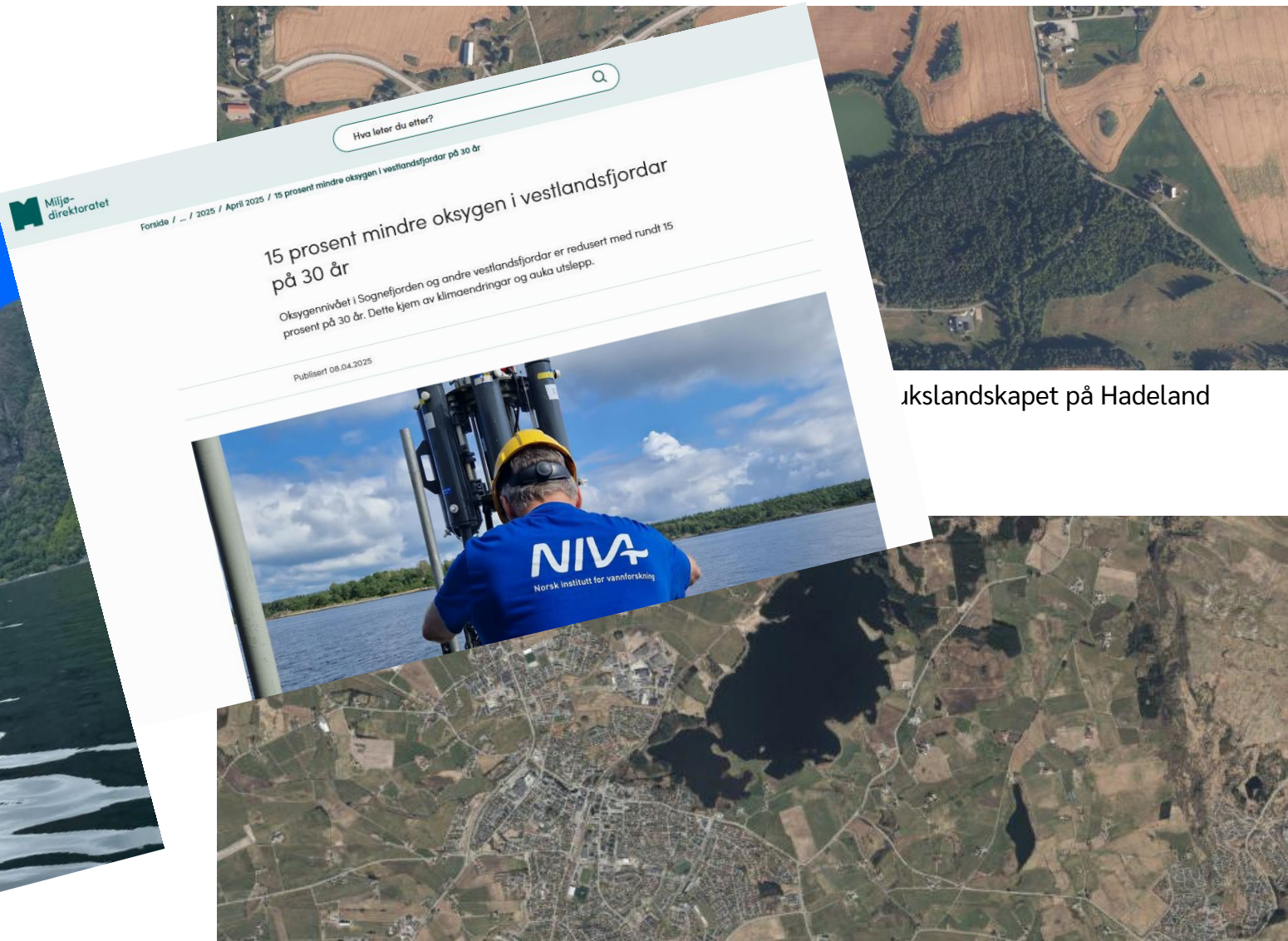


Fotos: venstre: Janne Gitmark/NIVA; midten: Torsten Källqvist/NIVA; høyre: Jarl Eivind Løvik/NIVA

Både innsjøer og kystområder i Norge utfordres av eutrofiering

NIVA

RAPPORT L.NR. 7744-2022



Målrettede og effektive tiltak krever kunnskap om hva som er begrensende næringsstoff

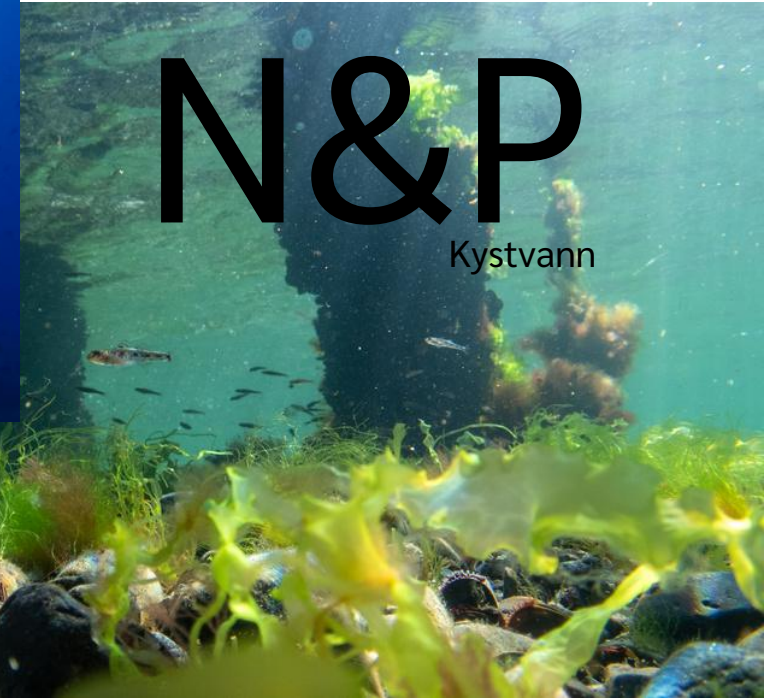
P
Ferskvann



N
Åpne havområder



N&P
Kystvann



Typen næringsbegrensning (P eller N) kan få konsekvenser for klassifiseringen – og dermed for krav om tiltak

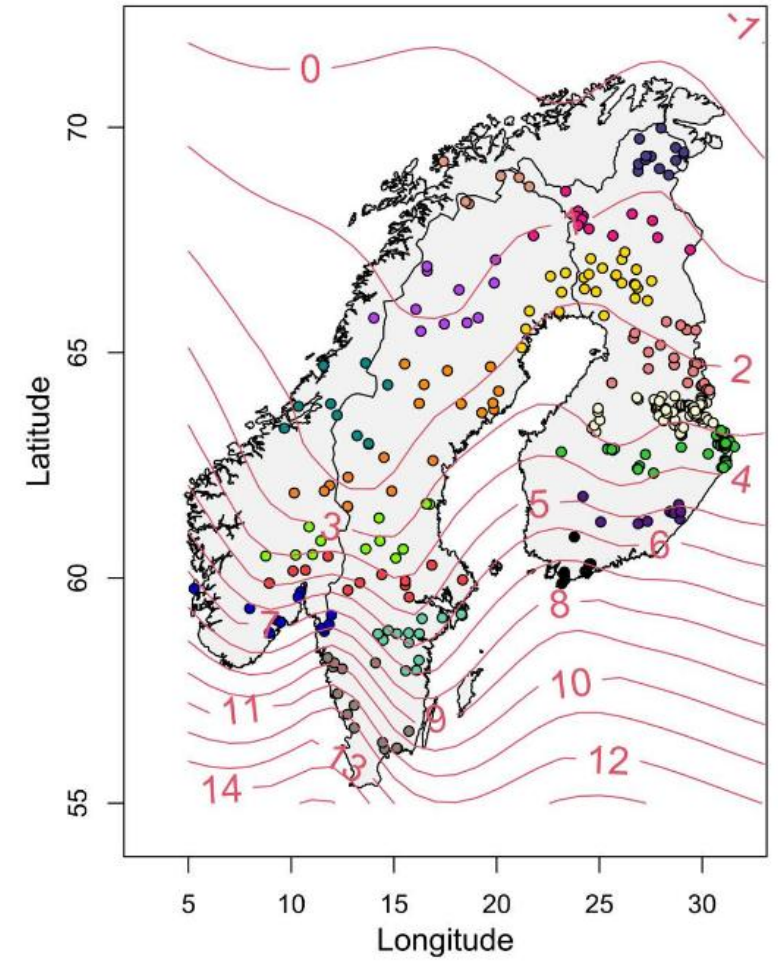
parameter. Tilsvarende gjøres for eutrofieringsparameterne total fosfor (Tot-P), totalnitrogen (Tot-N), siktedyp, og oksygenkonsentrasjon (O₂). Totalnitrogen brukes kun dersom vannforekomstene er nitrogenbegrenset, noe som hovedsakelig forekommer i sterkt eutrofierte vannforekomster.

Nitrogenbegrensning kan forekomme dersom Tot-N / Tot-P forholdet er lavere enn 20 (på vektbasis) (middelverdi for vekstsesongen) og summen av nitrat (NO₃) og ammonium (NH₄) er under deteksjonsgrensen (dvs. 10 µg/l) på minst ett tidspunkt gjennom vekstsesongen.





N-deposisjon (kg N / ha / år)

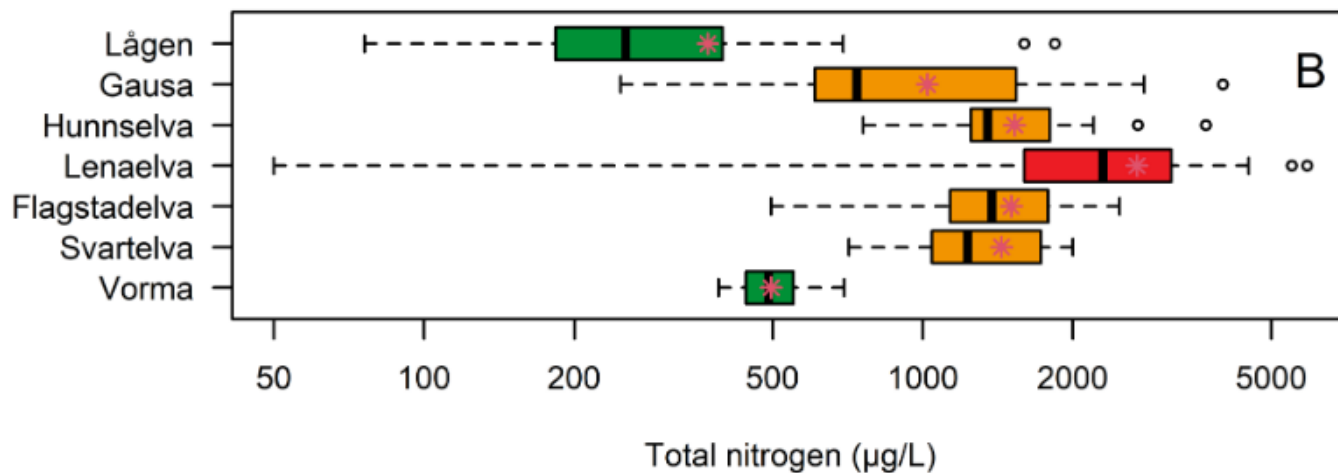
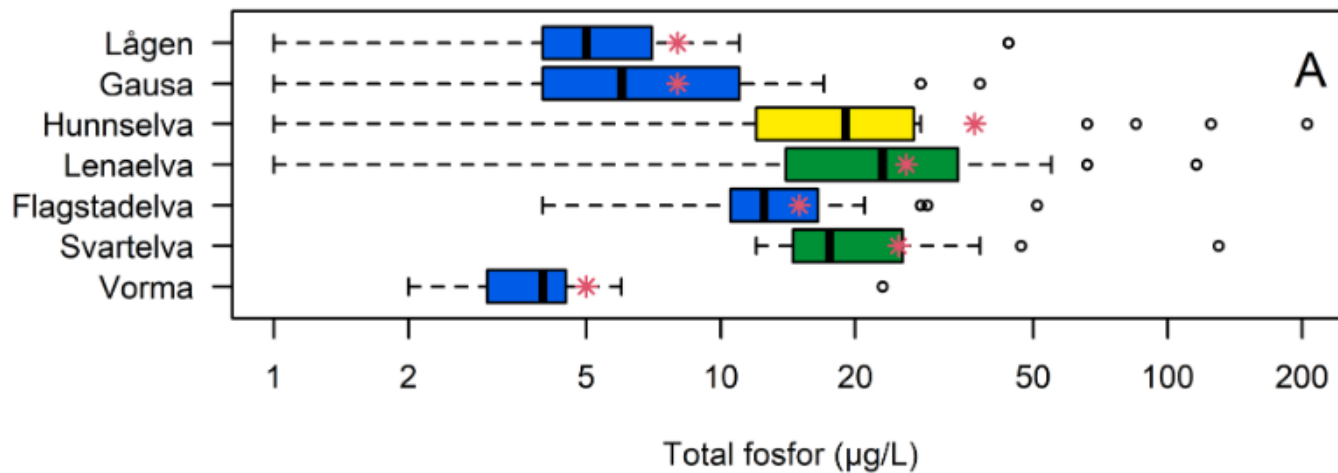


Kalksjøer i jordbrukslandskap (Lunner og Gran kommuner)

Lokalitet	Vannforekomst ID	Nasjonal vanntype	Ca (mg/L)	År med klif-data	Klf α ($\mu\text{g/L}$)	Tot-P ($\mu\text{g/L}$)	Tot-N ($\mu\text{g/L}$)	Cyano max (mg/L)	Plante-plankton nEQR	Vann-planter nEQR
Omdalsvann	012-4915-L	L207	39							G
Oppentjernet	012-4909-L	L207	26							G
Kalvsjøtjernet	012-4891-L	L207	40	3	5,7	17,9	598	0,16	0,51	M
Raknerudtjernet	012-4832-L	L207	64	3	20,3	31,3	2101	0,10	0,24	
Jarenvatnet	012-557-L	L109	54	2	6,4	11,9	2023	1,69	0,57	0,35
Krugerudtjern	012-4849-L	L207	29	3	1,7	8,9	1046	0,02	0,86	M
Stumnetjernet	012-4858-L	L207	43	3	8,6	17,2	1682	0,23	0,49	-
Harpetjernet	012-3303-R	L207	26							D
Grønntjernet	012-3303-R	L207								D
Bergstjern	012-4742-L	L109	73	1	7,1	17,5	1735	0,14	0,81	0,34

Lokalitet	Vannmiljø-ID	Vannforekomst	Vann-type	Tot-P	Tot-N	Fosfat	Nitrat	PIT	Samlet tilstand
Askjumbekken (ASK1)	012-42316	012-734-R	R109	25	4600	7 (noe forhøyet)	4075 (sterkt forhøyet)	M	M
Vigga (VIG1)	012-30637	012-3315-R	R110	19	2533	2 (nær bakgrunn)	2125 (sterkt forhøyet)	M	M
Vangselva (VAN1)	012-28770	012-1681-R	R109	13	1630	3 (nær bakgrunn)	1400 (sterkt forhøyet)	M	M
Sløvikelva (SLØ1)	012-28759	012-400-R	R109	21	2091	6 (noe forhøyet)	1642 (sterkt forhøyet)	G	G
Grymyrbekken (GRY1)	012-53731	012-366-R	R109	23	2300	7 (noe forhøyet)	1900 (sterkt forhøyet)	M	M

Mesteparten av TN er NO_3



**Men er det egentlig et problem at vi
«overser» slike høye nitrogen-
konsentrasjoner i ferskvann?**

Flere argumenter *mot* et for ensidig fokus på fosfor



POLICY ANALYSIS

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Rationale for Control of Anthropogenic Nitrogen and Phosphorus to Reduce Eutrophication of Inland Waters

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ABSTRACT: Concentrations of phosphorus and nitrogen in surface waters are being regulated in the United States and European Union. Human activity has raised the concentrations of these nutrients, leading to eutrophication of inland waters, which causes nuisance growth of algae and other aquatic plants. Control

$P + N =$

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Review Paper

On the Phosphorus Limitation Paradigm for Lakes

key words: lake, nitrogen, iron, eutrophication, production

Abstract

Lakes are often said to be primarily phosphorus limited, but this paradigm has been described in numerous ways and there is considerable evidence that algae in lakes are often limited by other elements too. Crucial whole-ecosystem experiments that support the paradigm of the primacy of P limitation are few in number and have been limited to naturally oligotrophic lakes. A large amount of observational

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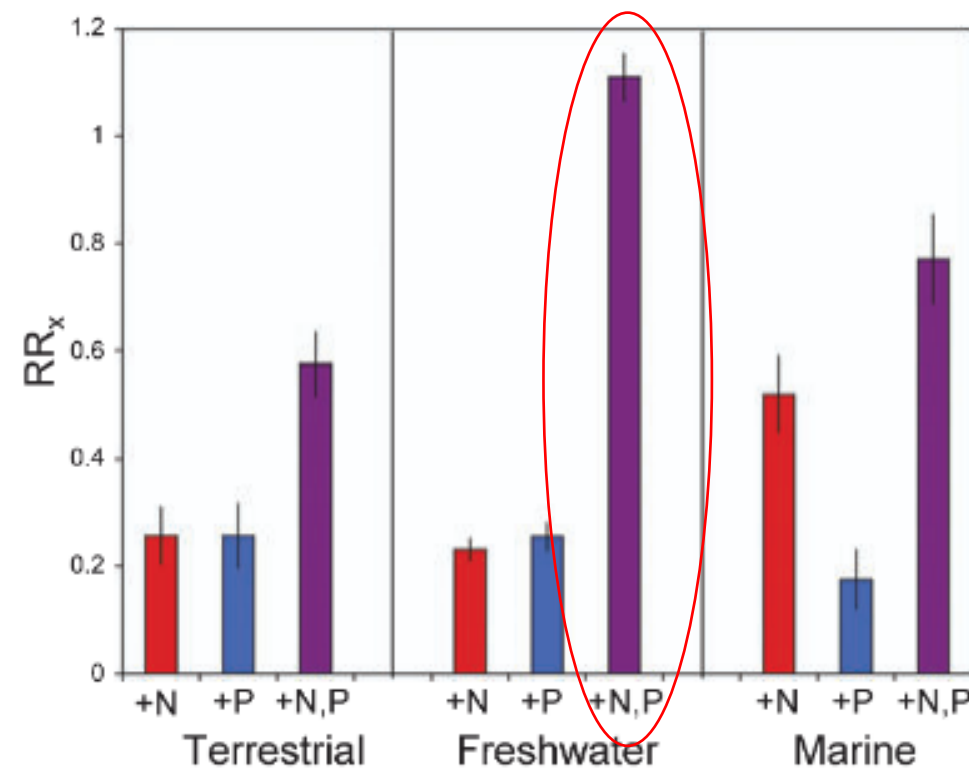
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Argumenter for at nitrogen bør få økt fokus for å begrense eutrofi i ferskvann

- Veksteksperimenter viser at N+P begrensing er vanlig
- N-fiksering kan ikke kompensere fullt ut for N-mangel
- Mange naturlige innsjøer er faktisk N-begrensede
- Svært eutrofe innsjøer har periodevis N-begrensning

LETTER

Global analysis of nitrogen and phosphorus limitation of primary producers in freshwater, marine and terrestrial ecosystems

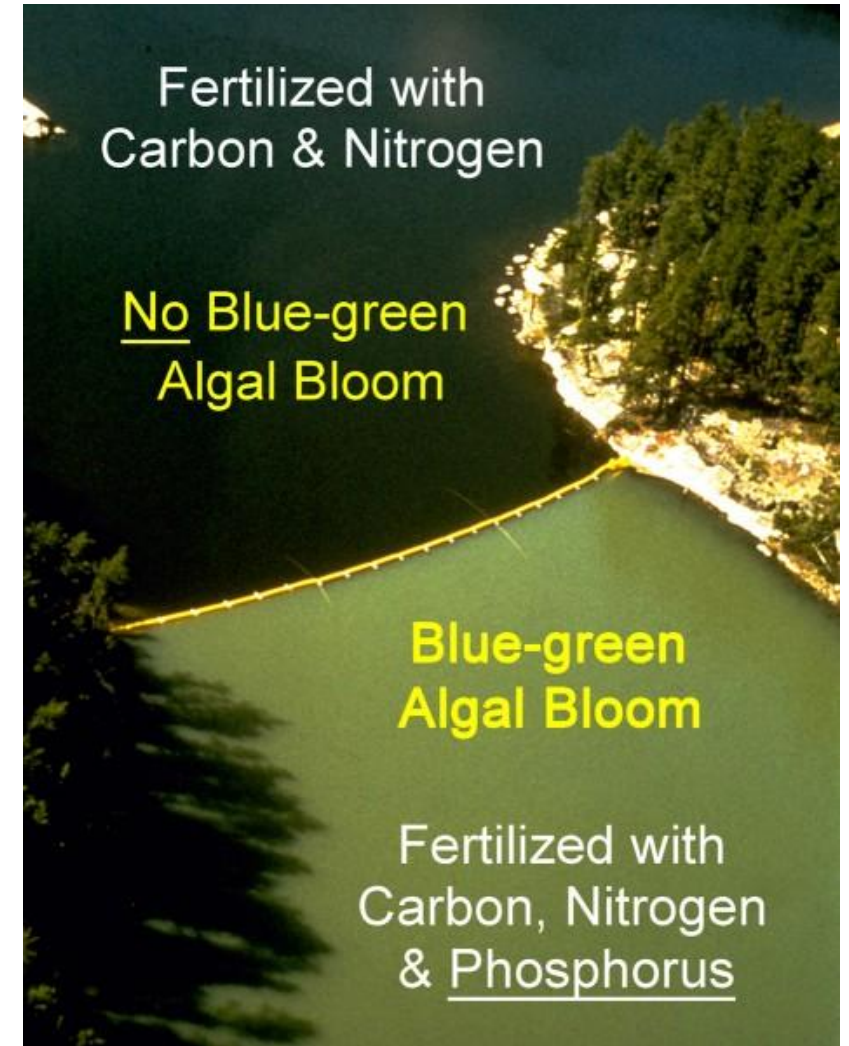
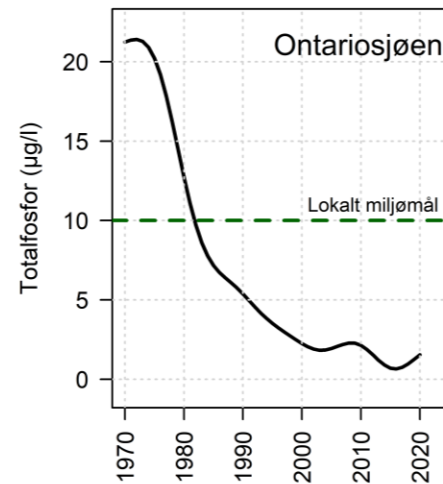
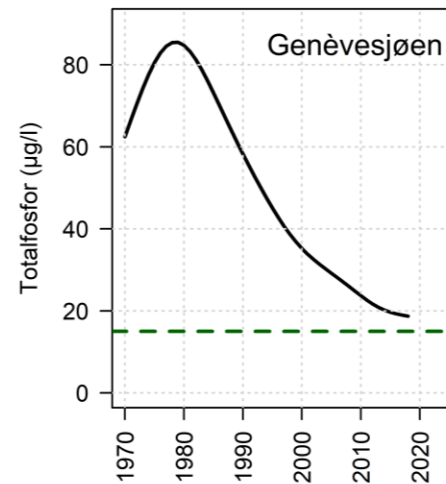
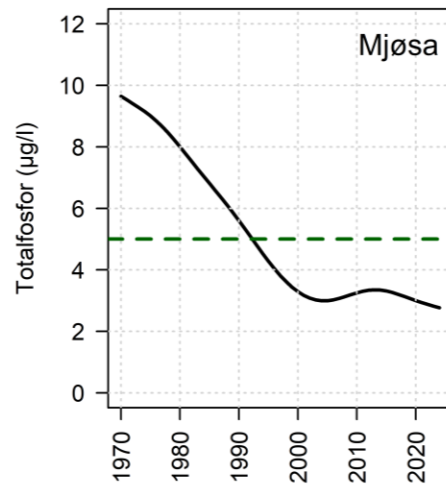


Eutrophication of lakes cannot be controlled by reducing nitrogen input: Results of a 37-year whole-ecosystem experiment

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Contributed by David W. Schindler, May 28, 2008 (sent for review March 25, 2008)



Både N og P må kontrolleres om eutrofi skal begrenses i et «land-til-hav» perspektiv

« Improvements in the water quality of many freshwater and most coastal marine ecosystems requires reductions in both nitrogen and phosphorus inputs. »

POLICY FORUM Controlling Eutrophication: Nitrogen and Phosphorus

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The need to reduce anthropogenic nutrient inputs to aquatic ecosystems in order to protect drinking-water supplies and to reduce eutrophication and "dead zones" in coastal marine ecosystems (2) has been widely recognized. However, the costs of doing this are substantial, hence, developing the appropriate nutrient management strategy is very important. Nitrogen (N) and phosphorus (P) needed for protein synthesis, energy transfer, and plant growth are both required to support aquatic plant growth and are the key limiting nutrients in most aquatic and terrestrial ecosystems. However, a cascading set of consequences has been set in motion, arising from massive increases in fixed N additions to the biosphere, largely through the production of fertilizers and increases in fossil fuel emissions (3). P levels have also significantly increased because of the production of fertilizers from municipal and industrial wastewater. Here, we explore the intricate and complex interactions between nutrient reduction strategies for aquatic ecosystems, especially in estuarine and coastal marine regions.

The question of whether one or both nutrients should be controlled to reverse the detrimental effects of eutrophication of lakes was thought to be solved in the early 1970s by Schindler (4), who established that P was the primary limiting nutrient in remarkable long-term experimental manipulations at Lake 227 in the Experimental Lakes Area, Canada (5). These and other results (6) led to widespread reductions in P loading to North American lakes and estuaries, and consequent improvements in water quality (7). On the basis of lake examples, P controls were presented by environmental regulatory agencies for estuarine and coastal marine ecosystems as well (8). P-reduction programs improved water quality in many lakes, but broader water-and

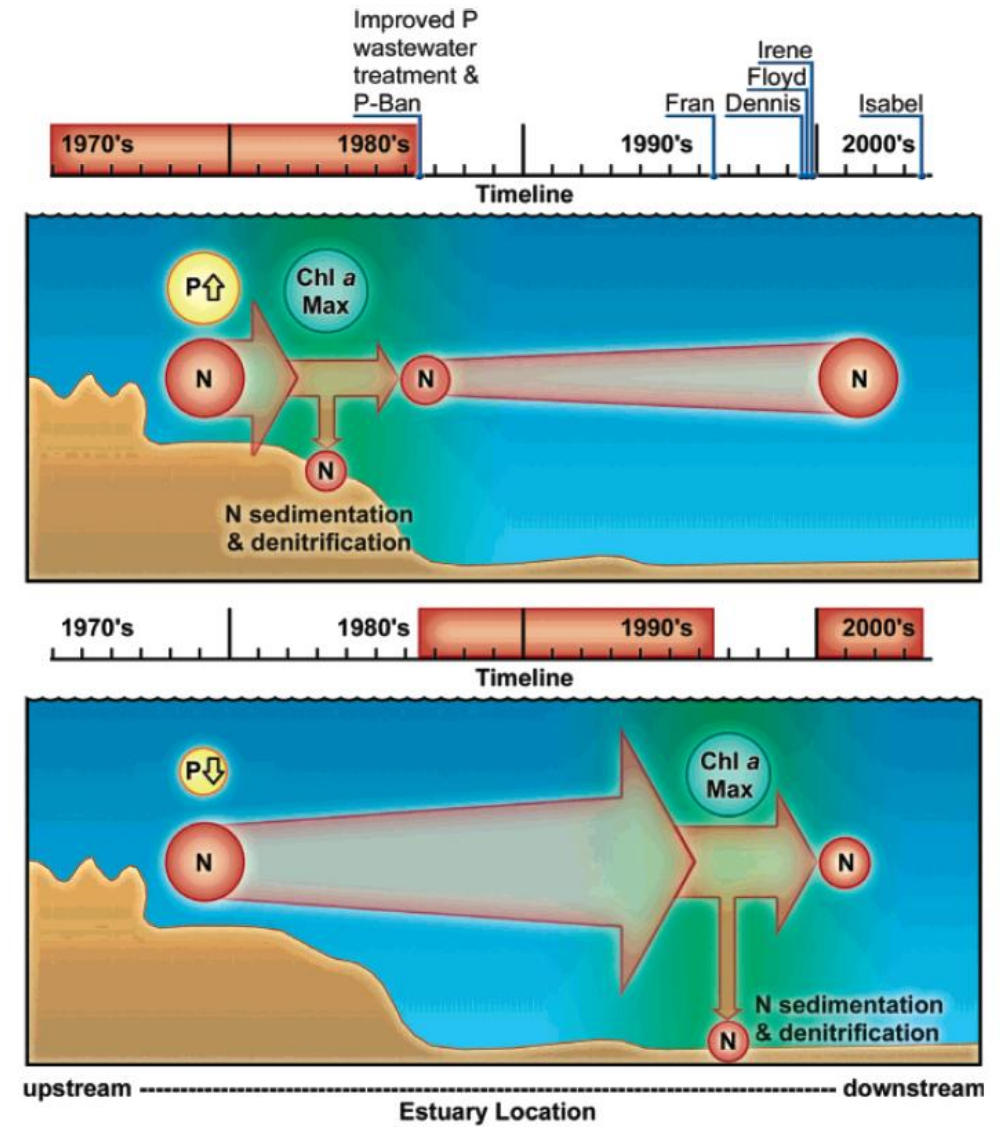
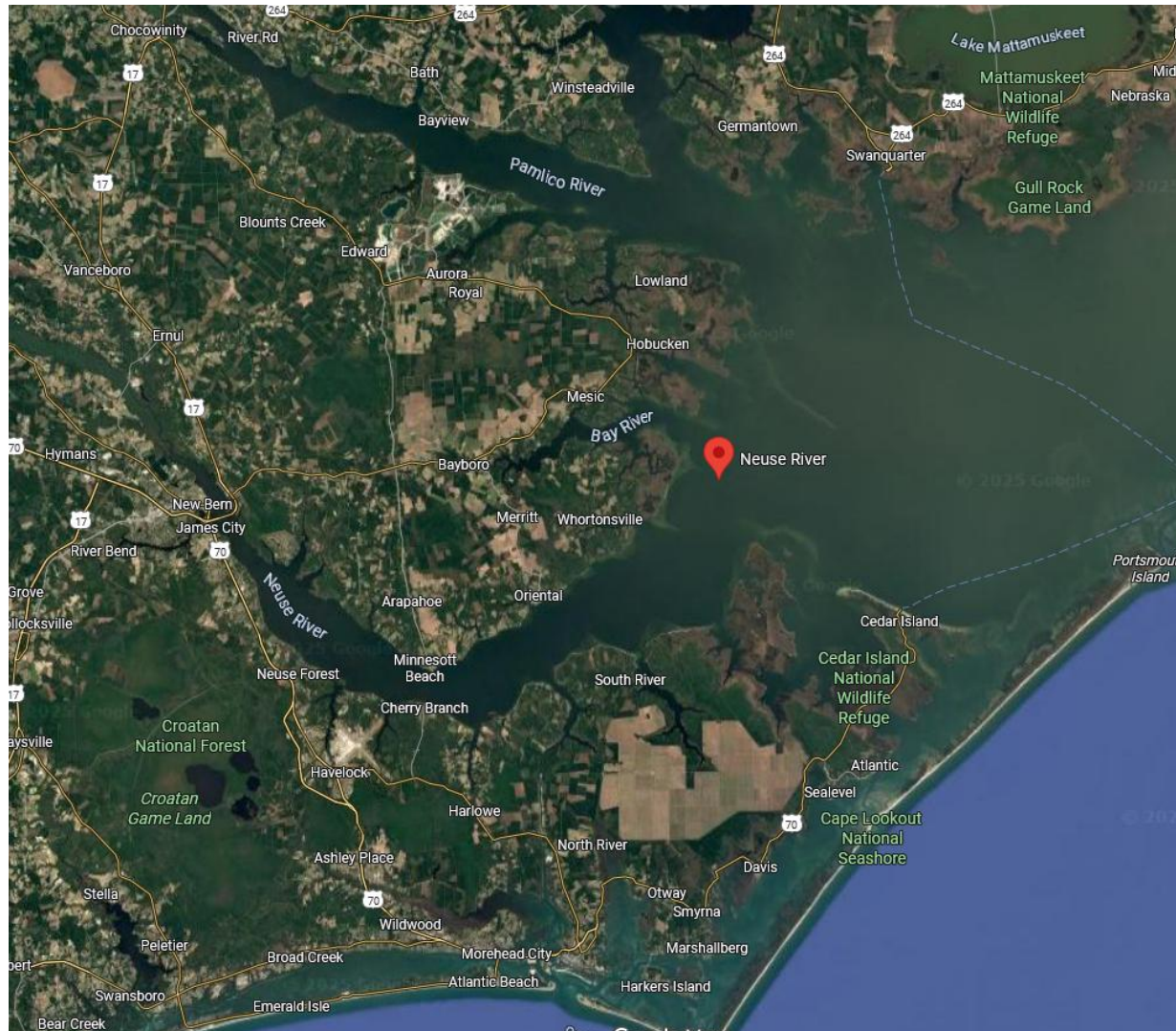
improvements in the water quality of many freshwater and most coastal marine ecosystems requires reductions in both nitrogen and phosphorus inputs.

In lakes, the key symptom of eutrophication is cyanobacterial blooms (see figure, left). Planktonic N-fixing cyanobacteria bloom in fresh waters when P is replete and N availability is low. Such blooms are undesirable because cyanobacteria can be toxic, cause hypoxia, and disrupt food webs (1, 10). N₂ fixation by cyanobacteria also can help to alleviate N shortages and hence maintain a lake in a P-limited condition (5).

N₂ fixation by planktonic cyanobacteria is much less likely in estuaries and coastal seas than in lakes. Significant coastal planktonic N₂ fixation has not been observed at salinities greater than 8 to 10 (ocean salinity is ~35), even in estuaries that are strongly N-limited, except in rare cases (7). If N₂ fixation were the only factor governing blooms of N-fixing cyanobacteria, then their blooms would be widespread in estuarine and coastal marine ecosystems so abundant that they are not. Thus, reducing N loads to the saline waters of estuaries should not cause blooms of N-fixing cyanobacteria (5). Furthermore, eutrophication results in loss of seagrasses and hypoxia, which are more serious ecosystem problems than cyanobacterial blooms (see the figure). Why is N₂ fixation recurrent in estuaries? Numerous hypotheses have been put forward (10, 12). Most researchers have concluded that no single factor is responsible, but rather interactions between two or more factors control the rates (13, 14). Mesocosm experiments in Narragansett Bay (12) indicated that the combination of silicate uptake and zooplankton inhibition of silicate accumulation of silicate by the cyanobacteria

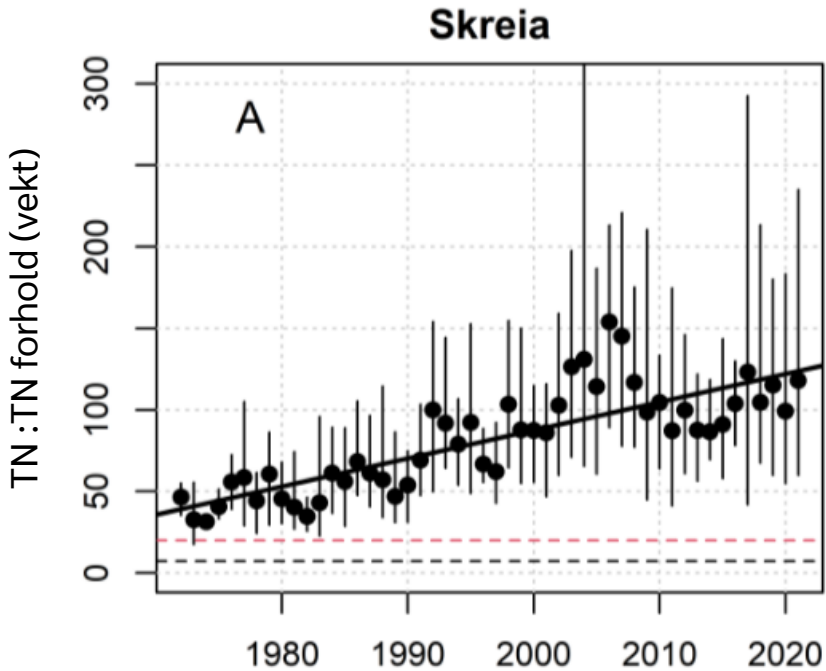
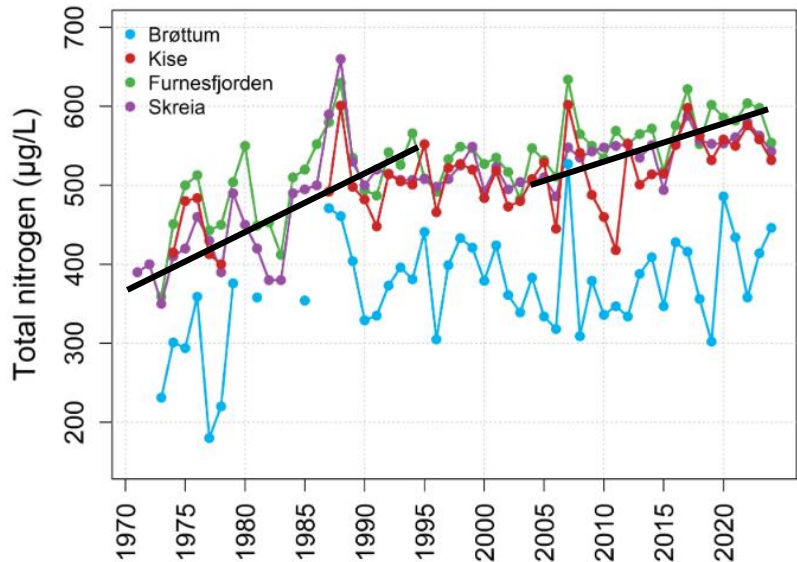
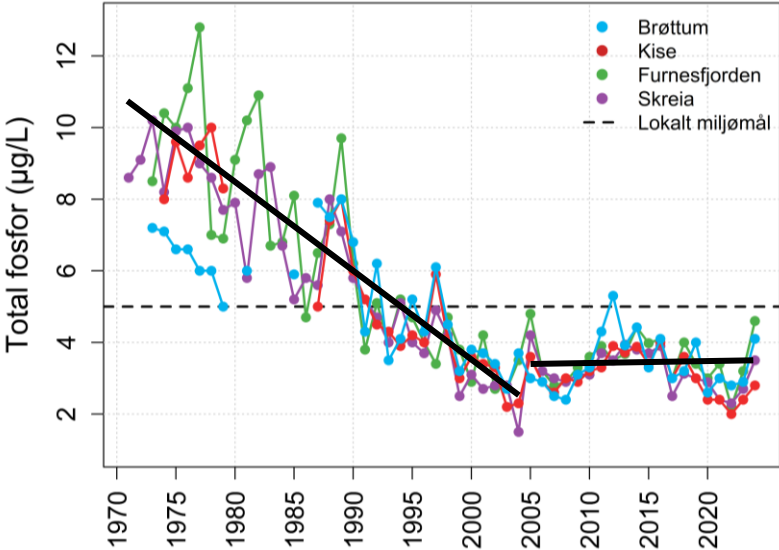
Too much algae. (Top) Removing macroalgal blooms at the Olympic Sailing venue, China. (Middle) Seagrasses covered with attached algae in a Danish estuary. (Bottom) Non-N₂-fixing cyanobacteria blooms in Lake Okechobee, Florida, U.S.A.

Conley et al. 2009 (Science)



- H. W. Paerl, L. M. Valdes, A. R. Joyner, M. F. Piehler, *Environ. Sci. Technol.* 38, 3068 (2004).

Mjøsa – fosfor er kraftig redusert, men nitrogen og N:P forholdet øker



Tabell 6. Målinger av næringssalter i overflatelaget, hovedsakelig fra perioden 2017-2019. For ammonium mangler det på mange stasjoner nyere data, og da er eldre data brukt. I denne tabellen er klassegrensene justert for saltholdighet i tråd med Veileder 02:2018. Enheten er µg/L. NOx er summen av nitrat og nitritt.

Stasjon	Bredde-grad	Lengde-grad	Salth. 0-5m (psu)	TN Jun-Aug	TN Des-Feb	NOx Jun-Aug	NOx Des-Feb	NH4 Jun-Aug	NH4 Des-Feb	TP Jun-Aug	TP Des-Feb	PO4 Jun-Aug	PO4 Des-Feb	Grunnlag parameter	Grunnlag NH4
D-2	59.6280	10.4210	2.5	330	393	181	233	15.0		8.9	12.2	3.3	9.0	2018-2020	2001-2007
D-3	59.7060	10.3140	2.6	374	475	194	282	21.0		7.9	16.3	2.5	11.7	2018-2020	2001-2007
BC-1	59.1040	9.6180	7.5	352	385	136	201	45.9	134.9	8.7	13.0	3.2	11.5	2018-2020	2001-2007
ID-2	59.0750	11.3850	10.3	362	607	112	286	40.0		10.8	20.3	1.9	14.6	2018-2020	2001-2007
R-5	59.1120	11.3140	10.8	359	649	83	310	21.4	46.4	14.2	23.6	3.7	16.9	2018-2020	2001-2007
I-1	59.1090	11.0020	18.5	286	364	88	147	23.4	15.9	10.9	20.2	3.1	14.7	2018-2020	2001-2007
SP-1	59.0892	11.2296	19.2	262	308	37	137	18.5		12.6	29.2	2.8	22.3	2018-2020	2001-2007
Hu6	59.2089	11.0720	19.5			148	197	67.0	325.0	51.0	111.0			1999	1999
VT67	59.0391	9.7332	20.1	193	245	27	104	12.4	18.2	13.5	21.3	3.6	14.3	2018-2020	2018-2020
S-9	59.1140	11.1620	22.5	254	384	33	156	15.9	17.3	10.6	20.2	2.2	14.7	2018-2020	2001-2007
VT66	59.0227	9.7968	23.5	182	238	13	97	8.0	17.9	12.8	21.6	3.0	14.4	2018-2020	2018-2020
MO-2	59.4840	10.6780	23.6	205	315	23	143	19.3		8.6	20.6	2.1	15.6	2018-2020	2001-2007
SKJ-1	59.1800	11.1800	23.9	226	271	18	127	16.0		12.1	21.1	1.6	15.3	2018-2020	2001-2007
Ø-1	59.1370	10.8340	24.0	244	316	22	118	13.2		13.5	20.0	2.1	14.5	2018-2020	2001-2007
VT10	59.4867	10.4583	24.1	185	241	12	119	11.3	10.5	11.2	23.1	2.9	16.2	2017-2019	2017-2019
Ep1	59.7863	10.7238	24.4	232	352	31	213	9.9	5.3	14.9	38.0	1.5	18.2	2017-2019	2017-2019
VT4	59.6047	10.6334	24.9	200	312	12	159	14.1	17.8	10.8	26.4	3.1	17.8	2018-2020	2018-2020
Im2	59.6220	10.6282	24.9	208	323	31	139	5.6	11.2	21.1	26.8	1.2	11.0	2017-2019	2017-2019
VT68	58.9069	9.6233	25.1	168	223	3.6	85	7.3	22.4	14.0	22.6	2.9	15.3	2018-2020	2018-2020
Dk1	59.8150	10.5694	25.3	222	338	21	182	7.0	12.7	15.5	30.9	1.1	19.1	2017-2019	2017-2019
VT2	59.3587	10.5906	25.4	178	259	5.3	120	8.5	16.7	11.7	22.8	2.5	15.5	2018-2020	2018-2020
VT3	59.0407	10.7608	26.0	174	236	8.0	84	7.6	18.9	11.9	23.7	2.9	15.5	2018-2020	2018-2020
LA-1	59.0190	10.0520	26.0	210	240	10.1	90	12.9		10.6	20.3	2.5	14.5	2018-2020	2001-2007
VT65	59.1867	10.6917	26.2	178	247	6.1	105	7.9	18.3	12.2	22.9	2.6	15.7	2018-2020	2018-2020
BO-1	59.1899	10.5362	26.2	187	248	7.7	103	16.0		9.4	18.5	1.6	14.9	2018-2020	2001-2007
TØ-1	59.2030	10.3550	27.2	201	320	51	125	27.7		12.2	23.8	2.7	16.7	2017-2020	2001-2007
KF-1	59.3100	10.7690	27.3	201	287	7.2	105	32.0		11.2	21.8	2.6	16.6	2018-2020	2001-2007
SF-1	59.0770	10.2460	27.8	200	273	6.9	104	26.4		11.4	21.5	1.9	15.1	2018-2020	2001-2007

265 µg/L

85 µg/L

490 µg/L

460 µg/L

540 µg/L

Lågen/nord i Mjøsa



Skreia



Vormå



Glomma, Oslofjorden

?

Oppsummering

- Eutrofiering er en betydelig utfordring i innsjøer i jordbruksområder og urbane strøk, samt i utsatte fjord- og kystområder
- Fosfor er som regel begrensende i ferskvann, men nitrogenbegrensning forekommer og tid- og stedvis
- Reduksjon av fosfortilførsler bør imidlertid prioriteres for å redusere eutrofi i ferskvann
- Et ensidig fokus på P og P-begrensning kan bidra til at høye nitrogentilførsler til ferskvann neglisjeres
- Konsentrasjoner og tilførsler av N øker eller er stabile mange steder
- N:P forholdet i tilførsler til kysten øker – dette kan forverre eutrofiproblemer i kystvann